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| 16. Abstract<br>This report summarizes past research regarding freeway guide signing. This literature review was used to determine the significant findings from past studies, and to determine areas where future research is needed. This report covers a number of areas related to freeway guide signing. Differences between the current Texas <i>Manual on Uniform Traffic Control Devices</i> (MUTCD) and national MUTCD are summarized. Research on driver information processing is examined, and past studies that identified deficiencies in guide signs in the field are reviewed. Research related to the selection of guide sign messages is reviewed, and guidelines for the design and layout of guide signs are summarized. Procedures for maintaining freeway guide signs are also examined. This information will be used to formulate guidelines for the <i>Freeway Signing Handbook</i> that will be produced by this project. It will also serve to focus the scope of new research that will be used to create guidelines for the <i>Handbook</i> . |  |   |  |   |           |
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**FREEWAY GUIDE SIGNING:  
REVIEW OF PAST RESEARCH**

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## **DISCLAIMER**

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## CHAPTER 1. INTRODUCTION

Freeway guide signs provide an important means by which to communicate navigational information to motorists. Guide signs are intended primarily for motorists that are not familiar with the freeway and provide important information that allows drivers to travel to their destinations. The signs provide essential visual cues that allow drivers to determine their routes and proper lane choices on the freeway. It is important that guide signs be used properly and consistently in order to serve the expectancy of drivers on the freeway.

While the Texas *Manual on Uniform Traffic Control Devices* (Texas MUTCD) provides some guidance for the design and placement of freeway guide signs, there are still areas where engineers or sign designers must use their judgment (1). Other documents, such as the Texas Department of Transportation standards sheets, provide additional guidance that the designer must consider (2). Sometimes inconsistencies can arise in the way the guide signs are designed and placed due to different interpretations of the guidance in these various documents. Inconsistent application of existing signing standards has the potential to increase the amount of time required to read and process guide signs, potentially resulting in motorist confusion about lane choice or travel path.

This project is being conducted to provide a single set of guidelines for the design, layout, and placement of freeway guide signs. A *Freeway Sign Handbook* will be developed in order to provide a single document that should be consulted for all issues related to freeway guide signs. It is anticipated that these guidelines will improve consistency in the way the guide signs are used across Texas, and produce signs that will better serve the informational needs of the motorists.

This report documents the results of a literature review that examined past research on freeway guide signs. This literature review was used to identify areas where there was already guidance available from past studies that could be incorporated into the *Freeway Sign Handbook*. The literature review will also be used to identify areas where further research is needed in order to provide clear guidelines to sign designers.

### PROJECT OBJECTIVES

This project was conducted, in part, to develop guidelines for the placement and design of freeway guide signs. In order to achieve these goals, researchers established the following objectives:

- identify state-of-the-practice in freeway guide signing, including innovative practices and guidelines used in other transportation agencies;
- evaluate driver information needs for freeway guide signs;
- work closely with TxDOT staff to provide recommendations and guidelines that have implementation value; and
- create a document that engineers can use to select and design freeway guide signs in a manner that will ease the navigation of freeway drivers.

This document addresses the first objective. Future research reports will address the remaining objectives.

## REPORT ORGANIZATION

This report summarizes the results of a literature review of the state-of-the-art in freeway guide signing. Past research and current innovative practices are reviewed in order to develop potential guidelines for the use of freeway guide signing. The information in this report is divided into eight chapters. The organization of the report is summarized below.

- [Chapter 1](#) provides a brief introduction to the scope of the project and a brief overview of some of the issues associated with freeway guide signing.
- [Chapter 2](#) examines the major differences in content between the current Texas MUTCD and the federal *Manual on Uniform Traffic Control Devices: Millennium Edition* (U.S. MUTCD) (3).
- [Chapter 3](#) discusses the information needs of drivers while performing the driving task. The information processing capabilities of drivers are also discussed.
- [Chapter 4](#) identifies common guide sign deficiencies that have been observed in past studies both in Texas and across the country.
- [Chapter 5](#) examines research that investigates various message content on guide signs. This section contains information about past studies that examined ways to sign various exit configurations.
- [Chapter 6](#) summarizes the design guidance that is present in various documents. This chapter deals specifically with the guidance that is available for the actual design and layout of signs.
- [Chapter 7](#) identifies some general procedures for the maintenance of freeway guide signs and the expected service life of the signs.
- [Chapter 8](#) provides some preliminary guidance for freeway guide sign design and placement based on the information included in chapters 2 through 7. This chapter also summarizes some future research directions for this project. In some cases, these future research needs are justified based on deficiencies in existing research. In other cases, the research is needed because there has been no project to examine the issue.

## CHAPTER 2. MUTCD SIGNING DIFFERENCES

With the release of the 2000 U.S. MUTCD, TxDOT has been determining whether the existing Texas MUTCD should be modified to bring it into substantial compliance with the new manual, or if the new U.S. manual should be adopted in its entirety. There are several areas where the new federal MUTCD provides guidance that differs from the current Texas MUTCD. This chapter examines differences in guide signing standards between the U.S. MUTCD and the Texas MUTCD (1, 3).

Some of the discrepancies between the two manuals are due to changes that were made in the 2000 U.S. MUTCD, while other differences were present in the previous editions of the MUTCDs. The purpose of this chapter is to identify situations where there is a difference in the guidance provided by the current national and Texas MUTCDs and to suggest when the changes should be made to the Texas MUTCD. Differences in organization or formatting will not be discussed in this chapter. Only differences in the actual guidance are discussed, and areas where the Texas MUTCD and U.S. MUTCD are in agreement will not be covered. The section titles in this chapter correspond to the sections in the U.S. MUTCD.

### **REFLECTORIZATION OR ILLUMINATION (U.S. MUTCD 2E.05, Texas MUTCD 2F-17)**

There are two areas where the Texas MUTCD and U.S. MUTCD are not in agreement. The Texas MUTCD generally has less stringent requirements for illumination and retroreflectorization than the U.S. MUTCD. The following list summarizes areas where the requirements in the two documents differ. The U.S. MUTCD states that:

- Where there is no serious interference from extraneous light sources, retroreflectorized ground-mounted signs usually provide adequate nighttime visibility.
- Overhead sign installations should be illuminated unless an engineering study shows that retroreflectorization alone will perform effectively.

In contrast, the Texas MUTCD states that:

- In general, where there is no serious interference from extraneous light sources, reflectorized signs will usually be adequate.
- On freeways, all overhead signs that are not independently illuminated shall be reflectorized.

### **Discussion**

In general, the current Texas MUTCD appears to be less restrictive than the U.S. MUTCD in using retroreflective materials rather than illumination. The U.S. MUTCD states that retroreflective materials are usually adequate for ground-mounted signs, while the Texas MUTCD does not differentiate between ground-mounted and overhead signs.

There is also a significant difference in the way that sign illumination is treated. The U.S. MUTCD states that overhead signs must be illuminated if an engineering study shows that

retroreflectorization is not effective. The Texas MUTCD states that any overhead sign that is not illuminated shall be retroreflectorized. The current Texas MUTCD does not require an engineering study to determine if retroreflectorization will provide adequate visibility. This difference was found to exist between the Texas MUTCD and the previous edition of the U.S. MUTCD.

## **CHARACTERISTICS OF URBAN SIGNING (U.S. MUTCD 2E.06, Texas MUTCD 2F-4)**

The U.S. MUTCD adds some new characteristics of urban conditions and new considerations for urban sign design. These additions are described below. The U.S. MUTCD adds the following characteristic of urban conditions:

- visual clutter from roadside development.

The following desirable sign treatment was also added:

- frequent use of street names as principal message in guide signs.

The U.S. MUTCD also adds the following guidance, which is not present in the Texas MUTCD:

- Lower speeds which are often characteristic of urban operations do not justify lower signing standards. Typical traffic patterns are more complex for the road user to negotiate, and large, easy-to-read legends are, therefore, just as necessary as on rural highways.

## **Discussion**

The additional characteristics of urban conditions and desirable sign treatments do not appear to conflict with any information in the Texas MUTCD. The guidance on signing for lower speeds is in conflict with some information currently in the Texas MUTCD. Section 2F-28 of the Texas MUTCD permits shorter spacings between guide signs for lower speed roads. This is not permitted by the current federal manual and may need to be changed.

## **SIGN SPREADING AND PULL-THROUGH SIGNS (U.S. MUTCD 2E.11, Texas MUTCD 2F-35)**

The Texas MUTCD has some additional requirements for the placement and content of pull-through signs that are not found in the 2000 U.S. MUTCD. These additional requirements are summarized below:

- If the mainline goes over the crossroad the sign should be placed on a cantilever or it may be ground-mounted, and should be located behind the guardrail leading to the bridge rail.
- Pull-through signs when needed indicate the route number, cardinal direction, and the next major destination served by the through route. The sign is usually mounted over the through lanes on the overhead structure where the exit direction sign is mounted.

## Discussion

Texas currently provides additional guidance on the placement of pull-through signs. This information does not conflict with any guidance in the U.S. MUTCD.

### **DESIGNATION OF DESTINATIONS (U.S. MUTCD 2E.12, Texas MUTCD 2F-7)**

The Texas MUTCD adds additional information on how to sign for destinations off the freeway. The details of the guidance are included in appendices of the Texas MUTCD. The language included in the Texas MUTCD is shown below:

- The determination of destination names to be shown for routes intersecting the freeway or expressway should follow the Guideline Criteria for the Selection of Destination Names given in Appendix C-1. In many cases, it will be necessary to refer to both Appendix D-1, Guideline Criteria for Signing Traffic Generators, as well as Appendix C-1, when making the final selection of destinations to be shown on the main lane guide signs.

## Discussion

The Texas MUTCD offers more detailed guidance for selecting destination names for guide signs. This additional guidance should not create a problem with compliance with the U.S. MUTCD, and the information in the appendices of the Texas MUTCD should be retained.

### **SIZE AND STYLE OF LETTERS ON SIGNS (U.S. MUTCD 2E.13, Texas MUTCD 2F-11)**

There are several cases where the U.S. and Texas MUTCDs differ on the size of letters, numerals, and route markers on freeways. [Table 1](#) summarizes some of the differences between the two documents. The table summarizes only situations where there is a difference in size or guidance between the two documents.

## Discussion

When there is a difference between the Texas and U.S. MUTCDs, the Texas MUTCD usually requires larger text or route markers. There are three areas where the Texas MUTCD does not provide more stringent guidance than the current U.S. MUTCD:

- *Changeable Message Signs:* The U.S. MUTCD specifies larger character heights than the Texas MUTCD, particularly for high-speed or complex environments.
- *Rest Area and Scenic Area Signs:* The Texas MUTCD uses a 10 inch height for distance fractions, while the U.S. MUTCD uses a 12 inch height.
- *Diagrammatic Signs:* The Texas MUTCD does not specify any sizes for arrowheads on diagrammatic signs.

These sections should be added or modified in the Texas MUTCD so that it is brought into compliance with the U.S. MUTCD. Guidance in the Texas MUTCD that specifies a size that exceeds the minimums in the U.S. MUTCD does not need to be changed.

**Table 1. Differences in Sizes and Styles of Freeway Legends (1,3).**

| <b>Sign</b>                     | <b>Sign Component</b>                              | <b>Description</b>              | <b>U.S. MUTCD</b>  | <b>Texas MUTCD</b>                             |
|---------------------------------|--|---------------------------------|--|--|
| Sequence Signs                  | Route Markers                                      | Interstate, US Routes           | Not Provided   | Located in table II-2, page 2F-7               |
| Advance Guide Sign              | Interstate Route Marker - Expressway               | 1-2 Digit Shield                | 36" by 36"   | 45" by 36"                                     |
|                                 |  | 3 Digit Shield                  | 45" by 36"   | 48" by 48"                                     |
|                                 | Interstate Route Marker - Freeway                  | 1-2 Digit Shield – Ground Mount | 35" by 36" minimum, 48" by 48" desirable   | 45" by 36" minimum, 60" by 48" desirable       |
|                                 |  | 3 Digit Shield – Ground Mount   | 45" by 36" minimum, 60" by 48" desirable   | 48" by 48" minimum, 60" by 48" desirable       |
|                                 |  | 1-2 Digit Shield – Overhead     | 36" by 36"   | 45" by 36"                                     |
|                                 | Business Loop or Spur Interstate                   |                                 | Not Included   | Located in table II-2, page 2F-7               |
|                                 | Cardinal Directions – Category B Major Interchange | Word                            | 12"  | 15" desirable, 12" minimum                     |
| First Letter of Word            |  | 15"                             | 18" desirable, 15" minimum   |  |
| Gore Signs                      | Major and Intermediate Interchanges                | Numeral and Letter              | 15"  | 18"  |
| Pull-Through Signs              | Route Markers                                      | 3 digit shield                  | 45" by 36"   | 36" by 36"                                     |
| Changeable Message Signs        |  |                                 | 10.6" for all characters, 18" when speed >55 mph, weather is bad, or complex driving is involved | Between 8" and 10.6" depending on type of word |
| Rest Area and Scenic Area Signs | Freeway  | Distance Word                   | 10"  | 12"  |
|                                 |  | Distance Fraction               | 12"  | 10"  |
| Diagrammatic Signs              | Freeway  | Arrowhead                       | 8"   | Not specified                                  |

**ABBREVIATIONS  
(U.S. MUTCD 2E.16, Texas MUTCD 2F-14)**

The U.S. MUTCD provides some guidance for abbreviations that is not found in the Texas MUTCD. The U.S. MUTCD states that periods should not be used, except when a



cardinal direction is abbreviated as part of a destination name. For example, “East Main Street” may be abbreviated “E. Main Street.”

### **Discussion**

This guidance should be added to the Texas MUTCD.

### **ARROWS FOR INTERCHANGE GUIDE SIGNS (U.S. MUTCD 2E.18, Texas MUTCD 2F-16)**

The Texas MUTCD provides some additional guidance for the use of downward-pointing arrows on guide signs. The Texas MUTCD specifies that a separate arrow should be centered over each lane for the signed destination or route.

### **Discussion**

The U.S. MUTCD does not explicitly require that a separate arrow be used over each lane. The Texas MUTCD should retain this guidance.

### **DIAGRAMMATIC SIGNS (U.S. MUTCD 2E.19, Texas MUTCD 2F-41)**

The U.S. MUTCD provides several additional standards and guidance for the use of diagrammatic signs that are not present in the Texas MUTCD. The U.S. MUTCD presents two standards for the design and placement of guide signs that are not present in the Texas MUTCD:

- No other symbols or route shields shall be used as a substitute for arrowheads.
- They shall not be installed at the exit direction location.

The Texas MUTCD implies that diagrammatic signs should not be used at the exit direction location, but it is not explicitly stated. The U.S. MUTCD also adds a case where diagrammatic signs should be used that is not found in the Texas MUTCD:

- Left exit interchange lane drop situations: In these situations an EXIT ONLY panel should be used without a down arrow for advance guide signs.

### **Discussion**

This project will address the effectiveness of using diagrammatic signs for left lane drops. The Texas MUTCD should not add this guidance until the results of this project have been obtained.

## **CHANGEABLE MESSAGE SIGNS (U.S. MUTCD 2E.21, Texas MUTCD 6F-2)**

The U.S. MUTCD has added a section for permanent freeway changeable message signs in addition to a section on portable changeable message signs for work zones. The Texas MUTCD addresses the use of only portable changeable message signs for use in work zones.

### **Discussion**

The section on permanent changeable message signs should be added to the Texas MUTCD.

## **LATERAL CLEARANCE (U.S. MUTCD 2E.23, Texas MUTCD 2F-20)**

The U.S. MUTCD provides detailed guidance for the placement of signs on freeways. The Texas MUTCD provides some guidance, but not at the same level of detail as the U.S. MUTCD. The U.S. MUTCD provides several recommendations for the placement of signs on freeways and expressways. The following standard is provided:

- The minimum lateral clearance outside the usable roadway shoulder for expressway and freeway signs mounted at the roadside or for overhead sign supports, either to the right or left side of the roadway, shall be 6 feet. This minimum clearance also should apply outside of the barrier curb. If located within the clear zone, the signs shall be mounted on crashworthy supports or shielded by appropriate crashworthy barriers.

The following guidance is also included:

- When practical, a sign should not be less than 10 feet from the edge of the nearest travel lane. Large guide signs should be farther removed, preferably 30 feet or more from the nearest travel lane.
- Where an expressway median is 12 feet or less in width, consideration should be given to spanning both roadways without a center support.
- Butterfly-type sign supports shall not be installed in gores or other unprotected locations within the clear zone.
- Lesser clearances, but generally not less than 6 feet may be used on connecting roadways or ramps at interchanges.

The Texas MUTCD avoids providing specific lateral clearance numbers, stating that liberal horizontal clearance should be provided so that out-of-control vehicles can recover. Other than stating that in no case should any part of a sign or sign structure be within 2 feet of the surface prepared for normal or emergency travel of vehicles, the Texas MUTCD does not provide any specific distance recommendations.

## **Discussion**

It may be desirable to provide specific guidance for lateral clearance in the Texas MUTCD. The guidance in the U.S. MUTCD should be considered for inclusion in the Texas MUTCD.

### **INTERCHANGE GUIDE SIGNS (U.S. MUTCD 2E.27, Texas MUTCD 2F-28)**

The U.S. and Texas MUTCDs offer conflicting guidance on the minimum spacing between interchange guide signs. Both manuals state that the minimum spacing between signs should be 800 feet, but the Texas MUTCD permits shorter spacings for low operating speeds. According to the Texas MUTCD, the minimum spacing can be reduced, where necessary, to 650 feet if operating speeds are low. The U.S. MUTCD does not permit this.

## **Discussion**

The minimum spacing for low-speed roads should be increased to 800 feet to bring the Texas MUTCD into compliance with the U.S. MUTCD. The current U.S. MUTCD specifically states that signing standards should not be reduced on low-speed roads.

### **INTERCHANGE NUMBERING (U.S. MUTCD 2E.28, Texas MUTCD 2F-24)**

There are several differences between the U.S. and Texas MUTCDs in the area of interchange numbering. The U.S. MUTCD has the following requirements:

- Interchange numbering is required on all freeways, although it is optional on expressways.
- A 30-inch exit number plaque is required.
- The word “LEFT” may be added to the exit number plaque. [Figure 1](#) shows the use of a left exit panel.

In contrast, the Texas MUTCD has the following requirements:

- Numbering is required only on Interstates.
- A 24-inch exit number plaque is required.
- The word “LEFT” is not explicitly permitted on the exit panel.

## **Discussion**

There are several issues that need to be resolved in this section. Texas should consider whether it wants to require all freeways to use exit numbering systems. The size of the exit number plaque should also be upgraded from 24 to 30 inches. Finally, Texas should consider allowing the use of the word “LEFT” within the exit number panel. This addition could serve to reinforce the message that the exit is to the left. It should be noted that the “LEFT EXIT” exit number panel is green, not yellow like the “LEFT EXIT” supplemental panel. It is possible that

a yellow “LEFT EXIT” exit number panel would serve to draw more attention to the unusual exit geometry.



**Figure 1. Acceptable Left Exit Panels According to the U.S. MUTCD.**

**INTERCHANGE CLASSIFICATION  
(U.S. MUTCD 2E.29, Texas MUTCD 2F-27)**

The U.S. MUTCD provides some specific guidance for the classification of minor interchanges that is not present in the Texas MUTCD, specifically:

- Where the sum of exit volumes is estimated to be lower than 100 vehicles per day (vpd) in the design year, the interchange is classified as minor.

No volume requirement for minor interchanges is currently in the Texas MUTCD.

**Discussion**

The provision of a specific volume number for the classification of a minor interchange could be helpful to sign designers in Texas. The 100 vehicles per day requirement should be added to the Texas MUTCD.

## **ADVANCE GUIDE SIGNS (U.S. MUTCD 2E.30, Texas MUTCD 2F-30)**

The U.S. and Texas MUTCDs offer differing guidance for the number of advance guide signs to be used for major and intermediate interchanges and for the location of advance guide signs for minor interchanges. The U.S. MUTCD states:

- For major and intermediate interchanges, two and preferably three advance guide signs should be used.
- Advance guide signs for minor interchanges should be located 0.5 to 1 mile from the exit gore.

The Texas MUTCD has the following requirements:

- For major and intermediate interchanges, two advance guide signs should be used. Three advance guide signs are preferable for major interchanges.
- Advance guide signs for minor interchanges should be located between 0.25 and 0.5 miles from the exit gore.

### **Discussion**

The U.S. MUTCD requirements are generally more forgiving than the Texas requirements. The requirements in the Texas MUTCD should be changed to comply with those in the U.S. MUTCD. Additional research may be needed to determine if three advance guide signs are sufficient in situations where geometric conditions are complex or traffic volumes are heavy.

## **EXIT GORE SIGNS (U.S. MUTCD 2E.34, Texas MUTCD 2F-34)**

There is a minor difference between the way that exit numbers for gore signs are treated in the U.S. and Texas MUTCDs. The Texas MUTCD requires that the exit number be displayed on a separate plaque attached to the gore sign. The U.S. MUTCD permits the exit number to be included within the face of the sign or on a separate plaque. [Figure 2](#) shows these two options.

### **Discussion**

The provision of the exit number within the face of the sign could potentially reduce sign fabrication costs, although it would create longer replacement times should a sign be damaged. If the number were provided in the face of the sign, each gore sign would need to be customized for a specific exit. The merits of providing the exit number on the gore sign should be investigated further.



**Figure 2. Exit Numbering for Exit Gore Signs.**

## **CHAPTER 3. DRIVER NEEDS AND INFORMATION PROCESSING**

When designing and placing freeway guide signs, the engineer should be cognizant of the limitations of drivers on the roadway. Information should be presented in a clear, concise, and consistent manner to help ensure that motorists unfamiliar with the route can easily interpret the information presented. Repetition of messages is also encouraged.

The purpose of this chapter is to provide a brief review of issues related to driver information needs and processing as related to freeway guide signing. This chapter provides a brief description of the various components of the driving task. Research on legibility and information processing is also briefly discussed. Readers are advised to consult the relevant source material for a more detailed treatment of these topics. Finally, a methodology for evaluating the adequacy of guide signing is reviewed.

### **POSITIVE GUIDANCE AND THE DRIVING TASK**

The concept of positive guidance is often used as a guiding principle for providing information to drivers. Positive guidance consists of creating and maintaining a driving environment that has the following characteristics (4):

- Motorists are provided with the maximum amount of useful visual information.
- Information is presented in such a way that it is prioritized in importance.
- Information is presented uniformly, allowing drivers to develop expectancies about the location of information.
- Information is visible under most, if not all, environmental conditions.

If the principles of positive guidance are applied consistently, drivers will subconsciously develop expectations about where to seek information. When the concepts of positive guidance are applied, it is important to understand the demands that are placed on the driver during the driving task. The driving task is made up of a number of subtasks that require varying levels of time and cognitive activity. The three most basic subtasks are (5):

- control,
- guidance, and
- navigation.

Performance of these subtasks allows drivers to maintain their positions in the lane and find their way to their final destinations. Drivers perform these subtasks continuously at various cognitive levels, although the amount of attention and cognitive resources allocated to each task may vary depending on the specific conditions that are present at a given point and time. A detailed description of each of these subtasks is given below.

## Control

The control subtask consists primarily of steering control and speed control (5). Steering control consists of maintaining the orientation of the vehicle with respect to the roadway and usually has the highest priority to the driver. Speed control involves using the brake and accelerator to select an appropriate speed for a given situation. Table 2 summarizes the basic characteristics of these two components of the control subtask.

**Table 2. Characteristics of the Control Subtask (5).**

| Characteristic         | Steering Control   | Speed Control   |
|------------------------|--|---|
| Priority               | High   | High  |
| Driver Level of Effort | Varies depending on geometrics                                 | Varies depending on geometrics and traffic  |
| Information Needs      | Vehicle response characteristics, relative position of vehicle | Vehicle braking and acceleration characteristics, road conditions ahead of driver |
| Demand on Driver       | Usually low because subtask is overlearned                     | Greater than steering since driver must look farther down the road                |

## Guidance

The guidance subtask consists of maintaining a safe and efficient path relative to all factors in the roadway environment (5). Some examples of actions included in the guidance subtask are car following, passing, and response to traffic control devices. Table 3 summarizes the characteristics of the guidance subtask.

**Table 3. Characteristics of the Guidance Subtask (5).**

| Characteristic         | Guidance   |
|------------------------|--|
| Priority               | Varies depending on conditions, but usually intermediate between control and navigation                        |
| Driver Level of Effort | Higher than control subtask, with more conscious decision-making necessary                                     |
| Information Needs      | Traffic conditions, road geometry, weather conditions, and other information that impacts the road environment |
| Demand on Driver       | Varies depending on the driver's previous experiences and <i>a priori</i> knowledge                            |

The ability to perform the guidance subtask is a function of the driver's previous knowledge of similar conditions. Once a particular condition has been observed by drivers, they must process the information to determine an appropriate course of action. The level of cognitive demand that this places on drivers is dependent on their previous experiences in a given situation.

## Navigation

The portion of the driving task that is most directly affected by freeway guide signing is the navigation subtask (5). The navigation subtask consists of planning a trip from the beginning to the end and then executing the trip plan. The navigation subtask can be broken down into trip preparation and planning and direction finding. Trip preparation and planning can consist of



anything from drivers using their own mental map of an area to consulting maps or knowledgeable persons in order to plan a trip. If drivers are well prepared prior to beginning a trip, they will be more successful in the navigation subtask even if there is limited en route information. Direction finding occurs while the drivers are en route and attempting to reach their destinations. This portion of the subtask involves interpreting direction guidance on signs to receive information about the appropriate path. The characteristics of the navigation subtask are summarized in [Table 4](#).

**Table 4. Characteristics of the Navigation Subtask (5).**

| <b>Characteristic</b>  | <b>Trip Preparation and Planning</b>   | <b>Direction Finding</b>  |
|------------------------|--|---|
| Priority               | Performed pre-trip, so no demands on driver while en route                           | Usually lowest of all subtasks, although demands may increase in complex or unfamiliar situations |
| Driver Level of Effort | Varies depending on driver familiarity with route                                    | Usually low   |
| Information Needs      | Location or origin and destination, and physical or mental map of alternative routes | Guide signs, route markers, street name signs, landmarks, etc.                                    |
| Demand on Driver       | Usually low  | Usually low, except in unusual circumstances  |

### **Additional Issues**

Attention is an important component of the driving task (5). When a subtask has a low demand, it can be performed with little conscious attention, allowing the driver to allocate attention to tasks that require more cognitive resources. When the demands of the driving task require that more attention be placed on a particular subtask, it comes at the expense of performing tasks requiring a higher level of attention. This process is known as load shedding. For example, a driver on an uncongested freeway can easily perform navigational subtasks. If traffic becomes extremely congested, the navigational subtasks become more difficult to perform because the driver must allocate more attention to the control and guidance subtasks.

Expectancy is also very important in the driving task (5). Drivers need to have a reasonable expectation about how their vehicles will perform, the geometry of the road downstream of their positions, and where to find navigational information. If the expectancy of the driver is violated, the performance of the driving task may suffer. This situation is particularly important in freeway guide signing where the unfamiliar driver will rely on guide signs to provide information to perform the navigation subtask.

### **READING TIME**

In a freeway environment, drivers must read, interpret, and react to freeway guide sign messages in a limited amount of time in order to obtain information for the navigation subtask. If a sign presents too much information, there is a possibility that a driver will not comprehend important navigational information. Several past studies have attempted to determine both the amount of time required to read a guide sign and also to set a maximum amount of information that should be displayed on a guide sign.

## Relationship between Number of Words and Reading Time

Researchers have hypothesized that the amount of time required to read a guide sign is a function of the number of words on a sign. Mitchell and Forbes defined one of the first relationships between sign reading time and the number of words on a sign (6). They developed the following equation to determine reading time for signs with more than three words:

$$T (\text{secs}) = N/3$$

Where: N = number of familiar words on the sign  
T = reading time (seconds)

This relationship yields an average reading time of 333 milliseconds per word. The researchers then modified this formula to incorporate a safety factor in case the driver was distracted while attempting to read the sign. The revised formula was (6):

$$T (\text{secs}) = 2N/3$$

The researchers next attempted to create a safety factor in order to account for the effect of driver distraction. The researchers arbitrarily determined that a safety factor of two should be provided. This safety factor was not the result of any research. The modified equation yields a reading time of 667 milliseconds per word.

Several more recent studies have found that reading time is not strictly a linear function of the number of words on the sign. Issues related to the placement of the sign, sign content, traffic conditions, and driver familiarity with the message can significantly alter the amount of time required to read a sign. Driver eye fixations were examined while driving on an Interstate highway in one study (7). This study found that drivers do not continually read signs. Instead, drivers make a series of discrete fixations on the sign that last between 100 and 600 milliseconds. As drivers became more familiar with a sign, they spent less time reading the sign to obtain information.

A British study attempted to evaluate the impact of information overload on the time required for drivers to respond to guide signs (8). The researchers evaluated guide signs on normal surface streets similar to D series guide signs. They found that the relationship between response time and the number of destinations was non-linear. Although the search times were greater when more destinations were present, there was no evidence that drivers' search abilities broke down when high numbers of destinations were present.

A study in 1989 attempted to determine the time necessary to read signs while subjects were performing very demanding driving tasks (9). Non-freeway guide signs were used in this evaluation. The number of destinations on the signs ranged from four to nine, with a maximum of three destinations in each direction. This study found that the reading times varied depending on whether the destination being sought was present or not present on the sign. Table 5 summarizes the reading times required to find a specific destination for different types of information and number of words on the sign. This research showed that reading time was not

necessarily solely a function of the amount of information presented. While reading times did increase as the number of words increased, there was not always a substantial increase in reading time.

**Table 5. Required Reading Times for Freeway Guide Signs (9).**

| Type of Information                                      | Number of Words    |                   |
|--|--------------------|-------------------|
|  | 2 to 4             | 4 to 10           |
| Mileage to a specific destination                        | 1.6 - 2.2 seconds  | 2.2 - 2.3 seconds |
| Destination information that was present on the sign     | 1.7 - 2.2 seconds  | 2.2 - 2.4 seconds |
| Destination information that was not present on the sign | 1.65 - 2.6 seconds | 2.6 - 2.9 seconds |

McNees and Messer conducted a study that examined the ability of drivers to successfully read and interpret freeway guide signs within limited time constraints (10). Drivers were presented with between two and five individual sign panels on a simulated overhead sign structure. Each sign panel contained between two and ten units of information per panel. Each place or street name, route number, cardinal direction, command, distance, or lane use arrow was counted as a separate unit of information. Subjects were asked to identify the proper travel lane that should be used to reach a pre-determined destination. Time constraints were applied in order to simulate the impact of heavy driver task loads under freeway speeds. Signs were displayed for 2.5, 4.0, and 6.0 seconds in order to reflect unacceptable, acceptable, and desirable amounts of available reading time.

Not unexpectedly, it took the subjects longer to read signs that had large amounts of information on them. When the exposure time was limited, subjects had lower accuracy for message interpretation when a great deal of information was presented. Table 6 summarizes the accuracy results of the test subjects for a variety of different information loads and display times.

**Table 6. Driver Response Accuracy to Varying Information Loads and Exposure Times (10).**

| Information per Panel (units) | Display Rate (seconds) | Percent of Drivers with Correct Response |          |          |          |
|-------------------------------|------------------------|--|----------|----------|----------|
|                               |                        | 2 Panels                                 | 3 Panels | 4 Panels | 5 Panels |
| 2                             | 6                      | 93                                       | 83       | 94       | 80       |
|                               | 4                      | 88                                       | 83       | 93       | 80       |
|                               | 2.5                    | 83                                       | 82       | 80       | 84       |
| 4                             | 6                      | 96                                       | 82       | 63       | 46       |
|                               | 4                      | 93                                       | 83       | 69       | 52       |
|                               | 2.5                    | 91                                       | 94       | 92       | 76       |
| 6                             | 6                      | 100                                      | 92       | 33       | 95       |
|                               | 4                      | 87                                       | 92       | 36       | 86       |
|                               | 2.5                    | 99                                       | 92       | 52       | 92       |
| 8                             | 6                      | 81                                       | 55       | 76       | 58       |
|                               | 4                      | 93                                       | 80       | 82       | 61       |
|                               | 2.5                    | 75                                       | 45       | 91       | 36       |
| 10                            | 6                      | 77                                       | 60       | 65       | 70       |
|                               | 4                      | 83                                       | 71       | 75       | 73       |
|                               | 2.5                    | 57                                       | 80       | 78       | 79       |

The researchers recommended an optimum value of 6 units of information per sign. The average correct response rate varied as a function of the total number of units of information presented on each sign.

### Desirable and Maximum Reading Times and Information on Guide Signs

McNees and Messer used the reading time data collected in the study to generate a table of desirable and minimum reading times that should be provided for overhead guide signs (10). The elapsed time between when a sign was initially displayed and when the subject made a correct lane choice was recorded. The researchers then developed a series of regression lines that they used to predict desirable reading times that should be provided for varying levels of information. Table 7 summarizes these results. Desirable reading times represent a predicted reading time where at least 85 percent of the drivers would make the correct lane choice decision. The minimum reading time represents a time where 75 percent of the drivers would make the proper decision. Cells with a dash indicate situations that should not be used on the road. These situations represent cases where more than 20 units of information are presented on the sign structure.

**Table 7. Desirable Reading Times for Overhead Guide Signs (10).**

| Units of Information per Panel | Condition | Reading Times (Seconds) |          |          |          |
|--------------------------------|-----------|-------------------------|----------|----------|----------|
|                                |           | 2 Panels                | 3 Panels | 4 Panels | 5 Panels |
| 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                     | -        | -        | -        |

*Note: - indicates situations that combination should not be used*

The researchers also generated a table of desirable and maximum amounts of information that should be placed on overhead sign structures. This information is shown in Table 8. The table shows that placing five sign panels on a single structure is not a desirable design, and should not be used if possible. The maximum amount of information on any sign structure should not exceed 20 units.

**Table 8. Maximum Amount of Information per Sign Structure (10).**

| Number of Panels | Condition | Maximum Units of Information per Structure |
|------------------|-----------|--|
| 2                | Desirable | 12   |
|                  | Maximum   | 16   |
| 3                | Desirable | 18   |
|                  | Maximum   | 20   |
| 4                | Desirable | 16   |
|                  | Maximum   | 20   |
| 5                | Desirable | Undesirable Design                         |
|                  | Maximum   | 20   |

## DETECTION AND LEGIBILITY

Before drivers can interpret the message on a sign, they must be able to determine that a sign is present and read the message on the sign. The initial detection of a guide sign occurs when a driver can see the sign without being able to read its legend. The ability of a driver to detect a guide sign is usually a function of the size of the sign and the contrast between the sign and the surrounding background. At night, the luminance of the sign also impacts the ability of a driver to detect it. This section provides a brief overview of some of the factors that can influence the legibility of a sign. Readers are advised to consult the literature for a more detailed discussion of these topics.

Drivers must be able to read the lettering on a sign before they can comprehend its message. The designer has the ability to alter a variety of factors that can influence sign legibility, including font, letter height, and type of sign illumination or retroreflectance. Each of these factors and its impact on legibility is discussed in this section.

### Letter Height

Some of the earliest research on legibility was performed in the 1930s by Forbes and Holmes (11). The researchers evaluated the day and night legibility of signs using series B and series D letters. Letter heights evaluated ranged between 6 and 24 inches tall. Approximately 400 observers were used to view the signs, and the age of the viewers tended to be younger than average. The observers would approach the sign, and the distance at which they could read the message on the sign was noted. All signs were ground-mounted. Nighttime legibility studies were performed using both reflectorized floodlighted letters for the series B signs, and both floodlighted and reflectorized letters for the series D signs.

The researchers examined the 80<sup>th</sup> percentile legibility distances for the signs. The daytime legibility was consistently better than the nighttime legibility for both letter series. The nighttime legibility was between 8 and 20 percent lower than the daytime legibility. They found that a person with a visual acuity of 20/40 had a legibility of 33 feet per inch of letter height for B series letters, and 50 feet per inch of letter height for D series letters. Since the subjects tended to be young, their eyesight was fairly acute, with a median value of 20/20.

In 1958, Allen evaluated the daytime and nighttime legibility of E series letters using a group of 48 subjects (12). The researchers tested four different levels of external illumination as well as button copy and retroreflective sheeting. Both ground-mounted and overhead guide signs were evaluated. Subjects approached the sign while traveling in a vehicle at 15 mph, and the distance at which the subjects could read the sign was noted. The average age of the subjects was 33. The average visual acuity of the subjects was 20/18, so the observers tended to have good vision.

Letter heights between 8 and 18 inches were evaluated. This study showed that the average daytime legibility of the message was about 88 feet per inch of letter height. When the sign was externally illuminated, the legibility declined by about 15 percent. There were several possible reasons for the differences between Allen's and Forbes' studies. Allen's study used four-letter words that were familiar to drivers. Forbes' study used six-letter words with deliberate misspellings in order to ensure that subjects read the entire word. By using familiar words, the legibility distances in Allen's study may have been increased. The visual acuity of the test subjects was also slightly better for Allen's study than for Forbes' study.

### Font

There is some concern that the E(Modified) font used on freeway guide signs is not suitable for use with prismatic materials. The E(Modified) font may be susceptible to irradiation, where the letter stroke is so bright that it may bleed into open spaces in the letter. This blurring can reduce the legibility of the letters. Researchers developed the Clearview font to mitigate some of these concerns by creating wider open spaces with the letters. Figure 3 shows the same sign with series E(Modified) and Clearview fonts.



**Figure 3. Guide Sign with Series E(Modified) (Left) and Clearview (Right).**

A study performed at Texas A&M University compared the daytime legibility of the E(Modified), Clearview, and British Transport fonts (13). This evaluation found no significant difference between the daytime legibility of these fonts. The author recommended that the type of font used on a guide sign be determined based on nighttime legibility concerns. A recent study by the Texas Transportation Institute (TTI) evaluated the difference in nighttime legibility between Clearview and E(Modified) when a prismatic sheeting was used (14). This study found that nighttime legibility distance increased by approximately 70 ft (10 percent) over E(Modified) when the Clearview font was used with the prismatic sheeting.

A study examined the relative effectiveness of the Clearview font across several material types (15). The study found that the Clearview font did not create significantly better recognition distances than the E(Modified) font, although it did perform better than a D series font during the day. At nighttime, the Clearview font did appear to improve recognition and legibility distances over the E(Modified) font. When the Clearview font was increased to 112 percent of its normal size, the legibility distances were approximately 50 feet greater than the E(Modified) font.

### **Letter Case**

Gordon examined the legibility of cardinal direction words using all capitals and mixed-case lettering (16). The mixed-case font used initial capital letters that were of the same size as the lower case letters. The researchers hypothesized that emphasizing the initial letter of the cardinal direction would improve legibility. The results of the study indicated that the cardinal directions could be identified from 10 percent farther away when the mixed-case font was used.

## **GUIDE SIGN LEVEL OF SERVICE**

In the early 1980s, Messer and McNeas developed a level of service indicator for analyzing freeway guide signs (17). The purpose of this indicator was to provide an objective means to determine if a guide sign was adequate for a driver with 20/40 vision. Their rating scheme was based on an assessment of three factors: navigation, workload, and response. The assessment of these factors was then used as input into an overall comprehensive level of service for the sign. This section briefly discusses this level of service concept.

### **Navigation**

The first component of the level of service concept was an assessment of the ability of a sign to guide motorists unfamiliar with an area to their destinations. Four factors were used to perform this assessment: sufficiency, consistency, expectancy, and reliability. Each one of these components was subjectively scored as good, fair, or poor, and the resulting rating was converted into a level of service. Basically, this portion of the assessment determined whether drivers received enough information to make an informed decision about their paths of travel.

### **Workload**

Messer and McNeas also assessed the workload that the sign placed on the driver. They defined the workload of the sign as the ratio of the time required to process the information on a

sign to the time available for this to occur. Workload ratings were then converted into a level of service for the sign. This level of service assessed whether a driver could read the information in the required amount of time.

## **Response**

The ability of the driver to react to the information on the sign within the space permitted was also examined as part of the level of service assessment. The total travel distance needed to respond to a sign was calculated, and then divided by the physical distance available at the site to perform these actions. This measure indicated whether enough time was provided for a driver to react to the message.

## **Assessment of Methodology**

Messer and McNees developed a tool to objectively assess the workload and response criteria, but the navigation criteria remain relatively subjective. This method will permit comparisons between signing alternatives, but it may be too cumbersome to use in practice. The user must perform a variety of calculations to determine the amount of time or space available to see and react to a sign, and the conditions used to determine these values often represent idealized situations. This methodology is a step in the right direction, but may have limited value to the practitioner.



## CHAPTER 4. OBSERVED GUIDE SIGN DEFICIENCIES

Several studies attempted to assess the adequacy of freeway guide signs that are actually in use around the country. This chapter summarizes some of the common problems that were observed on guide signs in Texas and around the country. This chapter also addresses some possible methods that can be used to better tie the planning and design of guide signs to the geometric design of a new facility.

### NATIONAL STUDIES OF GUIDE SIGN ADEQUACY

Several studies have assessed the state of guide signing around the country. Roberts evaluated freeway guide signing on over 1000 interchange approaches in New Jersey (18). This study found 583 situations where there was some problem with the freeway signing on the approach to the interchange. Over 97 percent of these situations involved a fixed object obstructing some part of a freeway guide sign. These obstructions included things like utility poles, vegetation, and geometric conditions that obstructed the view of the sign. Another 1 percent of the situations stemmed from the signs being located in a complex environment. In these cases, it may have been difficult for the driver to pick out the sign from the surrounding background. Another problem was information on the signs was sometimes incomplete, unclear, or wrong.

Research has also shown that major urban areas tend to have freeway signs with very high information loads (19). Researchers inventoried signs in four Texas cities and six cities from around the country and attempted to identify sign structures where there was a very high information load (greater than 16 bits per sign structure). Table 9 shows the number of signs with large information loads for these 10 cities in 1980. The presence of these high information loads could reduce the ability of the driver to read and react to the information presented on the guide signs. The results of this study showed that cities in Texas tended to have higher percentages of sign structures with large amounts of information than cities surveyed in other states.

**Table 9. Percentage of Signs with Large Information Loads (19).**

| City        | Number of Signs Inventoried | Number of Sign Structures with > 16 Bits of Information | Rate |
|-------------|-----------------------------|---|------|
| Chicago     | 249                         | 20  | 8.0% |
| Houston     | 308                         | 24  | 7.8% |
| Dallas      | 280                         | 20  | 7.1% |
| Atlanta     | 142                         | 10  | 7.0% |
| San Antonio | 331                         | 23  | 6.9% |
| Fort Worth  | 310                         | 19  | 6.1% |
| Kansas City | 192                         | 10  | 5.2% |
| Los Angeles | 220                         | 8   | 3.6% |
| Denver      | 176                         | 5   | 2.8% |
| New Orleans | 84                          | 1   | 1.2% |

## GUIDE SIGN ADEQUACY IN TEXAS

A number of Texas studies identified potential problems with freeway guide signing. These studies have either attempted to identify inadequate locations in the field or to gather motorist opinions as to common misunderstandings with regard to freeway guide signing. It should be noted that the vast majority of freeway guide signs are adequate in the state. These studies attempted to determine situations which were repeatedly found across the state that could create problems with motorist understanding.

### General Problems Observed with Texas Guide Signs

The Center for Transportation Research (CTR) used driver surveys, input from TxDOT officials, and accident data to attempt to identify common deficiencies in freeway guide signs in Texas (20). It discovered three general types of problems, which are described below:

- problems created by poor or insufficient signing;
- problems created by complex or unusual road geometry; and
- problems created by driver limitations.

#### *Problems Created by Poor or Insufficient Signing*

Three general classifications of signing problems fall into this category. They are:

- **Information is not available:** In this case, information on a sign is missing or incomplete. Inadequate advance signing falls into this category. Permanent obstructions that block the view of the sign also are included in this category.
- **Information is temporarily obstructed:** The information required by a driver is temporarily obscured, possibly by a large truck or maintenance work. Lack of illumination or inclement weather can also cause information to become temporarily unavailable. Interchange reconstruction work was frequently observed to interfere with freeway guide signs in Texas.
- **Confusing, misleading, or erroneous information:** Signs can be confusing if too much information is presented, or if the information is ambiguous. Consistency in signing can reduce some of this confusion. Concurrent signing was identified as a factor that significantly contributes to driver confusion in Texas.

#### *Problems Caused by Complex or Unusual Road Geometry*

These problems tend to be site-specific and are usually caused by geometric features. Observed problems included:

- exit-related problems (left-hand exits, optional exits, etc.);
- sight distance problems (overhead structures block signs, problems with horizontal curvature and lane assignment signs); and

- other geometric features (lane drops, freeway splits, auxiliary lanes).

### *Problems Caused by Driver Limitations*

As discussed in the [previous chapter](#), reading guide signs can place a variety of demands on drivers. A variety of factors can impact a driver's information processing capabilities. The designer needs to consider these factors, although it may be very difficult to design signs to accommodate everyone on the road.

### **Common Driver Complaints and Observed Problems**

TTI researchers conducted a series of surveys, workshops, and interviews to determine what problems drivers commonly encountered with freeway guide signs in Texas (21). This assessment identified several areas where drivers commonly felt that freeway guide signs were inadequate. Common perceived deficiencies in freeway guide signing included:

- Drivers had difficulty in finding the needed navigational information.
- Information was not provided far enough in advance of an exit to allow the driver to change lanes.
- The drivers felt that the lane assignment information was sometimes inadequate.
- Drivers felt that more advance signing and better lane assignment were needed for unexpected geometric configurations, such as left-hand exits.
- Drivers were confused when a route had more than one name (either concurrent signing or a named state or U.S. route). This caused them to believe that they may have taken the wrong route, even though they were still on the correct roadway.
- Drivers felt that there was inconsistency in the way that information was presented from one sign to the next.

The drivers identified 82 freeway locations that they thought were confusing. The researchers then examined the freeway sites to determine if these perceived deficiencies were actually present at the site. The researchers found three primary problems at these locations:

- Lane assignment information was lacking or absent at 30 of the 82 sites examined.
- Guide signs were not placed at locations that provided sufficient time for a driver to react to the message at 16 of the sites.
- The geometrics of the site limited sight distance at 11 of the sites examined.

### **IMPROVING GUIDE SIGN LOCATION PRACTICES**

As noted earlier, geometric features can sometimes obscure freeway guide signs. In these cases, it is possible that the location of the guide signs was not considered in the initial planning of the project. If the locations of guide signs are considered as an afterthought to the design process, the geometry of the road can limit sight distances to the signs or produce misleading situations where the lane assignment on the signs may not be readily apparent to approaching motorists.

Dean proposed that the planning for the placement of freeway guide signs take place concurrently with the design and planning of a highway (22). By doing this, some of the conflicts between the guide signs and the horizontal and vertical alignments of the roadway could be avoided and the expectancy of the driver could be better served. When this study was performed in the late 1970s, Dean proposed the use of perspective plots and physical mock-ups to show the relationship between the geometry of the road and the placement of signs. Now, 3-D imaging and visualization has progressed to the point where 3-D models of the placement of freeway signs could be created to identify any potential siting problems.

## CHAPTER 5. GUIDE SIGN MESSAGE SELECTION FOR SPECIFIC CONDITIONS

The results of the [previous chapter](#) showed that there are several areas where freeway guide signing could be improved in order to increase driver understanding. This chapter summarizes past tests of various sign messages. Some of this research resulted in changes to both the U.S. and Texas MUTCDs, and the research recommendations are now standards. Other research has not been implemented on a widespread scale.

### SIGNING FOR DOWNTOWN AREAS

A TTI research project investigated different methods of signing for the downtown of an urban area (23). There was some concern that just signing a generic “Downtown” message would not provide enough information to motorists. The researchers showed slides with different messages to 100 subjects. Driver reaction times and preferences were recorded to evaluate the effectiveness of the messages. [Table 10](#) shows the messages that should be used to designate the downtown area at various locations in an urban area.

**Table 10. Signing for Downtown Areas.**

| Location                                 | Message on Sign                              |
|--|--|
| Entering city limits                     | City name only, no downtown-specific message |
| Approaching beltway or loop road         | Downtown – city name                         |
| Intersecting freeway leading to downtown | Downtown                                     |
| Downtown exit                            | Name of road                                 |

### CONTROL CITIES FOR DESTINATION AND DISTANCE SIGNS

The national standard for the selection of control cities on interstate highways is the American Association of State Highway and Transportation Officials document *List of Control Cities for Use in Guide Signs on Interstate Highways* (24). TTI researchers attempted to define desirable attributes of control cities for use on destination and distance signs off the interstate system (23). They surveyed test subjects to determine desirable population and distance characteristics of control cities. The results of this preference survey are summarized in [Table 11](#).

**Table 11. Desirable Characteristics of Control Cities.**

| Characteristic of Control City      | Percent of Drivers Desiring Characteristic |
|-------------------------------------|--|
| Population between 5000 and 25000   | 21   |
| Population greater than 100,000     | 65   |
| Located no more than 100 miles away | 50   |
| Located no more than 200 miles away | 85   |

McClure developed a hierarchy of control cities that should be used on destination and distance signs (25). The final hierarchy for the selection of control cities was, in order of primacy:

- primary cities: Houston, Dallas, San Antonio, Austin, El Paso, and Fort Worth;
- logical extension to a primary city;
- secondary cities: cities with populations greater than 25,000;
- logical extension to a secondary city;
- tertiary cities and towns: cities with populations greater than 2500 or county seats;
- logical extension to a tertiary city or town;
- next town on the official travel map;
- other towns or communities, recreational or cultural traffic generators, or government facilities;
- logical extension to next town on map or other destinations; and
- junctions with state-maintained routes.

McClure also recommended distance limits for signing destination and distance signs. These limits are presented in [Table 12](#).

**Table 12. Maximum Distances for Destination Types on Destination and Distance Signs.**

| Type of Destination              | Maximum Distance Limit (miles) |
|----------------------------------|--------------------------------|
| Primary City                     | 200                            |
| Secondary City                   | 100                            |
| Tertiary City                    | 50                             |
| Other Destinations and Junctions | 30                             |

## CONCURRENT ROUTES

TTI researchers examined ways to sign routes that are concurrently signed with another route (26). This study found that two common routes appearing side by side on an exit guide sign misled drivers to think that they referred to different routes to be accessed by different lanes. When the destinations were moved under one another, drivers had a better understanding of the meaning of the concurrent signing.

## LANE ASSIGNMENT

Several studies have attempted to identify situations where drivers do not understand the lane assignment message being conveyed by a guide sign. These studies have presented hypothetical scenarios to the survey subject and then assessed whether the subject correctly understood the situation being presented. The section summarizes the results of these driver surveys.

TTI researchers conducted a series of surveys at the Houston Auto Show in 1990 to determine driver understanding of lane assignment arrows (21). Some of the findings of this extensive survey included:

- Conventional diagrammatic signs did not convey lane assignment information as well as a modified diagrammatic sign shown in [Figure 4](#).

- The modified diagrammatic sign was 10 percent better than conventional diagrammatic signs in indicating when the right lane must exit and was 13 percent better than conventional diagrammatic signs at showing optional lane usage.
- There was a great deal of driver misunderstanding of optional lane usage on exit signs. Provision of “Exit Only” signs over the lane with a required exit did not improve understanding.
- When two common routes appeared side by side, many drivers felt that this meant that the routes were accessed by different lanes. Understanding was significantly improved by placing the routes under one another.
- “Next Left” signs were misinterpreted as a mandatory exit by 30 percent of the drivers. “Next Right” signs were misinterpreted as a mandatory right exit by 56 percent of drivers.
- The number of arrows shown on a modified diagrammatic sign should equal the number of lanes at that particular location on the road. Trying to show added lanes downstream of the sign location resulted in increased driver confusion.

CTR developed a series of driver surveys based on the problematic conditions identified earlier by TTI. These driver surveys focused on lane choice at exit direction signs. These surveys produced the following findings (20):

- Drivers had difficulty understanding guide signs when the number of lane assignment arrows did not equal the number of lanes on the road. When the number of lane assignment arrows were consistent with the number of lanes, this was not a problem.
- Diagrammatic signs were effective, but their effectiveness declined if too much information was presented. Information overload was particularly problematic with concurrent routing.

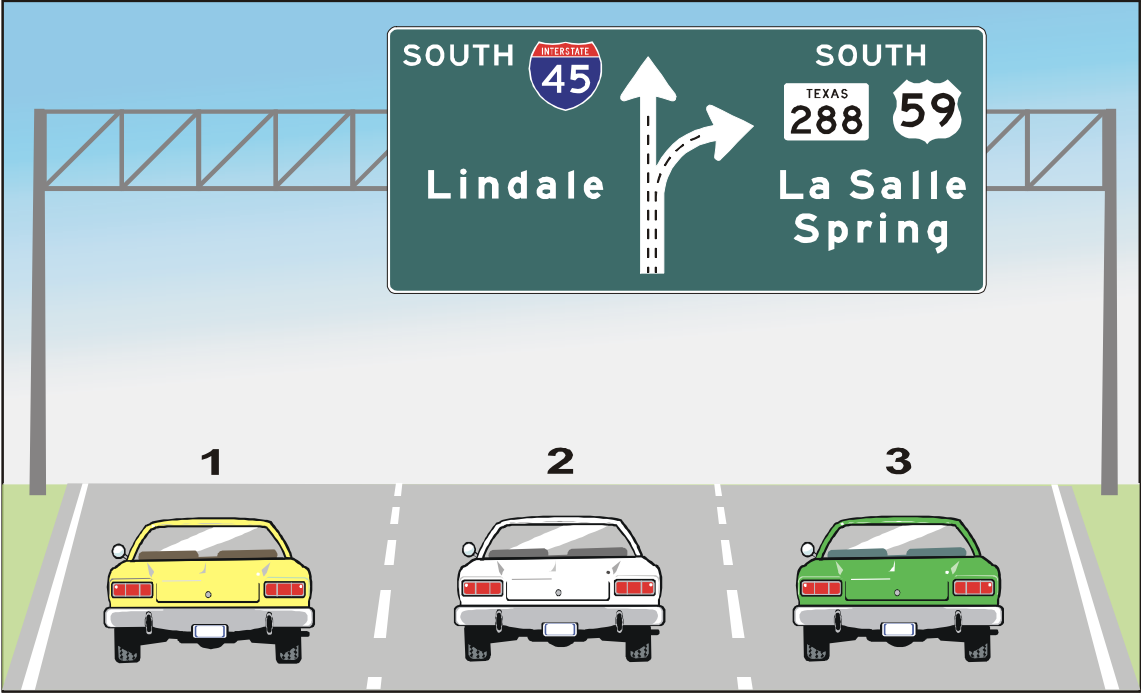
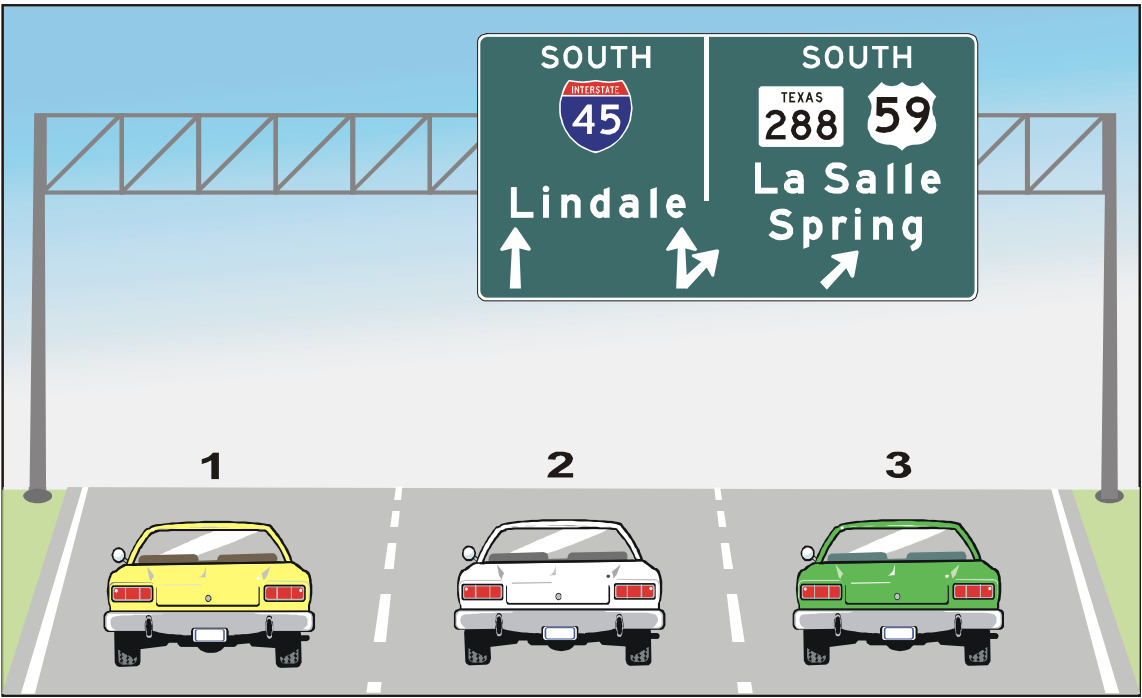


Figure 4. Diagrammatic Sign Types Tested (26).



## SIGNING AT INTERCHANGE LANE DROPS

Interchanges can represent very complex situations where the driver must make a series of decisions in a time-constrained environment. Situations where a lane is dropped at a freeway interchange have the potential to violate driver expectancy and can cause confusion among drivers. A variety of research has been performed to assess the effectiveness of different ways of signing lane drops at interchanges.

A study was conducted in the mid-1970s to assess the effectiveness of interchange lane drop signing standards (27). This study examined left- and right-side exits for single lane drops. After reviewing the literature, surveying state agencies, and performing some limited driver surveys, the researchers developed several recommended treatments for signing interchange lane drops:

- **Right-side interchange lane drop:** “Exit Only” signs placed on the advance guide signs and exit direction sign significantly improved driver understanding of the lane drop. This research provided support for these signs being made part of the MUTCD requirements for signing lane drops.
- **Left-side interchange lane drop:** Based on previous research, diagrammatic signs were recommended for use on left-side exits. The researchers did not conduct any independent evaluation of the effectiveness of diagrammatic signs in this context.

Another study examined four alternative ways to sign for an interchange lane drop. The following different exit panel messages were evaluated: “MUST EXIT,” “EXIT ONLY,” “ONLY,” and “EXIT LANE” (28). Drivers viewed signs with these supplemental panels, and then needed to match the signing to the appropriate geometric layout for the interchange. This study found that supplemental messages positively influenced the selection of an appropriate route geometry, with the “EXIT ONLY” and “MUST EXIT” plaques being most effective. The “EXIT ONLY” panel was found to be more effective than the “MUST EXIT” plaque for left-hand exits. This research supported the findings of the earlier study that showed the “EXIT ONLY” panel was effective in indicating an interchange lane drop.

## EXITS WITH OPTIONAL LANES

Somers et al. evaluated alternative treatments for right-side multilane exits (29). First, the researchers evaluated innovative ways to sign an optional exit lane for a multilane exit. They tested the supplemental messages “EXIT OK” and “MAY EXIT” for use on the optional exit lane. They also examined the use of a divergent arrow over the optional lane to indicate lane usage. The divergent arrow was tested by itself, as well as in conjunction with the “EXIT OK” and “MAY EXIT” messages. They hypothesized that this additional guidance would improve driver understanding of the use of the optional lane. Examples of these messages with divergent arrows are shown in Figure 5.



**Figure 5. Signage Alternatives Examined for Multilane Exits.**

These alternatives were evaluated by surveying 548 subjects and evaluating their lane choices and comprehension of the messages. This survey produced several results:

- Only between 50-65 percent of Texas drivers understood the current method for signing optional lanes on multilane exits.
- Adding the supplemental message “MAY EXIT” improved driver understanding of the optional lane use.
- The divergent arrow confused many survey participants, who misinterpreted its navigational meaning.

The researchers then examined methods for signing a multilane exit with an optional lane exit followed by a secondary ramp split. This study evaluated treatments that utilized the “MAY EXIT” supplemental message and modified standards from Ohio and Texas. This study showed that the differences between the “MAY EXIT” and modified Texas standard were not as large as the earlier survey results indicated. None of the methods provided a significant improvement over existing methods for signing a multilane exit followed by a secondary ramp split.

In another study, TTI researchers examined problems with signing exits that had optional lane usage (26). The researchers evaluated the following conditions by using a driver survey:

- right-side exit with a lane drop and optional exit lane and
- optional left-side exits.

The findings for the right-side exit with a lane drop and optional exit lane included:

- Traditional diagrammatic signs did not convey lane assignment information very well.
- The researchers tested a modified diagrammatic sign that used arrows similar to lane assignment arrows. The modified diagrammatic sign performed about 10 percent better than conventional diagrammatic signs.
- White downward-pointing arrows were not understood by drivers as conveying optional lane usage. Driver understanding did not improve even if the white down arrow was positioned directly over the appropriate lane.
- When the message “NEXT RIGHT” was added to a guide sign beneath a destination, 56 percent of drivers misinterpreted the message as a mandatory movement.

The findings for the optional left-side exit included:

- Use of the message “NEXT LEFT” was misinterpreted by 30 percent of drivers as meaning a mandatory left exit.

## **DIAGRAMMATIC SIGNS**

Diagrammatic freeway guide signs have been studied extensively since the early 1970s. Many of these early studies produced contradictory results regarding the efficacy of diagrammatic signs, but many of these differences were attributed to site-specific characteristics

of the interchanges being studied. This section describes some of the past research on diagrammatic signing and reviews some past studies on the use of modified diagrammatic signs.

### **Laboratory Testing**

One early laboratory evaluation of diagrammatic signs was conducted by Gordon in 1972 (30). Sixty test subjects viewed a series of slides with diagrammatic or conventional signs for six interchanges on Interstate 495 in Washington, D.C. The lane choice, reaction time, and driver preference for each type of sign was evaluated. This study found that drivers generally performed better at lane selection and had shorter reaction times with conventional signing. The conventional signs were also preferred by a larger number of test subjects than the diagrammatic signs. It is possible that these results may have been influenced by greater driver familiarity with conventional signs than the then experimental diagrammatic signs.

The National Highway Traffic Safety Administration (NHTSA) conducted another laboratory study of diagrammatic signs (31). The researchers showed 102 subjects a series of signs with different guide signing concepts. The signs included conventional signing, diagrammatic signs showing a plan view of the interchange, and diagrammatic signs that attempted to provide a driver's eye perspective of the upcoming interchange. Although the diagrammatic signs did not perform significantly better than conventional signing in most cases, they significantly improved lane choice selections when collector-distributor roads were present, when a secondary split occurred on a ramp, and when there was a major split in the highway. Driver preference studies showed that drivers preferred diagrammatic signs with plan views over all other types of signs.

A study examined the relative effectiveness of using diagrammatic signs rather than conventional guide signs (32). A series of slides were shown to 120 subjects. Subjects indicated which lane they would travel in to reach a predefined destination, and the correctness and latency of the response was recorded. This study found that there was no significant difference between the use of diagrammatic and conventional guide signs. The findings showed that subjects responded more quickly to conventional guide signs, and generally seemed to prefer them to diagrammatic signs. These results may be biased, however, since the study was conducted at a time when diagrammatic signs were not familiar to many drivers. It is possible that results would be different if the study were conducted today.

Another study of diagrammatic signs by McGuiness surveyed driver opinions about diagrammatic signs in the Columbus, Ohio, area (33). The survey showed that the diagrammatic signs were preferred over conventional guide signs by unfamiliar drivers.

In general, the laboratory evaluations of diagrammatic signs did not show conclusive evidence that the diagrammatic signs outperformed conventional signs. The research did identify specific geometric situations where the diagrammatic signs performed better than the conventional signs, but they did not show a widespread superiority over conventional guide signing across a range of conditions.

## Field Evaluations

Diagrammatic signs were also tested in the field on two separate occasions. Roberts examined the use of diagrammatic freeway guide signs in New Jersey by implementing diagrammatic signs at an interchange (34). The researchers collected data on erratic maneuvers and traffic volumes at the interchange when conventional signing, diagrammatic signing, and diagrammatic signing with lane lines were used. In general, the diagrammatic signs performed better than the conventional signing. The number of erratic maneuvers dropped when diagrammatic signs were implemented and was reduced further when lane lines were added to the diagrammatic signs.

Hanscom examined a field application of diagrammatic signs to an interchange on Interstate 495 (35). Traffic volumes and the number of erratic maneuvers at the site were examined. The number of erratic maneuvers actually increased after the diagrammatic signs were installed, but the researchers noted that data for diagrammatic signs were collected during late spring and early summer. During these months, the proportion of drivers not familiar with the area increases on the highways around Washington, D.C. The researchers hypothesized that these non-local drivers were responsible for the increase in erratic maneuvers.

## Modified Diagrammatic Signs

In *Guidelines and Recommendations to Accommodate Older Drivers and Pedestrians*, several recommendations are made to alter diagrammatic signs in order to improve the understanding of older drivers (36). The authors recommend using a modified form of diagrammatic signing where a separate lane assignment arrow indicates the lane use on a freeway. The modified diagrammatic sign is shown at the top of Figure 4. The number of arrow shafts on the modified diagrammatic sign should be the same as the number of lanes on the freeway. The report notes that this configuration is not approved by the MUTCD and requires FHWA permission before it can be used. Two studies have evaluated the effectiveness of modified diagrammatic signs in the past.

As noted earlier, a research study revealed that modified diagrammatic signs can convey lane assignment information better than a traditional diagrammatic sign (26). The researchers tested a modified diagrammatic sign that used arrows similar to lane assignment arrows. Drivers performed about 10 percent better at selecting appropriate lanes when modified diagrammatic signs replaced conventional diagrammatic signs.

Skowronek examined the use of modified diagrammatic signs at freeway interchanges in Houston (37). Skowronek evaluated a variety of signing treatments at problematic Houston interchanges in an attempt to improve driver understanding. He conducted a driver survey where he tested conventional signing, diagrammatic signing, and modified diagrammatic signing. The major findings of Skowronek's study included:

- The position of the sign had a major impact on the correctness of lane choice decisions for the conventional and modified diagrammatic signing. The signs should be positioned over the appropriate lanes in order to ensure the drivers understand the message correctly.

- The modified diagrammatic sign appeared to be effective in communicating lane assignment information. It appeared to provide superior performance to other sign types for signing optional exit lanes.
- More study is needed to develop guidelines for the amount and placement of information on modified diagrammatic signs.

Based on these research results, modified diagrammatic signing appears to be worthy of more research. Past research on conventional diagrammatic signing has not provided conclusive results about its efficacy. The modified diagrammatic signs may provide a chance to improve driver understanding and also reduce sign fabrication costs.

## CHAPTER 6. GUIDE SIGN DESIGN

The Texas MUTCD, TxDOT standards sheets, and the *Standard Highway Sign Designs for Texas* volume contain information on how to properly design a freeway guide sign (1, 2, 38). While these documents provide basic information on how to design and layout a guide sign, it may be difficult for someone who is inexperienced at sign design to easily make use of this information. In many cases, the detailed information required to design a sign properly is “hidden” within paragraphs of text or is scattered among many different sections of the two documents.

Most guide signs are not designed manually. A number of commercially available software packages can be used to help designers create guide signs. Typically, a designer will select a blank guide sign template, and then add whatever components are necessary for the sign. The program usually has some requirements that set the size and spacing of the different components of the sign.

There are several potential issues with the use of sign design software in the guide sign process. This literature review did not uncover any objective analyses of the capabilities of sign design software or of the extent to which the software replicates the guidance in the MUTCD and other design documents. There is the potential that software may produce signs that are in compliance with the U.S. MUTCD but not Texas guidelines. Second, users of the software must have a basic understanding of guide sign design principles. They must be able to determine when the software produces a design that does not meet the MUTCD or appears to be unrealistic. The user must also be able to make judgments that may reduce sign fabrication costs but still comply with the appropriate design documents.

This chapter briefly summarizes existing design guidance found in the Texas MUTCD, the *Standard Highway Sign Designs for Texas*, and the TxDOT standard sheets. Several states have attempted to create detailed documents for sign design. This chapter also examines sign design documents created by the Ohio Department of Transportation (ODOT) and the Washington Department of Transportation (WSDOT). Finally, issues related to sign retroreflection and illumination are briefly reviewed.

It is expected that the information in this chapter may help form future design guidelines for the *Freeway Sign Handbook*. The contents of the manuals from other states may serve as models for the development of portions of the *Freeway Sign Handbook* that will be produced by this project. These sections will provide important guidance for sign designers to consult when using software to develop guide signs.

### TEXAS DESIGN GUIDANCE

This section summarizes some of the design guidance in the Texas MUTCD, the *Standard Highway Sign Designs for Texas*, and the TxDOT standard sheets. The appropriate sources are referenced in each section.

## Size of Lettering and Legend Spacing

### *Legend Size*

The Texas MUTCD provides guidance as to the letter height on guide signs (I). All signs should use series E(Modified) letters. Tables 13 and 14 show the letter heights specified by the Texas MUTCD.

### *Uppercase and Lowercase Letters*

All names of places, streets, and highways shall be composed of lower case letters with initial capital letters (I). The initial capital letters shall be 1.333 the loop height of lowercase letters. Other word legends shall be in uppercase letters only.

### *Intraword Spacing*

The amount of space between letters in a word varies with the shape, size, and series of the letters involved. Refer to the spacing charts provided in the *Standard Highway Sign Designs for Texas* for the required amount of space between letters in a word (38).

## Placement of Legend

### *Message Alignment*

Messages should usually be centered around the vertical axis of the sign background (I). There are two exceptions to this rule:

- destination and distance signs, and
- interchange sequence signs.

These signs should have equal margins to the left and right for every line of copy.



**Table 13. Letter and Numeral Sizes for Expressway and Freeway Guide Signs in Inches (I).**

| Type of Sign                              | Element of Sign      | Expressway <sup>a</sup> |          |              |         |          | Freeway <sup>a</sup> |          |              |         |          |                |     |
|---|----------------------|-------------------------|----------|--------------|---------|----------|----------------------|----------|--------------|---------|----------|----------------|-----|
|   |                      | Major                   |          | Intermediate | Minor   | Overhead | Major                |          | Intermediate | Minor   | Overhead | Sequence Signs |     |
|   |                      | Cat. (a)                | Cat. (b) |              |         |          | Cat. (a)             | Cat. (b) |              |         |          |                |     |
| A. Advance Guide and Exit Direction Signs | Exit Panel           | Word                    | 10       | 10           | 10      | 8        | 10                   | 10       | 10           | 10      | 10       | 10             | N/A |
|   |                      | Numeral                 | 15       | 15           | 15      | 12       | 15                   | 15       | 15           | 15      | 15       | 15             |     |
|   |                      | Letter                  | 15       | 15           | 15      | 12       | 15                   | 15       | 15           | 15      | 15       | 15             |     |
| Route Marker Interstate                   | Numeral              | 18                      | N/A      | N/A          | N/A     | 18       | 20 min, 24 max   18  | N/A      | N/A          | N/A     | 18       | 15 min, 18 max |     |
|   | 1-2 Digit Shield     | 45 × 36                 | N/A      | N/A          | N/A     | 45 × 36  | 60 × 48   45 × 36    | N/A      | N/A          | N/A     | 45 × 36  | 45 × 36        |     |
|   | 3 Digit Shield       | 48 × 48                 | N/A      | N/A          | N/A     | 48 × 48  | 60 × 48   48 × 48    | N/A      | N/A          | N/A     | 48 × 48  | 45 × 36        |     |
| Business Loop or Spur Interstate          | Numeral              | 18                      | N/A      | N/A          | N/A     | 18       | 24 18                | N/A      | N/A          | N/A     | 18       | 18             |     |
|   | 1-2 Digit Shield     | 36 × 36                 | N/A      | N/A          | N/A     | 36 × 36  | 48 × 48   36 × 36    | N/A      | N/A          | N/A     | 36 × 36  | 36 × 36        |     |
| U.S. or State Marker                      | Numeral              | 18                      | 18       | 18           | 12      | 18       | 24 18                | 18       | 18           | 12      | 18       | 12             |     |
|   | 1-2 Digit Shield     | 36 × 36                 | 36 × 36  | 36 × 36      | 24 × 24 | 36 × 36  | 48 × 48   36 × 36    | 36 × 36  | 36 × 36      | 24 × 24 | 36 × 36  | 24 × 24        |     |
|   | 3 Digit Shield       | 45 × 36                 | 45 × 36  | 45 × 36      | 30 × 24 | 45 × 36  | 60 × 48   45 × 36    | 45 × 36  | 45 × 36      | 30 × 24 | 45 × 36  | 30 × 24        |     |
|   | Alternate Initials   | 15                      | 12       | 12           | 10      | 12       | 15                   | 15 12    | 12           | 10      | 12       | 10             |     |
|   | Alternate Numeral    | 18                      | 15       | 15           | 12      | 15       | 18                   | 18 15    | 15           | 12      | 15       | 12             |     |
| Cardinal Direction                        | Word                 | 15                      | 12       | 10           | 8       | 12       | 15                   | 15 12    | 12           | 8       | 12       | 10             |     |
|   | First Letter of Word | 18                      | 15       | 12           | 10      | 15       | 18                   | 18/15    | 15           | 10      | 15       | 12             |     |
| Business                                  | Word                 | 12                      | 10       | 8            | 8       | 10       | 12                   | 12 10    | 10           | 8       | 10       | 8              |     |
| Name of Place, Street or Highway          | Word                 | 20 15                   | 16 12    | 13.3 10      | 10.6 8  | 16 12    | 20 15                | 20 15    | 16 12        | 13.3 10 | 16 12    | 13.3 10        |     |
| Distance                                  | Numeral              | 18                      | 15       | 12           | 10      | 15       | 18                   | 18 15    | 15           | 12      | 15       | 12             |     |
|   | Fraction             | 12                      | 10       | 10           | 8       | 10       | 12                   | 12 10    | 10           | 8       | 10       | 10             |     |
|   | Word                 | 12                      | 10       | 10           | 8       | 10       | 12                   | 12 10    | 10           | 8       | 10       |                |     |
| Action Message                            | Word                 | 10                      | 10       | 10           | 8       | 10       | N/A                  | N/A      | N/A          | N/A     | N/A      | N/A            |     |

<sup>a</sup> Numbers separated by a “|” represent the preferred and minimum sizes (“preferred|minimum”)

**Table 14. Letter and Numeral Heights for Expressway and Freeway Guide Signs in Inches (I).**

| Type of Sign                             | Expressway <sup>a</sup> | Freeway <sup>a</sup> |
|--|-------------------------|----------------------|
| <i>B. Gore Signs</i>                     |                         |                      |
| At Major and Intermediate Interchanges   |                         |                      |
| Word                                     | 10                      | 12                   |
| Numeral and Letter                       | 12                      | 18                   |
| At Minor Interchanges                    |                         |                      |
| Word                                     | 8                       | 8                    |
| Numeral and Letter                       | 10                      | 10                   |
| <i>C. Pull-Through Signs</i>             |                         |                      |
| Destination Message                      |                         |                      |
| Word                                     | 13.3 10                 | 16 12                |
| Route Marker as Message                  |                         |                      |
| Cardinal Direction                       | 10                      | 12                   |
| First Letter of Cardinal Direction       | 12                      | 15                   |
| Route Marker                             | 36 × 36                 | 36 × 36              |
| <i>D. Supplemental Guide Signs</i>       |                         |                      |
| Exit Number                              |                         |                      |
| Word                                     | 8                       | 10                   |
| Numeral                                  | 12                      | 15                   |
| Letter                                   | 12                      | 15                   |
| Place Name                               | 10.6 8                  | 13.3 10              |
| Action Message                           | 8                       | 10                   |
| <i>E. Interchange Sequence Signs</i>     |                         |                      |
| Word                                     | 10.6 8                  | 13.3 10              |
| Distance Numeral                         | 10                      | 10                   |
| Fraction                                 | 8                       | 10                   |
| <i>F. "Next – Exits" Signs</i>           |                         |                      |
| Place name                               | 10.6 8                  | 13.3 10              |
| Next – Exits                             | 8                       | 10                   |
| <i>G. Distance Signs</i>                 |                         |                      |
| Word                                     | 8 6                     | 8 6                  |
| Numeral                                  | 8                       | 8                    |
| <i>H. "Exit Only" Sign</i>               |                         |                      |
| Word                                     | 12                      | 12                   |
| <i>I. Diagrammatic Signs</i>             |                         |                      |
| Lane Width                               |                         | 5                    |
| Lane Lines                               |                         | 1 × 6                |
| Vertical Space between Lane Lines        |                         | 6                    |
| Stem Height                              |                         | 30                   |
| Space between Arrowhead and Route Shield |                         | 12                   |

<sup>a</sup> Numbers separated by a “|” represent the preferred and minimum sizes (“preferred|minimum”)

### *Route Shield Placement*

Route shields should be located either above or beside a destination. Cardinal directions, JCT, BUSINESS, and TO should be placed either above or beside the route shield. When placed above the route shield, the message should be centered. When placed beside the shield, the top of the message should be on the same horizontal line as the top of the route shield. When placed beside the route shield, JCT and TO should be located to the left of the shield while cardinal directions and BUSINESS should be located to the right of the shield.

### *Arrow Placement*

On all exit direction signs, “up” arrows shall be upward slanting and located on the same side of the sign as the actual exit ramp (*I*). Arrow angles shall approximate the departure angle of the ramp.

Downward-pointing arrows are to be used only for lane assignment. They shall be used only on overhead guide signs to indicate specific lanes that must be used for traffic to reach a destination. A separate arrow should be centered over each lane for the signed destination or route.

## **Spacing**

Before the final dimensions of a sign can be determined, a number of individual components need to be sized. This section addresses the required spacing for borders, between lines of text, and between words in a line.

### *Border Width*

For guide signs larger than 10 feet by 6 feet, the border should be 2 inches wide (*I*). For smaller guide signs, the border should be approximately 1.25 inches wide. However, the width of the border should not exceed the stroke width of the letters on the sign.

### *Top Border Spacing*

The spacing between the bottom edge of the top border to the top of the nearest line of copy should be equal to the average letter height in the first line of copy (*I*). In no case should the spacing be less than 0.5 of the average letter height in the first line of copy (*38*).

### *Bottom Border Spacing*

The spacing between the top edge of the bottom border to the bottom of the nearest line of copy should be equal to the average of the letter and numeral heights in the last line of copy (*I*). In no case should this spacing be less than 0.5 of the average letter and numeral heights in the last line of copy (*38*).

When a downward-pointing arrow is present in the last line of text, this spacing requirement changes (*38*). In this case, the top edge of the bottom border should be placed a

distance equal to the average of the arrow and letter height in the last line of the copy from the bottom edge of the text. This distance can be reduced to up to 0.5 of the average of the arrow and letter height, if necessary.

If an arrow is placed by itself in the last line of text, the spacing between the border and the lowest point of the arrow shall be equal to the spacing at the top of the sign (38).

#### *Right and Left Vertical Spacing*

The spacing from the inside edge of the vertical borders to the nearest copy on the longest line shall be equal to the letter height of the largest uppercase letter or numeral on the sign (I). All remaining lines of copy shall be centered with the sign, with the exception of interchange sequence and distance signs.

#### *Corner Radii*

The corner radii should be approximately 0.125 of the minimum dimension on guide signs (I). In no case should the radii exceed 12 inches. The sign area outside of the border does not need to be trimmed.

### **Interline Spacing**

#### *Between Lines of Text*

The spacing between the top and bottom of uppercase letters in adjacent lines of text should be equal to 0.75 the average height of the uppercase letters (I). This spacing may be reduced to up to 0.5 of the average height, if necessary (38).

#### *Between Route Markers and Lines Below*

The spacing between a route marker and an adjacent line of text shall be equal to 0.75 of the average height of the numeral in the route marker and the largest letter, numeral, or arrow in the next line of text (38). This distance shall be measured from the lowest point on the route markers to the top of the uppercase letter in the next line of text.

#### *Between a Line of Text and an Upward-Sloping Arrow*

The interline spacing between a line of text and an upward-sloping arrow shall be equal to the average height of the uppercase letters in the line of text above the arrow times 0.75 (38).

#### *Between a Route Marker and an Upward-Sloping Arrow*

The interline spacing between a route marker and an upward-sloping arrow shall be equal to the height of the numeral inside the route marker times 0.75 (38).

## **Intraline Spacing**

The spacing between different words, numerals, arrows, and route markers is usually equal to 1.5 times the upper case letter height on a specific line of text (38). This spacing applies to the following situations:

- between two words;
- between a word and a numeral;
- between a word and an arrow;
- between a word and a route marker; and
- between an arrow and a numeral.

### *Between Adjacent Route Markers*

When two route markers are in the same line of text, they shall be optically centered on the sign (38). The spacing between the markers should be greater than or equal to the height of the numeral within the route marker.

## **Final Sizing of Sign**

The size of the sign is primarily dictated by the length of the message on the sign, although several other factors can influence a sign's dimensions (38). For example, the size of overhead signs may be limited by the amount of available space, particularly if the sign must be mounted over a specific lane. The size of available materials for constructing the sign may also act to limit the shape of the sign. The designer must weigh these factors in order to determine the final size of the sign. Spacing dimensions should then be adjusted so that the dimensions of the sign are multiples of 6 inches. However, all previous guidelines should be adhered to.

## **Areas Where Guidance is Needed**

Review of the Texas sign design guidelines revealed several situations where no guidance was available. These areas include:

- There are no guidelines for the spacing between a route marker and the top border. The only guidelines available are for the spacing between text and the top border.
- More information is needed on how to space text around fractions.
- Guidelines for the use of separation lines should be developed. These lines are often used to distinguish between destinations, but there is no official guidance on their use.

## **SIGN DESIGN LAYOUT STANDARDS FOR DIRECTIONAL GUIDE SIGNS**

The Ohio Department of Transportation has developed a document that provides detailed design standards for freeway guide signs (39). This section summarizes the major parts of this document, with particular emphasis on portions of the manual that are not in any of the Texas standards.

## Legend Size Determination

The ODOT layout standards provide an easy-to-use table that helps the designer choose the appropriate legend size for a sign based on the characteristics of the roadway. This guidance is summarized in [Table 15](#).

**Table 15. ODOT Guidelines for Text Size (Inches) (39).**

| Category | Description  | Shield Size | Letter Size (U.C./L.C.) | Number Size | All Capitals |
|----------|--|-------------|-------------------------|-------------|--------------|
| 1        | Major guide signs on freeway main lanes  | 36          | 16/12                   | 16          | 12           |
| 2        | Signs on main lanes of expressways, or for supplemental guide signs on freeway main lanes  | 30          | 13.33/10                | 13.33       | 10           |
| 3        | Signs on 4 lane streets approaching interchanges with freeways or expressways, or for supplemental guide signs on expressways          | 24          | 10.67/8                 | 10.67       | 8            |
| 4        | Ground-mounted signs on freeway and expressway exit ramps, and signs on two-lane streets at interchanges with freeways and expressways | 24          | 8/6                     | 8           | 6            |

## Sign Width

The ODOT manual also provides detailed procedures for determining the width of a sign. First, the length of the text on the sign is determined. Spacing charts in the manual address all combinations of letters and text heights. The manual also specifies that the spacing between words is equal to 1.25 times the height of the uppercase or capital letters in the line of text. Once the length of the text has been determined, edge spacing factors are applied and the cumulative length is rounded off. The requirements for edge spacing and rounding are shown in [Table 16](#).

**Table 16. ODOT Edge Spacing and Rounding Criteria (39).**

| Category | Edge Space Size | Rounding Off Criteria                 |
|----------|-----------------|---------------------------------------|
| 1        | 36              | If > 0.375 ft, round up to next foot  |
| 2        | 30              | If > 0.3125 ft, round up to next foot |
| 3        | 24              | If > 0.250 ft, round up to next foot  |
| 4        | 18              | If > 0.1875 ft, round up to next foot |

## Sign Layout

The majority of the ODOT manual involves providing standardized layouts for a variety of different combinations of text, arrows, and route shields. The manual shows a series of vertical dimensions for 55 guide sign layouts and provides very general guidelines for laying out combinations that are not covered. [Figure 6](#) shows an example of some of the layout guidance provided.

# TYPICAL ARRANGEMENT OF GUIDE SIGN ELEMENTS

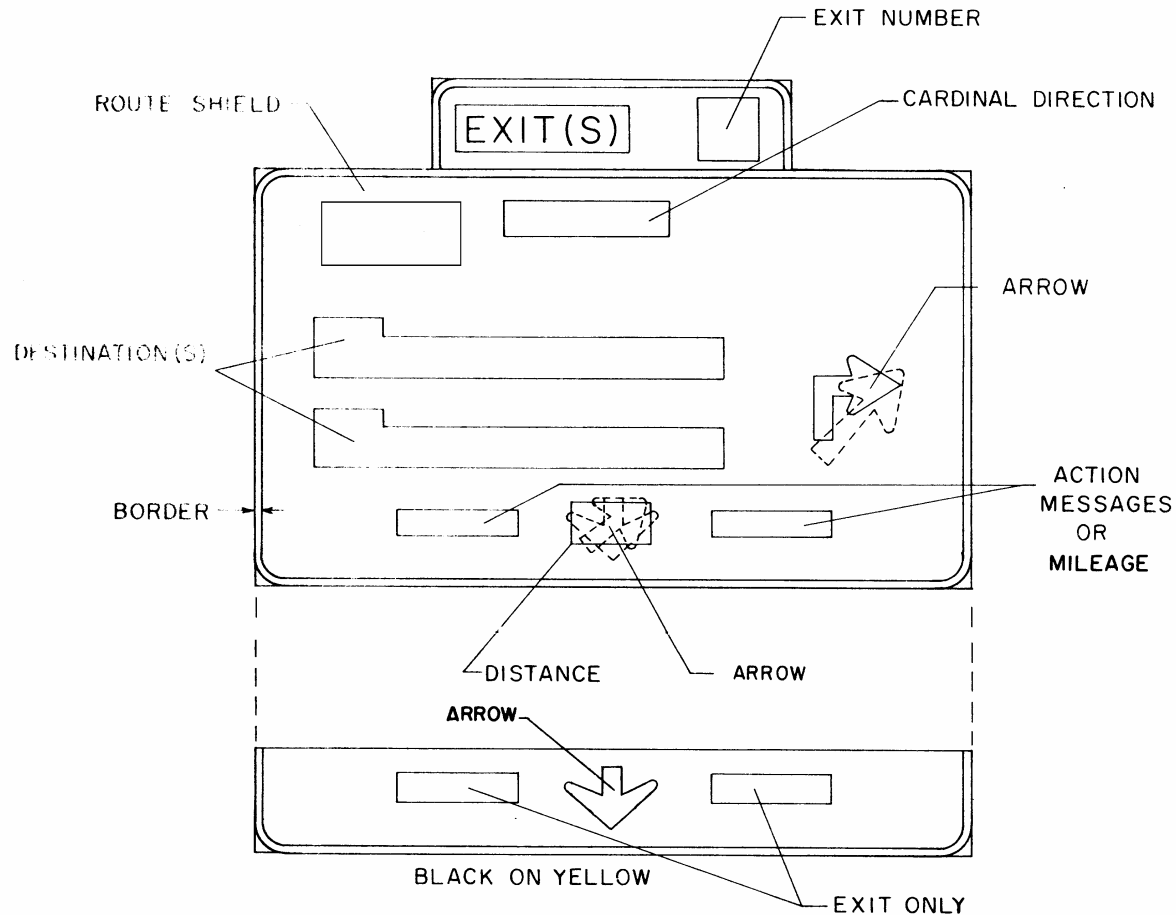


Figure 6. Arrangement of Guide Sign Elements from ODOT Manual (39).

## SIGN FABRICATION MANUAL AND INTERACTIVE WEB SITE

WSDOT has developed some innovative ways to present guidance for the design of guide signs. Information on guide sign design is found in three forms:

- **Sign Fabrication Manual:** This text document provides guidance on how to design and size a guide sign (40).
- **Interactive Web Site:** WSDOT maintains a web site that expands somewhat on the guidance in the *Sign Fabrication Manual*, and provides some examples of how to perform the appropriate calculations (41). Figure 7 shows the front page of the WSDOT sign web site.

- **Computer Programs:** WSDOT provides several simple computer programs and templates to aid in the sign design process. These programs are free and can be downloaded from the state web site. For example, a simple DOS-based program is available to calculate the width of a sign based on a line of text (42). A sample of the output of the program is shown in Figure 8.



Figure 7. WSDOT Sign Design Web Site (41).

The contents of the *Sign Fabrication Manual* will be discussed in this section. In general, the web site includes all of the information included in the *Sign Fabrication Manual*, supplemented by additional graphics and tables in order to better present the information.

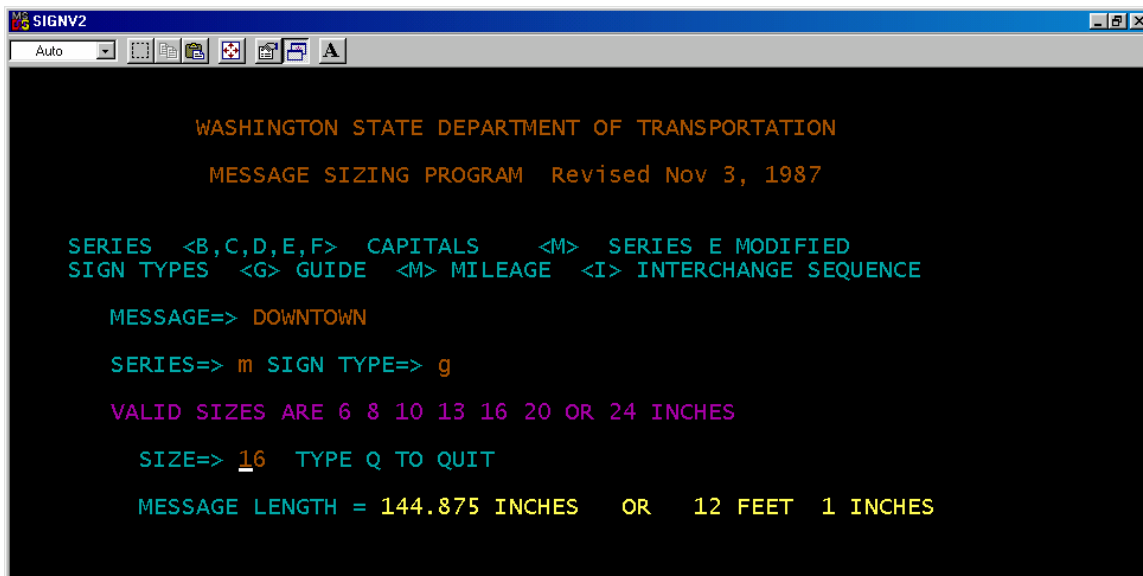


Figure 8. WSDOT Sign Design Program (42).



## General Guidelines

One area where the WSDOT manual differs from other documents is that it provides some general guidelines to deal with practical problems related to sign fabrication. Some of the general guidelines included in the manual are:

- WSDOT has a policy that all overhead signs facing the same direction on a sign structure should have the same height. This policy is to improve the aesthetics of the sign structure. The layout of the sign may be modified from the standards in order to meet this requirement.
- The WSDOT manual also recommends that the designer take the size of the available substrate material into consideration when designing the sign. The manual states that plywood and aluminum are available in sizes up to 5 feet by 12 feet. If a sign is taller than 12 feet, then a horizontal splice will need to be used.

## Spacing Requirements

The WSDOT manual also includes spacing regulations for the following conditions:

- between letters in a word;
- between words in a line;
- between lines of copy;
- edge spacing; and
- fractions.

## Sizing Fractions

The WSDOT manual provides information on how to size fractions and space other sign components around a fraction. Fractions are treated as a unit, called the fraction rectangle. The fraction rectangle includes both numerals and the diagonal divider. The length of the diagonal is equal to 1.7 times the numeral height in the fraction. It has the same stroke width as the fraction numerals and is mounted at a 60 degree angle from the horizontal. The width of the fraction rectangle is 2.5 times the numeral height, except when the upper numeral is a “1”. In this case, the width of the fraction rectangle is two times the numeral height.

## Sign Layout

Unlike the ODOT manual where there is a series of templates for laying out signs, the WSDOT manual provides general text guidelines for laying out messages. In addition to general guidance for the placement of words, arrows, and route shields, the WSDOT manual provides guidance to ensure the proper separation of messages on a guide sign. Specifically, it provides information on how to break up a message so that a single destination cannot be confused as being two destinations. Guidelines are also provided to use white separation bars to distinguish between two separate destinations on the same guide sign.

## Sample Calculations

The WSDOT web site includes a detailed example that illustrates the process of sizing and laying out a sign. This provides good information to someone that is inexperienced in the process of laying out a guide sign.

## SIGN LIGHTING AND RETROREFLECTORIZATION

Issues related to sign lighting and retroreflection are becoming increasingly important to many state transportation agencies. Advances in sheeting technology, as well as possible future federal minimum retroreflectivity requirements for signs have caused many agencies to critically examine their current procedures for providing illumination or choosing the type of retroreflective material to use on a sign. The current edition of the U.S. MUTCD states that (3):

Letters, numerals, symbols, and borders of all guide signs shall be retroreflectorized. The background of all signs that are not independently illuminated shall be retroreflectorized.

Providing sign lighting for all freeway signs can be very costly, so many state departments of transportation prefer to retroreflectorize the backgrounds of signs whenever possible. A study by McNees and Jones attempted to determine the legibility of lighted and unlighted signs (43). In 1986, they examined sign lighting policies from across the country. Some of the findings from this survey included:

- Most states prefer to have no sign lighting in most non-critical situations.
- There is a widespread preference for the use of high-intensity sheeting with no lights.
- Most states allowed sign lighting to be turned off if one of the following conditions did not exist:
  - The critical sight distance was greater than 1200 feet.
  - The horizontal curvature was no more than an 800 foot radius.
  - The sign contained an action message.

The researchers then attempted to define areas that should use sign illumination. They examined the target value of a variety of different signs by using an instrumented vehicle to drive urban freeways in Houston. The major findings of this study included:

- When vertical curves limit sight distance, sign lighting should be used instead of retroreflectorized backgrounds.
- The signs that were within the foveal region (0 to 5 degrees) performed significantly better when they were externally illuminated. In the peripheral region (5 to 10 degrees), the retroreflectorized sign performed significantly better.
- The target value of the sign was generally equal to two to three times the legibility distance.

This project was conducted prior to the introduction of microprismatic sheetings. Several ongoing research projects are investigating the legibility impact of microprismatic sheeting on interchange guide signs. It is not the purpose of this document to exhaustively review research

related to sign legibility and retroreflectivity, and the reader is advised to consult appropriate reports to learn more information.



## CHAPTER 7. SIGN MAINTENANCE AND MANAGEMENT

Many freeway guide signs currently in place on the road have exceeded their useful service lives. Maintenance and replacement of existing freeway guide signs has taken on a high priority in many states, causing many to implement a sign maintenance and improvement program. This section covers a variety of issues related to sign maintenance.

### SIGN MAINTENANCE AND IMPROVEMENT PROGRAM

Researchers developed a generic program for guide sign maintenance and improvement based on interviews and on-site visits to eight states (44). The basic purpose of these programs was to identify signs that were damaged, deteriorated, or had some other deficiency in the quality of the background or legend. The maintenance could consist of either refurbishing an existing sign or completely replacing the guide sign installation. The programs that were reviewed ideally had the following basic components:

- Sign Inventory – A database of what is in place in the field.
- Inspection – A standardized inspection program to assess the quality of signs that are in the field.
- Replacement Decision – A set of criteria used to determine when a sign should be replaced or repaired.
- Project Identification – A procedure for deciding on the scope of the improvement.
- Priority Programming – A process for determining which projects should be undertaken first.
- Implementation – Actual maintenance or replacement work.

### SIGN INVENTORY

A well-maintained sign inventory is usually a critical component to the maintenance process, although only 15 states in the U.S. were found to have a sign inventory program in 1990 (44). The inventory provides a record of the signs that are on the road, allowing the agency to better identify missing or deficient signs. Many states maintain records of their freeway signing using some sort of database program. Interested readers should consult *NCHRP Synthesis 157* (National Cooperative Highway Research Program) for more detailed information on sign inventory practices and management procedures (45). Some typical information that would be included for each sign in the inventory is listed below:

- sign location,
- MUTCD designation,
- width of sign,
- height of sign,
- sign message,
- sign substrate,
- sign color,
- sign material (background and legend), and
- date of installation and/or last maintenance.

## **SIGN INSPECTION**

A regular program of sign inspections must be carried out in order to determine whether a sign needs to be cleaned, repaired, or replaced. There are several possible methods that can be used to carry out these inspections.

### **Human Observation and Inspection**

In this method, inspectors examine the signs while driving at night and make subjective assessments of whether the signs appear to be performing adequately (44). This method is used by many state departments of transportation and has the advantages of being relatively inexpensive and quick to perform. However, this method is subjective, and it is possible that independent observers could come to different conclusions about the adequacy of a sign.

Past studies have shown that human observers can make relatively accurate decisions about the adequacy of a particular sign. The Washington State Department of Transportation trained observers to recognize adequate levels of retroreflectivity in STOP and warning signs (46). The human observer ratings of whether a sign was acceptable or unacceptable were in agreement with the values produced by a sign retroreflectometer for 75 percent of the signs evaluated. A recent study at TTI showed that when TxDOT inspectors applied normal nighttime inspection techniques, they generally considered fewer signs to be acceptable than strict application of retroreflectivity criteria (47). Both studies showed that visual inspection of signs can identify deficient signs that should be replaced.

### **Retroreflectometers**

It is also possible to assess the retroreflectivity of signs by collecting data using retroreflectometers. The advantage of this method is that it should produce an objective, repeatable measurement of the adequacy of the sign. However, collecting these data can be very time consuming and costly, particularly for overhead guide signs. Measurement of an overhead guide sign with a retroreflectometer may require that a lane on a freeway be closed in order to accommodate the work. Several non-contact retroreflectometers have been developed that may make it easier to measure overhead guide signs. The abilities of these instruments are currently the subject of an evaluation by the Highway Innovative Technology Evaluation Center. No standards have been established at the national level to determine what measurements are adequate for a specific color and type of sheeting.

## **SIGN SERVICE LIFE**

A freeway guide sign can be considered effective for as long as it provides a minimum required legibility distance for a large percentage of drivers. Degradation in this legibility distance can come as a result of reduced retroreflectivity, vandalism, and loss of color that can reduce contrast between the legend and the background.

A study performed in 1992 evaluated the retroreflectivity of over 5700 signs in 15 states to determine factors that could influence sign service life (48). Red, yellow, white, and green

signs that were made of engineering grade (EG) or high-intensity (HI) sheeting were examined. The signs measured were between 1 and 12 years old. The researchers compared their measured values with the values required for new sheeting specified in federal standard FP-85 (49). Years where the average value of the signs fell below the values specified in FP-85 are summarized in Table 17.

**Table 17. Sheeting Degradation.**

| Color  | Sheeting Type | New Sheeting R <sub>A</sub> per FP-85 | Year of Noncompliance with FP-85 |
|--------|---------------|---------------------------------------|----------------------------------|
| Red    | EG            | 14.5                                  | 9-10 years                       |
|        | HI            | 45.0                                  | 1-2 years                        |
| Yellow | EG            | 50.0                                  | 12 years                         |
|        | HI            | 170.0                                 | Always compliant within 12 years |
| White  | EG            | 70.0                                  | 9-10 years                       |
|        | HI            | 250.0                                 | 12 years                         |
| Green  | EG            | 9.0                                   | Always compliant within 12 years |
|        | HI            | 45.0                                  | 6 years                          |

There are several limitations to this study. First, degraded sheetings were compared to a specification for new sheeting. It is quite likely that the sheetings were not at the ends of their service lives when they fell below the values in FP-85. The researchers also noted that contrast ratio, rather than retroreflectance, was often the determining factor as to whether a sign was still adequate, especially for red signs. Finally, signs on high-intensity sheeting were underrepresented in this evaluation, particularly older high-intensity signs. It is possible that these results would be different now that there are more older high-intensity signs on the road.

A 1996 study by TTI surveyed TxDOT districts to determine average service life for signs in Texas (50). The average service life obtained from this survey is summarized in Table 18.

**Table 18. Average Service Life for Sheeting in Texas.**

| Color  | Average Service Life (Years) |                |
|--------|------------------------------|----------------|
|        | Engineering Grade            | High Intensity |
| White  | 6.5                          | 6.8            |
| Yellow | 6.4                          | 6.2            |
| Red    | 6.0                          | 5.7            |
| Green  | 6.8                          | 6.5            |

TxDOT districts also ranked factors that they felt significantly influenced the service life of signs. The factors in order from most important to least important were:

1. direction of exposure,
2. location,
3. color,
4. geographic region of Texas, and
5. manufacturer.





## CHAPTER 8. PRELIMINARY GUIDELINES AND FUTURE RESEARCH NEEDS

The review of past research facilitated the formulation of preliminary guidelines for inclusion in the *Freeway Sign Handbook* and also served to identify areas which still needed further research. This chapter summarizes some of the past research findings that could be readily incorporated into the handbook. It also lists areas in which the Texas MUTCD should be changed to bring it into compliance with the U.S. MUTCD. Areas where the existing research base appears to be incomplete or non-existent are also reviewed. These areas may be investigated in further detail during this project, subject to the consensus of the project advisory committee.

### SUMMARY OF CHANGES TO THE TEXAS MUTCD

This section provides a summary of the changes that may need to be made to the Texas MUTCD in order to bring it into compliance with the U.S. MUTCD. [Table 19](#) summarizes the additions and deletions that should be made to the Texas MUTCD, while [Table 20](#) summarizes information that is in the Texas MUTCD but not in the U.S. MUTCD that should be retained. More detailed descriptions of the potential changes can be found in [Chapter 2](#). In addition to these changes, the formatting of the Texas MUTCD should be made similar to the current U.S. MUTCD.

**Table 19. Potential Additions or Deletions to the Texas MUTCD.**

| U.S. MUTCD | Texas MUTCD | Description of Potential Change   |
|------------|-------------|---|
| 2E.05      | 2F-17       | An engineering study should be required to show that retroreflectorization is adequate for overhead signs.  |
| 2E.06      | 2F-4        | Additional characteristics and treatments for urban signing should be added. Guidance that lower speeds should not result in lower signing standards should be added.         |
| 2E.13      | 2F-11       | Change requirements for changeable message signs, rest area and scenic area signs, and diagrammatic signs.  |
| 2E.16      | 2F-14       | Add guidance for abbreviating the directions of streets.  |
| 2E.19      | 2F-41       | Add new guidelines for diagrammatic signs.  |
| 2E.21      | 6F-2        | Add new section including guidelines for permanent changeable message signs on freeways.  |
| 2E.23      | 2F-20       | Provide specific guidelines for the lateral clearance required for guide signs.   |
| 2E.27      | 2F-28       | Eliminate the shorter allowable spacings between guide signs on low speed roads.  |
| 2E.28      | 2F-24       | Require 30 inch exit number plaques. Consider requiring exit numbering for all freeways, instead of just interstates. Consider allowing the use of "LEFT EXIT" number panels. |
| 2E.29      | 2F-27       | Define minor interchanges as carrying no more than 100 vpd in the design year.  |
| 2E.30      | 2F-30       | Intermediate interchanges should preferably have three advance guide signs. Minor interchange spacing should be changed to 0.5 to 1.0 miles from the gore.                    |
| 2E.34      | 2F-34       | Consider allowing the exit number to be located within the face of the sign.  |

**Table 20. Information in the Texas MUTCD to be Retained.**

| U.S. MUTCD | Texas MUTCD | Description of Potential Change   |
|------------|-------------|---|
| 2E.11      | 2F-35       | Information on the location of pull-through signs in current Texas MUTCD should be retained.  |
| 2E.12      | 2F-7        | Information on how to sign off-route destinations in current Texas MUTCD should be retained.  |
| 2E.13      | 2F-11       | Retain all requirements where the font or shield size is larger than specified in U.S. MUTCD. |
| 2E.18      | 2F-16       | Retain guidance for lane assignment arrows.   |

**PRELIMINARY GUIDELINES**

One of the purposes of this document was to identify past research that could be used in the *Freeway Sign Handbook*. The Texas MUTCD, *Standard Highway Sign Designs*, and TxDOT standards sheets provide an obvious source of guidelines for the *Handbook*. These documents can be summarized to provide information on sign design and placement. Several past research studies have also produced results that could be easily incorporated into the *Handbook*. This section summarizes past research that has immediate application to the *Handbook*.

**Sign Information Content**

Based on previous research, there appears to be a maximum amount of information that a driver can process. [Table 21](#) should be incorporated into the *Freeway Sign Handbook* to ensure that drivers are not overloaded with information.

**Table 21. Maximum Information Content on Sign Structure (10).**

| Number of Panels on Structure | Condition | Maximum Units of Information per Structure |
|-------------------------------|-----------|--|
| 2                             | Desirable | 12   |
|                               | Maximum   | 16   |
| 3                             | Desirable | 18   |
|                               | Maximum   | 20   |
| 4                             | Desirable | 16   |
|                               | Maximum   | 20   |
| 5                             | Desirable | Undesirable Design                         |
|                               | Maximum   | 20   |

**Lane Assignment**

Past research studies have identified several issues related to lane assignment that could be immediately incorporated into the handbook. Some potential guidelines may include:

- When lane assignment information is presented on a freeway guide sign, the number of arrows shown on the sign should equal the number of lanes on the road (20).
- White downward-pointing arrows do not convey optional lane usage to many drivers (26). Alternative methods of signing optional lane use need to be developed.

- Signs saying “NEXT LEFT” or “NEXT RIGHT” were frequently misunderstood by drivers (26). Many drivers interpreted these signs to indicate a mandatory movement. These signs should be used with caution.

### **Concurrent Route and Named and Numbered Route Signing**

Research has shown that routes with more than one name confuse many motorists (21). Some drivers have noted that they thought they were on the wrong road when the name they were expecting to see was not presented to them. The use of multiple names for routes should be minimized.

When a freeway exit serves multiple routes, the route shields should be placed on top of one another (26). Drivers sometimes interpret two route shields side by side as indicating that the two routes are accessed from two different lanes.

### **FUTURE RESEARCH NEEDS**

While some of the research provided initial guidelines for the *Handbook*, other research provided insight into areas that needed more research before they were incorporated into the document. This section describes potential areas for future research.

#### **Diagrammatic Signs**

A number of studies have attempted to assess the effectiveness of diagrammatic signs, but many of the studies have failed to show dramatic improvements in driver comprehension over traditional text signing. It appears that the cost to use diagrammatic signs may not be justified based on the relatively small improvements in driver understanding. Potential avenues for further research in this area include:

- The use of modified diagrammatic signing should be examined in a more detailed manner. Initial evaluations of this signing have shown promise, but more research is needed to determine its effectiveness.
- Diagrammatic signing needs to be evaluated from a driver legibility perspective. Specifically, the lane lines in the shaft of the diagrammatic arrow should be examined to determine when drivers can realistically determine lane use information from a diagrammatic sign.

#### **Freeway Splits and Concurrently Signed Routes**

Past research has shown that drivers have difficulty understanding signing on concurrent routes or routes that have both a name and a numerical designation. Potential research areas include:

- Evaluation of alternative strategies for signing freeway splits should be examined. There appears to be a high level of misunderstanding connected to the MUTCD-specified method for signing splits. Potential alternatives could include diagrammatic signs, modified diagrammatic signs, and signing the split as an exit rather than as a split.

- There does not appear to be a high level of understanding of the meaning of downward-pointing arrows on guide signs at freeway splits. Alternatives should be examined to better indicate the presence of a split.

### **Design and Placement Guidelines**

There are several areas where additional guidelines are needed for sign design and placement. Some potential areas where additional guidance is needed include:

- Improved guidelines for the number of advance guide signs required for left exits or complex situations are needed. The MUTCD specifies that up to three advance guide signs may be used, but it may be desirable to provide more advance warning to drivers when they are confronted with a complex situation.
- Guidelines are needed for the use of separation lines to distinguish between different destinations on interchange sequence signs and advance guide signs.
- Standardized layouts for common combinations of sign elements should be developed to increase the consistency of signing throughout the state. These layouts could take a form similar to the design manual used by the Ohio Department of Transportation.

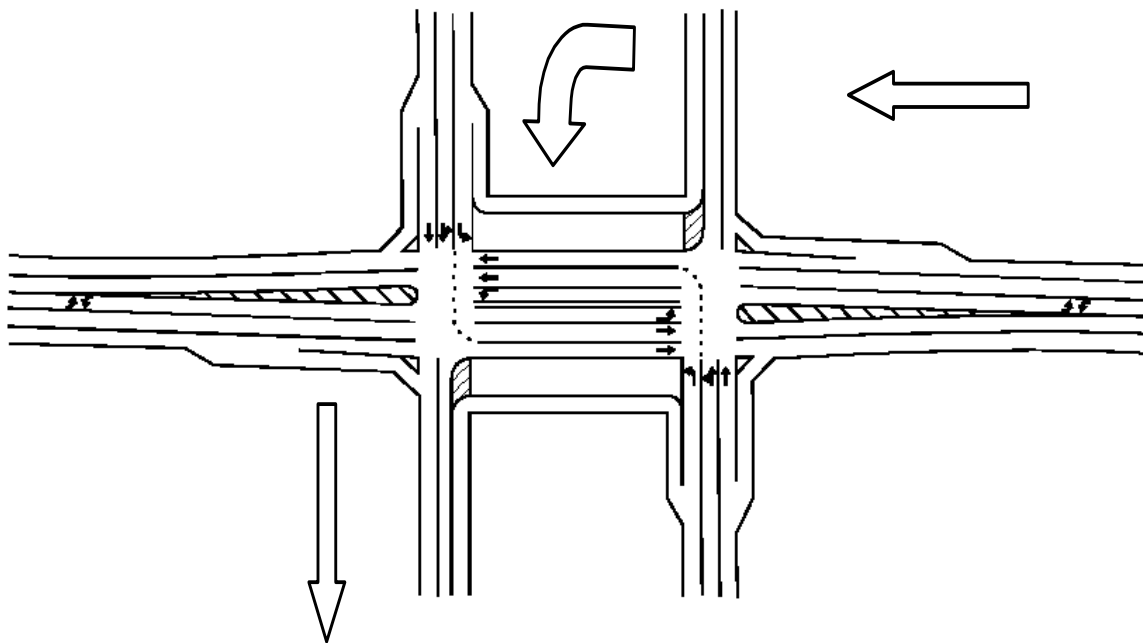
### **Frontage Road and Cross-Road Signing**

In Texas, frontage roads serve as a vital link between surface streets and freeways and also provide access to land surrounding the freeway. Even though frontage roads play a very important role in maintaining system connectivity, no research was found on how to properly sign frontage roads. The literature search found no instances where signing research was conducted on frontage road approaches at interchanges and on interchange cross streets. There are a number of potential research topics in this area that could improve signing at these locations, particularly in urban areas. Some potential areas where further guidance is needed for frontage roads include:

- Route marker placement on freeway frontage roads for freeway entrance ramps: No guidelines currently exist to tell the engineer whether to place the route marker on the right- or left-hand side of the frontage road. This guidance will probably be developed through consultation with the project advisory committee.
- Use and placement of lane control signs on approaches to cross street intersections: Conversations with TxDOT engineering staff have indicated that there is a need for more uniformity in how lane control signs are used on frontage roads. Specifically, there is a need to define which movements must be shown and whether advance lane control signs should be used in congested urban areas.
- Use of advance street name signs: Guidance is needed to determine under what conditions to use advance street name signs.
- Measures to prevent wrong-way freeway entry: Research is needed to determine ways that wrong-way entry onto freeways can be discouraged. A TxDOT project is currently set to examine this issue starting in September 2002.

In addition to frontage roads, more research is needed on how to sign the cross-road at an interchange. Some potential research areas include:

- Methods of signing two closely spaced intersections at diamond interchanges: Diamond interchanges are commonly used in many Texas cities. In congested, urban situations, the lane assignment on the cross street can violate driver expectancies. This can particularly be a problem when a driver needs to travel through one intersection of the frontage road with a cross street to reach the second frontage road intersection to turn left. Under congested conditions, drivers will need to select their lanes prior to the first intersection. If their mental maps of the interchange configuration are incorrect, they may not be able to easily change lanes in the short distance between the two frontage road intersections. See [Figure 9](#) to see an example of this movement.



**Figure 9. Left Turn Movement at a Closely Spaced Diamond Interchange.**

- Advance guide signing for interchanges: Some TxDOT personnel have indicated that they would like to see better guidance for the use of advance guide signs on major arterial streets approaching freeway interchanges.
- Signing for loop ramps: Given the prevalence of diamond interchanges in Texas, many drivers do not expect to encounter a loop ramp at an interchange. Some additional guidance is needed to better sign loop ramps on cross streets.



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