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16. Abstract

This report documents the research conducted during one phase 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. This report describes laboratory studies conducted in ten critical areas of Urban Freeway Guide Signing. Alternative signing strategies in each of these areas were evaluated using a visual-scenario technique. Subjects responses and decision reaction times were recorded. Some specific and a few general conclusions and recommendations were offered.

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EVALUATING URBAN FREEWAY GUIDE SIGNING- LABORATORY STUDIES

by

Roger W. McNees
Engineering Research Associate

and

Carroll J. Messer
Research Engineer

Preliminary

Research Report 220-3

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

February 1981

SUMMARY OF FINDINGS

This report is the third in a series which will document research conducted on various aspects of urban freeway guide signing in Texas. This particular report documents ten laboratory studies investigating several problem areas in urban freeway guide signing. These problem areas were selected based on a 35 mm slide inventory and film inventory of all route guidance signs along major freeways in Houston and Dallas, Texas.

The first area investigated was terminology motorists prefer to use to get to the downtown area. The results of this study indicate that, as motorists approach the city limits and progress towards the loop area, they prefer the city name (e.g., Denver) or Downtown. Around the loop area and as they progress towards the downtown area, motorists prefer to see Downtown and/or Business. As they approach an intersecting freeway leading to the downtown area, they prefer Downtown and/or the name of a major arterial in the downtown area. As motorists approach the downtown area, they prefer to see the name of the street their destination is on or a major arterial they are familiar with.

The second area investigated was formatting and method of presenting route transfer information. The studies performed in this area indicated that motorist key on both destination routes and control city names. As a minimum, the destination route may be used along if needed. When presenting this information, the legend on the signs should be the same from the first advance guide sign to the exit direction sign.

The third area involved the reading times of freeway guide signs. The results of this study indicated that, as both the amount of information on each panel and the number of panels increased, the accuracy level decreased proportionally and the reading time increased. It was determined that the

optimum level of information on each sign panel was about six "bits" of information.

The fourth area investigated the target value of different types and shapes of route guidance shields. In Texas, the state routes are rectangular in shape and have a higher target value than either the Interstate or U.S. route shields. The results of this laboratory study showed that the state route shield had the same target value as the other shields when the state shields were one size smaller.

The fifth area studied involved motorists' understanding of concurrent route markers. The results of this study indicated that the subjects neither (1) generally understood the meaning of concurrent route markers nor (2) were aware of their presence along Interstate freeways. The subjects indicated that, if they traveled mainly on an Interstate route to their destination, they wanted only Interstate route information. Similar findings also were noted for motorists traveling mainly on an U.S. numbered route. If an U.S. route joins an Interstate, the U.S. route marker could be presented twice and then dropped. Before the U.S. route leaves the Interstate, the U.S. route marker should reappear twice before exit guide signing of the U.S. highway from the Interstate begins. A more desirable solution is to avoid concurrent routing of an U.S. highway over an Interstate, particularly in urban areas.

The sixth area of study consisted of evaluating drivers' responses to junction signing of U.S.-Interstate concurrent routes. Two types of concurrent routing systems were considered: (1) where the Interstate and U.S. routes were concurrent over the entire trip and (2) where the U.S. highway joined the Interstate for a short distance and where the motorists evaluated had been traveling the U.S. numbered route before it joined the Interstate. The results of this study supported the findings of the previous one. Route selection times of drivers at the exit junction of the U.S. highway from the Interstate were longer in Case 2 (above) than in Case 1.

The seventh critical area involved the types of cities to be used as control cities and the location within an urban area where the control city name should change. The results indicated that motorists prefer large cities (population over 100,000) and not smaller cities as the control city. The location at which the control city name should change is after the motorists have left the downtown area and are headed away from the city.

The eighth area involved presentation of suburb city information when the suburb is within a large metropolitan area. The results indicated that when the term Downtown is used in the legend with another familiar city name the motorists tend to think the term Downtown applies to the downtown section of the familiar city and not with the suburb. Therefore, the suburb name and the term Downtown should not be used together on the same sign panel. If it is desired that the suburb should appear on the same sign panel with another familiar city, the name of the suburb should be used and not the term Downtown. Also, it was found that the term Downtown is easily associated with any major city name and, therefore, should not be used on a sign panel with any other city name except the central city name of the metropolitan area.

The ninth area studied involved signing for closely spaced right-hand exits where both exits must be signed for on the same sign structures. Two situations were studied. The first was an exit only situation and the second was an optional exit lane. The results for the first situation indicated that at both the one and two mile advance sign, both destinations be shown on the same panel with an exit only panel attached. Approximately one-half mile upstream a diagrammatic would be useful. Due to the economics involved using diagrammatic sign, an alternative conventional sign has been designed. As the motorists approached the first gore each destination would be placed on a separate panel with an exit only panel attached to the sign for the exit only lane. For the optional lane situation the subjects preferred each destination to be placed on separate signs indicating the distances to each exit gore point. At the one-half mile location a diagrammatic is not necessary.

The tenth area studied involved alternative signing systems for left-hand exits. In this particular area, three situations were considered. The first dealt with dual left-hand exits, the second with a single left-hand exit which is an option lane and the third with a single left-hand exit which is an exit only lane. In each of these situations, the signs were placed one-mile from the exit, one-half mile from the exit and at the gore area. Several alternative signing systems and one recommended signing system have been developed for each of these situations.

Implementation

Due to the severity of the problems and complexity of urban freeway guide signing in large urban areas the results of these laboratory studies should be implemented as soon as possible. These laboratory studies were developed to address the more pressing problems involved with urban freeway guide signing as exist today in the State of Texas.

The results of the laboratory studies in the ten areas under investigation indicate modifications to existing freeway guide signing which will increase the operational efficiency along urban freeways and reduce driver confusion. These results will be incorporated in a comprehensive freeway guide signing methodology to be developed at the conclusion of this research.

Disclaimer

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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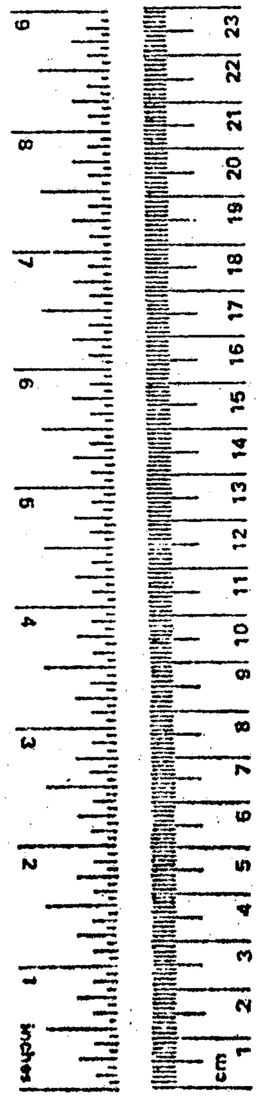
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

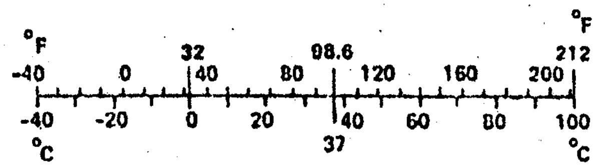
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2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

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



Approximate Conversions from Metric Measures

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



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CHAPTER 1

INTRODUCTION

The following sections describes the study areas, objectives, research methodology and results of the laboratory studies performed as a part of the project "Evaluating Urban Freeway Guide Signing" conducted for the State Department of Highways and Public Transportation, Contract Number 2-18-77-220. The purpose of this project was to study the existing freeway guide signing techniques used in the state of Texas to isolate those techniques which affect both traffic operation along urban freeways and driver behavior as they are travelling along the freeways and approaching major interchanges. Urban freeway guide signing throughout Texas is becoming more complex and the problem associated with route guidance is reaching major proportion as more and more motorists are added to the urban freeways each year. The State Department of Highways and Public Transportation wanted to study the overall route guidance signing system currently being used to determine areas in which major modifications could be implemented to increase operation and safety along urban freeways.

A. Human Factors Laboratory

The laboratory studies were conducted in the Human Factors Laboratory located in the Zachry Engineering Center at Texas A&M University. The laboratory consisted of two rooms separated by a glass wall. One side of the glass is painted white, forming the screen for the rear projection system. In one room, the slide projector and a mirror were arranged in such a manner that the slides were projected indirectly onto the glass projection screen. In the other room, six tables were placed for the subjects and the laboratory support personnel.

B. Test Subjects

The subjects selected to participate in these studies were selected on the basis of age, sex, educational background and a valid driver's license. Table 1-1 represents the theoretical distribution of 100 subjects to be used in these studies. Table 1-2 represents the actual distribution of the subjects used in all of the studies. A subject pool of faculty, staff, students and non-university employees was established to participate in these studies.

Each laboratory session took approximately one hour from the time the subjects entered the room until they vacated the room. A maximum of five subjects were scheduled for each hour session. This maximum was established due to the limitation of the recording equipment and the time required for the laboratory support personnel to manually record the data.

C. Test Equipment

The equipment used in these laboratory studies consisted of:

1. One Kodak Carousel 35 mm projector,
2. One Reaction Timer,
3. One student responder master console,
4. Five student responder units, and
5. One Kodak AV-450 Audio-Viewer

The reaction timer was used in those laboratory studies designed to obtain the subjects response times to various stimuli. The Kodak AV-450 audio-viewer was used in those studies requiring set projection times for various slide presentations. The audio-viewer advanced the slides at prescribed intervals and provided instructions to the subjects once the automated portion of the study commenced.

Table 1-1

Theoretical Distribution of 750 Male and Female Drivers, 18 Years of Age and Older, Completing the Educational Level Shown*

Age Groups	Elementary	High School 1-3 Years	High School 4 Years	College 1-3 Years	College 4 or more Years	Totals
18-24	38	74	53	30	8	203
25-34	15	23	53	22	23	136
35-44	15	23	45	15	14	112
45-54	30	23	37	15	14	119
55-64	30	15	22	15	8	90
Over 64	52	15	15	8	0	90
Total	180	173	225	105	67	750
Cumulative Total	180	353	578	683	750	
Cumulative Percent	24%	47%	77%	91%	100%	

*Adopted from United States Statistical Abstract, U.S. Bureau of the Census, Washington, D.C., U.S. Printing Office, 1971, and Highway Statistics, U.S. Department of Transportation, Washington, D.C., U.S. Printing Office, 1973.

Table 1-2

Actual Distribution of All Subjects Participating in All of the Laboratory Studies

Age Groups	Elementary	High School 1-3 Years	High School 4 Years	College 1-3 Years	College 4 or more Years	Totals
18-24	3	42	32	79	22	178
25-34	30	40	75	29	43	217
35-44	22	23	47	23	3	118
45-54	29	29	49	9	4	120
55-64	46	25	20	3	10	104
Over 64	1	0	0	0	12	13
Total	131	159	223	143	94	750
Cumulative Total	131	290	513	656	750	
Cumulative Percent	17%	39%	68%	87%	100%	

D. Study Areas

At least one laboratory study was conducted in the following study areas:

1. Study Area 1 - Designation of Routes to the Downtown Area
2. Study Area 2 - Formatting and Method of Presenting Route Transfer Information
3. Study Area 3 - Reading Times of Freeway Guide Signs
4. Study Area 4 - Target Value of Different Types of Route Guidance Shields
5. Study Area 5 - Concurrent Signing - Motorist Understanding
6. Study Area 6 - Concurrent Signing - Route Number Transfer
7. Study Area 7 - Control City Information
8. Study Area 8 - Suburb Signing
9. Study Area 9 - Right-Hand Interchanges Exiting Systems
10. Study Area 10 - Left-Hand Exit Signing Study

The objectives of each of these study areas will be described in greater detail in the appropriate sections of this report.

CHAPTER 2

STUDY AREA 1 - DESIGNATION OF ROUTES TO THE DOWNTOWN AREA

A. Objectives

The major objective of this study area is to determine the most appropriate terminology used to guide motorists to the downtown area, keeping in mind the terminology may change depending on their present location along the route. As motorists get closer to the downtown area, their preference in terminology may shift from more general terms, such as "Downtown" or "the city name", to more specific terminology, such as the "name of a major arterial" leading into the downtown area. Another objective of this study is to determine whether the terminology motorists expect to see on the guide signs is the same or different than the terminology they would prefer to see on the guide signs.

B. Research Methodology

This study area was investigated using two laboratory studies. The first was designed to determine the terminology motorists expect and the terminology motorists prefer to see at four different locations along their route. These four locations were:

1. Near the city limits entering the urban area,
2. Near the intersection with the loop around the urban area,
3. Near their exit with the intersecting freeway leading to the downtown area, and
4. Near their exit with the major arterial leading to their destination.

In the first study, the subjects were presented with a hypothetical situation. They were told they were traveling to a destination on Lamar Street in the downtown section of Denver. Their point of origin was a town, Jefferson, approximately 50 miles southwest of Denver. Six different one-word messages were presented at each of these four locations. These one-word messages used in this study were:

1. Downtown,
2. CBD (Central Business District),
3. Denver CBD,
4. Business,
5. Denver, and
6. Lamar Street

In addition to the six one-word messages, six two-word messages were also presented at each location. These messages were:

1. Downtown - Denver
2. Business - Denver
3. Denver CBD - Lamar Street
4. Business - Denver CBD
5. Downtown - Lamar Street
6. Business - Lamar Street

The subjects were presented a slide showing their present location preceding the test sign slide. This provided a visual reference for them to use in their decision. The test slide appeared and the subjects were asked to choose the sign or signs they would expect to see at this location. With the test slide still projected, the subjects were asked to choose the sign or signs they would prefer to see at this location. The subjects would push any button numbered one through seven on their student responder. Buttons numbered one through six corresponded to one of the test messages being studied. Button number seven was used only if the subjects did not either expect or prefer to see any of the test messages at a particular location or they did not like any of the test messages being studied. Immediately following the test slide with the one-word messages, a test slide containing the two-word messages was projected. The subjects were required to respond to the two-word messages in the same manner they responded to the one-word messages.

The second study was a decision-time study of the six one-word messages. Each message was presented at each of the four locations listed previously. The subjects were told their point of origin, destination, and the route they were to follow. Before each test slide was presented, a map outlining the subjects route and their present location was presented. Figure 2-1 shows the map at each location the messages were presented at. The subjects location, message terminology, and position of test panel was randomized to reduce the learning effect associated with presenting all six messages at each of the four locations in the same order.

Each test sign was projected for six seconds followed by a twenty second pause to allow sufficient time for the support personnel to record the subjects response. The subjects were required to find the test panel and respond by pressing the button corresponding to the number under the panel of their choice. The time required for the subjects to find the test signs and respond was also recorded.

This study was conducted to determine whether motorists could relate to all six messages in a simulated driving environment which was determined by the percent of correct responses. It was also conducted to distinguish between the subjects preferences with regard to the different messages by using the average decision time for the subjects to respond. It was assumed that the subjects would respond quicker to the messages which were more familiar to them than to those which were unfamiliar. In this way, non-significant differences between terms could be studied according to the subjects average decision (response) time.

C. Results

The results of the first study in which the subjects indicated the messages they would expect to see and the messages they would prefer to see are presented in Table 2-1. Both the frequency (f) and the percent (%) of all responses for both the one-word messages and the two-word messages are presented. Table 2-2 presents the decision time and percent of correct lane choices for the six one-word messages at each of the four locations. These results were obtained from the second study performed in this study area.

These results indicate that 69.7% of the subjects expect to see the message Denver and/or Downtown displayed as they approach the city limits and 61.4% of the subjects indicated they preferred the same two messages at this location. Seventy (70) percent of the subjects were able to choose the correct lane in an average of 5.7 seconds decision time. When the term Downtown was used 63% selected the correct lane in an average time of 5.7 seconds. The use of the terms Downtown and/or Denver at this location is strengthened when considering that almost half of the subjects (44.6%) indicated they expected to see Downtown - Denver or a two-word message. Thirty-three (32.7) percent of the subjects indicated they preferred Downtown - Denver as an attractive two-word message at that location. The next closest two-word messages were Downtown - Lamar St. in which 18.7% of the subjects selected.

As the motorists approach the loop area, 59.8% indicated they would expect Downtown (33.3%) and/or Business (26.5%). Twenty-one percent of

Table 2-1

Terminology Motorists Expect and Prefer at Different Locations As They Approach Their Destination in the Downtown Area by Frequency of Response (f) and Percent of Total Response (%)

	Near the City Limits				Near Loop Entering City				Near Intersecting Freeway Near CBD				Near Exit to CBD			
	Expect		Prefer		Expect		Prefer		Expect		Prefer		Expect		Prefer	
Test Messages	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%
<u>One-Word Messages</u>																
Downtown	20	18.3	30	26.3	39	33.3	43	35.5	37	34.6	30	27.8	16	14.6	11	10.7
CBD	3	2.8	2	1.8	3	2.6	5	4.1	5	4.7	5	4.6	3	2.8	3	2.9
Denver CBD	7	6.4	19	16.7	10	8.5	15	12.4	13	12.1	14	13.0	4	3.7	5	4.9
Business	16	14.7	11	9.6	31	26.5	18	14.9	14	13.0	9	8.3	10	9.2	6	5.8
Denver	56	51.4	40	35.1	25	21.4	18	14.9	19	17.8	15	13.9	6	5.5	3	2.9
Lamar Street	7	6.4	12	10.5	9	7.7	22	18.2	19	17.8	35	32.4	70	64.2	75	72.8
<u>Two-Word Messages</u>																
Downtown-Denver	45	44.6	35	32.7	46	43.0	36	33.0	39	34.2	29	26.6	13	11.5	5	4.6
Business-Denver	23	22.8	18	16.8	31	29.0	11	10.1	28	14.6	13	11.9	8	7.1	2	1.8
Denver CBD-Lamar St.	7	6.9	5	4.7	7	6.5	14	12.9	12	10.5	14	12.8	10	8.8	16	14.7
Business-Denver CBD	7	6.9	17	15.9	9	8.4	13	11.9	7	6.1	4	3.7	1	1.8	3	2.8
Downtown-Lamar St.	11	10.9	20	18.7	11	10.3	23	21.1	13	11.4	34	31.2	47	41.6	52	47.7
Business-Lamar St.	8	7.9	12	11.2	3	2.8	12	11.0	15	13.2	15	13.8	33	29.2	31	28.4

Table 2-2

Percentage of Motorists Selecting the Correct Lane and the Average Decision Time Required to Select by Message and Sign Location

	Near City Limits		Near Loop Around City		At Intersecting Freeway Near CBD		Near Exit to CBD	
Test Messages	Lane Choice (%)	Decision Time ($\bar{x}$)	Lane Choice	Decision Time	Lane Choice	Decision Time	Lane Choice	Decision Time
1. Downtown	63	5.7	64	5.4	47	6.4	66	7.2
2. CBD	62	5.5	45	6.3	41	6.4	39	8.3
3. Denver CBD	75	5.7	57	6.3	38	8.0	56	7.0
4. Business	72	7.2	(a)	(a)	48	5.9	59	6.2
5. Denver	70	5.7	59	5.8	32	5.9	38	7.7
6. Lamar Street	(a)	(a)	40	5.4	53	6.8	75	5.7

(a) Lane Choice Responses and Decision Times Were Not Obtained Due to Experimental Error.

the subjects indicated they would also expect to see Denver at the same location which means that 81.2% of the subjects expect to see either Downtown, Business or Denver. Sixty-five percent of the subjects indicated they preferred to see Downtown (35.5%), Business (14.9%) and/or Denver (14.9%). Sixty-four percent of the subjects selected the correct lane in an average time of 5.4 seconds when the term Downtown was used, and 59% chose the correct lane in 5.8 seconds when Denver was used. Over half of the subjects (72%) said they would expect the two-word messages when Denver, Downtown and Business were used in combination, and 43.1% said they would prefer these two-word messages in which these three terms were used. The wide disparity between these messages the motorists expect and those they prefer show a shift between driver expectancy and driver preference. Driver expectancy is based on past driving experiences. A portion of their previous driving experience relates to the signing presented which becomes an integral part of each driver data base and driving expectancy. What the drivers learn to expect and what they would prefer to see may be two completely different things. For this reason the term the drivers expect to see and what they prefer to see may be different. The results obtained from this study tend to bear out this initial premise.

As the motorists approach an intersecting freeway leading into the CBD, 70.2% of the subjects indicated they would expect (1) Downtown (34.6%), (2) Denver (17.8%) and (3) Lamar St. (17.8%). Seventy-four percent indicated they preferred to see (1) Downtown (22.8%), (2) Denver (13.9%) and (3) Lamar St. (32.4%). Again this fact is borne out when considering that almost half (45.6%) of the subjects selected two-word messages, containing the three terms described alone, they would expect to see, and over half (57.8%) of the subjects said they would prefer to see these messages at this location. The two, two-word messages were; (1) Downtown - Denver and (2) Downtown - Lamar St. When the term Lamar St. was used 53% of the subjects selected the proper lane in an average time of 6.8 seconds. When Downtown was used, 47% selected the correct lane in 6.4 seconds, and when Denver was used 37% chose the correct lane in 5.9 seconds.

At location 4, the Lamar St. Exit from the freeway 64.2% of the subjects said they would expect to see Lamar St. used and 72.8% said they preferred to see Lamar St. used. At this location 75% of the subjects selected the correct lane in 5.7 seconds. When the two-word messages were used over half of the subjects (70.8%) selected one of two messages, the first was Downtown - Lamar St. (41.6%) and the second was Business - Lamar St. (29.2%) as those they would expect to see at this location. These same two messages were selected by 76.1% of the subjects they would prefer to see at this location.

CHAPTER 3

STUDY AREA 2 - FORMATTING AND METHOD OF PRESENTING ROUTE TRANSFER INFORMATION

A. Objectives

The first objective is to determine whether motorists use destination names only, destination routes only, or on both destination routes and names when they are diverting from one route to another. By knowing what motorists key on when they get ready to change freeways, the amount and types of information presented at these locations may be modified providing more time for the motorist to read the sign and change lanes prior to the gore point. The second objective is to determine what effect different route transition strategies have on the motorists as they approach the gore area.

There are basically three different strategies to be evaluated in this study area. The first method requires that all information leading to a gore remain relatively constant from the first advance guide sign to the exit direction sign. The second strategy employed is called the increasing information method. This method requires that the amount of information presented to the motorists increases as the motorist approaches the gore. And the third strategy is called the decreasing information method, which states that the motorist will receive the maximum amount of information on the first advance guide sign and the amount of information will decrease as the motorist gets progressively closer to the gore. When considering these three strategies, it is assumed that with increasing information the number of errors will increase the closer the motorist gets to the gore and the longer the time required for the motorist to react to the information presented. In contrast, it is assumed that with the decreasing method the number of errors and decision time will decrease the closer the motorists get to the gore area.

B. Research Methodology

To determine the types of information motorists require when diverting from one freeway to another, the subjects were presented with several situations in two different cities. One of these cities was a belt-type and the other was a radial. In each city they were given six different situations. For each situation they were told their point of origin, destination, the route they are presently on, the route they would follow to get to this destination, and their present location. After they were given the information and shown a slide representing the traffic they would expect at their location they were asked two questions. The first question was "Which of these signs would you expect at this location?" After the subjects had responded to that question they were then asked "Which of these signs would you like to see at this location?" The subjects were then given sufficient time to answer this question before the next situation was presented.

The study which evaluated the three route transition strategies required the subjects to select the proper lane to be in as they approached their transition area. The subjects were given instructions in which they were told the route they were going to transition to, and their present location. The subjects were given two situations for each of the three test conditions. These test conditions were increasing, decreasing and constant information presented on each sign as they approached their transition area. For each situation the subjects were shown three sign bridge structures: two were advanced guide signs, and the third was the exit direction sign. The subject's lane choice and the time required to select the lane were recorded.

C. Results

Table 3-1 presents the results of the study to determine the types of information required by motorists transitioning from one freeway to another. These results are segregated according to the type of city and the types of information motorists expect and want. From this study it is apparent that motorists both want and expect the destination route for both the belt city and the radial city. Over 80% of the subjects said they expect the destination route displayed on the transition sign. Thirty-five percent said they expect the destination route only and 45.3% said they expect both the destination route and the control city name. When they were asked what they preferred, 30.6% said they preferred the destination route and 45.0% indicated they preferred the destination route and the control city name for the belt city. In the radial city, 74.7% of the motorists indicated they expected to see the destination route displayed and 67.8% said they preferred to see the destination route displayed. The results of this study indicate that signing within a major transition area should display the destination route as a minimum.

Table 3-2 presents the results of the study in which three different route transition strategies were investigated. These three route transitions were:

(1) Increasing information - The level of information on each sign panel increases as the motorist gets closer to the exit ramp,

(2) Constant information - The level of information remains the same the closer the motorist gets to the exit ramp,

(3) Decreasing information - The level of information decreases, the closer the motorist gets to the exit zone.

Table 3-1

Frequency and Percent of Motorists Responding to Different Types of Destination Route Signing By Type of City

Type of City What Motorist Expect and Desire (Total Responses)	Destination Route and Control City Name		Control City Name Only		Destination Route Only		Does Not Like Any of Them	
	f	%	f	%	f	%	f	%
Belt City								
Expect (882)	372	45.3	155	18.9	289	35.2	6	0.7
Desire (777)	350	45.0	182	23.4	238	30.6	7	1.0
Radial City								
Expect (815)	345	42.3	194	23.8	164	32.4	12	1.5
Desire (797)	314	39.4	242	30.4	226	28.4	15	1.9

Table 3-2

Percent of Error and Decision Times by Amount of Information (Increasing, Decreasing, Constant) and Location of Sign in Sequence (1, 2, or 3).

	Amount of Information					
	Increasing		Decreasing		Constant	
Sign Location	Percent Error	Decision Time	Percent Error	Decision Time	Percent Error	Decision Time
#1	30.8	4.62	43.0	6.22	23.1	4.71
#2	28.3	4.64	37.0	5.48	29.5	4.43
#3	34.7	5.19	37.2	4.97	36.6	4.31

When considering the percent of errors in which lane to be in and the amount of time required by the motorist to make his decision, it appears that the motorists make fewer errors as to lane placement and require less time to make their decision when the level of information remains constant as they approach their exit ramp. When the level of information is increased, the drivers make more lane placement errors (31.3%) and they require more time (4.82 seconds). When the level of information is decreased even more errors (39.1%) are the result and the drivers require even more time (5.56 seconds). These results are not that surprising when we consider that drivers get adjusted to a certain level of information being presented to them. After they have associated a certain message with a particular exit, if the level of information is adjusted, the drivers require more time to readjust to the new information and more errors are likely to result.

CHAPTER 4

STUDY AREA 3 - READING TIMES OF FREEWAY GUIDE SIGNS

BACKGROUND

One of the critical elements in motorists usage of urban freeway guide signing is the time they require to read and react to navigational messages presented to them. Surprisingly, there is little literature specifically related to the subject. King (1) presented an analytic analysis of signing in 1970 in which the sign reading literature was summarized. Two equations for predicting the time required to read a sign were noted as:

$$t = \frac{N}{3} + 1.0 \qquad (1)$$

and

$$t = 0.31N + 1.94 \qquad (2)$$

where t is the time required to find and read the sign and return the visual field back to the freeway and N is the "number of familiar words on the sign". King (1) expanded this definition of N to include numerals together with familiar shapes and symbols such as route shields and lane assignment arrows. No experimental evidence for this expanded definition was given. One may conclude that the time required to read a familiar word is assumed to be about 0.32 seconds per word.

As is evidenced by the previous equations, it is generally believed that unfamiliar motorists require more total time to read the information on a sign as more "words" are added to the message. It is assumed in the models that the increase in time is a linear constant with the number of words, although this assumption is questionable. Using King's expanded definition of "N", the reading time required of a 4-panel overhead guide sign might require a total of 14.3 seconds to read, assuming each panel had 10 "words" on it. Personal driving experiences would suggest that 14.3 seconds is an unreasonably long required reading time. Thus, the need to study this problem area is clearly evident.

RESEARCH OBJECTIVES

The objectives of this study were: (1) to determine the time required to find and read the correct test sign panel embedded on a simulated urban freeway sign bridge structure, and (2) to determine the accuracy of the selection process as related to sign design (information presented) and reading time. The research objectives were addressed in a laboratory environment using licensed drivers as test subjects. The responses of these subjects to 35 mm slides of signs projected on a screen were recorded and evaluated.

STUDY VARIABLES

The specific magnitudes and variables studied during this phase of the research effort were as follows: (a) the number of panels per overhead sign structure (2, 3, 4 and 5 panels), (b) the amount of "bits" of information on each panel (2, 4, 6, 8 and 10 bits), (c) the display time available for subjects to "read" the signs (2½, 4 and 6 seconds), and (d) the percent of the subjects giving the correct response. A discussion of these variables follows.

Number of Panels

The number of panels selected for study includes almost all likely overhead sign designs. Most overhead guide signs in large cities have 3 or 4 sign panels per sign structure. A very few signs have 5 panels on them. In the fringe areas of cities and in smaller cities and towns, 2 and 3 panel signs are more common, A typical sign panel might contain an exit number, route number, cardinal direction, two destinations, and an exit direction for a total of 6 "bits" of information. Sign panels having up to 10 bits of information have been observed at major interchanges.

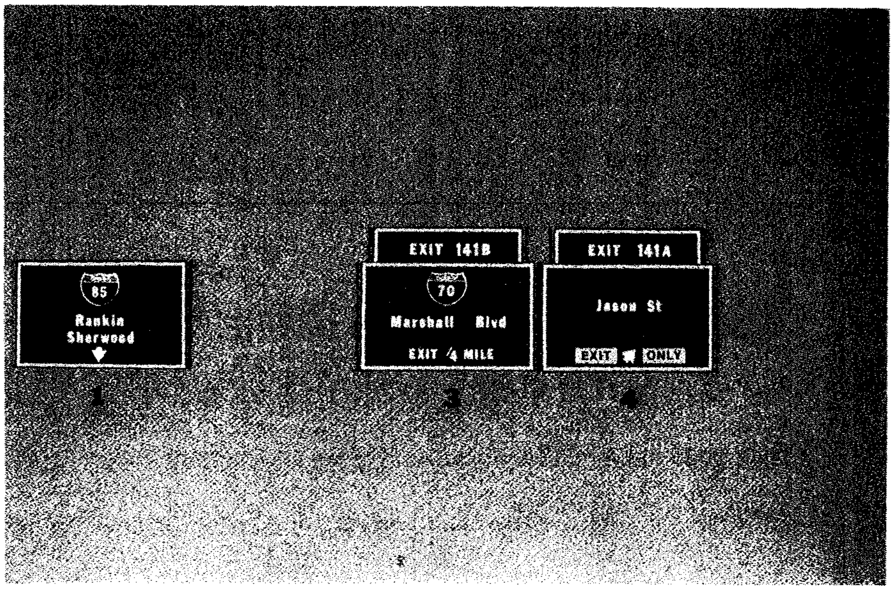
Bits of Information

The information unit being used has been called a "bit". The term is being loosely used when compared to the basic precepts of information theory (2). The same criticism could be said about "familiar words" or "number of message units" used by others (1, 3). The following list illustrates what is defined in this study as a bit of information:

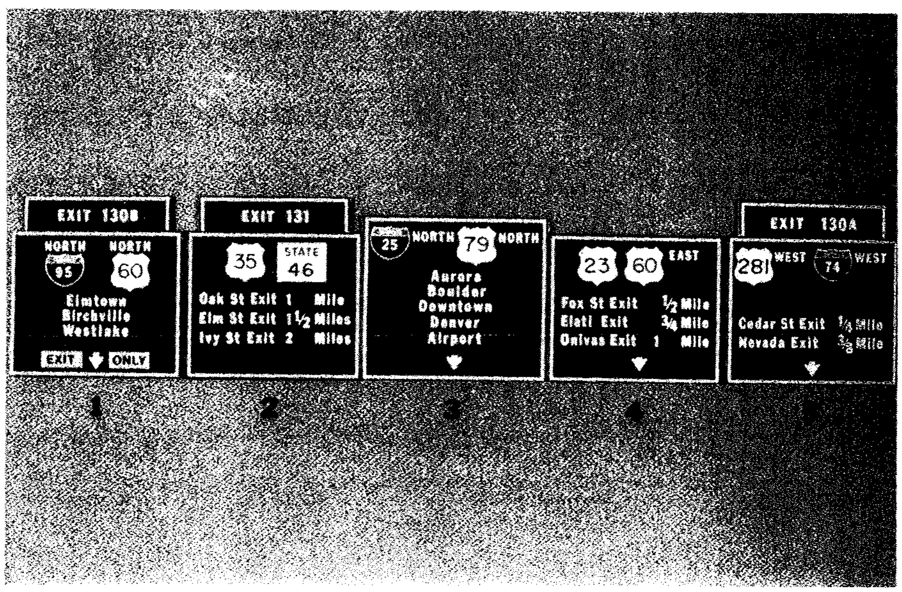
- place name (Denver)
- street name (Lamar St)
- route number (I-95)
- cardinal direction (North)
- exit number (Exit 243A)
- command (Exit)
- distance (1/2 mile)
- lane use arrows (↓)
- junction (Jct)
- Exit Only

Some differences of opinion and need for discretion are to be expected in applying these measures. For example, all lane use arrows to the same destination are counted as one bit in this information measurement scheme. Some complex traffic facility names, particularly freeways (like Central Expressway or Santa Barbara Freeway) may be considered two (2) bits of information because of their size and possible confusion with a destination city.

The two signs presented in Figure 4-1 illustrate simulated signs used in this study having 3 panels per sign structure with 4 "bits of information" per panel, and 5 panels with 10 bits of information per panel. One should keep in mind that information rates in reality are only those messages which



3 Panel X 4 Bit



5 Panel X 10 Bit

Figure 4-1. 3 Panel 4 Bit Test Sign and a 5 Panel 10 Bit Test Sign.

are needed and evaluated by the driver and may not be accurately reflected by the total content of all words, numerals and symbols on a sign.

Display Time

The projection or display times of the slides of the signs in the laboratory simulated the total time a motorist may have available to read freeway guide signs in a typical urban freeway traffic environment. The reading time is only a portion of the total time that the sign is visible. It is also less than the total static legibility distance (or time), which is less than the visibility distance (or time). The reason for this latter reduction is that motorists must time-share reading signs with the other driving tasks such as lane tracking and avoiding adjacent traffic. In addition, the last 150 feet or so immediately in advance of the sign is likely to be difficult to read due to the large vertical angle and relative motion of the sign with respect to the driver's visual scene.

The display times provided for reading the signs in the laboratory were selected to represent extreme, minimum and desirable traffic (and design) conditions. High-quality guide signs are readable for most people in the absence of obstructions, beginning about 900 feet away, or about 11 seconds of lead time. Deducting 2 seconds for clearance of the sign and 50% of the remaining time as required for conducting other driving tasks leaves 4.5 seconds available for sign reading. From a conservative design viewpoint, it would be desirable to provide freeway motorists with perhaps 6 seconds of unobstructed reading time in an unloaded driving task condition for each overhead freeway guide sign. The motorists would take a portion of that time (perhaps 4 seconds) to select the appropriate sign panel by locating and reading the route number, cardinal direction and destination. Some additional confirmation time might be allowed. A minimum acceptable design criterion might assume that the overhead guide signs were readable for at least 4 seconds, reflecting higher traffic congestion, more critical alignments, and higher probabilities for vehicle blockage of the signs. As the previous calculations showed, the laboratory display times of 2½, 4 and 6 seconds seem to reasonably reflect extreme (unacceptable), minimum (acceptable), and desirable reading times.

Accuracy

The accuracy of the responses were measured in addition to reading times. The percent correct response based on the total laboratory subject population was determined for each test condition. It was expected that as the total information load increased and as the display time decreased for the same level of experience, accuracy levels would drop. An uninformed (or first-try) accuracy rate of 80% was arbitrarily selected as the minimum acceptable accuracy level.

RESEARCH METHODOLOGY

Two similar laboratory studies were conducted in an effort to accomplish the study objectives. In both studies, laboratory subjects were asked to follow a hypothetical route through an unfamiliar city based on: (1) navigational directions provided by a schematic map of the area and (2) simulated guide signing presented by 35 mm slides at 22 locations along the route. A total of 87 subjects participated in the first laboratory study conducted during March 1978. The second study, conducted during March 1979, contained 70 subjects taken primarily from the initial subject pool. A discussion of the components of the research methodology follows.

Trip Scenarios

The freeway route which subjects were ask to follow during each laboratory scenario is presented in Figure 4-2. Subjects approached the city of "Denver" from the southwest on the I-50 freeway. They were then directed to follow the south loop around the city, and then were directed to take I-25 freeway to Omaha. The subjects were advised of their trip before testing began. The loop route was selected to maximize the number of interchanges that could be conveniently studied.

A set of 22 test signs having preselected design attributes was developed for testing as the subjects "drove" along the route. The 22 signs were composed of 4 types of panels by 5 levels of information bit rates (or 20 test signs) plus duplicates of the 4x10 and 5x10 panels. An artist developed the test signs following the style (to some extent) of overhead freeway guide signs found in the urban centers of Texas. Photographs of the signs were taken and converted into 35mm 2x2 inch slides. Two examples of the 22 test signs were presented in Figure 4-1. The colors of the various sign elements were as close to the correct colors as could be obtained. The background for all the signs was sky blue.

The laboratory scenarios called for the slides to be projected in a sequence consistent with the simulated trip. The slides were projected upon a built-in wall screen in the laboratory using rear projection techniques. Viewing conditions and legibility of the signs shown to the subjects were controlled to approximate the average legibility requirements of signs on freeways. The design, placement and display of the test signs along the route were selected such that large differences between the amount of information on each sign were not placed on consecutive locations. One practice

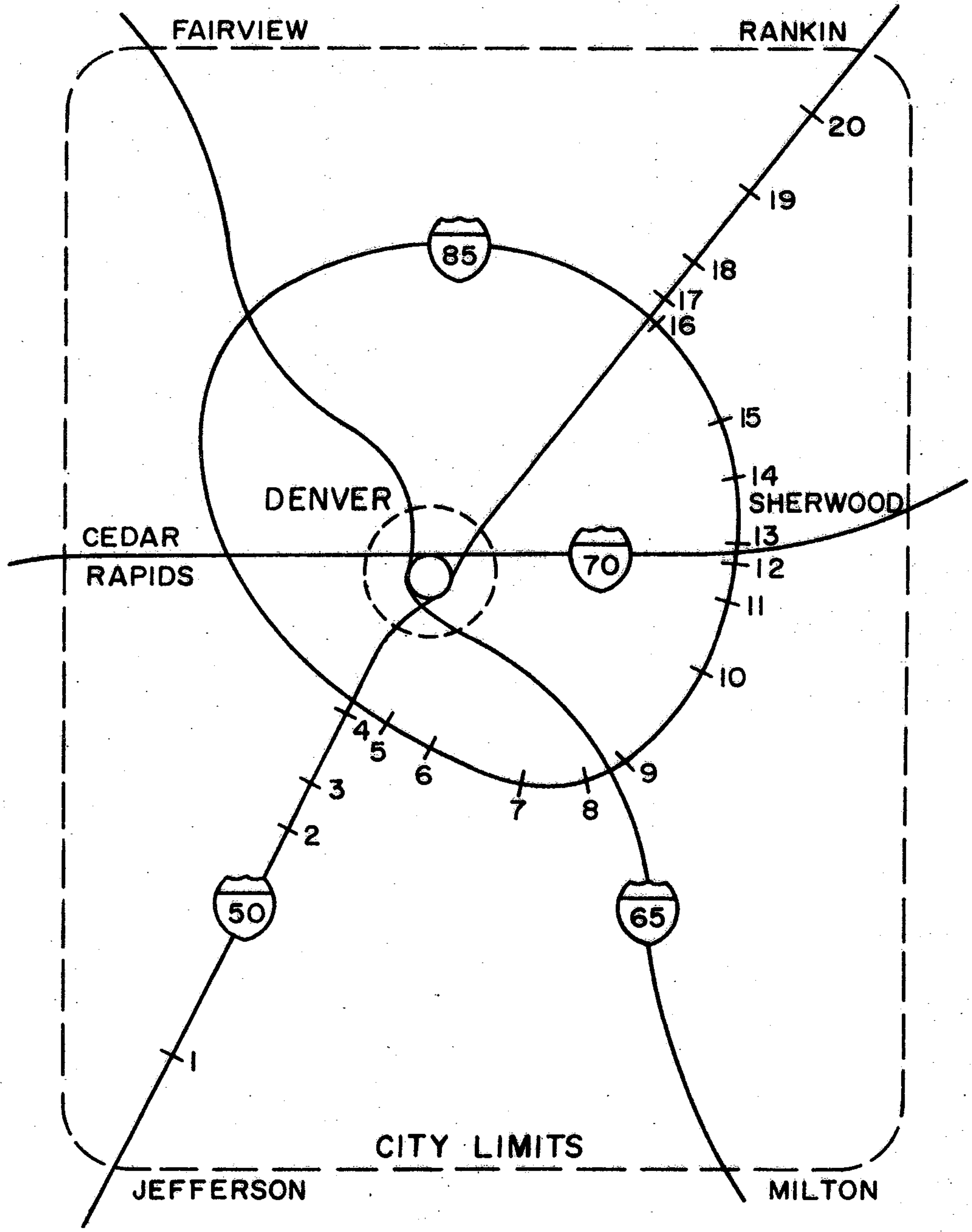


Figure 4-2. Map of Hypothetical City and Route Used in the Sign Reading Study.

slide was provided at the start of the trip to acquaint the subjects with the laboratory testing procedures. Map slides, similar to Figure 4-2 but showing the present location of the trip, were alternated between the 22 test signs so that the subjects hopefully knew the information needed to navigate along the route.

The subjects were asked to select the correct sign panel from the set of panels in the sign cluster. It was assumed, and stated in the laboratory, that the sign panels would be placed immediately overhead of the corresponding freeway lane to drive in. The lane (or sign) number selected was given in the slides for each panel.

Some subjects may have been confused in a few cases where the signing sequence (from the left) did not correspond to the lane assignments. For example, the first sign from the left may have been over lane 2 and the associated sign panel number would have been 2. To aid the subjects the relative positions of sign panels over specific lanes were consistently maintained throughout the study.

Measurements

Estimates of subject reading times of the signs were obtained from electronically timed measurements of the time the slide became visible (human operator input) until the time each subject activated his recorder unit. One of five numbered buttons could be selected with the correct choice varying with each test sign. Subjects were asked to respond as soon as they were confident of their lane assignment answer by pushing the corresponding numbered button on their data recording unit. The accuracy of each response was also recorded for each subject. A maximum of five subjects could be tested at one time.

The subjects' average reaction time to a zero-level information sign was developed such that this reaction time could be subtracted from the overall response times so that the reading time could be estimated. The zero-level information slides were slides having distinct red background with the message "Push Button No. 1" on them. The subjects were shown one of the slides prior to the testing, were informed of its purpose, and permitted to practice responding to it one time. The subjects were told that four of these slides would be randomly distributed throughout their trip, and to respond to it accordingly. From these signs, it was determined that an average subject population reaction time of 1.0 seconds existed. This time was subtracted from all measured response times to determine sign "reading times".

Test Sequence

The 6 and 4 seconds display times were tested in the laboratory during March 1978. The sequence of projection times began with 6 seconds and the subjects "drove " the trip not knowing that, after a 10 minute break, the trip would be redriven using the same set of signs but displayed at 4 seconds. This procedure did result in some learning effect and improvement in response skill due to the previous experience. This was as expected since the repeat test was conceptualized as a simulation scenario of semi-familiar urban freeway motorists who are experienced with the types and locations of decisions required.

The 2½ second rate was a test to see how the subjects would perform under anticipated and expected high-stress levels. This study was conducted one year after the previous tests. Some 8 improvements to the original 22 signs were made to improve route following.

RESULTS

The results of the 6, 4 and 2½ second display times are presented in the following paragraphs. The results show that the faster the display time, the faster the subjects responded. The results also show that, in general, the greater the information load, the slower the reading time. It is also important to note that the faster the display rate or the greater the information load on a sign, the lower the percent correct response. Most of the anomalies in the results to follow can be explained by either the simplicity or complexity of determining the correct sign panel (and lane) of a particular sign as tested in the laboratory.

Display Time of 6 Seconds

The 50th and 85th percentile reading time values (in seconds) for 6 second display times are presented in Figures 4-3 and 4-4. Figure 4-3 summarizes the findings for all 2-panel and 3-panel sign designs. Figure 4-4 likewise gives the 4-panel and 5-panel results. The percent correct response for each test sign is also presented in the figures immediately above the 85%-ile reading times. The information bit rate per sign panel in each figure varies from 20 to 10 bits per panel. Efforts were made to have the same number of bits on each panel such that a 3-panel overhead sign having 6 bits per panel would have a total of 18 (3x6) information bits on the sign structure. Additivity is assumed. The results shown for the 4x10 and 5x10 panels are averages of two signs.

A summary of these results shows that the median (50%-ile) reading time was 2.9 seconds, the average 2.9 seconds, and the 85%-ile was 4.6 seconds. The average percent of correct responses is 75% for 84 usable subjects.

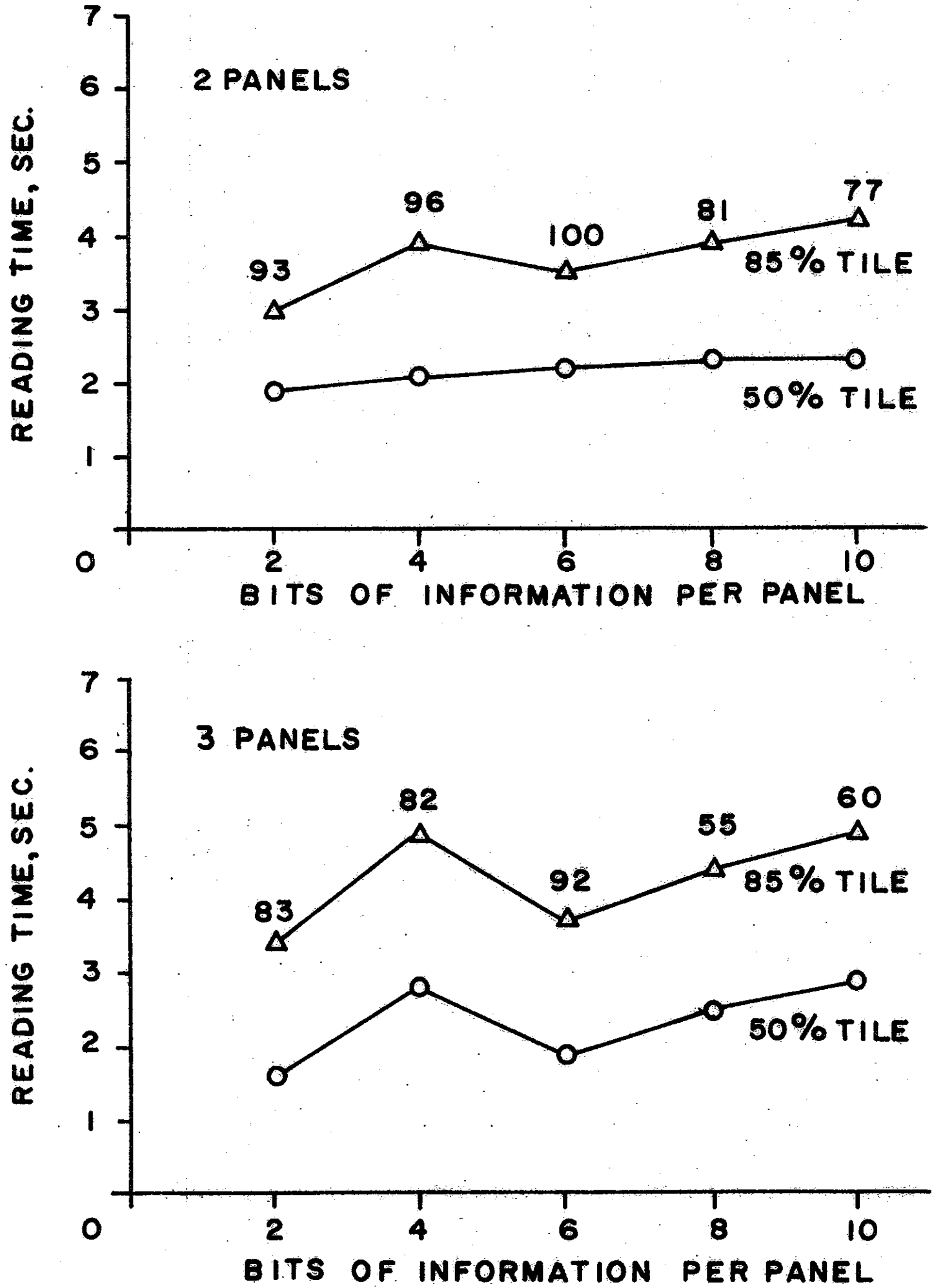


Figure 4-3. Reading Times and Percent Correct Responses for 2 Panel and 3 Panel Signs at 6 Second Display Times.

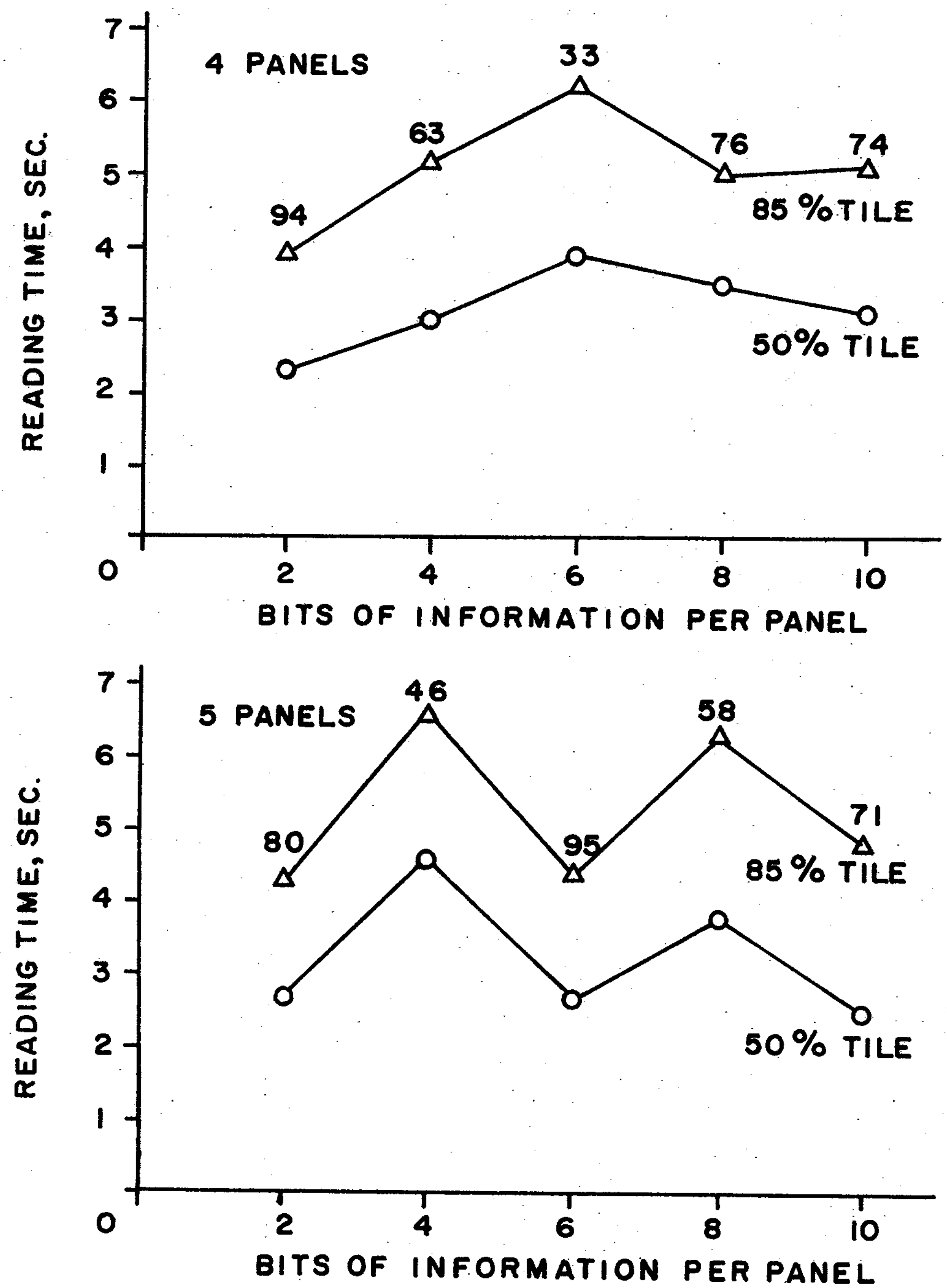


Figure 4-4. Reading Times and Percent Correct Responses for 4 Panel and 5 Panel Signs at 6 Second Display Times.

There are some important trends to be noted from the figures. As the amount of information bits per sign panel (and total on the sign structure) increased, increased reading times and decreased accuracy levels generally were the result. These inverse trends are interrelated as the following comparisons show. The average values of the 50%-ile reading times and 85%-ile accuracy levels for all 2-panel signs in Figure 4-3 are 2.2 seconds and 89%, respectively. On the other hand, the average values of the 50%-ile reading times and 85%-ile accuracy levels for all 5-panel signs in Figure 4-4 are 3.3 seconds and 70%, respectively. Assuming 80%-ile correct response is selected as the minimum acceptable value, then 4 of 5 of the 2-panel signs in Figure 4-3 would be acceptable, whereas only 1 of 5 of the 5-panel signs in Figure 4-4 would be acceptable.

Display Time of 4 Seconds

The 4 second display test was a repeat of the same 22 signs used in the 6 second study. As noted previously, a break of about 10 minutes separated the two simulated trips. The subjects were given no advance clues that the second study was going to be a repeat of the first run. Some learning effects and skills improvement were expected. The reason for the repeat lab was that it might more readily simulate a semi-familiar motorist, who has driven the facility in the recent past.

The results of the reading and accuracy measures for the 4 second projection times are presented in Figures 4-5 and 4-6. Percent correct responses are the numbers immediately above the 85%-ile responses. Similar response characteristics with the 6 second display times may be noted, particularly for the 3, 4 and 5 panel signs.

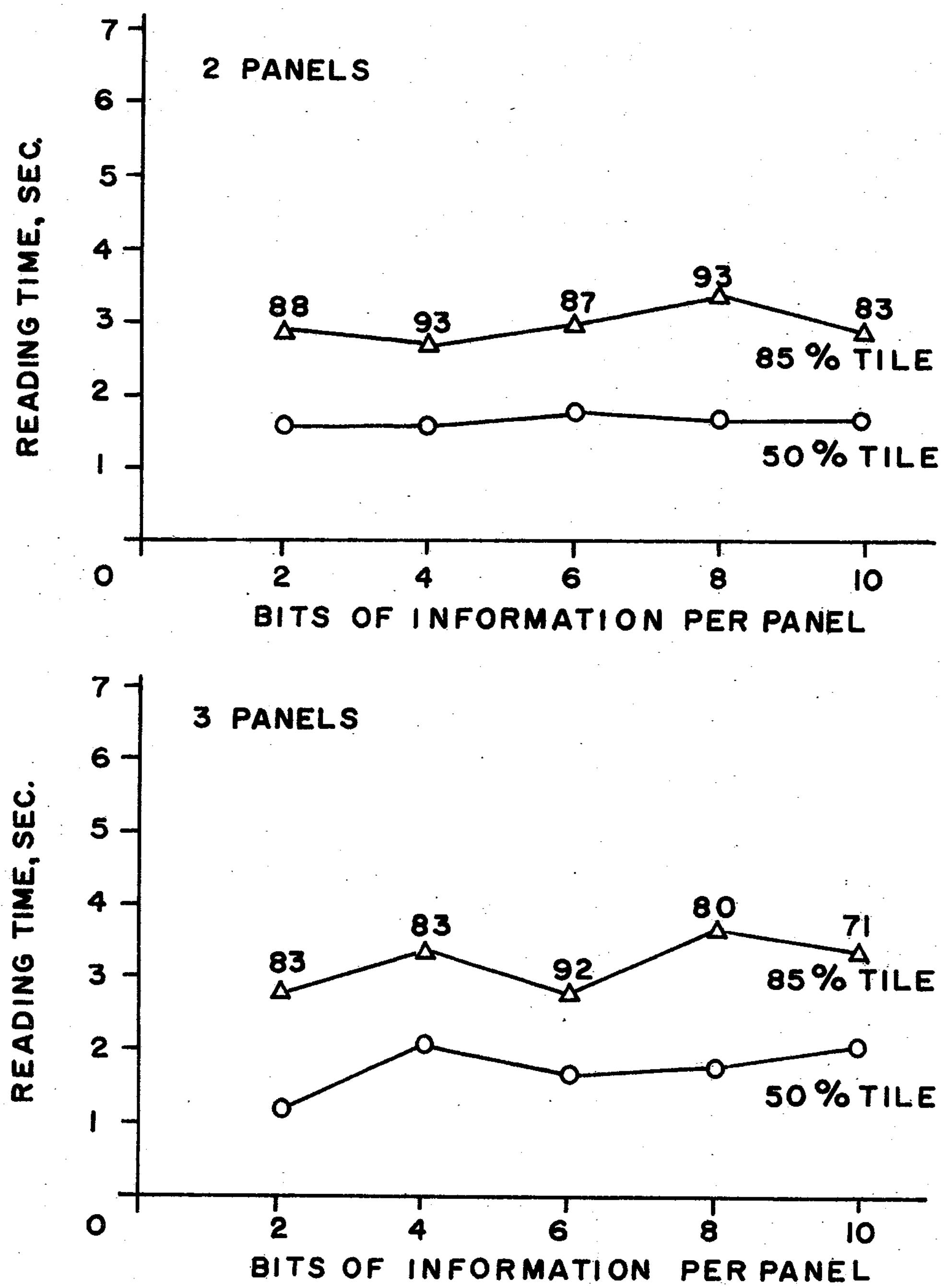


Figure 4-5. Reading Times and Percent Correct Responses for 2 Panel and 3 Panel Signs at 4 Second Display Times.

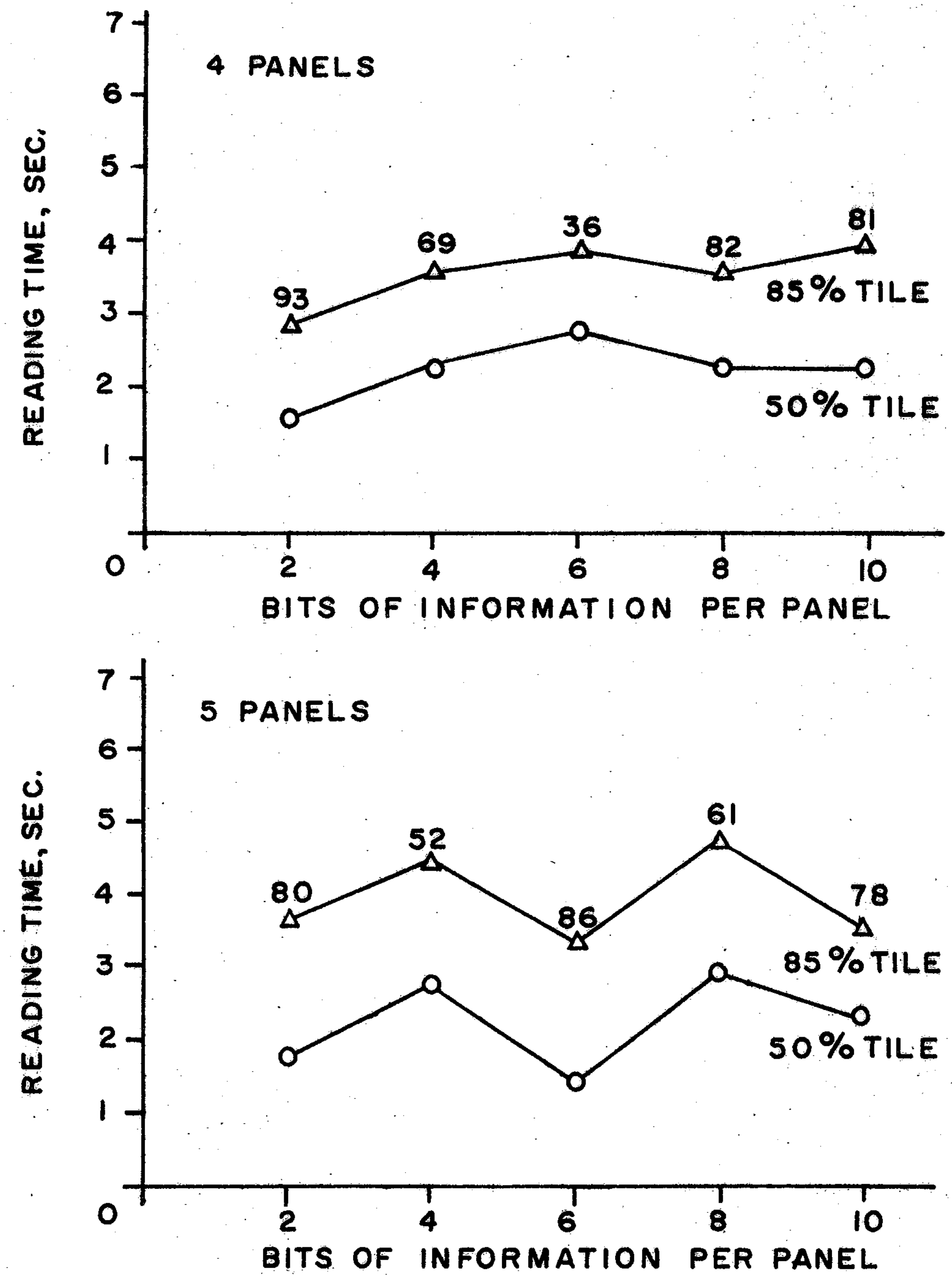


Figure 4-6. Reading Times and Percent Correct Responses for 4 Panel and 5 Panel Signs at 4 Second Display Times.

A summary of the 4 second display test follows. The median (50%-ile) reading time was determined to be 2.0 seconds, the average 2.3 seconds, and the 85%-ile 3.5 seconds. A mean percent correct response of 78% was obtained for 84 useable subjects. This is a 3% increase above the initial run and illustrates the subject improvement due to learning and experience.

The inverse relationship between reading time and accuracy continued with the 4 second display experiment. For example, the average values of the reading times for all 2-panel and 5-panel signs were 1.7 and 2.3 seconds, respectively. That is, reading times increased with increasing information load. The respective accuracy levels, on the other hand, decreased from 89% to 71%. Again using 80% as a minimum acceptable accuracy level, then all 5 of the 2-panel signs performed acceptably. Only 2 of the 5 5-panel signs had acceptable accuracy levels.

Display Time of 2½ Seconds

The 2½ second display time laboratory was conducted one year after the previous two studies. Of a total of 70 subjects, 67 useable subject responses were evaluated. Some improvements to the design of 8 of the initial 22 test signs were made in addition to rearranging the test sequence for several of the modified test signs to improve the logic of the signing sequence. As will be shown later, these modifications produced significant improvements in route selection accuracy and clouded the aggregate accuracy results.

The results of the reading and accuracy measures for the 2½ second projection times are presented in Figures 4-7 and 4-8. Percent correct responses are the numbers immediately above the 85%-ile responses. Some changes in the overall response characteristics may be noted when compared to the earlier studies.

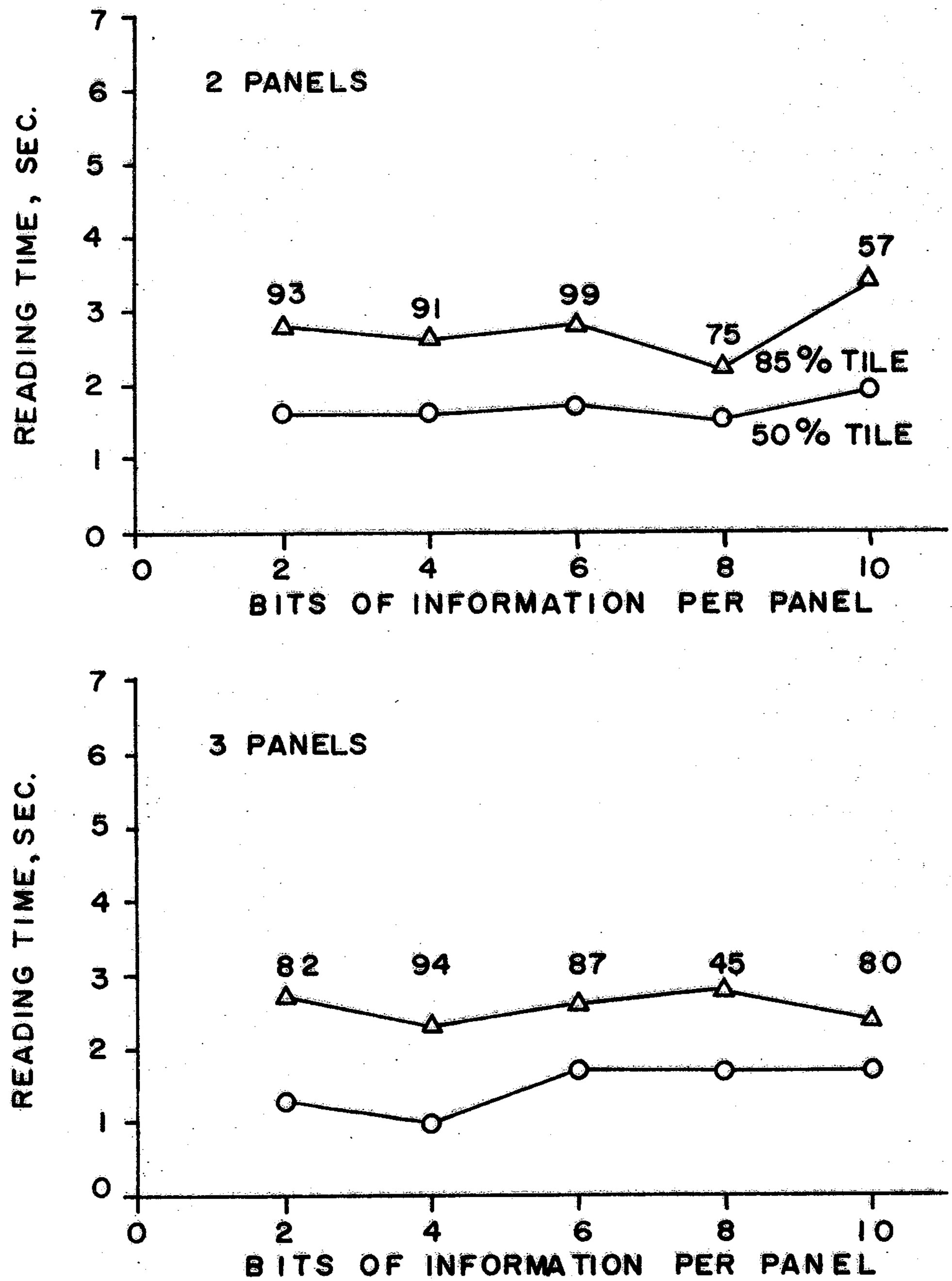


Figure 4-7. Reading Times and Percent Correct Responses for 2 Panel and 3 Panel Signs at 2½ Second Display Times.

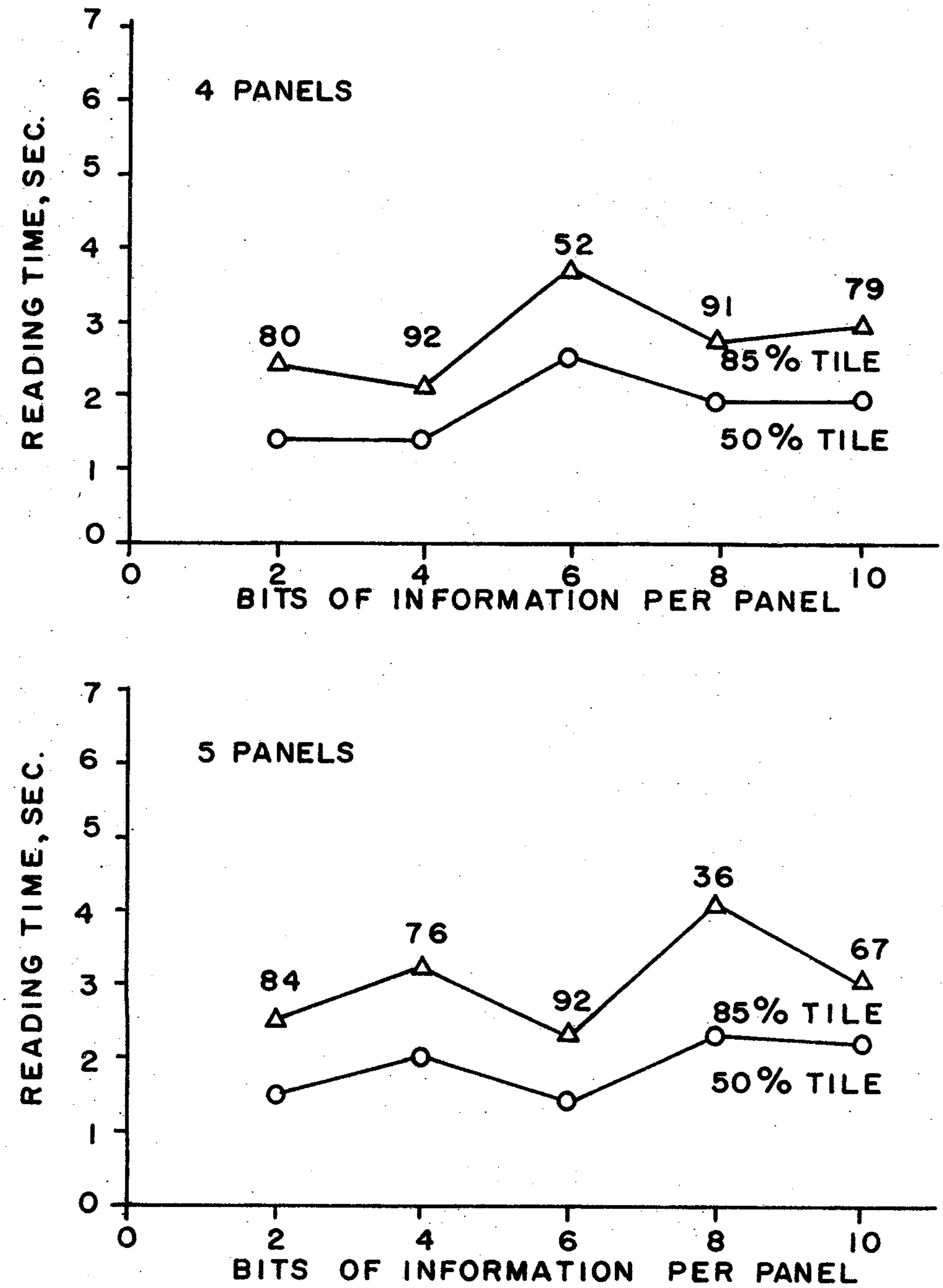


Figure 4-8. Reading Times and Percent Correct Responses for 4 Panel and 5 Panel Signs at 2½ Second Display Times.

A summary of the 2½ second display test results follows. The median (50%-ile) reading time was calculated to be 1.7 seconds, the mean 1.8 seconds, and the 85%-ile 2.8 seconds. An average percent correct response of 78% was determined for 67 usable subjects.

The inverse relationship between reading time and accuracy level continued to be observed in this subsequent experiment. The average of the 50%-ile reading times was determined to be 1.7 seconds for all 2-panel signs and 1.9 seconds for all 5-panel signs. The average percent correct response for all 2-panel signs was 83%, but only 71% for all 5-panel signs. Only 3 of 5 2-panel signs had accuracy levels above 80%. However, only 2 of 5, 5-panel signs performed acceptably.

DISCUSSION OF RESULTS

A discussion of the results of the three display time experiments follows. Comparisons will be made from among the accuracy and reading time results. Useful research findings will be drawn from these comparisons and analyses.

Accuracy

The ability of the laboratory subjects to select the correct sign panel was found to depend on several variables; namely, total bits of information on the sign, sign design, display time and experience. Sign modifications also were found to impact the accuracy results.

Information. A summary of the average percent correct response results by the sign information test variables - number of sign panels per sign structure and information bits per test panel - are presented in Table 4-1. At the outset, the sign modification impacts between the 6 second and 2½ second

Table 4-1

Summary of Average Percent Correct Responses by Number of Panels and Information Per Panel

Information per Panel	Display Rate	Number of Panels Per Sign 2	3	4	5
2	6	93	83	94	80
	4	88	83	93	80
	2½	83	82	80	84
	Mean	91	83	89	81
4	6	96	82	63	46
	4	93	83	69	52
	2½	91	94*	92*	76*
	Mean	93	86	75	58
6	6	100	92	33	95
	4	87	92	36	86
	2½	99	87	52*	92
	Mean	95	90	40	91
8	6	81	55	76	58
	4	93	80	82	61
	2½	75	45	91*	36
	Mean	83	60	83	52
10	6	77	60	82,65	71,70
	4	83	71	88,75	83,73
	2½	57	80*	81,78	55*,79*
	Mean	72	70	78	72

*Modified before 2½ second laboratory.

display rates should be noted from Table 4-1. Of the 14 test signs not modified, 11 of them showed reductions in accuracy levels, 1 was unchanged, and 3 experienced slight accuracy increases. The mean percent correct response of this data set dropped 5 percentage points on the average from 82% to 77%. Of the 8 signs that were modified, all 8 showed increases in percent correct response. These 8 modified signs accuracy levels increased 13 percentage points from 64% to 77%. While there was no objective originally to sub-optimize the sign designs, these findingd do show that sub-optimal sign designs can be significantly improved.

If it is assumed that the 6, 4 and 2½ second display test results represent samples of existing sign designs, reading requirements and representative driver experiences for design evaluation purposes, then the results of the 66 tests (3 display rates by 22 test signs) may be pooled to analyze combined accuracy results. The following analyses are conducted under this assumption.

The pooled accuracy results of Table 4-1 suggest that 6 bits of information per panel is about optimum recognizing that 2 bits is not a practical value. This conclusion is drawn from a consideration of the average accuracy levels of the 2, 4, 6, 8 and 10-bit signs in Table 4-1, (i.e., 86, 78, 79, 70 and 73%, respectively). It can also be determined from Table 4-1 that the average percent correct response decreased with increasing number of panels and with total information load I, where I is the product of number of panels, P, by average number of bits of information per panel B, or $I = P \times B$. The average percent correct response for 2, 3, 4 and 5-panel signs in Table 4-1 is 87, 78, 73 and 71% respectively. The average percent correct response for I-levels of 8, 12, 16, 24 and 40 bits of information is calculated from the average of two cells for each I-level to be 91, 91, 83, 51 and 65%, respectively.

An analysis of the 66 individual data points from the three display time experiments further reveals the reduction in accuracy rates with increasing total information levels on a sign. From Table 4-1, it can be determined that all 21 test signs having I-levels of 12 bits or less had accuracy levels of 80% correct or better. Again, 80% correct response is assumed to be the minimum acceptable level per test for this laboratory. These results are reflected by the upper curve in Figure 4-9. This curve shows the percent of all data points (i, p) having i $\leq$ which also have accuracy levels p $\geq$ 80%. Ninety percent (90%) - 27 of 30 - of all samples having I-levels for 18 bits or less had accuracy levels of 80% or more. Only 78% (28 of 36) performed acceptably. Over the complete data set, 41 of 66 (or 62%) of the signs were acceptable, as the upper curve in Figure 4-9 depicts at the upper bound I-level of 50 bits.

The average percent of the signs performing acceptably (i.e., $\geq$ 80% correct response) based on the laboratory results is given at the bottom of Figure 4-9 for three intervals of information load. In the interval of 0-15 bits, 100% of the signs performed acceptably. In the interval from 15-30 bits, 51% of the signs were acceptable. In the interval from 31-50 bits, only 33% of the test signs were found to be acceptable.

Another sign design parameter which seems to affect accuracy levels to some extent is the ratio of the number of panels, (P), divided by the average information bit rate per panel, B, or R = P/B. If one analyzes the 4 and 2½ second display time results in Table 4-1, it will be determined that in 8 of 14 paired comparisons existing at similar total information levels up to, but not including, 20- bit I-levels that in only 1 of 6 cases did the percent

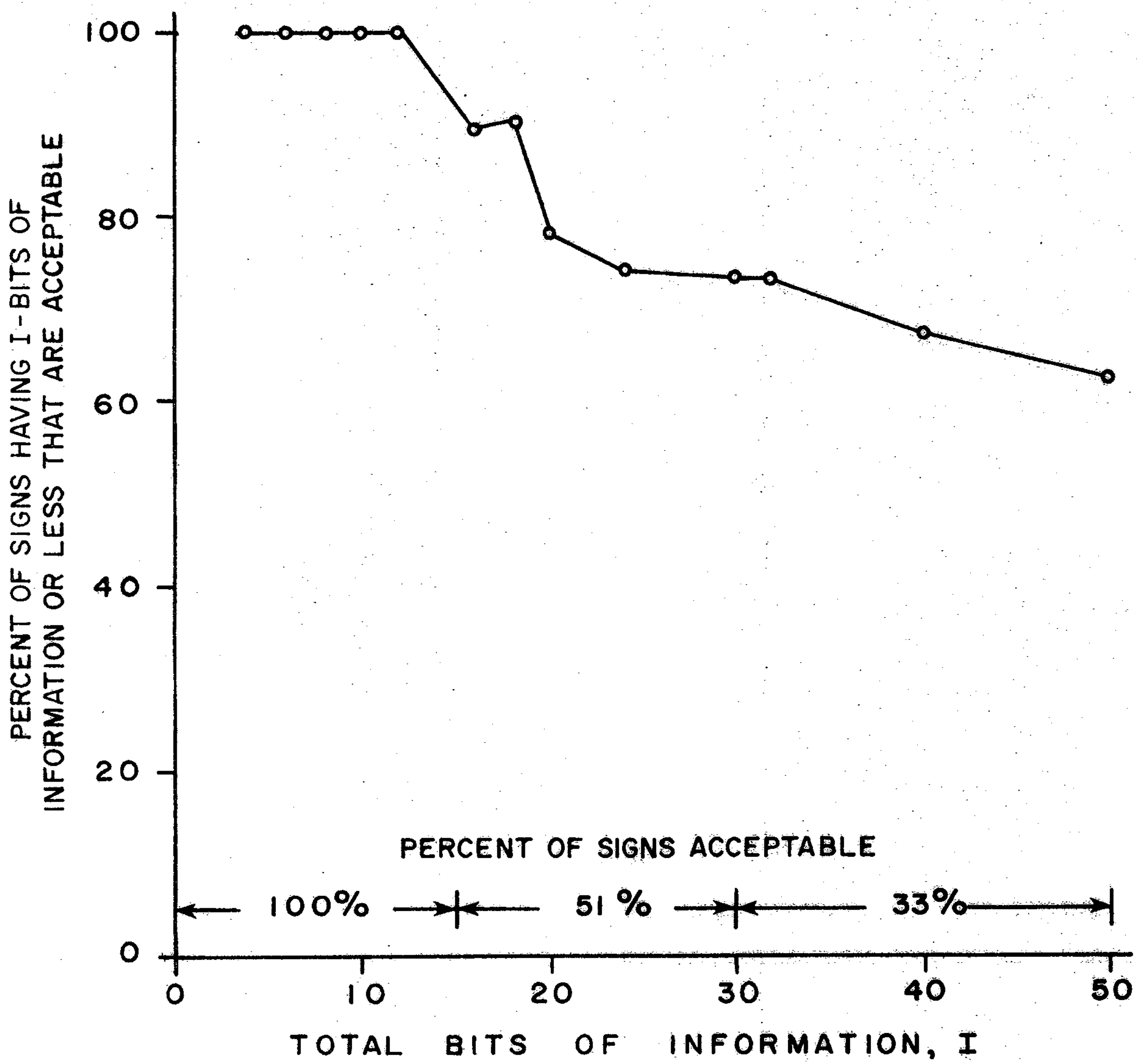


Figure 4-9. Acceptance Levels Related to Total Information on Sign.

correct response increase as the ratio R decreased for a given I-level. This one case was at an I-level of 16 bits with 2½ second display time. However, in the 8 cases where paired comparisons were possible from I-levels of 20-bits or more, no trend is evident; 4 cases rose with decreasing R values and 4 cases dropped. Again, it is concluded that somewhere in the vicinity of 15-20 bits of information is a critical design level for total bits of information (I) per sign structure. Above this level there are just too many choices (panels) or too much clutter per sign panel for efficient decision making to occur.

Display Time. A comparison of the 14 test signs not changed between the 6 and 2½ second display time experiments showed that this significant reduction in display time resulted in a moderate drop in route selection accuracy from 82% to 77%. It should be noted, however, that most of the signs that were not modified tended to be the smaller less complex signs.

Experience. The results of the 6 and 4 second display time experiments demonstrate how driver familiarity and experience yield improved driver performance. The mean percent correct response increased form 75% to 78% even though the average display time was reduced 33%. A total of 14 of the 22 test signs showed increases in percent correct response, whereas only 5 showed decreases.

Reading Time

The time the subjects took to read the signs depended not only on the sign design parameters but also on how much time was available to perform the task. This was to be expected as normal behavior. A brief review of the averages of the 85%-ile reading times for each display rate illustrates

Table 4-2

Desirable and Minimum Reading Times in Seconds for Overhead Freeway Guide Signs

Bits of Information Per Panel	Design and Operating Conditions	Number of Sign Panels for Overhead Sign Structure 2	3	4	5
2	Desirable	3.1	3.5	3.9	4.4
	Minimum	2.7	2.7	3.0	3.3
4	Desirable	3.6	4.2	5.0	5.7
	Minimum	2.7	3.2	3.7	4.2
6	Desirable	3.8	4.5	-	-
	Minimum	2.8	3.4	-	-
8	Desirable	3.9	-	-	-
	Minimum	2.9	-	-	-
10	Desirable	4.0	-	-	-
	Minimum	3.0	-	-	-

this point as follows:

Display Time, sec.	85%-ile Reading Time, sec.	Ratio DT÷RT
6	4.6	1.30
4	3.5	1.14
2½	2.8	0.89

A plot of these data shows that a 3.0 second display time would have produced a 3.0 second 85%-ile reading time, or a display time to reading time ratio of 1.00 for the 85%-ile driver. Thus, it would appear that the 4 second display time would represent a test conditions which is pressurized but yet provides minimum acceptable conditions. Since the 4 second display 85%-ile reading times were 75% of the 6 second times, the 6 second display time represents what may be reasonably considered to be a desirable set of operating conditions.

Linear regression analyses were performed to develop equations for estimating the reading times. The advantage of this approach is that smoothed estimates of each test sign can be estimated based on trends and characteristics of the complete study. Estimated desirable and minimum reading times based on these analyses are presented in Table 4-2. Minimum reading rates were assigned to be 75% of the desirable values subject to a 2.7 second minimum. Sign structures having a total of over 20 bits of information on them are not recommended, usually don't exist in the field, and are given in Table 4-1 for information purposes only.

CONCLUSIONS AND RECOMMENDATIONS

The results of this detailed laboratory study of urban freeway guide sign reading tasks form the basis for the following conclusions and recommendations.

Table 4-3

Recommended Maximum Sign Designs for Desirable and Minimum Design Conditions

Number of Route Alternatives	Maximum Bits of Information on Sign		Minimum Reading Time in Seconds to be Provided	
(Panels)	Condition	Bits	Desirable	Minimum
2	Desirable	12	3.8	2.8
	Maximum	16	3.9	2.9
3	Desirable	18	4.5	3.4
	Maximum	20	4.6	3.5
4	Desirable	16	5.0	3.7
	Maximum	20	5.2	3.9
5	Desirable	--*	--	--
	Maximum	20	5.7	4.2

* This is an undesirable design. Sign spreading, removal of redundant concurrent routing or other appropriate techniques should be examined.

It is apparent that route selection accuracy decreases as the number of of route choices (and related sign panels) increase. It is also clear that the information content of a large sign structure should not exceed 6 bits of information per panel.

The time required to read a sign also increases with the number of route choices available and total information on the signs as presented in Table 4-2.

The sign designs given in Table 4-3 respresent what are recommended as desirable and minimum acceptable design parameters for overhead freeway guide signing in urban areas.

Any sign which does not provide desirable design conditions, with respect to the number of panels and the level of information in each panel should have a sign layout which optimizes all other sign design criteria. Minimization of costs should not be the only controlling consideration for the minimum condition designs. All signs which do not meet minimum conditions should not only be redesigned, but the route structure should be redesigned, to eliminate concurrent routes, unnecessary exits, etc.

CHAPTER 5

STUDY AREA 4 - TARGET VALUE OF DIFFERENT TYPES OF ROUTE GUIDANCE SHIELDS

A. Objective

The objective of this study is to determine the proper mix of shield sizes so that all of the route marker shields on the route guidance signs have the same target value. Current practice specifies that the Interstate, U.S. and State route markers will be consistently placed on the panels and will be the same size. Due to the shape and color combination of these three route markers the state route marker appears to be larger, therefore, having a higher target value than either the Interstate and/or U.S. route markers.

Figure 5-1 represents a sign panel with an Interstate, U.S. and State shield which are the same size. Figure 5-2 represents a sign panel in which the Interstate and U.S. shields are the same size and the state shield is one size smaller. The target value for the Interstate and the U.S. shields are greatly increased in Figure 5-2 when compared to Figure 5-1 due to the size reduction of the State Shield.

B. Research Methodology

In this study the subjects were presented with 126 slides containing a sign panel with either 2 or 3 route marker shields. The route marker shields were used in various combinations of either one, two, or three different types. The sizes of the route marker shields were 16/32", 11/32" and 9/32" (outside dimensions). These three signs were selected because they (1) corresponded to actual route marker sized on route guidance signs in a simulated situation and (2) the size differentials are such that the subjects must be able to discriminate between subtle changes in the shield sizes.

The subjects were required to view each slide and select the shield

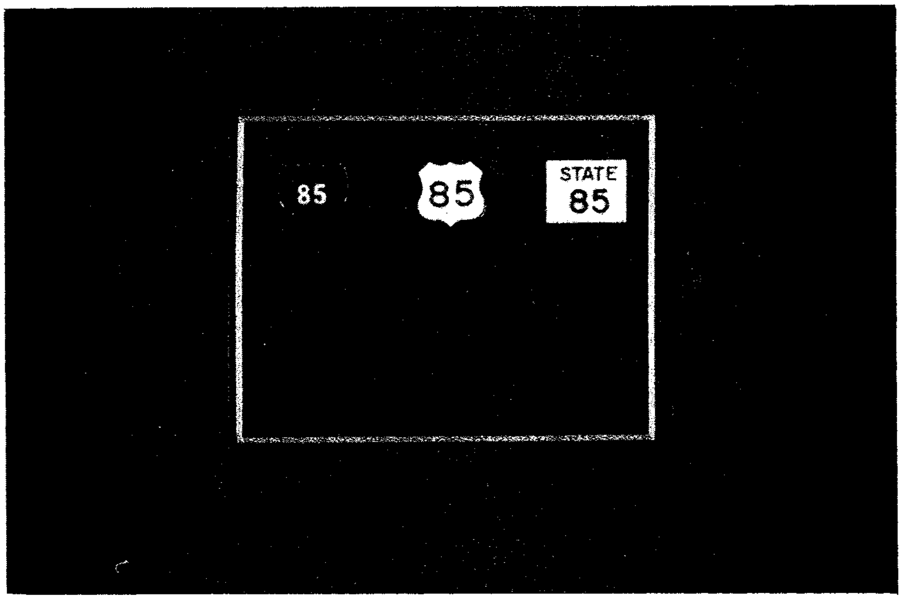


Figure 5-1. Interstate, U.S. and State Shields of the Same Size.

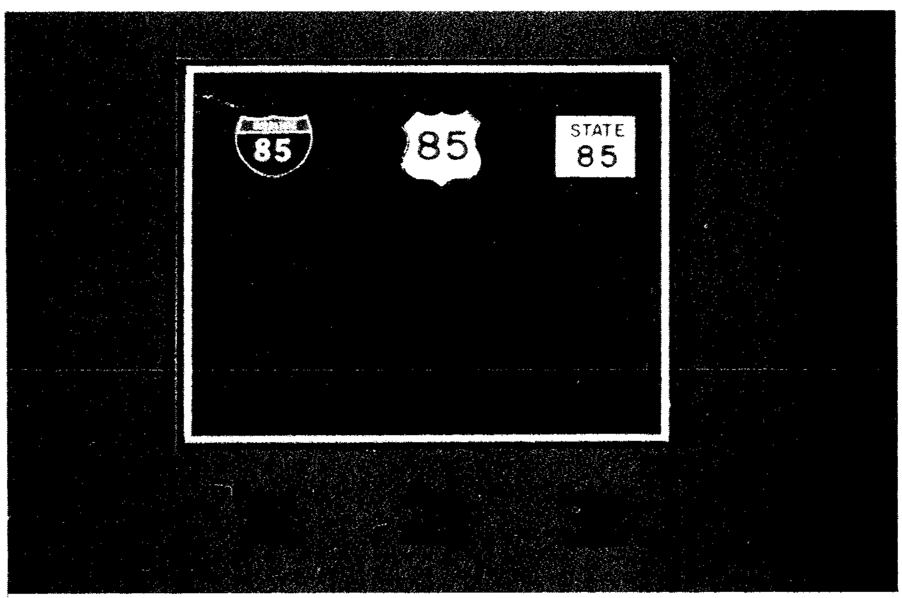


Figure 5-2. Interstate, U.S. and State Shields of Different Sizes.

which appeared to be larger than the other shield or shields. In those situations where more than one shield appears to be the same size and larger than the other shield the subject would respond by indicating the numbers of those shields. If the sign panel contained two route markers and they appeared to be the same size, the subject would respond by pushing both buttons, corresponding to the numbers under each shield. the number under each shield corresponds to the position of the shield on the sign panel. Each slide was projected for 8 seconds and the subjects had an additional 15 seconds in which to respone.

C. Results

The subjects responses to types of Route Marker and size of shield are presented in Table 5-1. The responses included in Table 5-1 are for those shields in which the subjects could not detect any significant differences in size. When comparing the size of the interstate shield with the use of the U.S. shields it can be seen that in all cases they were the same. Comparing the Interstate shields with the State shields indicates that in all cases when the subjects said that the state shield appeared to be the same size as the Interstate, the state shield was, in fact, one size smaller. The same situation exists in all of the cases when the state and U.S. shields were compared. "In the reading environment the color of the Interstate route shield increases the effective legibility distance. This effect may be reported when two or more different types of routes are concurrent."

The results of this study indicate that when Interstate, U.S. and State shield, of the same size, are placed on route guidance signs the state shield has a higher target value than both the U.S. and the Interstate shields. These results are in direct opposition to the priority of roadways. In general,

Table 5-1

Number of Subjects Responding There Was No Difference in the Size of the Shield - By Type of Shield, Shield Size And the Corresponding Chi-Square

Type of Shield							
Interstate		U.S.		State			
Shield Size (in.)	Number of Responses	Shield Size (in.)	Number of Responses	Shield Size (in.)	Number of Responses	Chi-Square	
						Computed x^2	Level of Significance *
11/32	62	11/32	56	9/32	71	1.82	p < 0.500
-	--	11/32	59	9/32	75	1.91	p 0.250
11/32	64	11/32	50	9/32	67	2.73	p 0.500
-	--	11/32	58	9/32	71	1.31	p 0.500
16/32	79	-	--	11/32	79	0.00	p 0.950
11/32	71	-	--	9/32	63	0.48	p 0.500
11/32	69	-	--	9/32	62	0.37	p 0.750
11/32	57	11/32	65	-	--	0.52	p 0.500
11/32	71	11/32	57	-	--	1.53	p 0.250

* The associated levels of significance for these computed chi-squares indicate no significant difference in dispersion between the number of responses for the different types of shields.

H_0: $f_I = f_{U.S.} = f_s$

motorists think the Interstate is the highest priority of roadway, followed by the U.S. and the state highways. The target value of the route shields is State, U.S., and then Interstate, which is in direct opposition to the class of roadway. It is recommended that in most cases the Interstate and U.S. route shields should be the same size since they seem to have the same target value, and the state shield should be one size smaller reducing the target value of the state shield to that of both the U.S. and Interstate shields. When U.S. shields and state shields are presented alone, the state shield should be one size smaller than the U.S. shield. When the Interstate and U.S. shields are presented alone the U.S. shield may be either (1) the same size as the Interstate, or (2) one size smaller. In this way the route guidance signs will reflect the priority of the highway system. These relationships between route priority and size of signs are expressed in Table 5-2.

Table 5-2

Route Priority and Size of Route Guidance Shields
Relationship for Interstate, U.S. and State Highways

Priority Ranking	Type of Facility	Type of Shield
1	Interstate	A
2	U.S.	B
3	State	C

Relationship between types of Shields A $\geq$ B > C

CHAPTER 6

STUDY AREA 5 - CONCURRENT SIGNING-MOTORIST UNDERSTANDING

A. Objective

The objective of this study is to determine the motorists' understanding and use of concurrent route signing information. Currently, Texas signing practices state that when two or more routes share a common roadway, route shields for all routes will be displayed on the route guidance signs. Recently this situation has created some major problems in large urban areas, such as Houston and Dallas, where several routes all converge together. It is not uncommon to find a route guidance sign with as many as 5 or 6 different route shields on it. In order to evaluate the criticality of this information, it must be determined whether motorists actually understand what concurrent signing means and whether they use the concurrent signing information or ignore it.

B. Research Methodology

In this study the subjects were given ten (10) routes they were to use around the state of Texas. They were told that they had some friends visiting from California and these friends wanted to tour the state before returning to California. The subjects were to give them directions so they could follow this route. Nine (9) of these ten (10) routes were concurrently signed on at least one leg of the route. The other one (1) was not a concurrent route. Table 6-1 lists the routes by city of origin, intermediate city, destination city and Interstate and U.S. route designation. Along these routes, locations on the map were marked indicating the location of the sign their friends were approaching. The subjects were required to give no more than two (2) route designation shields and no more than three control

Table 6-1

Routes Used in Determining Motorists Usage of Concurrent Signing By Origin City, Intermediate City, Destination City, Route Destination

Route Number	Origin City	Intermediate City	Destination City	Route
1	Laredo	San Antonio	Temple	I-35 & U.S.-81
2	San Antonio	Temple	Waco	I-35 & U.S.-81
3	El Paso	Big Spring	Dallas	I-20 & U.S.-80
4	Victoria	Giddings	Hillsboro	U.S.-77, I-35 & U.S.-81
5	Giddings	Waco	Hillsboro	I-35 & U.S.-81
6	Victoria	Houston	Nacogdoches	U.S.-59
7	Livingston	Huntsville	Madisonville	I-45 & U.S.-75
8	Sherman	Dallas	Houston	I-45 & U.S.-75
9	Junction	San Antonio	Houston	I-10 & U.S.-87
10	Del Rio	San Antonio	Houston	I-10 & U.S.-90

cities. The subjects were told that their friends were unfamiliar with the state of Texas, therefore, they must give them all the information they think they would need to get to their destination.

After the subjects had finished the first six (6) trips they were told the nature of the situation. Briefly they were told that in some cases, an Interstate freeway and a U.S. highway share the same roadway. We also told them that unfamiliar motorists may or may not be aware of this and that in the next few cases they should keep this problem in mind when giving their friends the required information. The subjects understood that they were going to determine whether their friends, as unfamiliar drivers, would require the information or not.

C. Results

Table 6-2, presents the results of this study. The frequency and percentage of total responses are given by trip number and whether the subjects think their friends need concurrent route signing (concurrent) or whether they do not need concurrent signing (non-concurrent).

The results of this study indicate that in general the subjects preferred non-concurrent signing (58%) to concurrent signing (42%) with a chi-square probability level of less than 0.01. Prior to the subjects being told the nature of the problem this study was addressing, the subjects significantly (probability less than 0.01) preferred non-concurrent signing (64%) to concurrent signing (36%); whereas, after the problem was explained, 54% of the subjects indicated they wanted concurrent signing as opposed to 46% of the subjects indicating they did not want concurrent signing. The differences in the number of responses between those wanting

Table 6-2

Frequency and Percent of Total Responses For Concurrent and Non-Concurrent Route Information by Trip

Trip Number	Concurrent Frequency	Concurrent Percent of Total	Non-concurrent Frequency	Non-concurrent Percent of Total	x^2
1	20	24	63	76	22.28*
2	40	48	43	52	0.11
3	44	56	35	44	1.03
4	14	21	52	79	21.88*
5	42	66	22	34	6.25**
6***	--	--	64	90	----
7	46	62	28	38	4.38**
8	29	54	25	46	0.30
9	14	31	31	69	6.42**
10	29	64	16	36	3.76
All Trips	278	42	379	58	15.53*
Before Explaining Nature of Problem	167	37	279	63	28.13*
After Explaining Nature of Problem	118	54	100	46	1.49

Ho: $f_c = f_{nc}$

* $p \leq 0.01$

** $p \leq 0.05$

*** Not a concurrent route

concurrent signing and those not wanting concurrent signing was not significant after the problem was identified. This could indicate that the subjects still prefer non-concurrent signing to concurrent signing, however, some of the subjects may have indicated they wanted concurrent signing because (1) they felt that this was the response we were looking for or, (2) they were not aware of concurrent routes until we pointed these routes out to them, and they genuinely want the concurrent information presented to them. From the results of this test we have no way of determining which of these two situations existed in the minds of each subject, by which to analyze the data. For this reason, additional research in this area is needed to determine the true cause of the shift in responses. Based on these results, however, it would seem that the subjects preferred non-concurrent signing to concurrent signing. If these results were implemented, it would appear that the route with the highest priority would be signed and the others would be eliminated.

Table 6-3 presents the number of subjects preferring not to have any interstate route information presented to their friends. This table also presents the percent of total responses and the type of route their friends must use to get to their destination. These results indicate that when the route consists mainly of a U.S. section with a small portion of Interstate, 77% indicated they wanted the U.S. route information only. When the route is all interstate with sections concurrently signed, only 8% wanted the U.S. route information presented.

These results indicate that for motorists traveling entirely along interstate freeways, the concurrent U.S. information may be eliminated. For those motorists traveling for long distances along a U.S. route and then

Table 6-3

Frequency and Percent of Total Responses For Those Subjects Indicating They Prefer U.S. Route Information Only - By Type of Route to Their Destination

Type of Route from Place of Origin to Place of Destination	Number of Subjects Responding They Want U.S. Route Information Only Presented(5)	Percent of Total Responses For This Study(%)
1. U.S. route all the way	70	98
2. Mainly U.S. - some Interstate	51	77
3. Interstate all the way	41	8

Ho: $f_1 = f_2 = f_3$

$x^2 = 8.04$ ($p < 0.025$)

join an interstate, the U.S. route information should be continued. To implement these results, it would seem that concurrent information could be presented for several miles after a U.S. route joins an interstate and several miles prior to the U.S. route leaving the freeway.

CHAPTER 7

STUDY AREA 6 - CONCURRENT SIGNING-ROUTE NUMBER REDUCTION

A. Objectives

The objective of this study was to evaluate the relative effectiveness of route numbering reduction schemes where a concurrent freeway route has its lower priority route number dropped from the route signing. Two types of current freeway routes were evaluated. One common type of concurrent routing in Texas is where the Interstate has been added to the existing U.S. numbered route when the freeway facility was constructed. In this case, the Interstate route designation has become the commonly referenced number, such as "I-35", rather than U.S. 81. The laboratory methodology will determine the effects of eliminating U.S. 81 from the route signing, for example. A less frequent type of concurrent routing along the Interstate freeways in Texas exists where a U.S. route joins the freeway and is concurrent with it for several miles. Traffic initially operating on the rural highway may respond differently once on the freeway if their concurrent U.S. numbered route were eliminated from the freeway signing over the concurrent section. This situation was also investigated in the laboratory study to follow.

B. Research Methodology

The laboratory methodology consisted primarily of measuring subject responses to artist renditions of route markers and overhead freeway guide signing for two hypothetical trip situations. Each trip was presented in a scenario format using slides combined with a narrative of the trip. Reaction times and correct responses were recorded for each subject. A total of 79 subjects were drawn from the available subject pool used in these laboratory experiments.

The first trip scenario consisted of the subjects assuming that they were driving for about 50 miles along a high-type, two-lane highway (numbered U.S. 84) until U.S. 84 joined the Interstate freeway (numbered I-50). The trip then continued along the freeway to the traveler's ultimate destination (being Taylor). After traveling several miles along the freeway, a simulated interchange was reached wherein the motorists (laboratory subjects) would have to select the correct route (sign panel) from three alternatives presented on a rear projection screen (as in Chapter 4). The visual simulation of the trip consisted of slides of actual roadways of the appropriate type alternating with slides of route markers. The artist rendition of the route markers were designed to resemble a typical post-mounted route marker placed on the shoulder of the road. Three cycles of facility plus marker scenes were used to simulate the rural, two-lane highway portion of the trip, followed by a similar set of three cycles of slides to simulate the freeway test section portion of the trip. The guide sign test panels replaced the route markers in the third cycle of the freeway portion of the trip. The subjects were requested to select the correct route sign panel from three alternatives shown in the test slide. Selection accuracy and response times in seconds were recorded.

The second trip scenario studied consisted of a trip made exclusively on a freeway to a hypothetical town named Walden. The initial portion of the trip had concurrent signing (I-65 and U.S. 79). This initial portion of the trip was simulated in the laboratory using three cycles of slides presenting an actual freeway followed by a route marker. The second half of the freeway trip was the test section portion of the trip. Again, three cycles of freeway scenes followed by route markers were shown to the subjects together with an oral description of the trip's progress and situation. A slide depicting an overhead sign structure containing three overhead sign panels replaced the last route marker in the test sequence. Subject's selections and response times were recorded for the last slide.

A summary of the concurrent route problems and route markings tested in the laboratory is presented in Table 7-1. Two freeway marking systems were evaluated for both types of the approach highways previously described. These route marking systems are denoted in Table 7-1 as R1 and R2 for the rural 2-lane road approach to the freeway test section. R2 has a full concurrent route marking system in the freeway test section, whereas, R1 has a complete deletion of concurrent signing on the freeway. The two freeway route marking systems are denoted as F1 and F2 in Table 7-1. In this case, F1 has the full concurrent route marking system, whereas F2 completely drops the concurrent U.S. numbered route in the test section.

For each of the four test cases illustrated in Table 7-1, two alternative designs for each of the junction test signs (the T's in Table 7-1) were designed and evaluated. Design A junction test sign panels are presented in Table 7-2, and Design B panels are given in Table 7-3. The actual representation of the panels were similar to those presented earlier in Figure 4-1. Essentially, one of the two designs presents no concurrent signing, whereas the other one does. Where concurrent signing was displayed in the freeway test case, the correct route did not contain concurrent signing. It was surmised that subjects might tend to select routes based on the number of shields, and shield patterns, and therefore erroneously choose the wrong route (panel).

It is helpful to note that the four Design B signs are the same signs as in Design A except that their positions within a route group are reversed. Thus, changes in response times for a given sign may be determined and related to the type of transition route markings used in the freeway section prior to the overhead junction test sign.

Table 7-1

Concurrent Route Marking Systems Tested in Laboratory for Rural Road and Freeway Approach Conditions

Approach Highway and Route Marking Sequence	Test Highway and Route Marking Sequence
Test Designation: R1	
Two-lane Road Marking Sequence	Freeway Marking Sequence
R • U.S. 84 • R • U.S. 84 • R • U.S. 84	F • I-50 • F • I-50 • F • T
Test Designation: R2	
Two-lane Road Marking Sequence	Freeway Marking Sequence
R • U.S. 84 • R • U.S. 84 • R • U.S. 84	F • I-50 / U.S. 84 • F • I-50 / U.S. 84 • F • T
Test Designation: F1	
Freeway Marking Sequence	Freeway Marking Sequence
F • I-65 / U.S. 79 • F • I-65 / U.S. 79 • F • I-65 / U.S. 79	F • I-65 / U.S. 79 • F • I-65 / U.S. 79 • F • T
Test Designation: F2	
Freeway Marking Sequence	Freeway Marking Sequence
F • I-65 / U.S. 79 • F • I-65 / U.S. 79 • F • I-65 / U.S. 79	F • I-65 • F • I-65 • F • T

R = Scene of rural two-lane highway; F = Scene of rural freeway

T = Scene of 3-panel simulated overhead sign used for testing

Table 7-2

Design A Junction Test Signs for Rural Two-Lane Highway and Freeway Approach Conditions

Panel No. 1	Panel No. 2	Panel No. 3
	Test Designation: R1	
I-85 U.S. 93 Benton Porter ↓	I-70 U.S. 76 Danbury Walker ↓	I-50 U.S. 84 Taylor Rogers ↓
	Test Designation: R2	
I-85 Benton Porter ↓	I-70 Danbury Walker ↓	I-50 Taylor Rogers ↓
	Test Designation: F1	
I-70 U.S. 82 Kendall Anders ↓	I-65 Walden Brooks ↓	I-85 U.S. 93 Davis Harrison ↓
	Test Designation: F2	
I-85 Davis Harrison ↓	I-65 Walden Brooks ↓	I-70 Kendall Anders ↓

Table 7-3

Design B Junction Test Signs for Rural Two-Lane Highway and Freeway Approach Conditions

Panel No. 1	Panel No. 2	Panel No. 3
	Test Designation: R1	
I-85 Benton Porter ↓	I-70 Danbury Walker ↓	I-50 Taylor Rogers ↓
	Test Designation: R2	
I-85 U.S. 93 Benton Porter ↓	I-70 U.S. 76 Danbury Walker ↓	I-50 U.S. 84 Taylor Rogers ↓
	Test Designation: F1	
I-85 Davis Harrison ↓	I-65 Walden Brooks ↓	I-70 Kendall Anders ↓
	Test Designation: F2	
I-70 U.S. 82 Kendall Anders ↓	I-65 Walden Brooks ↓	I-85 U.S. 93 Davis Harrison ↓

A summary of the overall experimental design is depicted in Table 7-4, where C and NC represent concurrent and non-concurrent signing, respectively. R1, R2, F1 and F2 are as in Tables 7-1 through 3.

Table 7-4

Concurrent Signing Experimental Design

Approach Route	Freeway Markers	Freeway Junction Signing	
		Design A	Design B
R1	NC	C	NC
R2	C	NC	C
F1	C	C*	NC
F2	NC	NC	C*

C* Concurrent except for destination route.

Two additional items complete the description of the research methodology. The experimentation was divided into two sections of about 20 minutes duration each. One of the following two sequences was alternatively tested in the first half of the laboratory, either sequence R1 · F1 or R2 · F2. In either case, the other sequence was selected for testing during the second half of the experiment. Randomization of R and F were not conducted due to the complexity of laboratory scheduling. Just prior to a ten-minute rest period provided midway through the laboratory and immediately following the first test sequence, a brief lab experiment on interstate business loop route recognition and experience was conducted. This supplemental lab was inserted into the overall experimental design to break-up the learning effects between the two primary test sequences and to provide some initial data for possible future research studies of freeway signing.

C. Results

Observations of subjects' responses were recorded for the number of route selection errors and response times. Most of the results are useful, but some response time comparisons are clouded most probably due to a lack of randomization of the placement of the correct sign panels.

Table 7-5 presents the number of subject route selection errors for each of the eight test cases. The results show that the subjects had little difficulty selecting their appropriate route given that the principal route and destination of trip were shown on the sign. Even for the cases where the concurrent signing was dropped only at the test sign (i.e., at R2A and F1B) no error increase in route selection was noted.

Table 7-5

Number of Route Selection Errors for Concurrent Signing
Route Number Reduction Laboratory

Designation of Sign Test	Design A		Design B	
	Number of Errors	Number of Subjects	Number of Errors	Number of Subjects
R1	1	31	1	48
R2	1	31	1	48
F1	1	31	0	48
F2	1	31	0	48

Response times were envisioned as a second measure of performance for strategies for marking concurrent routes. Median (50%-ile) response times in seconds for the eight test cases are presented in Table 7-6. Increases in response times are associated with increases in uncertainty, confusion and reading pattern.

Table 7-6

Median Response Times for Concurrent Signing Route Number Reduction Laboratory

Designation of Sign Test	Median Response Times in Seconds		
	Design A	Design B	Average Response
R1	3.6	3.1	3.35
R2	3.8	2.9	3.35
Average	3.7	3.0	3.35
F1	2.7	2.5	2.60
F2	2.5	2.3	2.40
Average	2.6	2.4	2.50

The median response times for the two-lane approach highway (R1 and R2) are considered first. One important result noted from the median response times in Table 7-6, when considering the experimental design and related signing given in Tables 7-1 through 3, is that the route signing that performed best was the one which was exactly like the freeway route marking sequence in the freeway section prior to the test sign. For R1, the 3.1 second time occurred for the case where the I-50 route marker (in Table 7-1) was the same as the I-50 shield for Panel No. 3 in Table 7-3. A similar result is noted for R2 wherein the 2.9 second time (R2B) had the same concurrent routing as the prior freeway markings. Observe that the 2.9 second concurrent signing (R2B) was the one that picked up the rural highway route and was slightly superior to the one that did not (the 3.1 second, or R1B).

The median response times determined for the four tests conducted where the freeway was concurrent from the start of the trip are also presented in Table 7-6.

The median values on the whole are 0.85 seconds less than for the highway-to-freeway scenario. An unknown portion of this difference is attributed to the consistent use of Panel No. 3 for the freeway scenario versus Panel No. 2 for the highway-to-freeway one. Some of the improvement is surmised to be due to the easier route tracking task of driving just on the freeway. Frankly, little practical difference exists among the four results. Little increase in response times can be attributed to even suddenly dropping the concurrent freeway signing only on the overhead sign structure since the median response times for the same sign in test cases F1B and F2A are both equal to 2.5 seconds. Some increase in response times were noted where false route shield group associations might be formed, as in test cases F1A and F2B.

D. Summary

Overall, some important causal trends and research findings regarding freeway route marking systems may be drawn from these experimental results.

1. Route signing performs best when the route numbers on the markers are the same as on the sign (subject to overload constraints).
2. On concurrent routes, dropping the lower priority concurrent freeway signing which began when the freeway started will perform more effectively than will dropping the lower priority highway-to freeway concurrent signing.
3. There was no evidence collected in this experiment to suggest that eliminating the redundant U.S. route numbers from an Interstate freeway would not be successful from a navigational viewpoint.
4. There is some evidence to suggest that eliminating the concurrent U.S. highway route numbering from a short section of concurrent Interstate would result in degraded navigational performance by motorists traveling the U.S. numbered highway.

CHAPTER 8

STUDY AREA 7 - CONTROL CITY INFORMATION

A. Objectives

The objective of this study is twofold. The first is to determine whether control cities should be major destination cities (population of 100,000 and above) located several hundred miles away; or strategic intermediate sized cities (below 100,000), no more than 100 to 150 miles away. The size of the cities, to some degree, dictates the types of services and facilities available to weary travelers. For example, a city with a total population of 2,000 people will probably have one or two restaurants and one or possibly two motels. A city of 50,000 population will have several restaurants and possibly 8-10 motels. By using cities with a population of 25,000 and above, as control cities for example, the motorists may be assured of having adequate facilities by which to spend the night. The distance away from the urban center to the first control city is of utmost importance. Unfamiliar motorists driving along I-45 N out of Houston around 6 or 7 o'clock in the evening will see a sign directing them to Dallas. These motorists may not want to stop driving at this time but will want to stop in another hour or two. When they see the sign directing them to Dallas, since they are unfamiliar and may not have a map readily available, they decide they will drive to Dallas for the night, not knowing that it is a four hour drive from Houston.

The second objective is to determine the approximate location within an urban area where the control city name changes. At present this location is near the geographical center of the city. This may create problems to unfamiliar motorists because they have seen the city limits and they can see the downtown section of the city and they are still tracking the name of the city as a control city.

B. Research Methodology

This research area was studied in two laboratory studies and a motorist survey conducted at Tourist Information Bureaus in Gainesville, Texarkana, Laredo and El Paso. One of these laboratory studies was conducted as a part of the laboratory study in area 5 - Concurrent Signing Information. At each location the subjects were to develop a sign for their friends from California, they were instructed that their sign could present no more than three (3) route number shields, at least one (1) cardinal direction, and no more than two (2) control city names. The subjects were given a map, indicating the location at which their friends were and the city of origin and destination. The subjects were not given any restrictions concerning the size of the control cities, only the number of control cities. They were further instructed that the control city listed on top would be the closest city to their friends present location. The size of the control cities were dependent on the route the subject's friends were on.

In the second study the subjects were required to drive a hypothetical route to three (3) different destinations. In this first trip, the subject's destination was Omaha, Nebraska, and at each location the subjects were presented a sign containing four panels. The first panel had a destination city of Omaha, the second panel contained Denver, and the third panel was Downtown. In the second trip, the subject's destination was at a location in downtown Denver and the subjects were presented with the same four (4) panels as in trip number one. And in the third trip the subjects were going to Greenwood, Colorado. The destination city was not presented to the subjects as a choice, instead, the control city was Fairview. The control city of Fairview was used to simulate an unfamiliar city, other than the subject's destination, instead of the destination city which would be a familiar name to them.

During June and July 1978 a survey was conducted at four Tourist Information Bureaus. The survey was designed to determine where control city information should change to the next control city within an urban area.

C. Results

The results of the first study, determining size and location of control city, are presented in Table 8-1. These results indicate that when considering both the first and second choices of the subjects, cities with a total population of 100,000 and over were selected 65 percent of the time, whereas, cities with populations of 5,000-25,000 were selected 21 percent of the time. In all ten (10) cases the responses were distributed in such a manner that they were highly significant at the chi-square 0.05 percent level. One one particular trip the subject's friends were traveling from Victoria to Nacogdoches through Houston. At present the subject's friends were in Houston. From Houston to Nacogdoches the largest cities have a population of 5,000 to 25,000, therefore, the subjects responses in this particular case represent 14 percent of the total 21 percent of all responses for cities with populations between 5,000 and 25,000. The results of this study indicate that the subjects prefer to have the largest city on a

Table 8-1

Subjects Choice of Control Cities By Trip Number, City of Origin, City of Destination, Present Location, and Control City Size

Trip No.	City Origin	City Destination	City Present	First Choice		Second Choice	
				Name	Size	Name	Size
1	Laredo	Temple	San Antonio	Austin	100,000 & over	Temple	25,000-50,000
2	San Antonio	Waco	Temple	Waco	100,000 & over	-------	
3	El Paso	Dallas	Big Spring	Abilene	100,000 & over	Dallas - Fort Worth	100,000 & over
4	Victoria	Hillsboro	Giddings	Waco	100,000 & over	----------	
5	Giddings	Hillsboro	Waco	Hillsboro	5,000-25,000	Dallas - Fort Worth	100,000 & over
6	Victoria	Nacogdoches	Houston	Cleveland	5,000-25,000	Nacogdoches	5,000-25,000
7	Livingston	Madisonville	Huntsville	Madisonville	1,000-5,000	-----------	
8	Sherman	Houston	Dallas	Houston	100,000 & over	-----------	
9	Junction	Houston	San Antonio	Houston	100,000 & over	-----------	
10	Del Rio	Houston	San Antonio	Houston	100,000 & over	-----------	

Table 8-1

Subjects Choice of Control Cities By Trip Number, City of Origin, City of Destination, Present Location, and Control City Size - Statistical Summary (Continued)

Population	1st Choice		2nd Choice		Total	
	(f)	(%)	(f)	(%)	(f)	(%)
100,000 & over	7	.50	2	.15	9	.65
50,000-100,000	0	---	0	---	0	---
25,000-50,000	0	---	1	.07	1	.07
5,000-25,000	2	.14	1	.07	3	.21
1,000-5,000	1	.07	0	---	1	.07
Under 1000	0	---	0	---	0	---
Total	10	.71	4	.29	14	1.00

particular route shown as the control city.

The subjects responses indicated that, when using the subjects first choice of control city as the test criterion, 50 percent wanted control cities to be no further than 100 miles away from their present location, and 85 percent wanted the control city to be no further than 200 miles away. When considering all responses of the subjects, 50 percent indicated they preferred control cities to be no further than 150 miles, whereas, 85 percent of all responses indicated the control city should be no further than 250 miles.

The results of the second study determining the location within an urban area, where control city names change are expected and wanted, are presented in Tables 8-2 and 8-3. Table 8-4 presents the control city names motorist expect and Table 8-5 presents the names the motorists want to see. Those locations in which two names appear, indicate that there was no significant difference in the number of responses between these two alternatives.

This study indicates that the subjects expect to see the name of the city they are entering displayed near the city limits. They also expect to see either (1) the city name or (2) the term downtown displayed from around the loop to approximately 5 miles away from the CBD. Any distance closer than 5 miles they expect to see the term downtown, and finally after they have passed the CBD they expect to see the name of the next control city. In general the message the subjects want to see are the same as those they expect to see. Those locations in which two names appear, indicate that there was no significant difference in the number of responses between these two alternatives. On the third trip in which the subjects were going to a destination which did not appear as the control city, the subjects responses

Table 8-2

Control City Names Motorists Expect at Various Locations
Within an Urban Area for Different Destinations
Frequency (f) and Percentage (%)

Location of Route Guidance Sign/ Control City Names	Destination in Another City Which is Signed as Next Control City		Destination in Downtown Denver		Destination in Another City Not Signed as Next Control City	
	(f)	(%)	(f)	(%)	(f)	(%)
Near City Limits Entering Denver						
(1) Omaha	29	31	4	4	-	-
(2) Denver	48	51	57	61	69	73
(3) Downtown	17	18	32	35	15	16
(4) Fairview	-	-	-	-	10	11
Near Loop Entering Freeway						
(1) Omaha	18	19	4	4	-	-
(2) Denver	41	45	45	49	54	59
(3) Downtown	33	36	44	47	31	34
(4) Fairview	-	-	-	-	7	7
Five (5) Miles From CBD						
(1) Omaha	11	12	5	5	-	-
(2) Denver	35	38	33	35	39	41
(3) Downtown	46	50	56	60	45	48
(4) Fairview	-	-	-	-	10	11
One (1) Mile or Less From CBD						
(1) Omaha	19	21	9	10	-	-
(2) Denver	20	22	15	16	17	18
(3) Downtown	53	57	70	74	68	74
(4) Fairview	-	-	-	-	7	8

Table 8-2 (Continued)

Control City Names Motorists Expect at Various Locations Within an Urban Area for Different Destinations Frequency (f) and Percentage (%)

Location of Route Guidance Sign/ Control City Names	Destination in Another City Which is Signed as Next Control City		Destination in Downtown Denver		Destination in Another City Not Signed as Next Control City	
	(f)	(%)	(f)	(%)	(f)	(%)
Near Interchange With Another Freeway Leaving Denver						
(1) Omaha	61	66	-	-	-	-
(2) Denver	20	22	-	-	30	33
(3) Downtown	11	12	-	-	19	21
(4) Fairview	-	-	-	-	42	46
Near Loop Exiting Denver						
(1) Omaha	75	82	-	-	-	-
(2) Denver	9	10	-	-	23	25
(3) Downtown	7	8	-	-	6	7
(4) Fairview	-	-	-	-	62	68

Table 8-3

Control City Names Motorists Want at Various Locations
Within an Urban Area for Different Destinations
Frequency (f) and Percentage (%)

Location of Route Guidance Sign/ Control City Names	Destination in Another City Which is Signed as Next Control City		Destination in Downtown Denver		Destination in Another City Not Signed as Next Control City	
	(f)	(%)	(f)	(%)	(f)	(%)
Near City Limits Entering Denver						
(1) Omaha	10	16	2	3	-	-
(2) Denver	34	57	35	60	43	73
(3) Downtown	16	27	22	37	13	22
(4) Fairview	-	-	-	-	3	5
Near Loop Entering Freeway						
(1) Omaha	9	16	3	5	-	-
(2) Denver	23	42	25	42	33	57
(3) Downtown	23	42	31	53	24	41
(4) Fairview	-	-	-	-	1	2
Five (5) Miles From CBD						
(1) Omaha	9	15	3	5	-	-
(2) Denver	19	32	20	34	26	44
(3) Downtown	31	53	36	61	32	54
(4) Fairview	-	-	-	-	1	2
One (1) Mile or Less From CBD						
(1) Omaha	14	24	7	12	-	-
(2) Denver	15	25	7	12	9	15
(3) Downtown	30	51	45	76	46	78
(4) Fairview	-	-	-	-	4	7

Table 8-3 (Continued)

Control City Names Motorists Want at Various Locations
Within an Urban Area for Different Destinations
Frequency (f) and Percentage (%)

Location of Route Guidance Sign/ Control City Names	Destination in Another City Which is Signed as Next Control City		Destination in Downtown Denver		Destination in Another City Not Signed as Next Control City	
	(f)	(%)	(f)	(%)	(f)	(%)
Near Interchange With Another Freeway Leaving Denver						
(1) Omaha	51	86	-	-	-	-
(2) Denver	6	10	-	-	10	17
(3) Downtown	2	4	-	-	9	16
(4) Fairview	-	-	-	-	38	67
Near Loop Exiting Denver						
(1) Omaha	55	93	-	-	-	-
(2) Denver	1	2	-	-	9	15
(3) Downtown	3	5	-	-	3	5
(4) Fairview	-	-	-	-	47	80

Table 8-4

Control City Names Motorists Expect at Various Locations
Within an Urban Area for Different Destinations
Summary of Results

Location of Route Guidance Sign	Control City Names		
	Destination in Another City - Omaha, Nebraska	Destination in Downtown Denver	Destination in Another City - Which is Not Signed For
Near City Limits Entering Denver	Denver	Denver	Denver
Near Loop - Entering Freeway	Denver/Downtown	Denver/Downtown	Denver
Five (5) Miles From CBD	Downtown	Downtown	Downtown/Denver
One (1) Mile or Less From CBD	Downtown	Downtown	Downtown
Near Interchange With Another Freeway - Leaving Denver	Omaha	--------	--------
Near Loop - Exiting Denver	Omaha	-------	Fairview

Table 8-5

Control City Names Motorists Want at Various Locations
Within an Urban Area for Different Destinations
Summary of Results

Location of Route Guidance Sign	Control City Names		
	Destination in Another City - Omaha, Nebraska	Destination in Downtown Denver	Destination in Another City - Which is Not Signed For
New City Limits Entering Denver	Denver	Denver	Denver
New Loop - Entering Freeway	Denver/Downtown	Downtown	Denver
Five (5) Miles From CBD	Downtown	Downtown	Downtown
One (1) Mile or Less From CBD	Downtown	Downtown	Downtown
Near Interchange With Another Freeway - Leaving Denver	Omaha	--------	Fairview
Near Loop - Exiting Denver	Omaha	-------	Fairview

indicated that very few were confused when their destination city was not presented as the control city.

The results of the motorist survey determining where the control city name should change, Table 8-6 shows that there was no significant difference in the motorist's responses for the following locations:

1. Near the loop entering the city,
2. Near the loop leaving the city, and
3. Near the city limits leaving the city.

The location with the highest frequency (26) was near the loop while entering the city. The location with the next highest frequency (24) was near the loop leaving the city. Since most motorists selected near the loop leaving the city than near the exiting city limits it would seem that most motorists would want the control city name change to take place at either (1) the loop entering the city, or (2) the loop leaving the city. These results are fairly consistent with those results obtained from the laboratory study, Tables 8-4 and 8-5. These results of the laboratory study and the motorist survey indicate that (a) the name of the city should be used as the control city until the motorists approach the loop, (b) at that location the term downtown would be presented, and (c) after the motorists have left the downtown area they will then pick up the next control city name.

Table 8-6

Location at Which the Motorists Want Destination City Names to Change Within an Urban Area (Survey Data)

Location Where Destination City Name Changes	Cities Where Survey Was Conducted			
	Laredo	Gainesville	Texarkana	Total
1. Near the Entering City Limits	4	19	12	35
2. Near the Loop Entering the City	7	10	26*	43
3. Near the Geographical Center of the City	10	12	10	32
4. Near the Loop Leaving the City	4	10	24*	38
5. Near the Exiting City Limits	6	7	17*	30
Totals	31	58	89	178
Chi-Square	4.00**	6.99**	11.29*	2.95**

Ho: $f_1 = f_2 = f_3 = f_4 = f_5$

*$p < 0.05$

** Not Significant

CHAPTER 9

STUDY AREA 8 - SUBURB CITY INFORMATION

A. Objective

The objective of this study is to determine the messages unfamiliar motorists prefer to lead them to the center of a suburb within a larger urban center. A problem exists in these suburbs which are surrounded completely by the larger urban areas, when a major freeway passes through the suburb. Motorists usually are not aware when they enter a suburb unless the city limit sign appears on the overhead sign bridge. To the unfamiliar motorist it is very difficult, if not impossible, to distinguish between when they are in the metropolitan area or in a suburb without getting off the freeway and asking. The unfamiliar motorist has no way of knowing whether or not a particular street will take them to the central business district of a particular suburb. This study was designed to determine the terminology to use on route guidance signs to direct unfamiliar motorists to the business district of a suburb.

B. Research Methodology

The study was conducted as a part of the second study in Area 7 - Destination City Information. In two of the four trips the subjects were making through Denver, their destination was either in a suburb or they must pass through a suburb to get to their destination. On the first trip the subjects were going to the Post Office in the business district of Sherwood, an island suburb of Denver. They were told they could get to the Post Office by either using Interstate 50 or an arterial street leading to the business district. As the subjects were approaching their destination, they were shown a slide indicating that they had just passed the city limits of Sherwood. Immediately following the city limits sign, the subjects were presented a slide with a four panel sign bridge. Two of the four signs gave the subjects directions which could lead them to the business district of Sherwood. The subjects were shown four sign structures (trials) and they were to indicate the sign they would use to get to the business district. The test messages by trial number are presented in Table 9-1. Each of the four trials were designed in such a manner that the subjects were evaluating different ways of presenting suburb information on the same sign bridge structure. In this situation the subjects were to evaluate the following types of messages to direct them to the center of the suburb:

1. Arterial street (Marion Avenue, Linsay St.)
2. Destination City on another freeway which passes through the suburb (Limon, Kansas City)

The subjects were to respond by pushing the button corresponding to the sign panel they would use to get to the business district of Sherwood.

On the second trip the subjects destination was another city, however, after they had passed the business district of Denver they decided it was too late to continue, so they were going to a motel in the downtown area of Denver. After they had continued on the loop for a while they entered the city limits of Sherwood, an island suburb of Denver. A city limits sign was presented to let them know they were now in Sherwood. As they approached the interchange with the freeway going to the downtown section of Denver they were shown a slide containing four sign panels. They were to respond by indicating the number of the panel they would use to get to their destination. One of the four test panels contained the test message being evaluated. As in the first situation the subjects evaluated four different

Table 9-1

Messages Directing Motorists to the Downtown Area of Island Suburb by Number of Trial For Trip #1

Trial Number	Message #1	Message #2
1	I-50 East Limon 3/4 ↓ Mile	Marion Ave. ↗
2	Linsay St. 1/4 Mile ↓	I-50 Downtown Kansas City ↗
3	I-50 East Limon 3/4 ↓ Mile	Marion Ave. ↗
4	Linsay St. 1/4 Mile ↓	I-50 Denver Kansas City ↗

messages in four trials at the same location. The test messages used for the trip are presented in Table 9-2. In this particular situation the use of the term Downtown and the name of the city were evaluated with regards to directing the motorists to the center of the metropolitan area when they are presently in a suburb. Again the subjects were to respond by indicating the sign they would use to get to the downtown area of Denver and their motel.

C. Results

The results of this study are presented in Table 9-3. These results indicate that there was no significant difference between the control city messages and the major arterial street messages. This would indicate that motorists can relate to either type of message when going to a specific destination in a suburb city. In this particular study there was no named street going to their destination. We told them that there was a street going to the downtown section of Sherwood and the name of the street was either Marion Avenue or Linsay Street. With regards to arterial street messages, the message Linsay Street 1/4 Mile had a significantly higher number of responses (80) than the message Marion Avenue exit to the right (47). The message giving advanced warning information had a significantly higher response frequency (143) than the exit direction or gore messages (94). The location of the test sign in relation to the destination the subjects were going to may have biased the subjects in responding more to advanced warning signs than to exit direction signs. The location of the test sign in the slide indicates that the subjects could have continued a little further down the loop before exiting.

The message I-50, Downtown - Kansas City, ↗ , in trip number 2 had the

Table 9-2

Messages Directing Motorists to the Downtown Area of Denver by Number of Trials For Trip #2

Trial Number	Test Message
1	I-50 Downtown Kansas City ↗
2	I-50 West Denver 1/2 ↓ Mile
3	I-50 Denver Kansas City ↗
4	I-50 West Downtown 1/2 Mile ↓

Table 9-3

Subjects Preference With Regard to Information Presented in Suburb Within a Metropolitan Area By Trip Number and Chi-Square Significance

Trip #	Category Tested	Messages	Frequency	Chi-Square Significance
1	Individual Messages	I-50 East, Limon, 3/4 ↓ Mile. I-50, Kansas City ↗. Marion Ave ↗. Linsay St., 1/4 Mile, ↗.	63 47 47 80	Ho: $f_1=f_2=f_3=f_4$ $\chi^2 = 13.04$ $\alpha = 0.005$
	Control City Messages	I-50 East, Limon, 3/4 ↓ Mile. I-50, Downtown-Kansas City, ↗.	63 47	Ho: $f_1=f_2$ $\chi^2 = 2.65$ n.s.
	Arterial Street Messages	Marion Ave., ↗. Linsay St., 1/4 Mile, ↗.	47 80	Ho: $f_1=f_2$ $\chi^2 = 8.57$ $\alpha = 0.005$
	Control City Versus Arterial Street Messages	I-50 East, Limon, 3/4 ↓ Mile; & I-50 - Kansas City, ↗. Marion Ave., ↗; and Linsay St., 1/4 Mile, ↗.	110 127	Ho: $f_1=f_2$ $\chi^2 = 1.37$ n.s.
	Advanced Warning Versus Immediate Exit Messages	I-50 East, Limon, 3/4 ↓ Mile, & Linsay St., 1/4 Mile, ↗. I-50, - Kansas City, ↗; and Marion Ave., ↗.	143 94	Ho: $f_1=f_2$ $\chi^2 = 10.59$ α 0.005

Table 9-3

Subjects Preference With Regard to Information Presented in Suburb Within a Metropolitan Area By Trip Number and Chi-Square Significance (Continued)

Trip #	Category	Messages	Frequency	Chi-Square Significance
2	Individual Messages	I-50, Downtown-Kansas City, ↗ . I-50, Denver-Kansas City, ↗ . I-50 West, Downtown, 1/2 Mile, . I-50 West, Denver, 1/2 ↓ Mile.	40 58 81 78	$Ho: f_1=f_2=f_3=f_4$ $\chi^2 = 17.07$ $\alpha = 0.005$
	Downtown Versus Denver Messages	I-50, Downtown-Kansas City, ↗ ; & I-50 West, Downtown, 1/2 Mile, ↓ . I-50, Denver-Kansas City ↗ ; & I-50 West, Denver, 1/2 ↓ Mile.	121 136	$Ho: f_1=f_2$ $\chi^2 = 0.88$ n.s.
	Immediate Exit Message	I-50, Downtown-Kansas City, ↗ . I-50, Denver-Kansas City, ↗ .	40 58	$Ho: f_1=f_2$ $\chi^2 = 3.31$ n.s.
	Advanced Warning Messages	I-50 West, Downtown, 1/2 Mile, ↓. I-50 West, Denver, 1/2 ↓ Mile.	81 78	$Ho: f_1=f_2$ $\chi^2 = 0.06$ n.s.
	Advanced Warning Versus Immediate Exit Messages	I-50 West, Downtown, 1/2 Mile ↓; & I-50 West, Denver, 1/2 ↓ Mile. I-50, Downtown-Kansas City, ↗ , & I-50, Denver-Kansas City ↗ .	159 98	$Ho: f_1=f_2$ $\chi^2=14.48$ $\alpha = 0.005$

worst response rate and the largest decision time than that of the other three (3) messages. This indicates that when the term Downtown is used with a familiar city name the subjects were confusing the term downtown to mean downtown Kansas City and not Downtown Denver. The term downtown in all other cases performed well. This means that the term Downtown should be used by itself or with the name of the urban center the motorists are presently in. It should not be used with a familiar city name several miles away. To determine differences between individual messages the subjects decision time was recorded along with their sign choice. The results of the decision time analysis, Table 9-4, indicate that there was not enough dispersion between the decision times for meaningful relationships to be determined. A Chi-Square test of dispersion was performed on the subjects decision times for each category in which a Chi-Square test was performed on the frequency of subjects responses for particular messages. In trip number 1 the total amount of dispersion was 1.5 seconds and for trip number 2 the dispersion was 7.63 seconds. For trip number 2 the average decision time was significant at the $\alpha \geq 0.250$ level, however, our cut-off level was the $\alpha \geq 0.050$ level.

This study should be redesigned in such a manner that a 3x3 analysis of variance can be performed on the decision time to determine whether any significant relationships exist with regard to the different types of messages. If this study was conducted in a laboratory situation by itself, the results may be different than the results obtained in this study being conducted as a part of another study.

Table 9-4

Subjects Average Decision Time With Respect to Various Messages By Trip Number and Chi-Square Significance

Trip #	Category Tested	Messages	Total Decision Time (sec)	Frequency*	Average Decision Time (sec)	Chi-Square Significance
1	Individual Messages	I-50 East, Limon, 3/4 ↓ Mile. I-50, Downtown/Denver-Kansas City, ↗. Marion Ave., ↗. Linsay St., 1/4 Mile, ↗.	703.6 640.8 524.3 958.8	58 47 42 73	12.13 13.63 12.48 13.13	$Ho:ADT_1=ADT_2=ADT_3=ADT_4$ $\chi^2 = 0.11$ n.s.
	Control City Messages	I-50 East, Limon, 3/4 ↓ Mile. I-50, Downtown/Denver-Kansas City, ↗.	703.6 640.8	58 47	12.13 13.63	$Ho:ADT_1=ADT_2$ $\chi^2 = 0.09$ n.s.
	Arterial Street Messages	Marion Ave., ↗. Linsay St., 1/4 Mile, ↗.	524.3 958.8	42 73	12.48 13.13	$Ho:ADT_1=ADT_2$ $\chi^2 = 0.02$ n.s.
	Control City Messages Versus Arterial Street Messages	I-50 East, Limon, 3/4 ↓ Mile, & I-50, Downtown/Denver-Kansas City, ↗. Marion Ave.,↗: and Linsay St., 1/4 Mile, ↗	1344.4 1483.1	105 115	12.80 12.90	$Ho:ADT_1=ADT_2$ $\chi^2 = 0.00$ n.s.
	Advanced Warning Versus Exit Direction Messages	I-50 East, Limon, 3/4 ↓ Mile; & Linsay St., 1/4 Mile, ↗. I-50, Downtown/Denver-Kansas City, ↗. and Marion Ave., ↗.	1662.4 1165.1	131 89	12.69 13.09	$Ho:ADT_1=ADT_2$ $\chi^2 = 0.01$ n.s.

CHAPTER 10

STUDY AREA 9 - RIGHT-HAND INTERCHANGES EXITING SYSTEMS

A. Objectives

Presently there are numerous situations where right-hand exits diverge from the freeway within a relatively short distance, say 1/4 of a mile or less. This poses an operational as well as safety problem for motorists using these types of exits. Signing is the only means of increasing operations and safety near these exit locations. The spatial limitations near these exits pose a severe problem with respect to signing in an efficient manner. The level of information on each sign should be kept at an acceptable level that motorists have sufficient time to receive and interpret the information and maneuver into the lane safely for their exit.

The objective of this study is to determine the number of signs and the level of information required by the motorists to safely execute the maneuver based on the spatial limitation imposed upon them by the particular design. Two geometric designs were investigated thoroughly in this study. The first design involves an exit only lane in which the motorist must exit at one of the two locations and the second involves an optional exit lane (forgiving design) where the motorist may return to the through lanes of the freeway if they made a mistake and do not want to exit the freeway. This study involved all the signs relating to the exit from the first advanced guide sign to the last exit direction sign for the second exit ramp.

B. Research Methodology

The laboratory study consisted of a 16 mm film and a set of 35 mm color slides. The 16 mm film consisted of a vehicle driving along a freeway for a two mile distance before exiting at the second exit ramp. Along the freeway, sign bridges were located at the exact location the test signs would be studied. As the vehicle approached a sign bridge, the signs on the bridge were blacked out for a total period of six (6) seconds. In that time period the test sign (35 mm slide) was projected and the subjects were required to do two things. On the first time through the test section, the subjects selected the sign they thought most appropriate for the test situation at that location. The second time through they were to evaluate, on a scale from one (1) to five (5), the sign at that particular location. An evaluation of one (1) meant the sign was poor and a five (5) meant the sign was very good. Before each test run, the subjects were told the particular geometric design in which they were either selecting the signs for or the signs they were evaluating. Figure 10-1 depicts the exit only situation in which they must leave the freeway once they entered the exiting ramp. The solid black line simulates a solid white line edge marking or median barrier which prevents the motorist from re-entering the freeway once they have committed themselves to exit the freeway. Figure 10-2 depicts the optional exit lane where the motorists may continue along the freeway if they decide later they had made a mistake and did not want to exit the freeway at either location.

In situation 1, Figure 10-1, the locations marked A through E are the locations at which different signing alternatives were being investigated. In

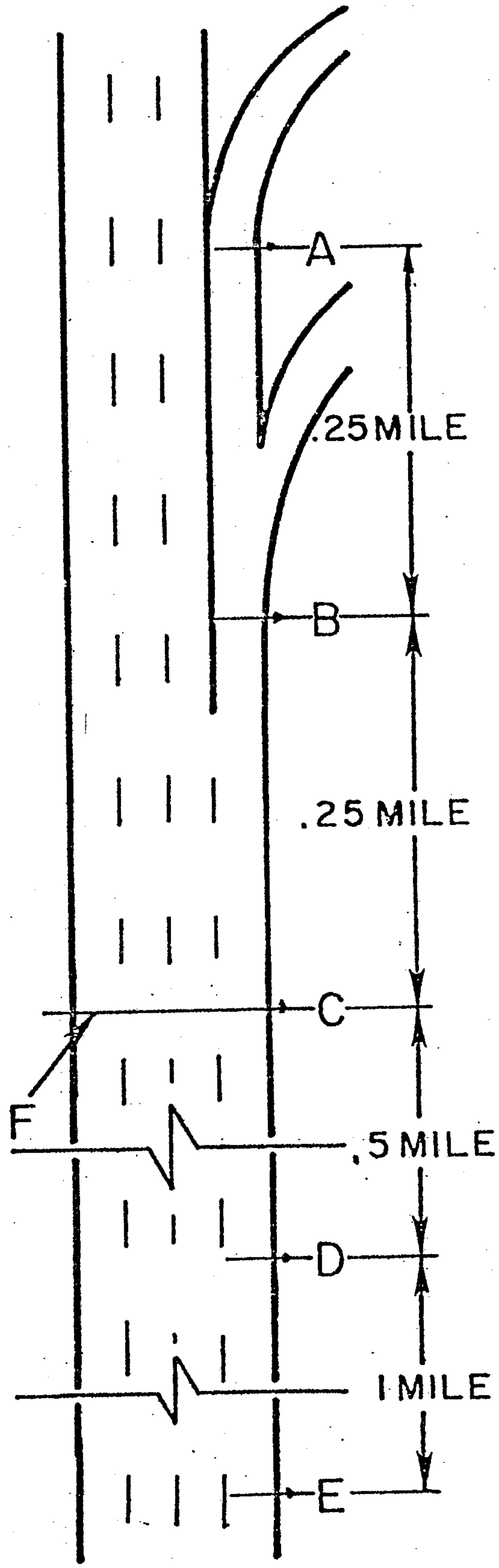


Figure 10-1 - Situation 1 - Exit Only Lane

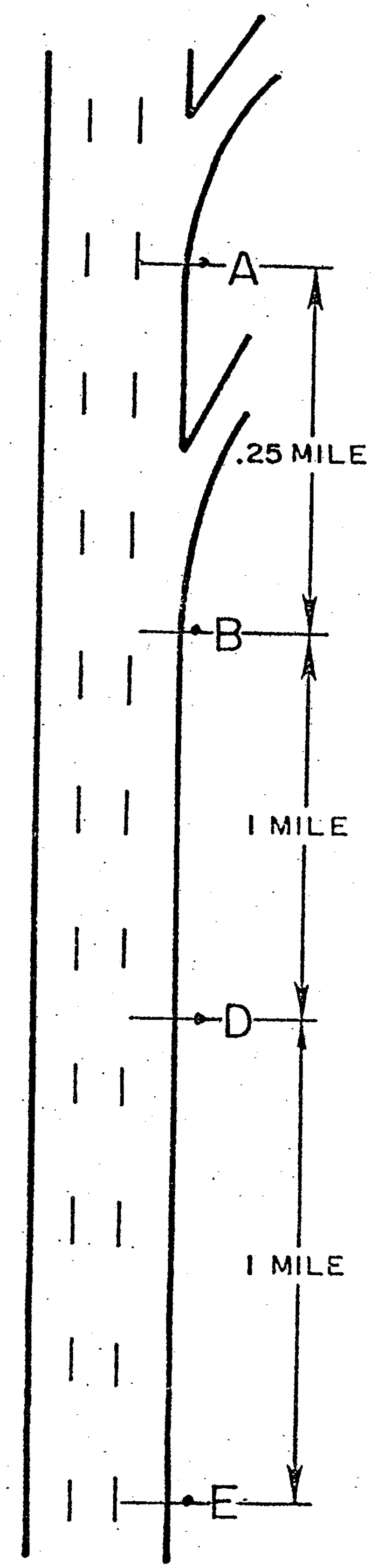


Figure 10-2 - Situation 2 - Optional Exit Lane situation 2, Figure 10-2, alternative signs were investigated at locations A, B, D, and E. Figure 10-3 presents the alternative sign designs for situation 1 starting from location E and progressing through the exit direction sign at the terminal exit ramp. Figure 10-4 presents the alternative signs for situation 2 starting from location E through the terminal exit ramp at location A. Due to the similarity of the test signs at location E and D in situation 2, the subjects selected and evaluated the signs at location E and the evaluation statistics obtained for location E was also used for location D.

The first time through each situation the film was stopped at each location and each alternative sign design was presented to the subjects. After they had seen all of the designs at that location they chose the design they preferred at that location. This procedure was repeated until all of the alternative designs for both situations were presented to the subjects. The second time through the subjects evaluated, on a scale from one (1) to five (5) the particular sign design at each location. The system being evaluated for each test situation was selected based on those sign designs the subjects selected the day before. It is for this reason that sign designs C-2 and C-3 in situation 1 were never evaluated. These two sign designs were never selected by the majority of the subjects on any particular day.

C. Results

Tables 10-1 and 10-2 present the results of this study for situation 1 and situation 2. At location E for situation 1, signs E-1 and E-3 were selected

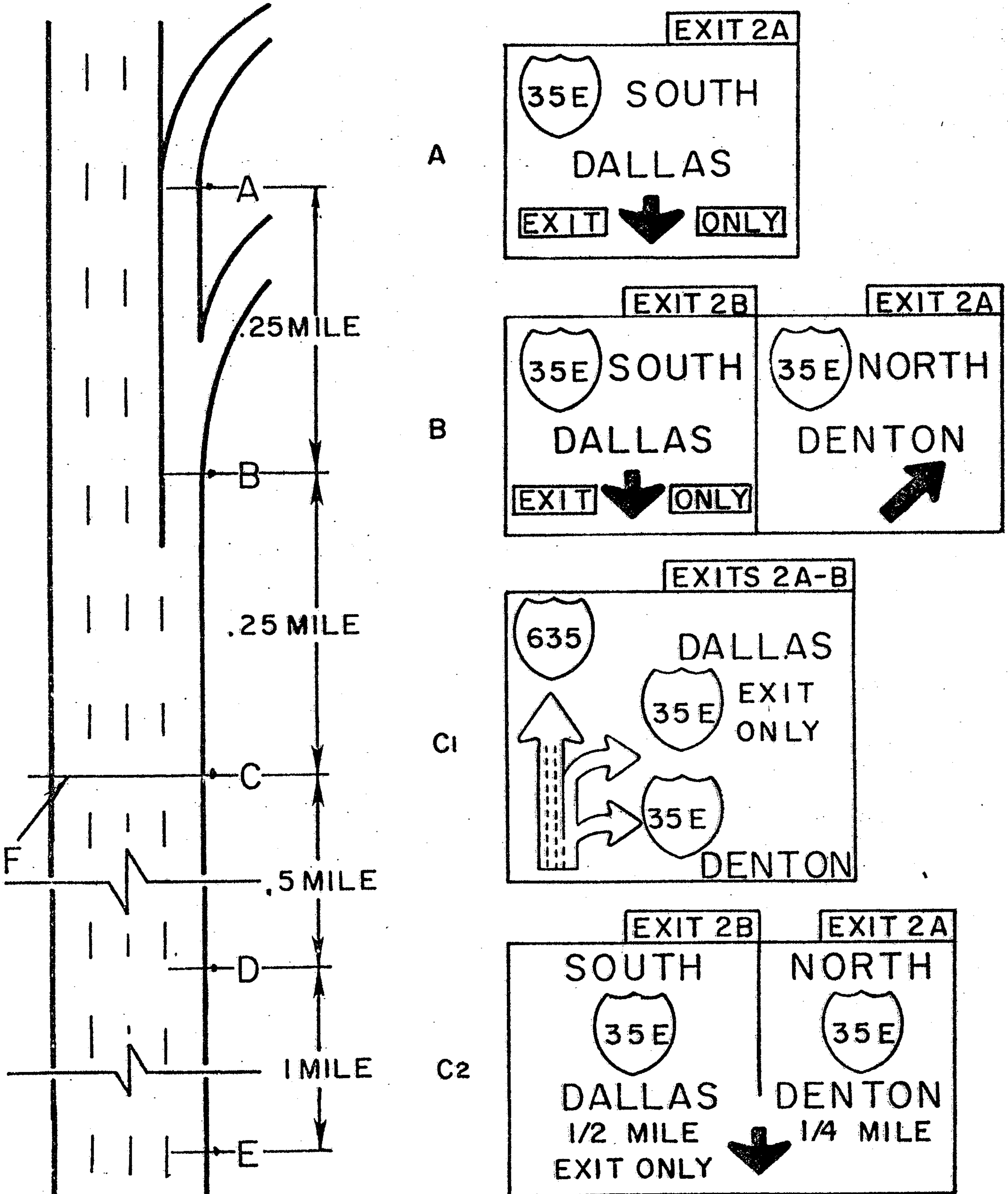


Figure 10-3 - Situation 1 - Diagrammatic of Test Situation and Test Panels at Each Location.

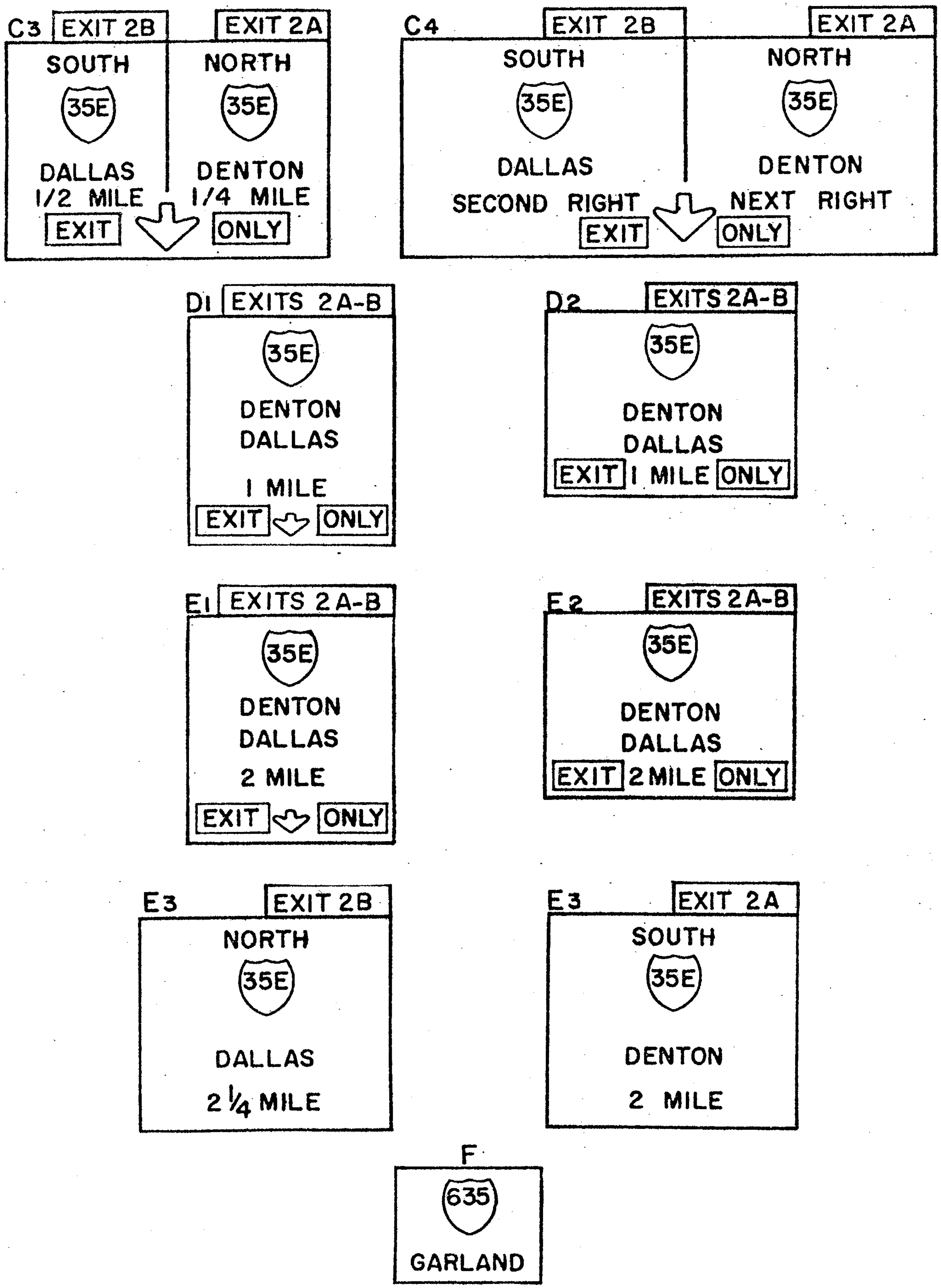


Figure 10-3 - Situation 1 - Test Panels at Locations C, D and E (Continued).

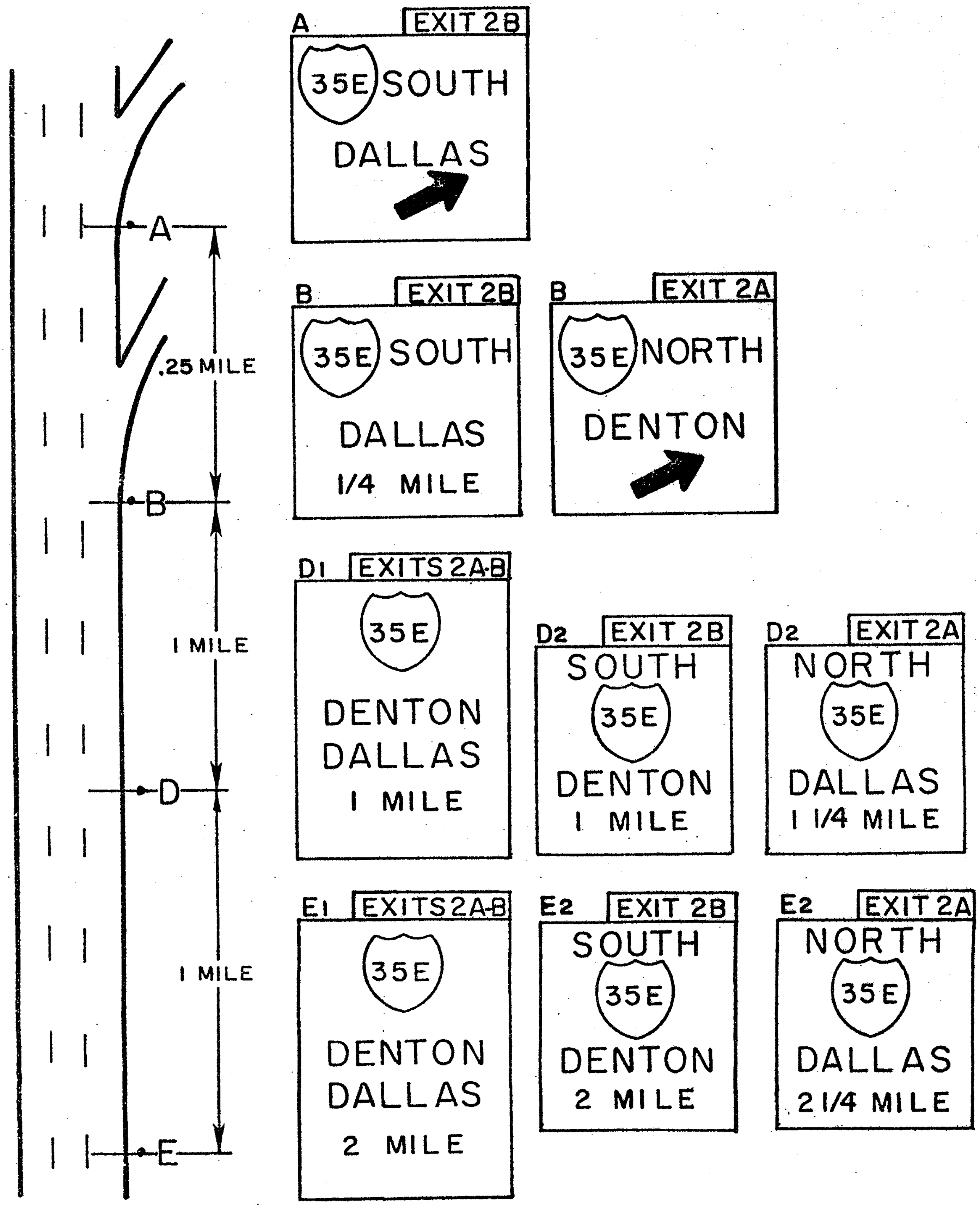


Figure 10-4 - Situation 2 - Diagrammatic of Test Situation and Test Panels at Each Location.

Table 10-1

Results of the Closely Spaced Right-Hand Exit - Exit Only Situation - Subjects Preference and Rating

Alternative Sign Designs	Subject Preference (f)	Subject Sign Rating ($\bar{x}$)
A-1	n.a.	4.30
B-1	n.a.	4.03
C-1	27	4.00
C-2	6	n.a.
C-3	10	n.a.
C-4	28	3.81
D-1	39	4.28
D-2	32	3.79
E-1	27	4.02
E-2	14	3.54
E-3	30	3.00

n.a. - not applicable

Table 10-2

Results of the Closely Spaced Right-Hand Exit - Optional Exit Lane Situation - Subject Preference and Rating

Alternative Sign Designs	Subject Preference (f)	Subject Sign Rating ($\bar{X}$)
A-1	n.a.	4.68
B-1	n.a.	4.09
D-1	30	3.95
D-2	42	3.75
E-1	30	3.95
E-2	42	3.75

n.a. - not applicable

by 80% of the subjects participating in the study. Sign E-1 was selected by 38% of the subjects and sign E-3 was selected by 42% of the subjects. At location D, 55% of the subjects selected sign D-1 and 45% of the subjects selected sign D-2. At location C, 77% of the subjects selected either sign C-1 (38%) or C-4 (39%). Sign C-2 was selected by 9% of the subjects and sign C-3 was selected by 14% of the subjects. A total of 71 subjects participated in this study.

At location E and D, situation 2, the signs were identical, therefore, to conserve on time for this study, the signs at location E were evaluated. It is felt that the responses obtained from the subjects would be the same at these two locations since the signs were so similar. A total of 72 subjects responded to the sign. One subject came to the study late and responded only to situation 2. Sign E-1 was selected by 42% of the subjects and sign E-2 was selected by 58% of the subjects.

In the second part of this laboratory study the subjects evaluated each sign as a part of a total signing system. As the subjects traveled along the route, at each sign location they were presented with a particular sign to be evaluated. The subjects were to evaluate each sign ranging from poor to very good. Button A (position 1) was for a poor sign and button F (position 5) was for a very good sign. On any particular day the signing system the subjects evaluated were selected from those signs the majority of the subjects selected the previous day. To determine the exact numerical evaluation statistic, each different response possibility was given a number from 1 (poor) to 5 (very good), with 3 being fair. Table 10-1, presents the numerical evaluation statistics for each sign panel evaluated at each location for situation 1. Any evaluation statistic between 4.0 and 5.0 is very good, between 3.0 and 4.0 is fair, between 2.0 and 3.0 is marginal, and between

1.0 and 2.0 is poor. Sign E-1 received an evalution statistic of 4.02, sign E-2 received 3.54 and E-3 received 3.00. At location D, sign D-1 was evaluated at 4.28 and D-2 was evaluated at 3.79. At location C, C-1 was 4.00 and C-4 was 3.81. These evaluation statistics are averages of the evaluation statistics from each of the subjects evaluating each sign. The sign at location B was evaluated as 4.03 and location A was 4.30.

Table 10-2, presents the evaluation statistics for each sign panel for situation 2. At location E, E-1 had an evaluation statistic of 3.95 and E-2 was evaluated at 3.75. Due to lack of time, both signs at location D were not evaluated. For evaluation purposes sign D-1 was used and received an evaluation statistic of 4.00 which, as we suspected, was not significantly different from the evaluation statistic of E-1 which was 3.95. The evaluation statistic at location B was 4.09 and at location A 4.68. In both situations being studied, no sign was evaluated lower than 3.00 which means that the subjects found these signs to be fair or very good.

Tables 10-3 and 10-4, presents the total evaluation statistic for all possible combinations of alternative signs for both situations. Sign A-1 and B-1 were not compared with any other signs at these locations, therefore they are not taken into account in the evaluation statistics. Those combinations of signs with higher evaluation statistics rated higher with the subjects than those with lower values. In situation 2, Table 10-4, at location D, signs D-1 and D-2 were given the same evaluation statistics as those associated with signs E-1 and E-2.

In conclusion, it is suggested that those signing systems with total evaluation statistics higher than 4.00 would provide better than average signing for these types of exiting ramps. The recommended signing system

Table 10-3

Evaluation of All Possible Signing Systems for the Closely Spaced Right-Hand Exits - Exit Only Situation (Rank Ordered)

Alternative Sign Designs Comprising Signing System	Individual Evaluation Statistics					Total System Evaluation Statistics	Percentile Level
	A	B	C	D	E		
A-1, B-1, C-1, D-1, E-1	4.30	4.03	4.00	4.28	4.02	4.10	80
A-1, B-1, C-4, D-1, E-1	4.30	4.03	3.81	4.28	4.02	4.04	
A-1, B-1, C-1, D-2, E-1	4.30	4.03	4.00	3.79	4.02	3.94	75
A-1, B-1, C-4, D-2, E-1	4.30	4.03	3.81	3.79	4.02	3.87	
A-1, B-1, C-1, D-1, E-3	4.30	4.03	4.00	4.28	3.00	3.76	
A-1, B-1, C-4, D-1, E-3	4.30	4.03	3.81	4.28	3.00	3.70	70
A-1, B-1, C-1, D-2, E-3	4.30	4.03	4.00	3.79	3.00	3.60	
A-1, B-1, C-4, D-2, E-3	4.30	4.03	3.81	3.79	3.00	3.53	

Table 10-4

Evaluation of All Possible Signing Systems for the Closely Spaced Right-Hand Exits - Optional Lane Situation (Rank Ordered)

Alternative Sign Designs Comprising Signing System	Individual Evaluation Statistics				Total System Evaluation Statistics	Percentile Level
	A	B	D	E		
A-1, B-1, D-1, E-1	4.68	4.09	3.95	3.95	3.95	75
A-1, B-1, D-2, E-1	4.68	4.09	3.75	3.95	3.85	
A-1, B-1, D-1, E-2	4.68	4.09	3.95	3.75	3.85	
A-1, B-1, D-2, E-2	4.68	4.09	3.75	3.75	3.75	

to be used at locations A, B and C for the exit only situation are depicted in Figure 10-5. Locations D and E are depicted in Figure 10-6. In situation 2 all of the signing systems received a total evaluation statistic below 4.00. It is suggested that the system depicted in Figure 10-7 be used for the option lane situation prior to the use of any of the other alternate systems.

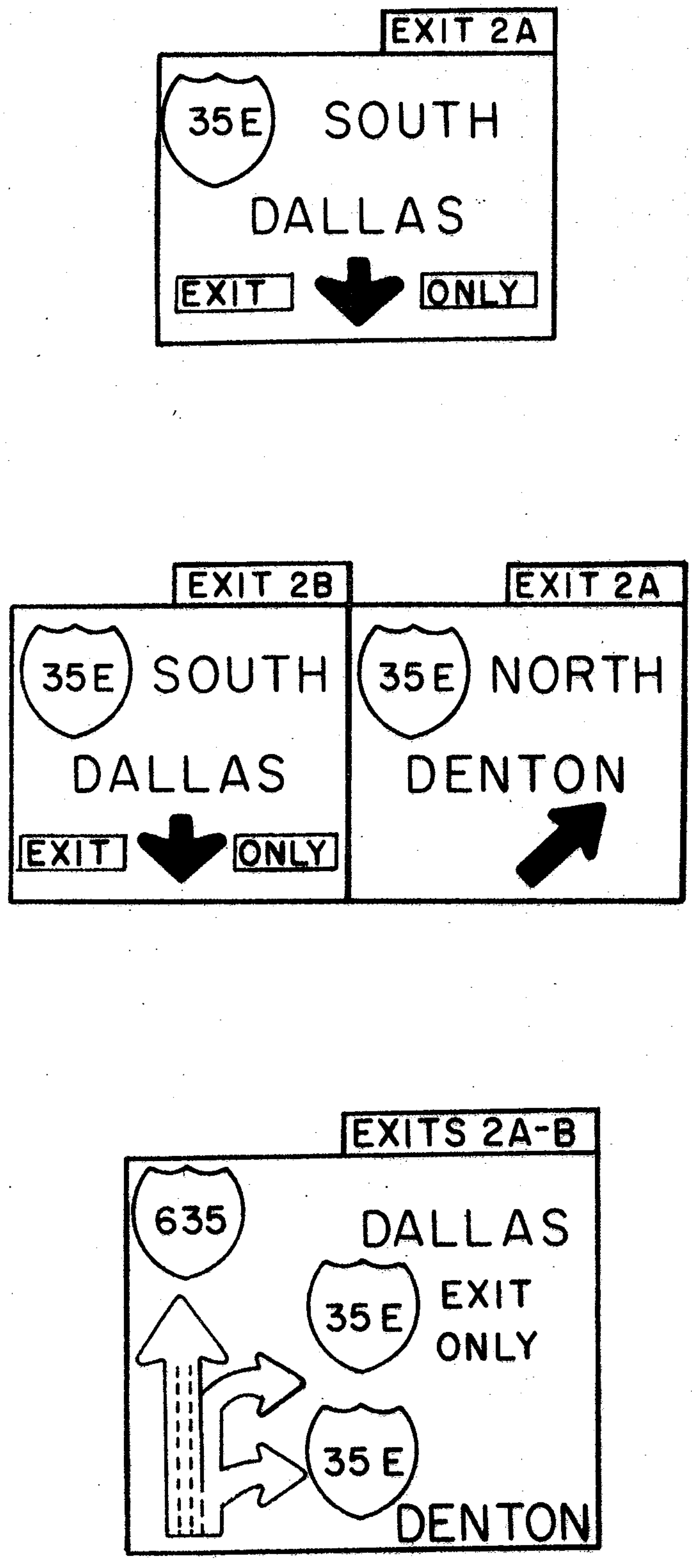
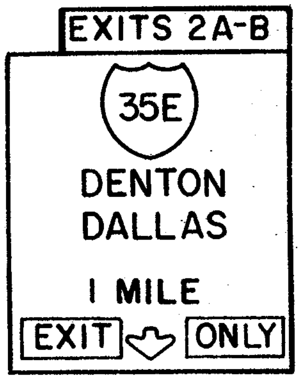


Figure 10-5 - Recommended Signing System to be used for the exit - only situation at locations A, B and C.



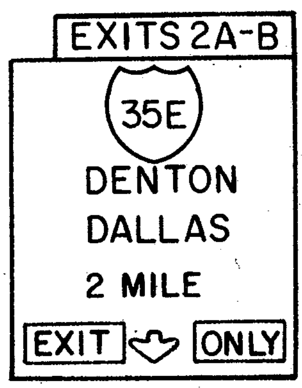


Figure 10-6 - Recommended Signing System To Be Used For The Exit - Only Situation at Location D and E.

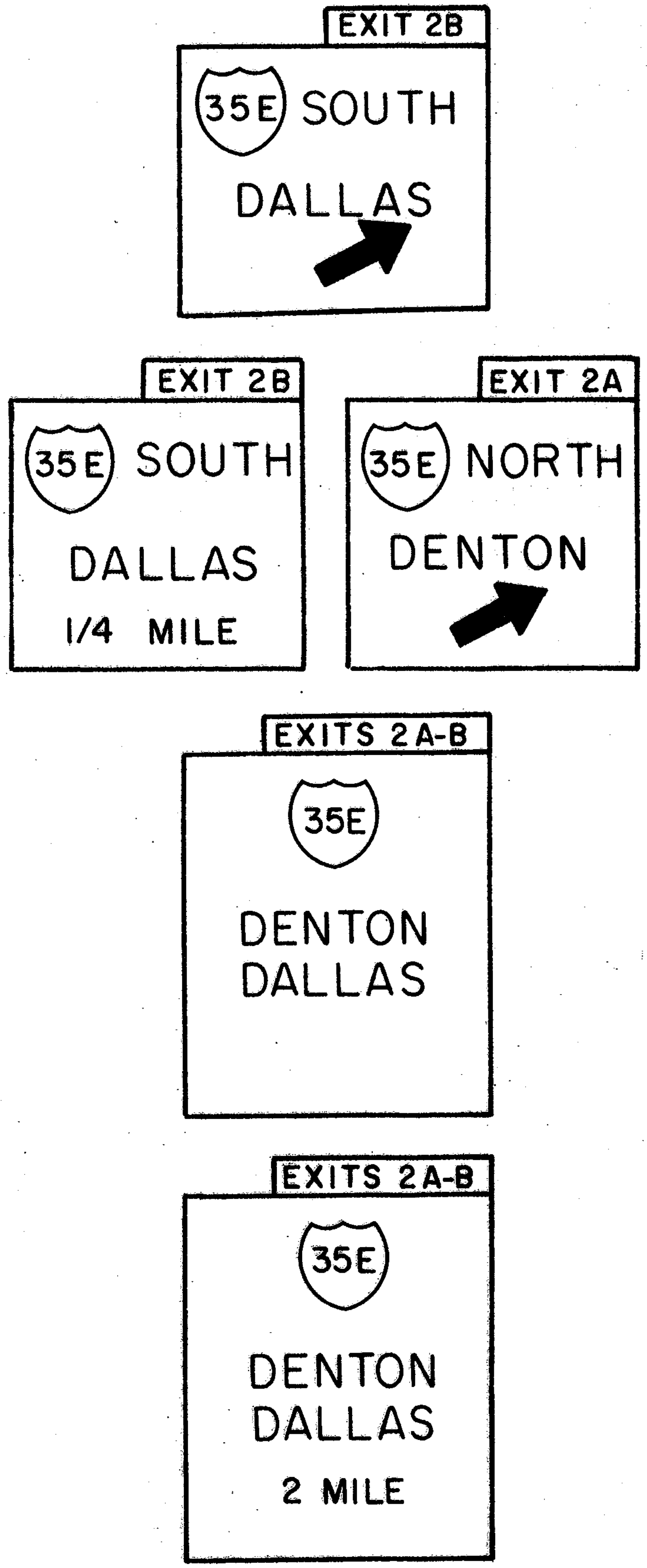


Figure 10-7 - Recommended Signing System to be Used For The Optional Lane Situation.

CHAPTER 11

STUDY AREA 10 - LEFT-HAND EXIT SIGNING STUDY

A. Objectives

The objective of this study was to develop a route guidance signing system for left hand exits diverging from an urban freeway. The signing system for left hand exits is critical from the motorists perspective, because left hand exits violate driver expectancy. At least 85 percent of all exits from urban freeways are right hand exits. The motorists do not expect left hand exits from urban freeways. When the motorists are faced with a left hand exiting situation, their perception and reaction time are increased while they are assimilating the required information and are making the correct decision on leaving the freeway.

The signing system for left hand exits should present sufficient information in as clear and concise a format as possible. This type of signing will tend to (1) enforce the drivers perspective of the approaching exit, and (2) reduce the reaction time so that the motorist may safely exit the freeway.

B. Research Methodology

In the left hand exiting signing system study, three separate situations were examined. Figure 11-1, depicts the first situation examined in this study. The exit ramp is a dual lane left hand exit from the freeway. The extreme left lane, marked (A), is an exit only lane, whereas the second left lane, marked (B), is an option lane. If the motorist is in the lane marked (A) he must exit the freeway. If he is in the lane marked (B) he may exit the freeway or continue along the freeway. Figure 11-2, depicts the second situation examined in this study. The exit ramp is a single lane left hand

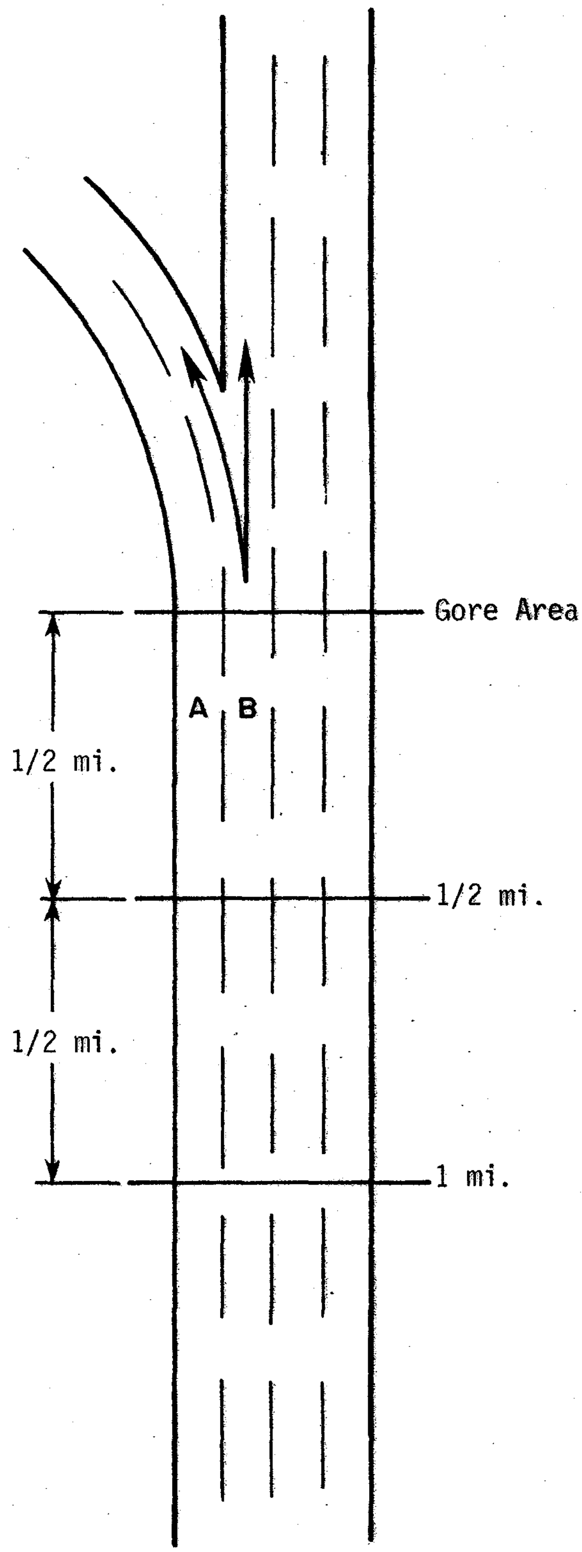


Figure 11-1. Left-Hand Two-Lane Exit Situations.

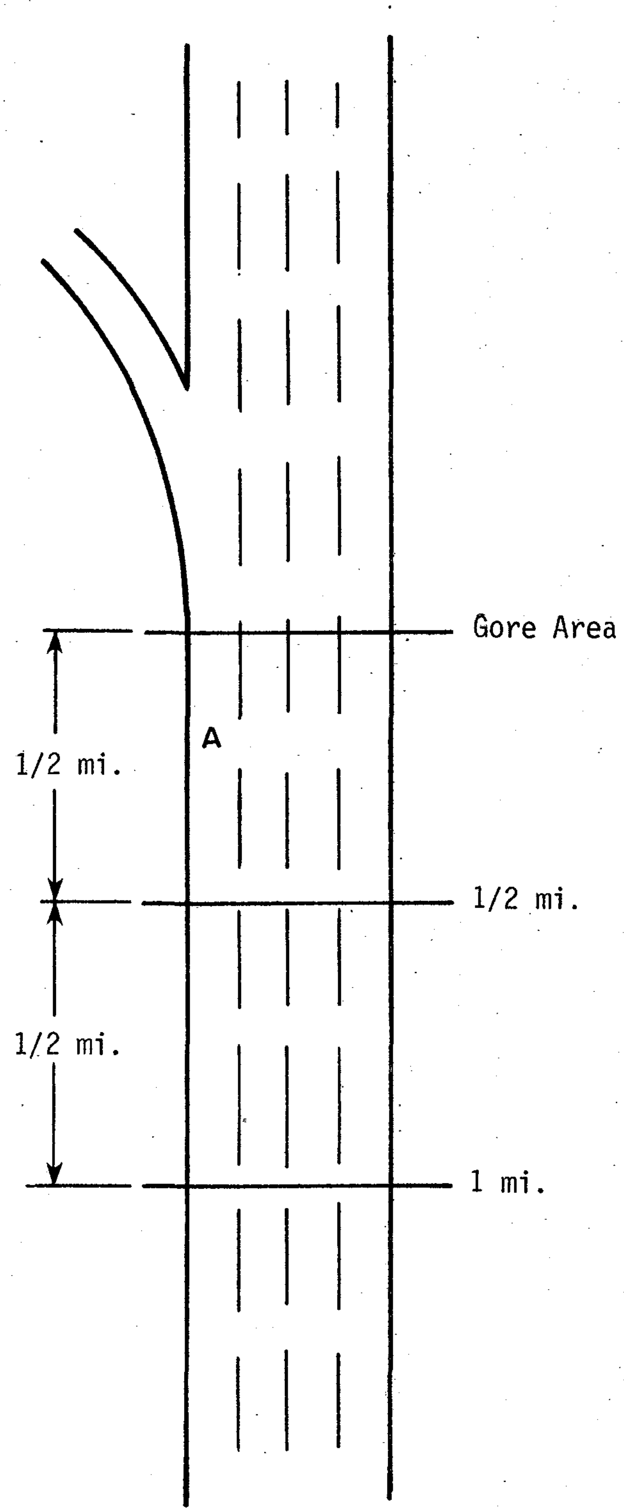


Figure 11-2. Single Lane Left-Hand Exit Situation with the Extreme Left-Lane Being an Option Lane.

exit. In this situation the extreme left lane, marked (A), is an option lane, in which the motorist may exit the freeway or continue along the freeway. Figure 11-3 depicts the last situation examined during this study. In this situation the extreme left lane, marked (A), is an exit only lane in which the motorist must leave the freeway. In all three situations the subjects were asked to select the sign they preferred at several locations as they approached the exit ramp.

In each of the three situations, the subjects were to select the sign they preferred from several alternative signs. The three locations were: (1) one-mile from the exit, (2) one-half mile from the exit, and (3) at the gore area. To add realism to the laboratory study, the subjects were shown a 16mm movie of a car travelling down a freeway and approaching a left hand exit similar to the one being examined. The subjects were told they were driving this car on a loop around Dallas, and they were going to downtown Dallas. As the sign bridge appeared at each location, where the subjects were to select the sign they would prefer, the movie was stopped. A 35-mm slide projector was started and the various alternative signs at this location was presented. The subjects would select the signs they preferred by pushing the button on their responder corresponding to the slide number which contained the sign they preferred. After a short break, the subjects would rate a system of signs for each situation. The subjects rated these signs on a scale of one (1) to five (5). A rating of one (1) indicated the sign was poor, a rating of three (3) indicated the sign was fair, and a rating of five (5) indicated the sign was excellent. The subjects were to rate the signs based on information content and format, in relation to the location of the sign on the freeway. The subjects decision time was also recorded. The decision time was used to isolate differences

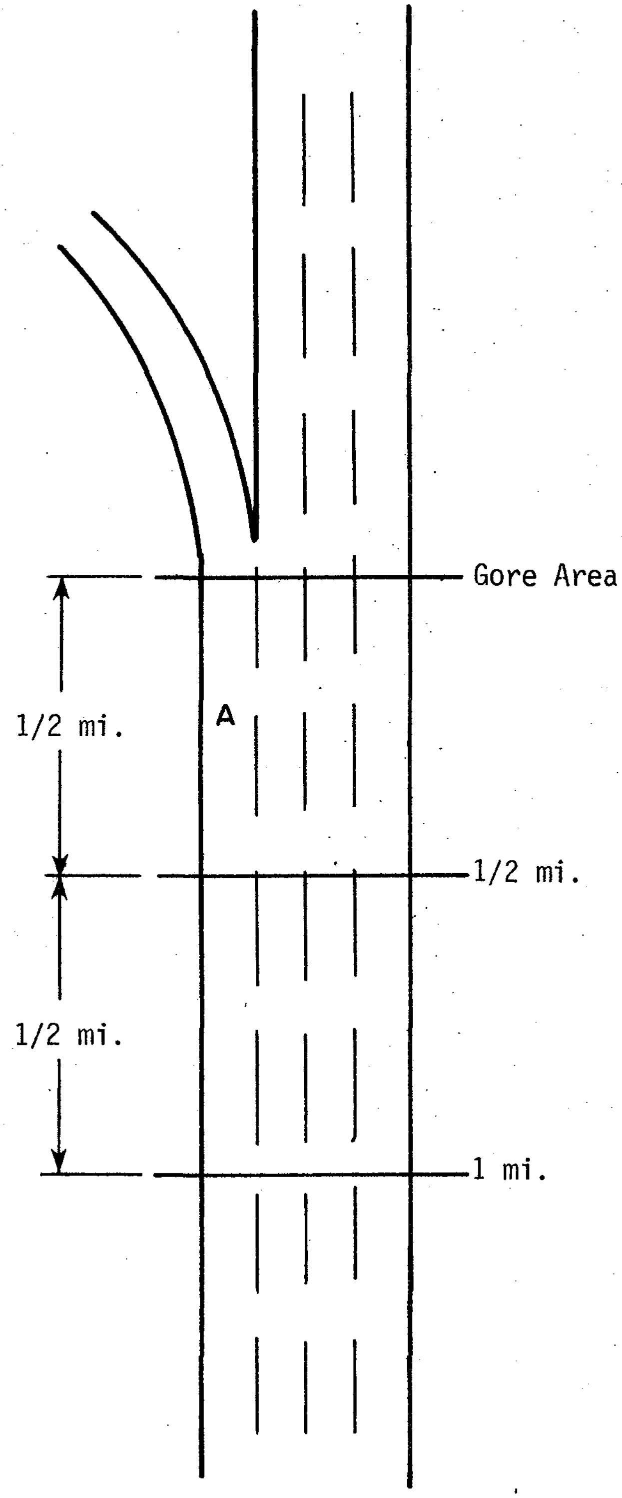


Figure 11-3. Single Lane Left-Hand Exit Situation with the Extreme Left-Lane Being an Exit Only Lane.

between sign alternatives when the subjects rating of two or more signs were virtually identical.

Figures 11-4 through 11-6 present the alternative signs used in the dual left exit situation. The signs in Figure 11-4 were presented one-mile from the exit. The signs in Figures 11-5 (a) and (b) were presented one-half of a mile away from the exit, and those signs in Figure 11-6 were presented at the gore area. Figures 11-7 through 11-9 present the various signs used in the single left exit-option lane situation. The signs in Figure 11-7 were presented one-mile from the exit, the signs in Figure 11-8 were presented one-half mile from the exit, and the signs in 11-9 were presented at the gore area. Figures 11-10 through 11-12 presented the signs used in the single left exit-exit only lane situation. Figure 11-10 presents the signs used at the one-mile location, Figure 11-11 presents the signs used at the one-half mile location, and Figure 11-12 presents the signs used at the gore area.

C. Results

Table 11-1 presents the results of the laboratory study for the dual left-lane exit situation. The subjects preference, rating of the signs being evaluated, and the average decision time it required the subjects to rate each sign. The signs being rated were based on the subjects preference of signs at each location on the previous day. For this reason, several of the signs do not have a rating or a decision time associated with it. At the one-mile location when considering the subjects preference, there was no significant difference between signs A1, A2 or A3. However, when taking into account both the rating and the decision time it appears that sign A-1 has a slight edge over both sign A2 and A3. Sign A2 received a rating of 4.13 whereas sign A-1 received a rating of 3.51. These two ratings are virtually the same, however

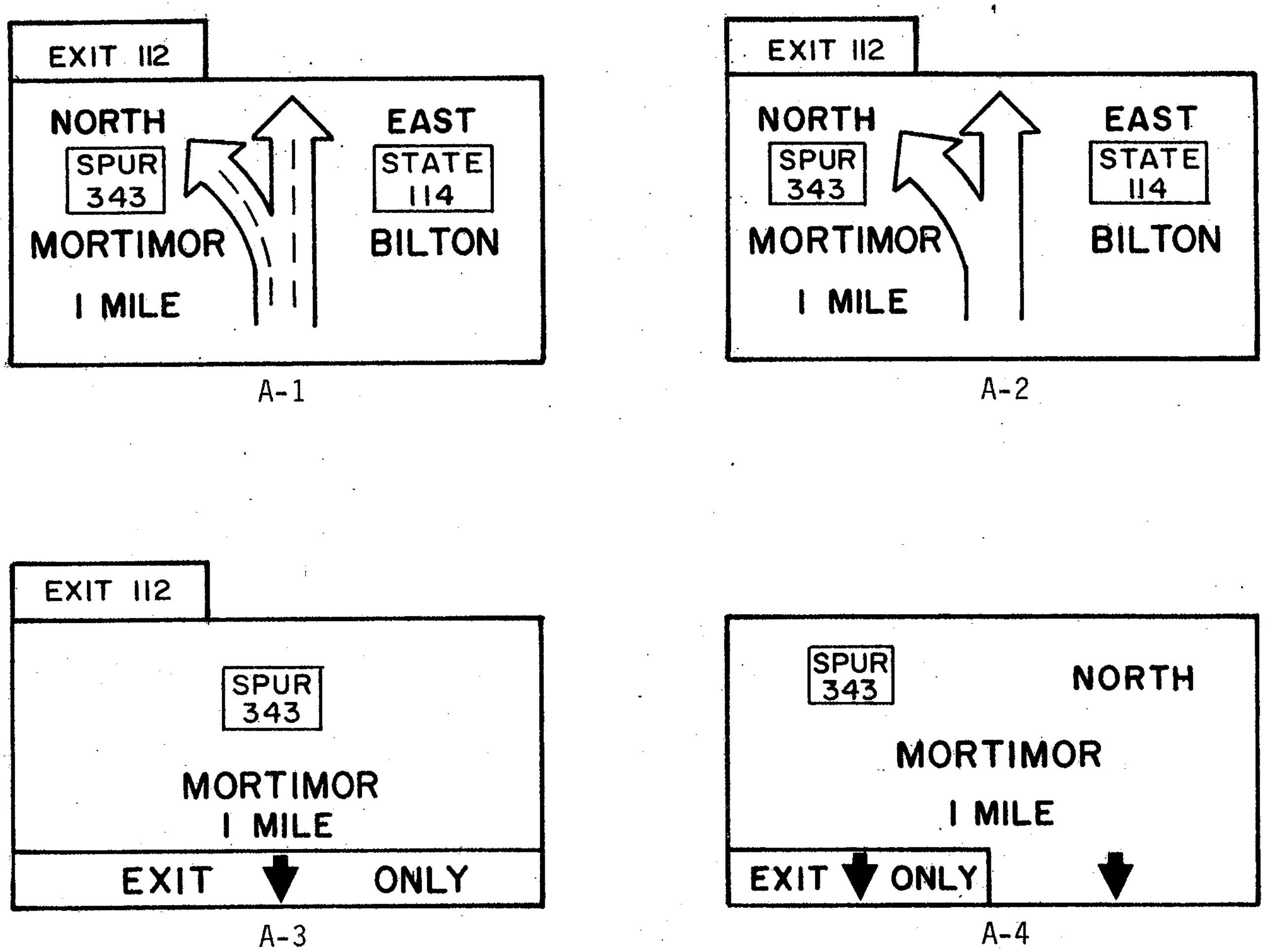
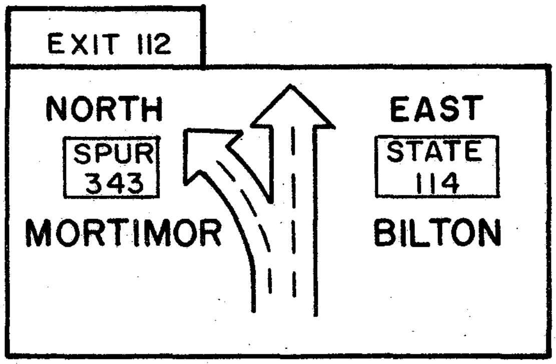
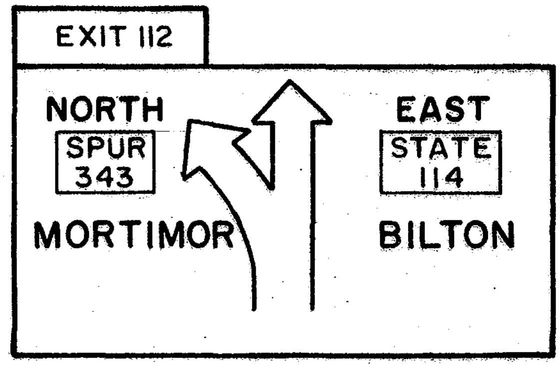


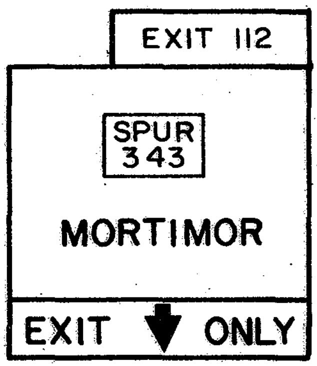
Figure 11-4. Alternative Sign Designs Used in the Dual Left-Lane Exit Situation One Mile Upstream of the Gore Point.



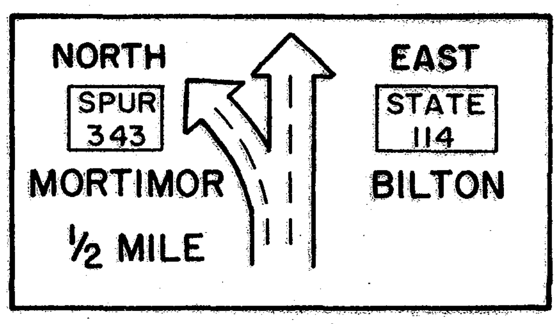
B-1



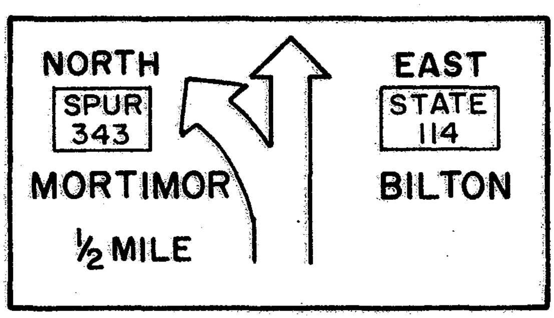
B-2



B-3

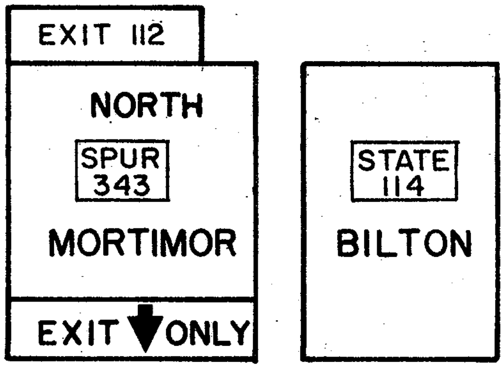


B-4

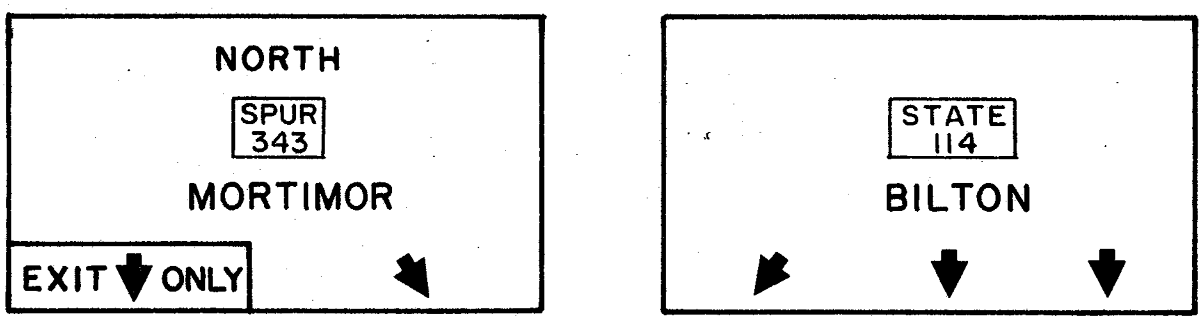


B-5

Figure 11-5 (a). Five Alternative Sign Designs Used for the Dual Left-Lane Exit Situation One-Half Mile Upstream of the Gore Point.



B-6



B-7

Figure 11-5 (b). Two Additional Alternative Sign Designs Used for the Dual Left-Lanes Exit Situation One-Half Mile Upstream from the Gore Point.

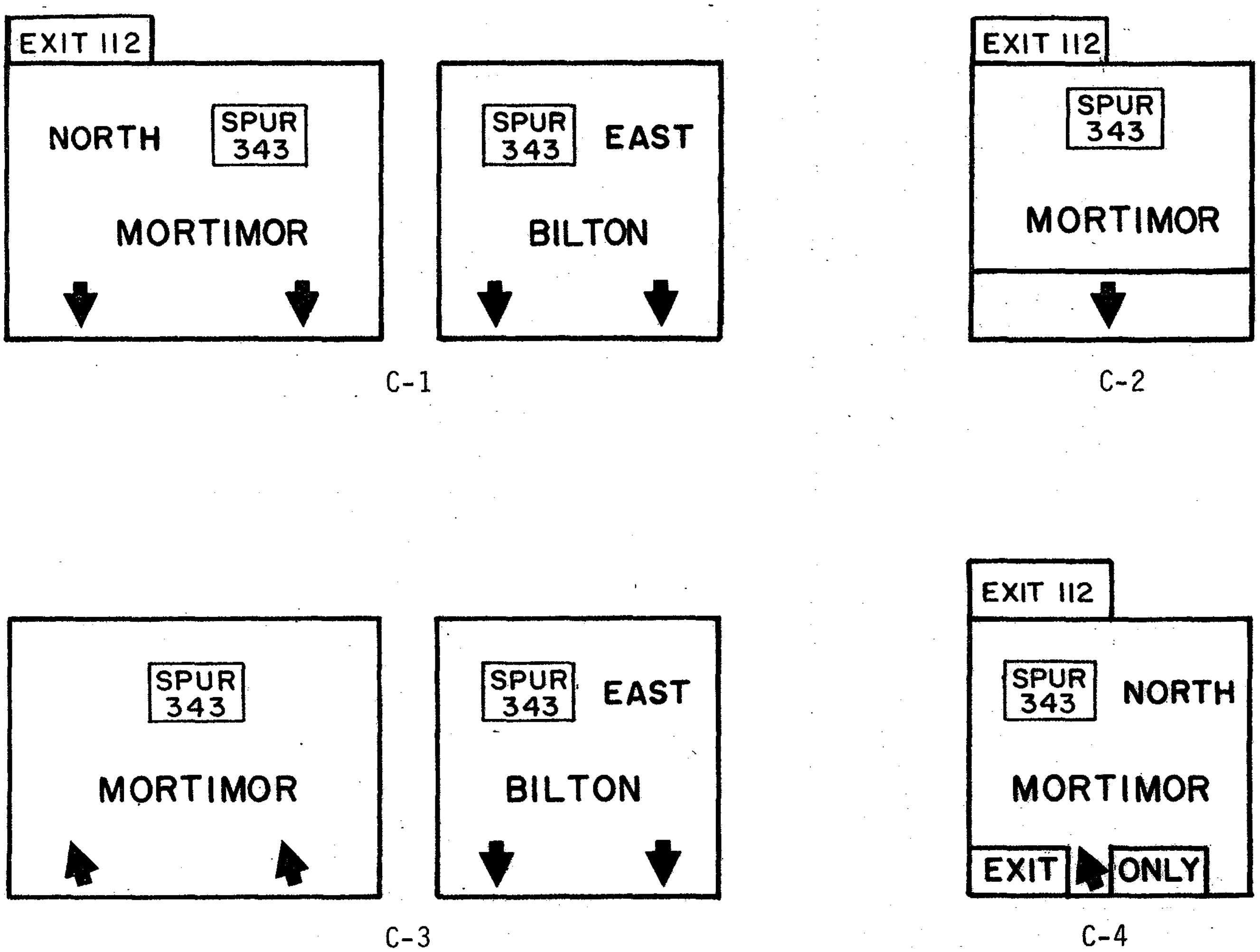
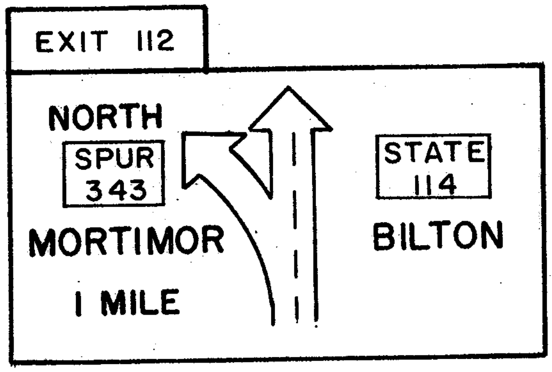
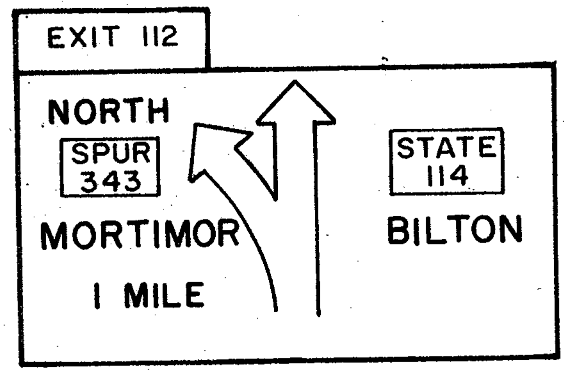


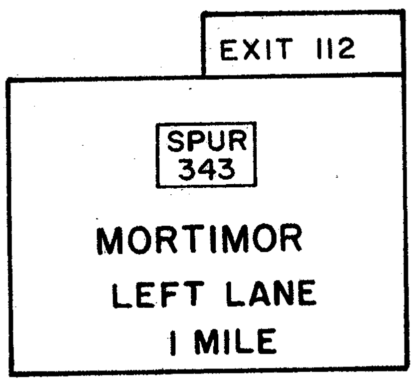
Figure 11-6. Alternative Sign Designs Used in the Dual Left-Lane Exit Situation at the Gore Point.



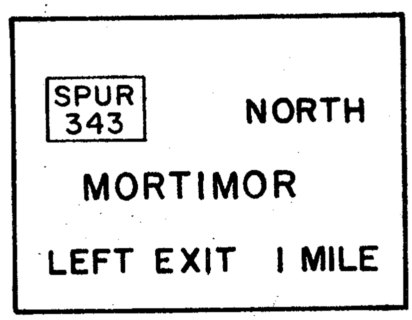
A-1



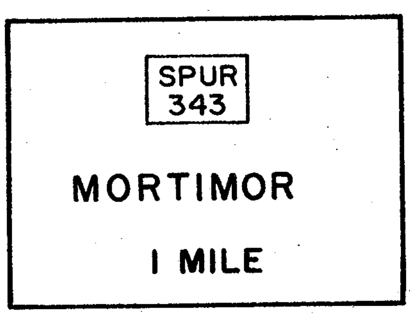
A-2



A-3

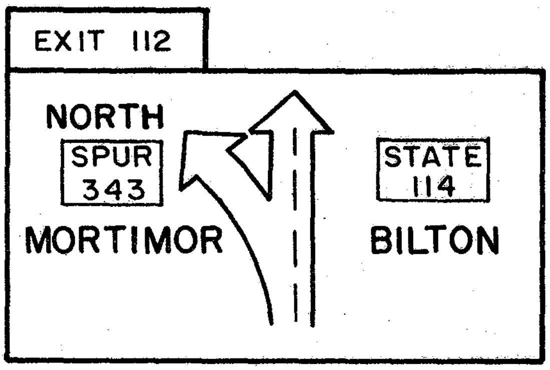


A-4

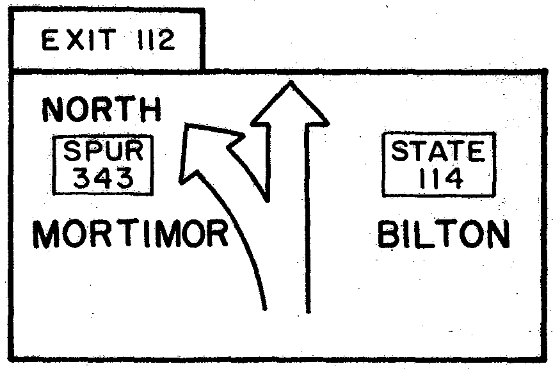


A-5

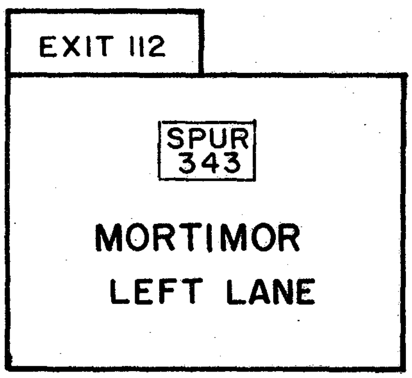
Figure 11-7. Alternative Sign Designs Used for the Single Left-Lane Exit Situation, Where the Extreme Left-Lane is an Option Lane, One-Mile Upstream from the Gore Point.



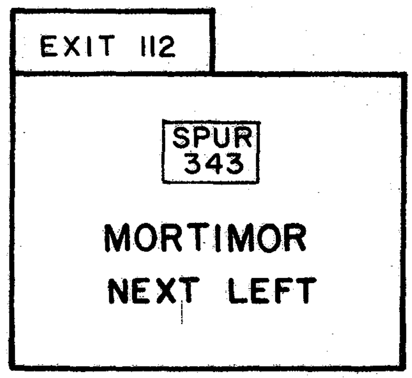
B-1



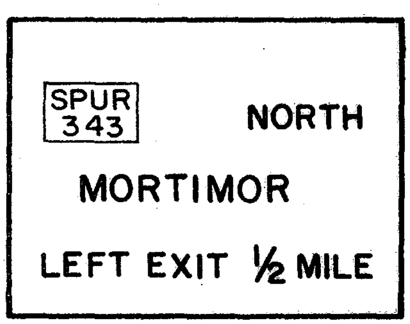
B-2



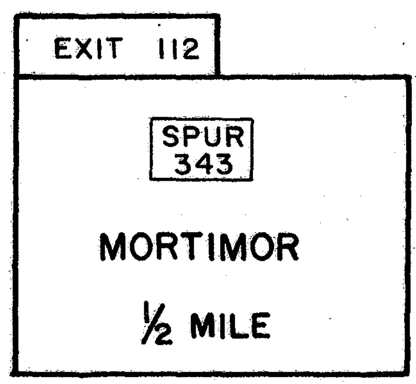
B-3



B-4

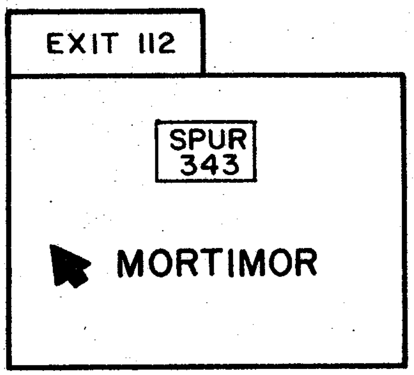


B-5

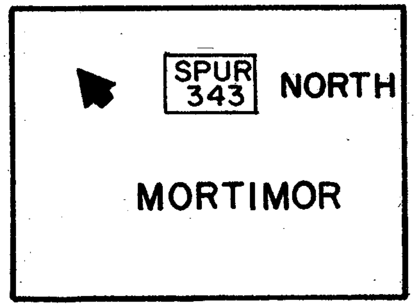


B-6

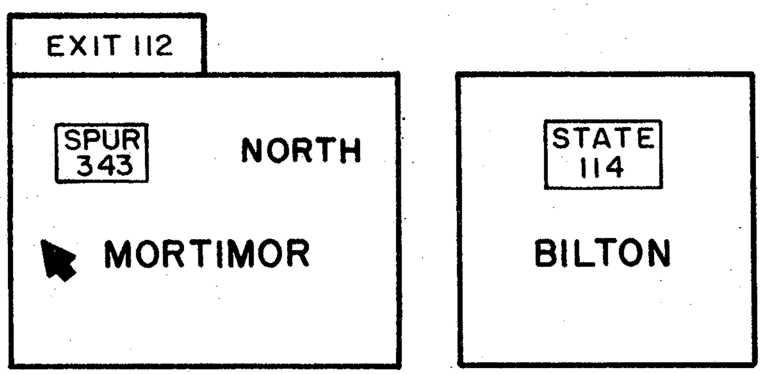
Figure 11-8. Alternative Sign Designs Used for the Single Left-Lane Exit Situations, Where the Extreme Left-Lane is an Option Lane, One-Half Mile from the Gore Point.



C-1

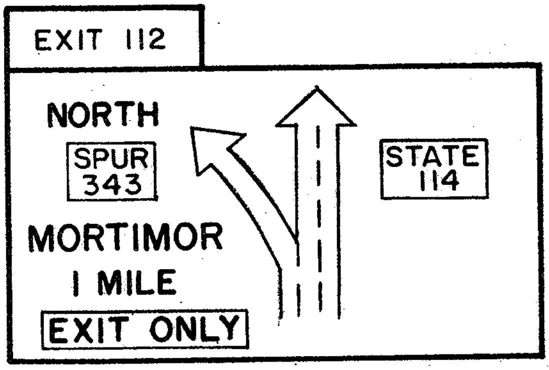


C-2

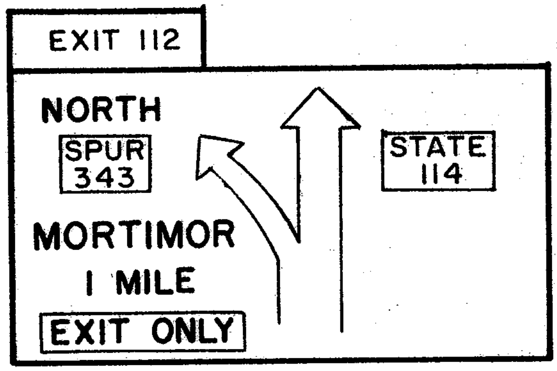


C-3

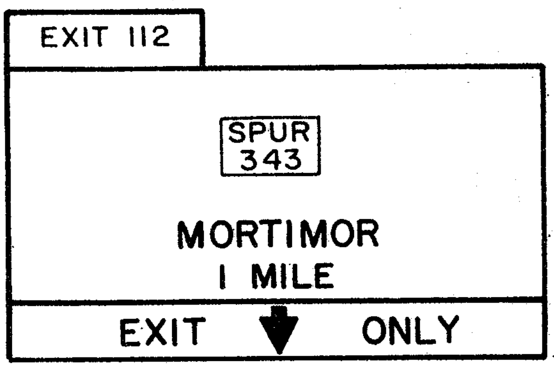
Figure 11-9. Alternative Sign Designs Used for the Single Left-Lane Exit Situation, Where the Extreme Left-Lane is an Option Lane, at the Gore Point.



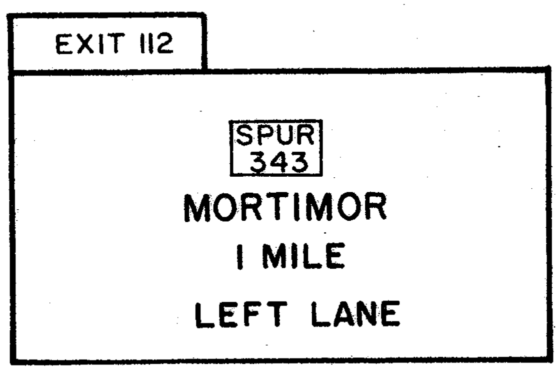
A-1



A-2

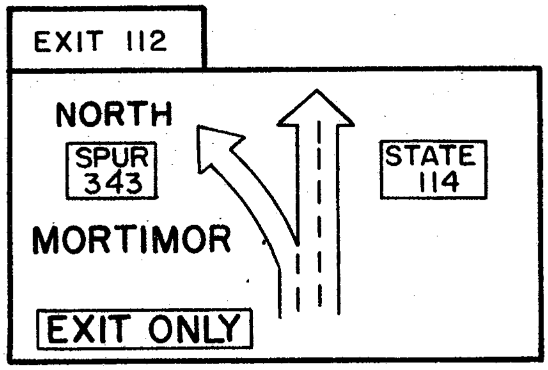


A-3

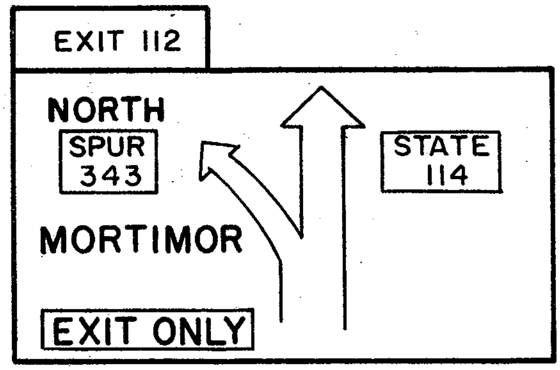


A-4

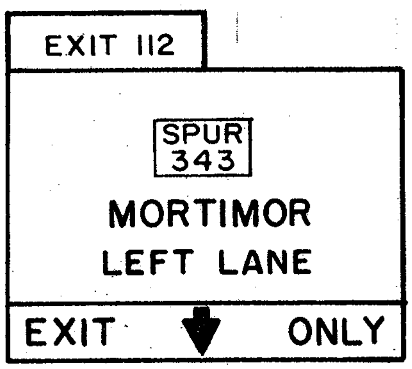
Figure 11-10. Alternative Sign Designs Used for the Single Left-Lane Exit Situation, Where the Extreme Left-Lane is an Exit Only Lane, One Mile Upstream from the Gore Point.



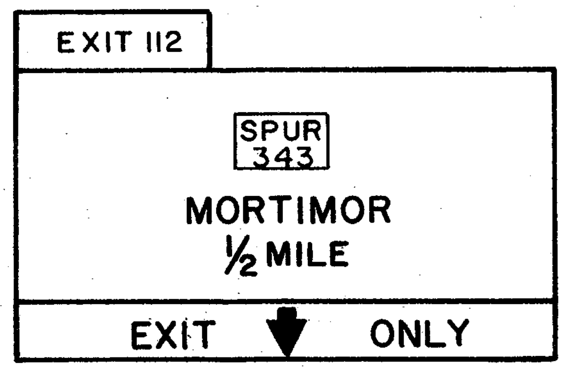
B-1



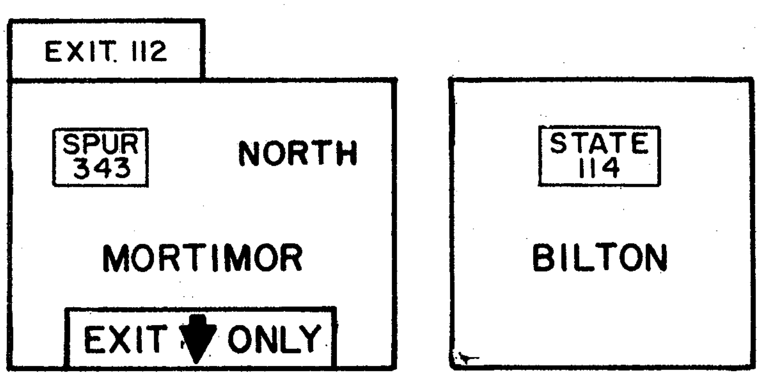
B-2



B-3



B-4



B-5

Figure 11-11. Alternative Sign Designs Used for the Single Left-Lane Exit Situation, Where the Extreme Left-Lane is an Exit Only Lane, One-Half Mile Upstream from the Gore Point.

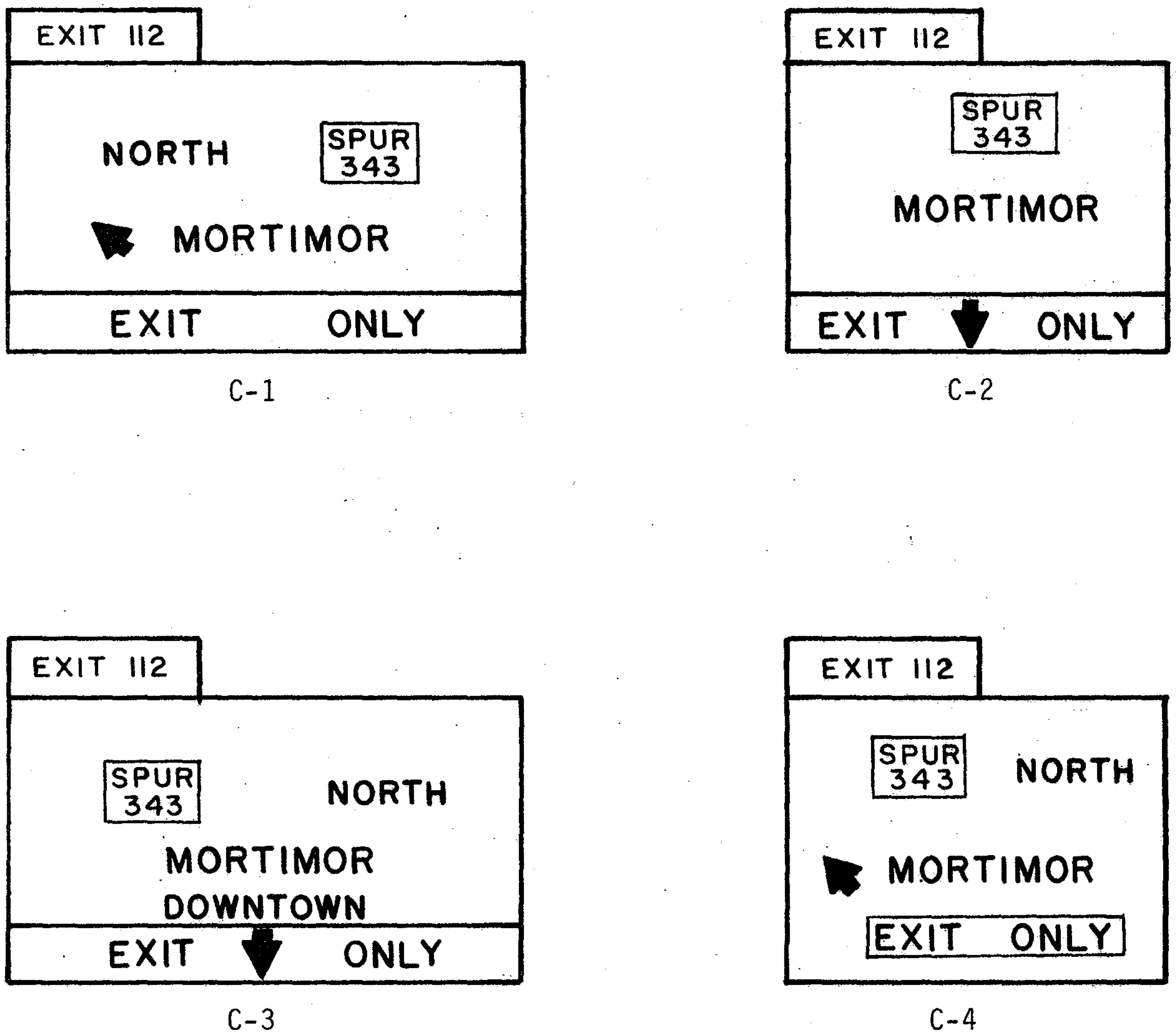


Figure 11-12. Alternative Sign Designs Used for the Single Left-Lane Exit Situation, Where the Extreme Left-Lane is an Exit Only Lane, at the Gore Point.

Table 11-1

Results of the Dual Left-Lane Exit Situation-
Subjects Preference, Rating, and Decision Time

Alternative Sign Designs	Subject Preference (f)	Subject Sign Rating ($\overline{x}$)	Decision Time (sec)
A-1	26	3.51	5.5
A-2	23	4.13	6.7
A-3	15	2.91	7.2
A-4	12	2.40	6.0
B-1	4	3.75	5.1
B-2	1	n.a.	n.a.
B-3	12	n.a.	n.a.
B-4	35	3.47	5.0
B-5	7	n.a.	n.a.
B-6	7	n.a.	n.a.
B-7	10	n.a.	n.a.
C-1	4	2.75	4.8
C-2	18	n.a.	n.a.
C-3	15	n.a.	n.a.
C-4	39	3.61	4.8

n.a. - not applicable

when considering the decision times the subjects required 5.5 seconds to rate sign A-1 whereas it took the subjects 6.7 seconds to rate sign A-2. This is a savings of 1.2 seconds. When considering all three variables, sign A-1 has a slight edge over sign A-2. At the one-half mile location sign B-4 had a significant difference in subject preference over all other signs listed at this location. Sign B-1 was evaluated with regards to rating by a smaller number of subjects and the rating was virtually the same as for sign B-4. The rating for B-1 was 3.75 and the rating for B-4 was 3.47. It took the subjects 5.0 seconds to rate sign B-4 and it took them 5.1 seconds to rate sign B-1. The ratings and the decision time are basically the same for both signs B-1 and B-4. However based on the subjects preference sign B-4 should be used at the one-half mile location. At the gore point, sign C-4 was the definite subjects choice when considering both preference and rating. The decision time was the same, 4.8 seconds for both signs C-4 and sign C-1. Therefore sign C-4 was the subjects choice to be used at the gore point.

In the single left hand exit, with the exit lane being an option lane, situation, the results are presented in Table 11-2. At the one-mile location the subjects preference and rating for signs A-1, A-2 and A-3 were virtually identical. However the subjects took half as much time to rate sign A-3 (3.3 seconds) as they did to rate the next best sign A-1 (7.23 seconds). Based on the decision time and the preference sign A-2 in the choice to use at the one-mile location. At the one-half mile location more than half of the subjects selected sign B-5. The rating and the decision times for signs B-1 and B-5 were virtually the same with sign B-1 being rated 3.25 in 5.1 seconds and sign B-5 being rated 3.48 in 5.4 seconds. Based on the subjects preference alone sign B-5 should be used at the one-half mile location. At the gore point the

Table 11-2

Results of the Single Left-Lane (Option) Exit Situation-
Subjects Preference, Rating, and Decision Time

Alternative Sign Designs	Subject Preference (f)	Subjects Sign Rating ($\overline{X}$)	Decision Time (sec)
A-1	19	3.34	7.23
A-2	16	3.21	6.20
A-3	29	3.25	3.30
A-4	7	n.a.	n.a.
A-5	4	n.a.	n.a.
B-1	7	3.25	5.10
B-2	5	n.a.	n.a.
B-3	9	n.a.	n.a.
B-4	14	n.a.	n.a.
B-5	37	3.48	5.40
B-6	3	n.a.	n.a.
C-1	31	3.58	4.50
C-2	13	n.a.	n.a.
C-3	31	4.00	3.70

n.a. - not applicable

subjects preferred and rated signs C-1 and C-3 the same. Sign C-1 was preferred by 31 subjects and rated 3.58 whereas, sign C-3 was preferred by 31 subjects and rated 4.00. The subjects, however, took 3.7 seconds to rate sign C-3 and 4.5 seconds to rate sign C-1. Based on the rating and the time required to rate sign C-3, this sign should be used at the gore point for this situation.

For the final situation being studied, namely the single left hand exit, where the exit lane is an exit only lane, the results are tabulated in Table 11-3. At the one-mile location approximately half of the subjects, 35 subjects, preferred sign A-3 to all others. However the rating for sign A-3 (3.63) was not as high as the rating for sign A-1 (3.92). The subjects required less time to rate sign A-3 (5.10 seconds) than they took to rate sign A-1 (7.40 seconds). Based on the subjects preference and the time required to rate the signs, sign A-3 is clearly the subjects choice for this location. At the one-half mile location the subjects preferred and rated sign B-4 much higher than all other signs. Forty-six (46) subjects indicated they preferred sign B-4 and rated it at 3.90 while they rated sign B-1 at 2.38. Sign B-1 had a decision time of 4.5 seconds associated with it while the decision time for sign B-4 was 4.8 seconds. Therefore, sign B-4 is the sign which should be used at this location based on the number of subjects preferring this sign and the performance rating given to this sign.

At the gore location, two signs were preferred by the majority of the subjects. Sign C-4 was preferred by 36 (49%) subjects and sign C-1 was preferred by 23 (31%) subjects. These two signs received almost identical ratings by the subjects, 4.11 for sign C-1 and 4.07 for sign C-4. The subjects took 3.8 seconds to rate sign C-1 and they took 4.5 seconds to rate sign C-4. These results indicate

Table 11-3

Results of the Single Left-Lane (Exit Only) Exit Situation-
Subjects Preference, Rating and Decision Time

Alternative Sign Design	Subjects Preference (f)	Subject Sign Rating ($\overline{x}$)	Decision Time (sec)
A-1	17	3.92	7.40
A-2	12	n.a.	n.a.
A-3	35	3.63	5.10
A-4	11	n.a.	n.a.
B-1	8	2.38	4.50
B-2	6	n.a.	n.a.
B-3	9	n.a.	n.a.
B-4	46	3.90	4.80
B-5	6	n.a.	n.a.
C-1	23	4.11	3.80
C-2	7	n.a.	n.a.
C-3	8	n.a.	n.a.
C-4	36	4.07	4.50

n.a. - not applicable

that if subjects preference is the deciding factor then sign C-4 should be used at this location. However, if the decision time is the sole criteria, then sign C-1 should be used.

Tables 11-4 through 11-6 rank order the various combinations of signs for the three situations based on their total system evaluation statistics. Table 11-4 rank orders the various combinations of signs for the dual left-hand exit study. The percentile levels are based on the various percentage breakdown using 5.00 as the 100th percentile. Table 11-5 presents the same information for the single left-turn exit where the exit lane is an optional lane, and Table 11-6 presents the information for the single left-lane exit which is an exit only lane. It is recommended that the signing system corresponding to the higher percentile levels be used before those with lower percentile levels.

Table 11-4
Evaluation of All Possible Signing Systems
for the Dual Left Lane Exit Situation (Rank Ordered)

Alternative Sign Designs Comprising Signing System	Individual Evaluation Statistics			Total System Evaluation Statistics	Percentile Levels
	A	B	C		
A-2, B-1, C-4	4.13	3.75	3.61	3.83	75
A-2, B-4, C-4	4.13	3.47	3.61	3.74	70
A-1, B-1, C-4	3.51	3.75	3.61	3.62	
A-2, B-1, C-1	4.13	3.75	2.75	3.54	
A-1, B-4, C-4	3.51	3.47	3.61	3.53	
A-2, B-4, C-1	4.13	3.47	2.75	3.45	65
A-3, B-1, C-4	2.91	3.75	3.61	3.42	
A-1, B-1, C-1	3.51	3.75	2.75	3.34	
A-3, B-4, C-4	2.91	3.47	3.61	3.33	
A-4, B-1, C-4	2.40	3.75	3.61	3.25	
A-1, B-4, C-1	3.51	3.47	2.75	3.24	60
A-4, B-4, C-4	2.40	3.47	3.61	3.16	
A-3, B-1, C-1	2.91	3.75	2.75	3.14	
A-3, B-4, C-1	2.91	3.47	2.75	3.04	
A-4, B-1, C-1	2.40	3.75	2.75	2.97	55
A-4, B-4, C-1	2.40	3.47	2.75	2.87	

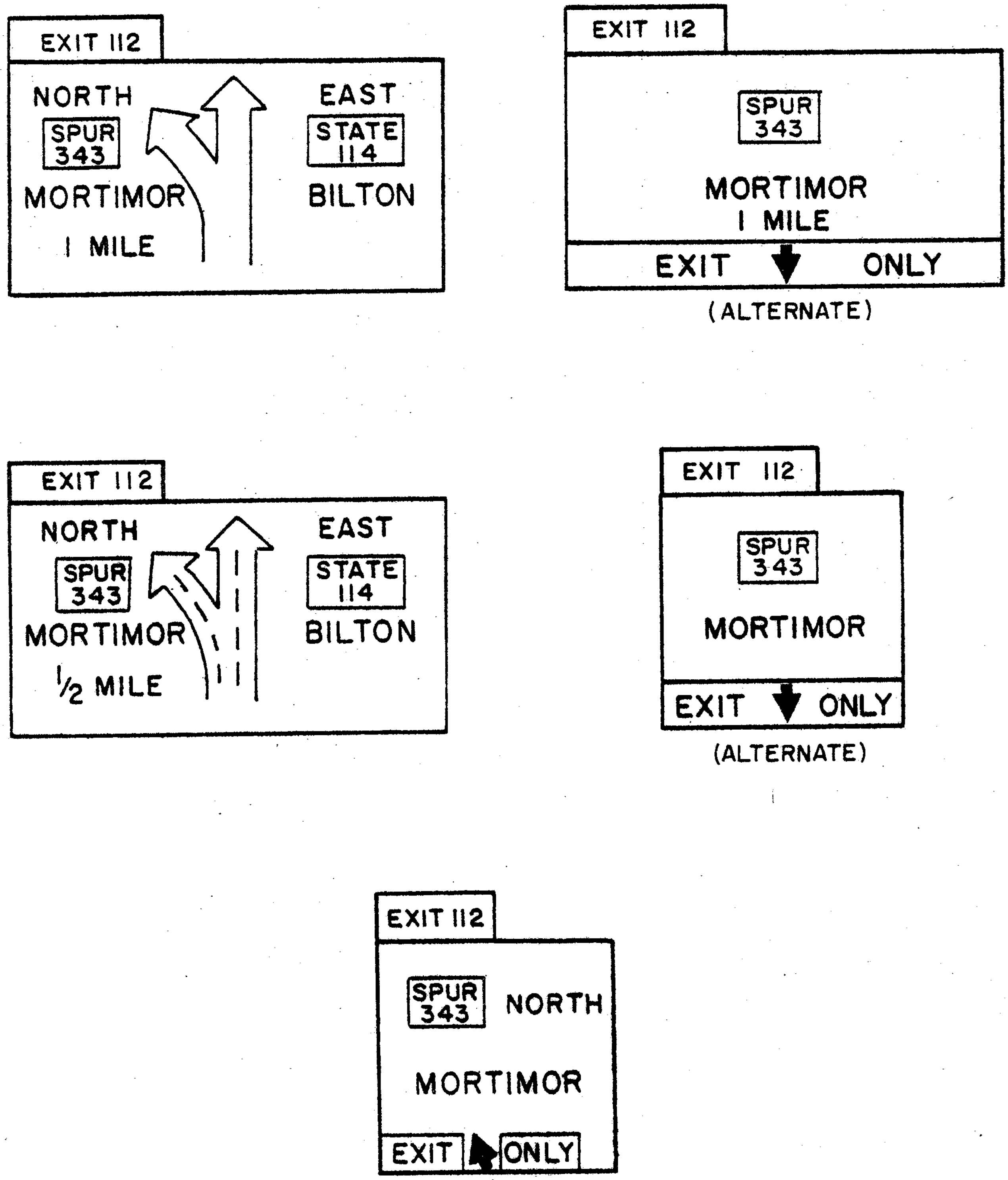


Figure 11-13. Recommended Signing System for Dual Left Lane Exit Situation.

Table 11-5

Evaluation of All Possible Signing Systems for the Single Left Lane (Optional) Exit Situation (Rank Ordered)

Alternative Sign Designs Comprising Signing System	Individual Evaluation Statistics			Total System Evaluation Statistics	Percentile Levels
	A	B	C		
A-1, B-5, C-3	3.34	3.48	4.00	3.61	70
A-3, B-5, C-3	3.25	3.48	4.00	3.58	
A-2, B-5, C-3	3.21	3.48	4.00	3.56	
A-1, B-1, C-3	3.34	3.25	4.00	3.53	
A-3, B-1, C-3	3.25	3.25	4.00	3.50	
A-2, B-1, C-3	3.21	3.25	4.00	3.49	65
A-1, B-5, C-1	3.34	3.48	3.58	3.47	
A-3, B-5, C-1	3.25	3.48	3.58	3.44	
A-2, B-5, C-1	3.21	3.48	3.58	3.42	
A-1, B-1, C-1	3.34	3.25	3.58	3.39	
A-3, B-1, C-1	3.25	3.25	3.58	3.36	
A-2, B-1, C-1	3.21	3.25	3.58	3.35	

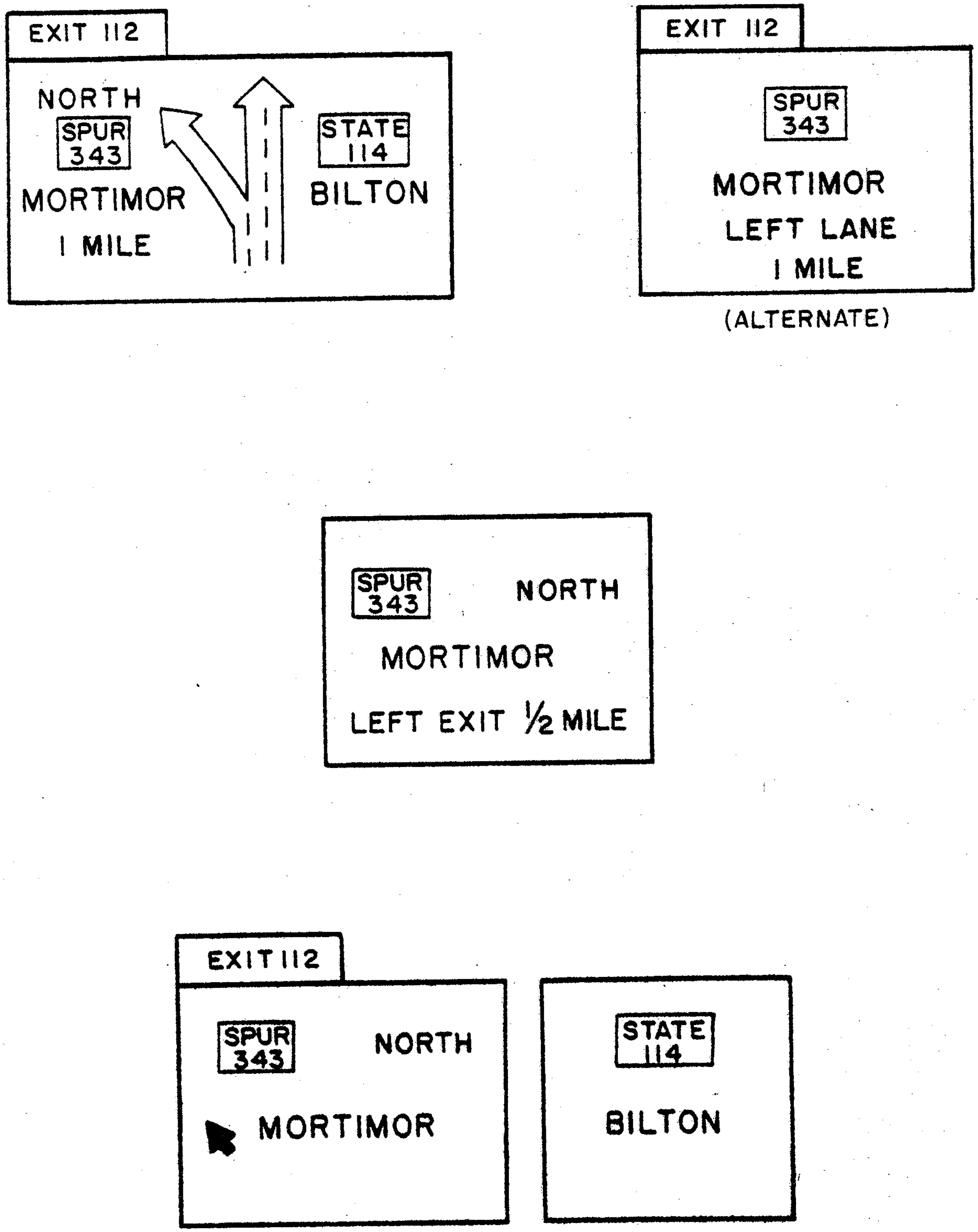


Figure 11-14. Recommended Signing System for the Single Left Lane (Optional) Exit Situation.

Table 11-6

Evaluation of All Possible Signing Systems for the Single Left Lane (Exit Only) Exit Situation (Rank Ordered)

Alternative Sign Designs Comprising Signing System	Individual Evaluation Statistics			Total Systems Evaluation Statistics	Percentile Levels
	A	B	C		
A-1, B-4, C-1	3.92	3.90	4.11	3.98	75
A-1, B-4, C-4	3.92	3.90	4.07	3.96	
A-3, B-4, C-1	3.63	3.90	4.11	3.88	
A-3, B-4, C-4	3.63	3.90	4.07	3.87	
A-1, B-1, C-1	3.92	2.38	4.11	3.47	65
A-1, B-1, C-4	3.92	2.38	4.07	3.46	
A-3, B-1, C-1	3.63	2.38	4.11	3.37	
A-3, B-1, C-4	3.63	2.38	4.07	3.36	

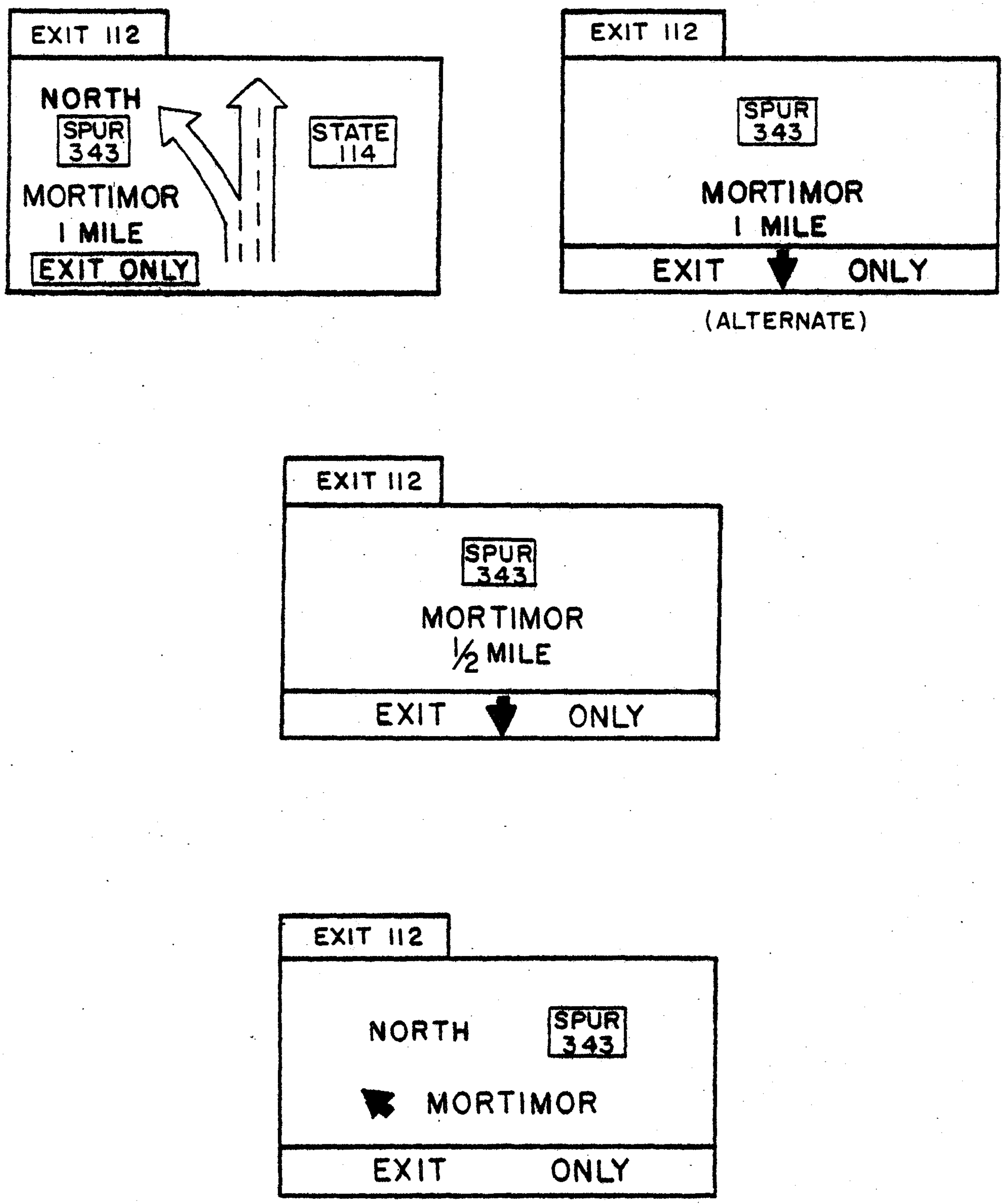


Figure 11-15. Recommended Signing System for the Single Left Lane (Exit Only) Exit Situation.

CHAPTER 12

SUMMARY OF CONCLUSIONS

The conclusions drawn from the responses obtained in these laboratory studies will be outlined briefly in this section. These conclusions will be outlined by study area for easier referencing to the appropriate section in this report.

In study Area 1, "Designation of Routes to the Downtown Area", it was determined, based on the subjects responses, that at the entering city limits the subjects both expected and preferred the city name as the one-word message. The two-word message both preferred and expected was Downtown-Denver. As the subjects approached the loop they would expect to see Downtown or Business. The two-word message that the subjects both expected and preferred was again Downtown-Denver. As they approached the intersecting freeway leading to the downtown area, the subjects indicated they would expect either Downtown or Lamar Street. The subjects responded that at this location they would expect the two-word message Downtown-Denver. And as the subjects were approaching their exit on Lamar St. they responded that they would both expect and prefer Downtown-Lamar St. as the two-word message. The analysis of variance indicated that the location and the message at each location had a significant effect on the subjects decision time, whereas, the messages themselves did not have a significant effect, at the 5% or lower level.

In study area 2, "Formatting and Method of Presenting Route Transfer Information," the responses indicated that the subjects both expect and prefer the destination route and control city at all diversion points for both belt and radial cities. If this is not possible the destination route should be given as a minimum. When studying the effects that different strategies of presenting information have on the number of errors and the motorists' decision time as they approach their exit location, the amount of information presented to them about their exit should stay constant or get progressively smaller. At their exit it might be best to give them an exit direction sign with their destination route being the only information.

In study area 3, "Reading Time of Freeway Guide Signs," showed results that the optimum accuracy level was about 6 bits of information per panel when combining the display times of 6, 4, and 2½ second. The average percent of correct responses increased as the number of panels and the information load per panel was increased. This was attributed to the subjects' familiarity with the signs and the order of presentation. When the information level was between 0 and 15 bits, 100% of the signs performed acceptably, when the level was 16-30 bits, 51% performed acceptably, and when the level was 31-50 bits, only 33% performed acceptably. It is apparent that route selection accuracy decreases as the number of route choices increases. On a large sign (4 or more panels) the information content should not exceed 16 bits of information per sign. The time required to read a sign also increases with the number of route choices and total information on the sign.

In study area 4, "Relationship of Shield Size and Placement of Route Markers on Sign Panels," the subjects responses indicated that when the State, U.S., and Interstate shields are the same size, the state shield appears larger in all cases, indicating that it has a higher target value, than both the U.S. and Interstate shields. This higher target value may be the result of either (1) the shape of the shield, (2) the color combination of the shield, or (3) both the shape and color combination of the shield. The results also indicate that to make the target value the same for all shields the state shield should be one size smaller than the other shields, That is to say, if a 48 x 48 inch U.S. and/or Interstate shield is sued, a 36" x 36" state shield should be used.

In study area 5, "Concurrent Signing - Motorist Understanding," the results of the laboratory study indicates that 57 percent of the subjects preferred non-concurrent signing as opposed to 43 percent preferring concurrent signing. This study was conducted in two parts. In the first part the subjects were not told the nature of the problem being studied and 63 percent of the subjects responded that they preferred non-concurrent signing, whereas, 37 percent preferred concurrent signing. In the second part of this laboratory study, the nature of the problem was explained, 54 percent responded they preferred concurrent signing and 46 percent preferred non-concurrent signing. We cannot explain, at this time, the shift in responses when comparing the before responses to the after responses.

In study area 6, "Concurrent Signing - Route Number Reduction", it was desired to evaluate the relative effectiveness of route number reduction strategies where a concurrent freeway may have its lower priority route number dropped from the route's signing. A highway-to-freeway scenario and a freeway-freeway scenario were studied. While the study had experienced limitations, some important research results were obtained. It was determined that the removal of U.S. numbered routes from existing Interstate facilities should be acceptable and should perform better than will the removal of an U.S. numbered route from an U.S. numbered highway which is connected with the Interstate freeway only for a short distance. There was no evidence collected in this experiment to suggest that eliminating the redundant U.S. route numbers from an Interstate freeway would not be successful from a navigational viewpoint. There was some evidence (i.e., increased response times) to suggest that eliminating the concurrent U.S. highway route numbering from a short section of concurrent Interstate would result in degraded navigation performance by motorists traveling the U.S. numbered highway.

In study area 7, "Control City Information", two problems were addressed. The first was to determine the size and the distance to the control city. The subjects responses indicate that 65 percent of the subjects selected cities with populations of 100,000 and above in population. Seven (7) percent selected cities with populations of 25,000-50,000, 21 percent selected cities with populations between 5,000 and 25,000, and seven (7) percent selected cities with 1,000-5,000 in total population. When considering the subjects first choice of control city, 50 percent wanted the control city to be no further than 100 miles away from their present location, and 85 percent wanted the control city to be no further away than 200 miles. When considering both the first and second choices of control cities, 50 percent indicated 150 miles or less, whereas, 85 percent indicated 250 miles or less. It is recommended that the control city be no smaller than a total population of 25,000 and located no further than 200 miles away. The second problem was to determine the location within an urban area where the control city name changes. In general, the subjects' responses indicate that what want and expect with regard to control city names are the same. As they enter the city limits the subjects expect the city name, as they approach the loop and to approximately 5 miles from the CBD they expect either the city name and/or Downtown, any distances closer to the CBD they expect to see the name of the next control city. The subjects' responses indicated that very few were confused when the control city was not their destination city. The results of the questionnaire survey indicated that the motorists were generally favorable to changing the control city at: (1) near the loop entering the city, (2) near the loop leaving the city, or (3) near the exiting city limits. Based on the results of the laboratory studies and the questionnaire survey, it is recommended that the name of the city should be used as the control city until they approach the loop, at that location they should pick-up the term Downtown, and near the CBD the name of the next control city should appear.

In study area 8, "Suburb City Information", the subjects responses for the control city messages were not significantly different than the major arterial messages for determining any meaningful relationship. The responses for the advanced warning messages were significantly different than those for the exit direction messages, indicating that the subjects preferred the advanced warning messages to the exit direction messages. This result, however, could be a result of the experimental design. The responses also indicated that there was no significant difference in response rates between the Downtown messages and the Denver messages. The decision time for any of the messages. The average decision time for the Downtown messages was 8.70 seconds and 8.66 seconds for the Denver messages. The only message in which there were very few correct responses and longer decision times was Downtown - Kansas City. This indicated that the subjects were interpreting their messages to mean Downtown - Kansas City literally and not Downtown Denver. In all other situations the term Downtown was competitive with the other messages. Thus, Downtown should be used on a sign panel either alone to refer only to the downtown area of the central city or in combination with the name of the central city of the metropolitan area.

In study area 9, "Right-Hand Interchanges Exiting Systems", the results indicate for situation 1 - Exit Only situation - the subjects preferred sign E-1. This determination was based on the number of responses and the evaluation of the subjects. At location D the subjects preferred sign D-1, and at location C they preferred sign C-1, the diagrammatic sign. In the second situation - the option lane - the subject preferred sign E-2 at location E. It is recommended that the signing systems with the higher system evaluation statistics be implemented before the other. A graphic representation of the recommended signing systems for each of the above situations are presented in Figure 10-5, 10-6 and 10-7.

The results of study area 10, "Left-Hand Exit Signing Study," indicate that for the dual left-lane exit situation, signs A-1 and A-2 could be used at the gore area, sign B-4 was the subject's definite choice at the one-half mile location and that sign C-4 should be used one-mile away from the exit. Sign B-1 recieved a higher rating by the subjects than did sign B-4, however only four subjects selected sign B-1 as the preferred sign whereas 35 subjects selected sign B-4. For the single left-lane exit situation when the exit lane is an option lane, the subjects preferred sign A-3 at the gore area, sign B-5 one-half mile away from the exit and either sign C-1 or sign C-3 at the one mile location. Sign A-1 received a slightly higher rating (3.34) than did sign A-3 (3.25), however this difference is not significant. There were ten (10) more subjects that preferred sign A-3 (29) than preferred sign A-1 (19). Either of these signs could be used interchangeably. At the one mile location sign C-3 received a higher rating (4.00) than did sign C-1 (3.58). In the single left-lane exit situation where the exit lane is an exit only lane, the subjects preferences indicate that signs A-3, B-4 and C-4 should be used at the various locations. Sign A-1 received a slightly higher rating (3.92) than did sign A-3 (3.63), however this difference is not significant. Also sign C-1 recieved a slightly higher rating (3.92) than did sign A-3 (3.63), however this difference is not significant. Also sign C-1 received a slightly higher rating (4.11) than did sign C-4 (4.07), again this difference is not significant. It is for these reasons that the signing system of A-1, B-4 and C-1 received a higher total system evaluation statistic (3.98) than did the signing system of A-3, B-4, C-4 which received a rating of 3.87. This difference is not significant and both lie within the 75th percentile level. Either of these systems could be used interchangeably. The recommended signing systems for each of the above situations are presented in Figure 5.

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2. Abramson, Norman. Information Theory and Coding. McGraw-Hill, New York, 1963.

3. Gatling, Frank P. The Effects of Auditory and Visual Presentation of Navigational Messages on Message Retention. DOT-FH-RD-76-94, June 1976.