Traffic Control Devices Pooled Fund Study

Guide Sign Design

Final Report

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BACKGROUND

The American Traffic Safety Services Association (ATSSA) Sign Committee developed a list of items with pictures of situations in the field that required research and/or guidance for constancy and uniformity. The Traffic Control Devices Pooled Fund Study (TCD PFS) decided to develop this analysis paper based on existing guidance and sign design principles.

INTRODUCTION

The Manual on Uniform Traffic Control Devices (MUTCD) defines a guide sign as "a sign that shows route designations, destinations, directions, distances, services, points of interest, or other geographical, recreational, or cultural information."[1] The MUTCD indicates that Guide signs on freeways and expressways should serve distinct functions as follows:

A. Give directions to destinations, or to streets or highway routes, at intersections or interchanges;
B. Furnish advance notice of the approach to intersections or interchanges;
C. Direct road users into appropriate lanes in advance of diverging or merging movements;
D. Identify routes and directions on those routes;
E. Show distances to destinations;
F. Indicate access to general motorist services, rest, scenic, and recreational areas; and
G. Provide other information of value to the road user.

Appropriate guide signing is essential to keeping road users informed of their location, providing navigational information, and promoting efficient operations. The MUTCD also states that for a traffic control device (TCD) to be effective it should:

A. Fulfill a need;
B. Command Attention;
C. Convey a clear, simple meaning;
D. Command Respect from road users; and
E. Give adequate time for proper response.

Aspects of design, placement, operation, maintenance and uniformity should all be considered in order to maximize the ability of TCDs to meet these five requirements.[1] This report focuses specifically on the design of Guide Signs.

DESIGNING FOR THE DRIVER

The driving task can be broken down into three key levels of subtasks: control, guidance and navigation[2]; drivers search the environment for the information necessary to complete these subtasks. According to Lansdown (2004), "Sign design should support anticipation of the network, reduce uncertainty, and, ideally, modify behavior to improve safety."[3] As such, the effectiveness of guide signs will be dependent on driver characteristics and factors such as their

mental or motivational state, experience of familiarity with the route, driver expectations and cognitive processes. Therefore, guide sign design should consider both the conditions of the situation and principles that consider human factors such as ensuring that signs are designed based on driver expectations (not just of signs, but of the entire roadway environment), understanding the impacts of perceptual factors which influence sign comprehension, selecting sign messages carefully and with good reason, and ensuring that signs are uniform and consistent based on situations encountered by road users.

DRIVER EXPECTATIONS

Drivers have expectations regarding many aspects of driving including, but not limited to, speed, traffic, the geometry of the roadway, what information will be provided to them, as well as when, how, and where that information will be provided. Roadway conditions which contribute to driver expectations include roadway alignment, width, shoulders, surface texture and/or signs and markings.[2] Lunenfield and Alexander (1984) define expectancy as "a driver's readiness to respond to situations, events, and information in predictable and successful ways" and provide the following attributes of driver expectations:[4]

- Expectancy influences response speed and accuracy.
- Drivers tend to anticipate upcoming situations and events that are common to the road they are traveling.
- The more predictable the roadway feature, the less likely will be the chance for errors.
- Drivers experience problems when they are surprised.
- Drivers, in the absence of counter evidence, assume that they will only have to react to standard situations.
- The roadway and its environment upstream of a site create an expectancy of downstream conditions. Drivers experience problems in transition areas and locations with inconsistent design or operation.
- Expectancies are associated with all levels of driving performance and all aspects of the driving situation. This includes expectancies relative to speed, path, direction, the roadway, the environment, geometric design, traffic operations, and traffic control devices.

Previous research has indicated that drivers experience problems and make errors when their expectations are violated[5] and information that violates expectancies leads to longer task times and/or errors, whereas information that reinforces expectancies helps drivers to respond faster[6]. Therefore, it is important to take driver expectation into account when designing guide signs.

Richard and Lichty (2013) conducted a thorough literature review and focus group discussions on driver expectations at interchanges; they reported the following conclusions, in the context of navigation of interchanges, which are consequently relevant to the design of guide signs:[7]

- Drivers expect that there will be functional relationships between lanes on the roadway and arrows/text on signs and that the signs themselves will make these relationships clear.

- Drivers expect that the distance between a guide sign and a "last chance" decision point will be sufficient to allow for making any necessary lane changes in a safe and timely manner.
- Drivers expect that they will have more than one opportunity to obtain necessary destination and lane information before they need to make a final decision regarding lane choices.
- Drivers expect that the freeway system (i.e., lanes, arrows, signs with text, lane markings, etc.) will provide them with the necessary information to construct a mental model and that it will be sufficient to support timely and accurate decisions about lane choice.
- Drivers expect that the information available to them through the freeway system will be sufficient to support decisions about lane choices. At the least, they will never have to move over more than one lane at the last moment.
- Drivers expect that the freeway system will provide sufficient information to support decisions about all route choices, not just frequent or popular choices.

PERCEPTUAL FACTORS

As described in the previous section, drivers form expectations about the upcoming geometry of the roadway, the information that will be provided to them, and the actions that they should take based on the design and placement of signs and markings. Specific factors related to the design of guide signs, including the location and layout of a sign, as well as how information is grouped within a sign, can influence how drivers interpret the sign.[7,8] Such factors must therefore be considered during the design of guide signs in order to ensure that the signs will be effective, intuitive, and usable to drivers.

According to Campbell et al., there are presumably three stages of perceptual and cognitive processes by which road users comprehend the meaning of a sign; these stages of driver comprehension, described in

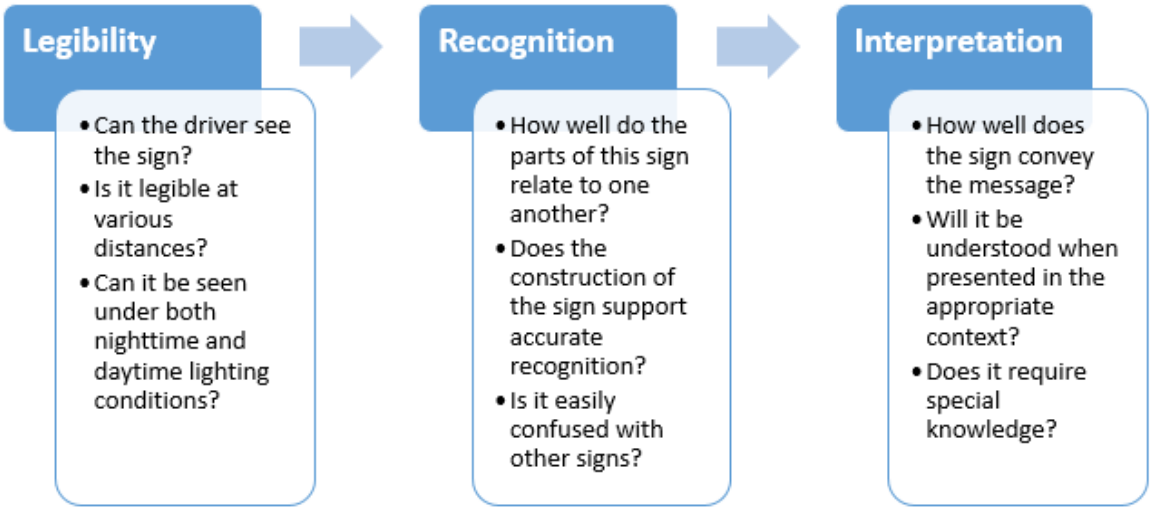

Figure 1, include legibility, recognition, and interpretation.[9]

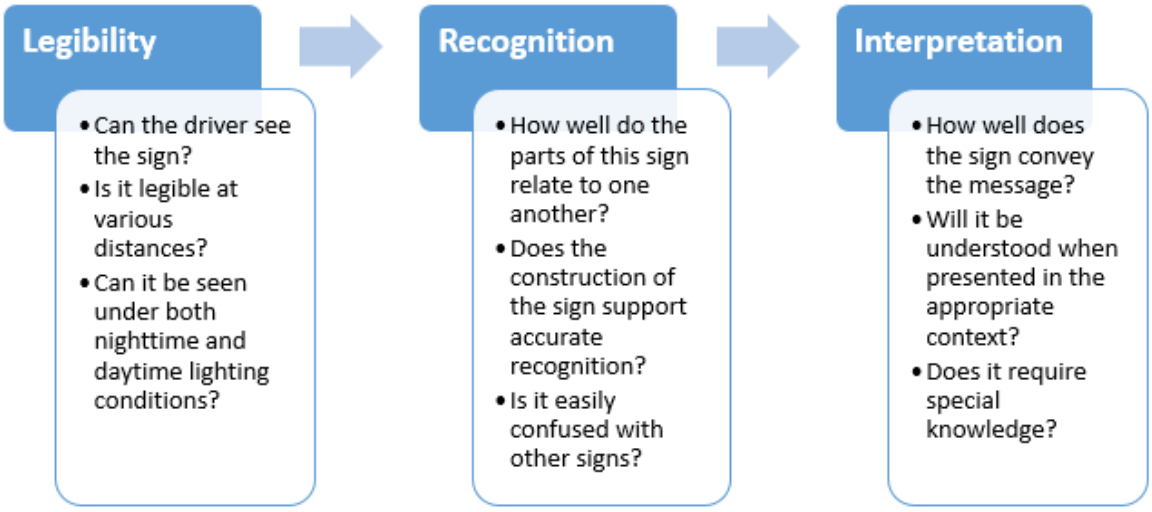

Figure 1 Cognitive processes of comprehending signs, as described by Campbell et al. (adapted from Campbell et al., 2004).

Legibility refers to the initial perception of the sign and the driver's ability to discern the elements of the sign. In order for signs to be legible, designers must consider retroreflectivity, color, font, letter height, letter case, spacing/margins, and other elements such as visual grouping and separation of information. Recognition refers to whether or not the driver can distinguish the sign. Uniformity and standardization within the roadway system can help shape the expectations of road users and thus facilitate in recognition of signs. Interpretation refers to whether the driver comprehends the meaning or intent of the sign. Guide signs should deliver the intended message clearly and adequately without creating confusion or hazards to road users, and should also elicit appropriate responses/actions by road users.

In order to design guide signs that are legible, recognizable, and interpretable to drivers, designers/engineers must consider driver expectations and human perception and cognitive process and how they relate to various design factors. The following section provides an overview of some factors/principles that may impact how drivers interpret guide signs.

GUIDE SIGN DESIGN FACTORS

This section provides an overview of various aspects of Guide Sign design as they relate to human expectations, abilities and limitations. This is intended to provide a general idea of factors that should be considered during the Guide Sign design process; this is NOT intended to be a comprehensive list of design specifications or an alternative to other design references.

POSITIVE GUIDANCE

Positive guidance is a concept that is commonly applied when providing information to drivers; when used consistently, these principles can help to shape driver expectations about what information will be provided to them and where to seek information.[10] The concept of positive guidance involves creating a driving environment that has the following characteristics[11]:

- Motorists are provided with the maximum amount of useful information.
- Information is presented in such a way that 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.

INFORMATION SELECTION: GUIDE SIGN MESSAGES

In the guide sign design process, designers must first consider the external design inputs, such as marked routes, control destinations, and geometric design[12]; these factors should guide the selection of information that is relevant and necessary to meeting driver expectations and helping them to complete the driving task.

Information should be Comprehensive and Relevant.

The information presented on Guide Signs should help drivers to understand the roadway scenario, provide drivers with the necessary navigation information, and help them to understand any actions/movements that they need to take. Guide Signs should not be misleading or confusing to drivers; they should include enough information so that they address drivers' needs and meet their expectations, without providing excessive information that could overload or confuse drivers. Table 1 provides examples of general principles to consider for providing comprehensive and relevant information on Guide Signs.

Table 1 General Guidance for Providing Comprehensive and Relevant Information

GUIDANCE	DESCRIPTION / EXAMPLE
Provide Information that Addresses Drivers' Needs	Guide signs should help drivers to understand the roadway scenario, provide them with the necessary navigation information, and help them to understand any actions/movements that they need to take.
Present Information that is Necessary and Useful	Drivers should not have to weed through unnecessary information to find what they need. Providing too much information may cause confusion or overload.
Provide Information that meets Driver Expectations	Be aware of driver attributes and target populations. Provide information that driver expects to see.
Provide Information that Structures Driver Expectations of the upcoming Roadway	Drivers should not be surprised by roadway elements; consider elements that drivers may find unusual and provide information on elements that are specific to a particular roadway. Signs should not be misleading or confusing.

Use Shorter Legends to Reduce Complexity

Although Guide signs should present the information necessary for road users to safely and effectively navigate the roadways, presenting too much information could lead to information overload. Lerner et al. define Driver Information Overload (DIO) as occurrences "…when the driver cannot process the roadway information in sufficient time to respond properly and safely at the design speed or the 85th percentile operating speed, whichever is higher."[13] Drivers are likely to experience DIO in the vicinity of freeway exits, and may react by reducing speed to allow more time to process the information, potentially resulting in traffic slowdowns, conflicts or collisions.[13] Therefore, guide sign legends should be designed for simplicity, and shorter legends should be used where possible in order to reduce the complexity of the signs. The MUTCD indicates the following regarding the amount of legend on guide signs:

- Section 2D.07, paragraph 01: "The longer the legend on a guide sign, the longer it will take road users to comprehend it, regardless of letter size."
- Section 2D.07, paragraph 02: "Except where otherwise provided in this Manual, guide signs should be limited to no more than three lines of destinations, which include place names, route numbers, street names, and cardinal directions. Where two or more signs are included in the same overhead display, the amount of legend should be further minimized. Where appropriate, a distance message or action information, such as an exit number, NEXT RIGHT, or directional arrows, should be provided on guide signs in addition to the destinations."
- Section 2E.10, paragraph 01: "No more than two destination names or street names should be displayed on any Advance Guide sign or Exit Direction sign. A city name and street name on the same sign should be avoided. Where two or three signs are placed on the same supports, destinations or names should be limited to one per sign, or to a total of three in the display. Sign legends should not exceed three lines of copy, exclusive of the exit number and action or distance information."

Fontaine, Chrysler & Ford (2002) summarized past research on the relationship between number of words presented on guide signs and reading time.[10] McNees and Messer (as cited by Fontaine et al.) conducted a study to evaluate the ability of drivers to read and interpret freeway guide signs under limited time constraints; the research was used to predict desirable reading times for varying levels of information, as well as desirable and maximum amount of information that should be placed on overhead sign structures, which is shown in Table 2.

Table 2 Maximum Units of Information per Sign Structure (Adapted from Fontaine et al., 2002)

NUMBER OF PANELS ON STRUCTURE	UNITS OF INFORMATION PER STRUCTURE*	
	Desirable	**Maximum**
2	12	16
3	18	20
4	16	20
5	Undesirable design	20

**Each place or street name, route number, cardinal direction, command, distance, or lane-use arrow is counted as a separate unit of information.*

The *Human Factors Guidelines for Road Systems* report by Campbell et al. also includes guidelines design principles for legends, which are summarized in Table 3.

Table 3 Design Guidelines for Sign Legends (Adapted from Campbell et al.)

TYPE OF SIGN	GUIDELINES
Advance Sign	• Limit route and destination information to a total of three lines • Do not use more than two destination/street names. • Place intersecting streets on top line and distance to intersecting streets on bottom.
Conventional Guide	• Limit route and destination information to a total of three lines.
Exit Direction	• Limit route and destination information to a total of three lines. • Do not include more than two destination/street names.
Tourist	• Limit information to a total of two lines.
Service	• Limit general road user services to six.
Distance	• Limit traffic generators to three accompanied by the related distance. • Keep the highest priority distance (nearest distance) at the top or left.

SEPARATION AND ORGANIZATION OF INFORMATION

Once designers have determine what information will be presented on guide signs, they must also consider *how* that information will be presented. Guide signs should be designed and presented in a manner that is clearly understood by road users, effectively conveys the intended meaning of the sign, and elicits the appropriate responses or actions by road users. Just as sign placement and sign size can be used to influence the emphasis of signs (e.g. larger signs interpreted as more important than smaller signs), so can typographical features, color, spacing, etc. be used to emphasize particular sign features or aid in attention allocation. Furthermore, the appropriate arrangement of sign legends can improve legibility and facilitate recognition and interpretation of guide signs. Therefore, information should be presented so that it is easily accessible and discernable to road users. In this context, accessibility/discernibility refers to how easy it is for drivers to pull information from the guide sign; this will be heavily influenced by the organization of the sign (i.e. spatial layout and orientation of legend components), as well as the separation and grouping of information.

Figure 2 displays how simply changing the alignment of legend items transforms individual units of information into a visual "group" of information, which can clean up the appearance of a sign and make it easier to recognize and interpret. Visually aligning related legend items to create logical groups of information can facilitate sign comprehension, as these groups not only indicate that items are related, but also help to more clearly convey *how* they are related.

Figure 2 Example of legend grouping.

Figure 3 further demonstrates how the organization of legend components can be manipulated to change the appearance and effectiveness of signs. The figure includes a field installation in Oklahoma (left) and a proposed design (right) that reduces the size of the sign and applies the concepts of legend grouping and size group selection and application[12]; in the proposed design, the route marker and roadway name are grouped together, then grouped with the cardinal direction, and that unit as a whole is then grouped with the destination. In the proposed design, the route marker and cardinal direction are grouped together, then grouped with the roadway name, and that unit as a whole is then grouped with the destination.

Guide Sign with Poor Legend Grouping
Source: Jeremy Lance, Mid America Roads (unpublished data)

Design Concept with Improved Legend Grouping

Figure 3 Legend grouping comparison.

Legend items should be located, oriented and organized such that the signs convey the appropriate connections between legend elements. For example, destinations should be appropriately aligned above arrows, and arrows should be appropriately aligned above lanes (so road users pair the destination information with an arrow, and subsequently pair an arrow with the travel lane). Although many of these topics are discussed in more detail in subsequent sections, Table 4 provides some examples of how sign legends can be manipulated to influence the legibility, recognition and/or interpretation of signs.

Table 4 Examples of Separation and Organization of Information

DESIGN CONCEPT	EXAMPLES
Visibility should be proportional to feature criticality.	• Legend items should be adequate size to be legible and to draw the appropriate amount of attention • Supplemental guide signing and posting of overcrossing road names is considered less critical • When providing multiple destination names, keep the highest priority/nearest distance at the top • Use colors/text to emphasize the most important things
The location and orientation of legend items should be used to provide information to road users.	• Location and orientation of arrows can be manipulated to provide lane/movement information • Arrow angles can be used to depict the approximate alignment of the roadway
Items should be organized such that road users make the appropriate connections between legend elements.	• Route shields and cardinal directions should be presented together so that road users interpret this as a unit of information • Legend grouping should be applied to group related information so road users can efficiently gather the information that they need • The use of divider or separator lines can help to provide visual separation of various sign components • Spacing and margins can be used to clean up the appearance of the sign and create visual groups; signs shouldn't be overcrowded or less legible

Although there are many other individual factors to consider, all of these items can work in conjunction to influence the effectiveness of the sign. By simply creating groups of legend information or slightly changing the alignment of information, the appearance of a sign can really be cleaned up, making it more legible and easier to recognize and interpret.

UNIFORMITY AND STANDARDIZATION OF SIGNS

As indicated in previous sections, drivers form expectations about where and how information is provided to them; therefore, standardization and uniformity in the meaning, design, position and application of guide signs is critical to their effectiveness. If there is uniformity in signing within and between States, then signing will more reliably meet the expectations of road users. Section 1A.06, paragraph 01 (page 2) of the MUTCD states:

> *Uniformity of devices simplifies the task of the road user because it aids in recognition and understanding, thereby reducing perception/reaction time. Uniformity assists road users, law enforcement officers, and traffic courts by giving everyone the same interpretation. Uniformity assists public highway officials through efficiency in manufacture, installation, maintenance, and administration. Uniformity means treating similar situations in a similar way. The use of uniform traffic control devices does not, in itself, constitute uniformity. A standard device used where it is not appropriate is as objectionable as a non-standard device; in fact, this might be worse, because such misuse might result in disrespect at those locations where the device is needed and appropriate.*

Uniformity and standardization can help to shape the expectations of road users and facilitate recognition and interpretation of signs. For example, the MUTCD provides standardized colors and shapes for different classes of traffic signs, which road users will presumably learn over time and use to extrapolate information. Therefore, if a driver sees a yellow diamond-shaped sign, they would know that the sign is warning of something and the driver can be on the lookout before they are even within range to read the sign. Uniformity in design includes shape, color, dimensions, legends, borders, and illumination or retroreflectivity.[1] There are various other aspects of uniformity including, but not limited to, uniformity of legend arrangements, uniformity of placement, and applying standards in a scalable way so that small signs are just as well-designed as large signs. The MUTCD provides standardization of application and recommendations for different environments and conditions.

Consistency and uniformity are interrelated, as consistency is a fundamental component of uniformity. Uniformity of the roadway system requires that standards and practices are applied consistently; given that uniformity in design includes guide sign legends, and legends include "all word messages and symbol and arrow designs that are intended to convey specific meanings", it stands to reason that this applies to layout of the sign as well. Consistency, in this case, refers to how guide signs are used together to provide a consistent and comprehensive message.

The MUTCD indicates the following regarding Interchange Guide Signs:

- Section 2E.30, paragraph 01: “The signs at interchanges and on their approaches shall include Advance Guide signs and Exit Direction signs. Consistent destination messages shall be displayed on these signs”
- Section 2E.30, paragraph 02: “New destination information should not be introduced into the major sign sequence for one interchange, nor should destination information be dropped.”

Because drivers expect that they will have more than one opportunity to obtain necessary destination and lane information[7], sequential signs should be used to reinforce the information that has already been presented, thus reinforcing driver expectations and promoting effective roadway operations. Not only should the overall message conveyed by the signs within a series be consistent, but the manner in which the information is presented, or the layout, should remain consistent as well. If the legend layout of sequential signs are not consistent, then this could lead to driver confusion and overload.

Figure 4 Example of inconsistent sign layout within a sign series (source: ATSSA guide sign document).

In the example in Figure 4, even though the overall message and content of these signs remains the same, the layout of the signs has changed. Providing road users with the same information, but in a slightly different layout (such as the example in Figure 4), can increase the time that it takes for them to process the sign because they cannot easily pick out the information that they need. Such inconsistencies in sign layout can also cause doubt, which could lead to driver errors such as unnecessary lane changes, missed exits, erratic maneuvers, etc. By keeping a consistent layout between sequential signs, drivers can use their attention to confirm their expectations, gathering information that they missed on the previous sign, or pick up new information (such as distance to interchange), rather than wasting attention on processing inconsistencies.

Therefore, although the MUTCD indicates that standardization of sign designs “does not preclude further improvement by minor changes in the proportion or orientation of symbols, width of borders, or layout of word messages” (Section 2A.06, paragraph 08), the layout/design of the message should remain consistent within a sign series.

SELECTED GUIDE SIGN TOPICS

The follow sections discuss existing guidance and sign design principles related to each of the topics proposed by the ATSSA Sign Committee.

SEPARATOR LINES

Concept:

The use of divider or separator lines can help provide visual separation of various sign components.

Discussion:

Vertical separator lines are small white lines which can be placed on single panel signs in order to create a visual separation between different destinations on the same sign. The MUTCD indicates the following regarding the use of vertical white separator lines on Overhead Arrow-per-Lane Guide Signs for Option Lanes:

- Section 2E.21, paragraph 07, item F: "A vertical white line shall be used to separate the route shields and destinations for the two diverging movements from each other."
- Section 2E.21, paragraph 08, item I: "The vertical white line that is used to separate the route shields and destinations for the two diverging movements from each other should not descend below the top of the arrowheads for the through lanes, and should be positioned approximately halfway between the diverging arrowheads for the optional movement lane."

Figure 5 shows an example of vertical white lines used to visually separate two diverging movements and Figure 6 shows an example of vertical white lines used on a sign for an exit ramp with two dropped lanes and a split beyond the mainline gore.

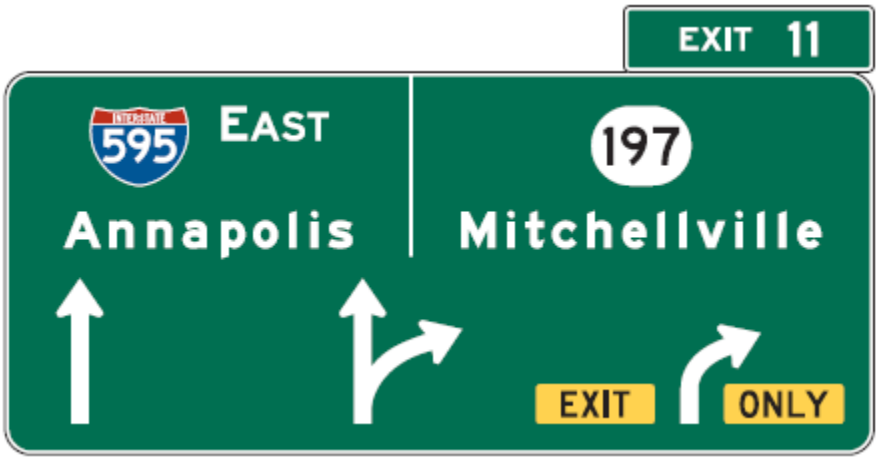

Figure 5 Overhead arrow-per-lane guide sign for a multi-lane exit with an option lane (MUTCD, 2009).

Figure 6 Example of signing for a two-lane exit ramp with two dropped lanes and a bifurcation beyond the mainline gore (MUTCD, 2009)

Separation cues, such as vertical separator lines, and lateral placement of destinations on a sign can influence how drivers associate destinations with specific lanes. For example, Richard & Lichty (2013) first examined two-lane exits with two destinations to compare drivers' tendency to link destinations with specific lanes using two different types of destination separators: hyphen separators (destinations on the same horizontal row, separated by a hyphen) and multi-line separation (destinations stacked vertically on top of one another). The multi-line separation caused a higher proportion of participants to associate the indicated destination with both lanes than the hyphen-separated destinations; this suggests that the spatial relationship between the exit destinations and the arrows seems to be important for communicating lane assignment information, as the destinations in the multi-line separation were not associated with any particular lane.[8] The researchers also examined different types of destination separators on guide signs for a two-lane exit that divides after the exit in order to determine whether the sign indicated an immediate split or a downstream split (i.e. they could use either lane to exit, and then would need to change lanes after the exit). In each condition, the EXIT ONLY sign panel extended the full length of the guide sign so that both destinations were above the EXIT ONLY sign panel; the researchers then examined multi-line separation (destinations stacked vertically on top of one another), vertical separator lines (destinations on the same horizontal row, separated by a vertical line), and hyphen separators (destinations on the same horizontal row, separated by a hyphen). An example of each type of destination separator is shown in Figure 7.

Figure 7 Examples of signs using multi-line separation (top), vertical separator lines (middle), and hyphen separators (bottom).

Richard & Lichty (2013) found that multiline and hyphen separators were better at communicating that both lanes would allow drivers to reach both destinations, whereas the vertical separator lines caused drivers to think that they had to change lanes immediately to reach their destination.[7] However, the researchers concluded that the EXIT ONLY sign panel spanning the entire exit sign also gave a cue to participants that both lanes would exit together, and therefore has a stronger effect than the hyphen separation but not the vertical line separation. Similarly, a simulator study examined three signing conditions for a Y-split: a split sign configuration in which all three signs (two Advance Guide signs and one Exit Direction sign) used vertical separator lines, a multi-line separation configuration in which all three signs used a vertically stacked format, and a condition where the two Advance Guide signs used the multi-line separation and the Exit Direction sign at the gore used the vertical separator lines. The results indicated that the lateral location of the destination on the sign influenced their lane-changing decisions.[8]

It is important to note that some sign elements (e.g. vertical separator lines) may have different effects when used in different scenarios and in combination with different sign elements. For example, a study by Katz, Golembiewski, Dagnall, O'Donnell & Shurbutt evaluating different sign elements for combined lane-use and destination signing indicated that the presence of vertical separator lines did not have a significant effect on driver comprehension of guide signs.[14] This study found no difference in driver comprehension based on the presence or absence of

vertical separator lines, but the researchers indicated that there may be situations where such signs can become more complex (longer destination names, cardinal directions added to route markers, etc.), in which cases vertical separator lines may be necessary in order to prevent the legend from visually running together.

The MUTCD indicates the following regarding the use of horizontal separator lines on Community Wayfinding Signs or Destination Signs:

- Section 2D.50, paragraph 24: "Horizontal lines of a color that contrasts with the sign background color should be used to separate groups of destinations by direction from each other."
- Section 2D.37, paragraph 03: "Adequate separation should be made between any destinations or group of destinations in one direction and those in other directions by suitable design of the arrow, spacing of lines of legend, heavy lines entirely across the sign, or separate signs."
- Section 2D.37, paragraph 04: "Separation of destinations by direction by the use of a horizontal separator line can enhance the readability of a Destination sign by relating an arrow and its corresponding destination(s) and by eliminating the need for multiple arrows that point in the same direction and excessive space between lines of legend."

Vertical and/or horizontal dividers may be used to visual separate information in a variety of scenarios. Figure 8 provides a few examples of different ways that separator lines may be used.

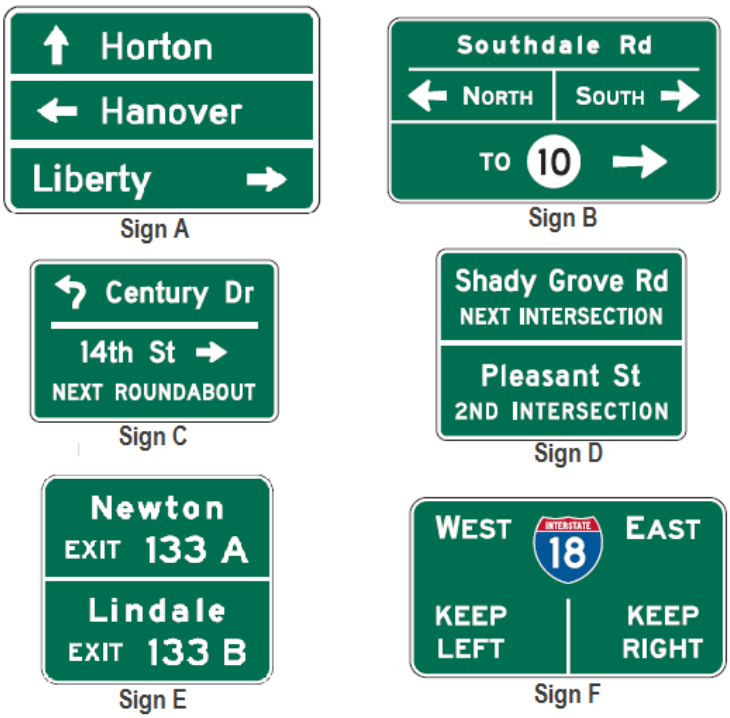

Figure 8 Examples of signs using vertical or horizontal separator lines.

Figure 8 also displays how the application of horizontal dividers may be used to convey varying types of information. For example, full-width dividers may be used to separate different destination by directions (Sign A) or different exits (Sign E), whereas partial width dividers may

be used to convey related information such as cardinal directions for the same road (Sign B) or movements within a roundabout (Sign C).

Recommendation:

Research shows mixed results regarding the use of separator lines depending on how they are used and the scenarios under which they are used. Additional guidance and examples should be developed in the MUTCD to show the various scenarios where separator lines can aid in sign interpretation.

CARDINAL DIRECTION WITH SHIELD

Concept:

The use of cardinal direction placement relative to the route shield can be inconsistent.

Discussion:

The MUTCD indicates the following regarding the placement of cardinal directions and route shields:

- Section 2D.36, paragraph 03: "If Route shields and cardinal directions are included on a Destination sign, the height of the route shields should be at least two times the height of the upper-case letters of the principal legend and not less than 18 inches, and the cardinal directions should be in all upper-case letters that are at least the minimum height specified for these signs."
- Section 2E.21, paragraph 08: "Overhead Arrow-per-Lane guide signs used on freeways and expressways should be designed in accordance with the following additional criteria…"
    - Item C: "Route shields, cardinal directions, and destinations should be positioned on the sign such that they are clearly related to the arrowhead(s) for the movement to which they apply."
    - Item D: "The cardinal direction should be placed adjacent to the route shield for exits or splits leading in a single cardinal direction."
- Section 2E.22, paragraph 03: "Diagrammatic guide signs used on freeways and expressways should be designed in accordance with the following additional criteria…"
    - Item E: "Route shields, cardinal directions, and destinations should be positioned on the sign such that they are clearly related to the arrowhead(s), and the arrowhead for the off movement should point toward the route shield for the off movement."
    - Item F: "For exits or splits leading in a single direction, the cardinal direction should be placed adjacent to the route shield, and the destination should be placed below the route shield and cardinal direction."

The MUTCD generally states that the cardinal direction should be placed "adjacent" to the route shield or placed "such that they are clearly related to the arrowhead(s)". These criteria were largely an effect of extensive research conducted on Diagrammatic signs dating back to the 1970's. Placement of the cardinal direction to the left of the shield for a left movement was a by-product of Diagrammatic signs, on which the shield was to be placed closest to the arrow. The purpose of this was to position the route shield so that it was clearly related to the arrowhead; the research did not show that the placement of the cardinal direction to the left of a shield indicated a left-side movement. However, some agencies choose to place the cardinal direction to the left of the route shield for left-side movement or left turn and to the right of the route shield for right-side movement or right turns. This could make it more difficult to quickly pull information from the sign, as the placement of the cardinal direction relative to the route shield would vary depending on the direction of the movement. On the other hand, if the cardinal direction is consistently placed in the same location relative to the route shield, regardless of the direction of the movement, road users will be more likely to recognize this as a single "chunk", or unit, of information (and thus facilitate their interpretation of the sign), and will still have other effective cues (i.e. arrows, sign placement, left exit plaques) to indicate the direction of the movement. Currently, the MUTCD provides specific methods for addressing left side exits, such as the LEFT and Left Exit Number Plaques.

Figure 9 Example of cardinal direction placement.

Regardless of the concept that is applied, successive signs on an approach should have route shields and cardinal directions placed in a consistent manner in order to support uniformity and driver expectations. Furthermore, the placement of cardinal directions relative to route shields must be consistent throughout the entire roadway system; even though some agencies use the placement of the cardinal direction to indicate left- or right-side movements, this concept will not be fully learned or effective unless it is applied consistently throughout the entire roadway system. Similarly, if road users do learn this concept in areas where it is applied, this will shape their expectation for all guide signs and thus cause confusion (and perhaps incorrect maneuvers) when they are exposed to signs that do not apply this concept.

Recommendation:

Consider adding language in the MUTCD directly addressing cardinal direction placement beyond the term "adjacent" to promote uniformity. Uniformity could be established through consensus determination by State Traffic Engineers.

LEFT EXIT PANEL LOCATION

Concept:

Some agencies have recognized the need to clarify the left exit message and have experimented with alternate locations of the left exit panel.

Discussion:

Because road users might not be expecting an exit to the left, the Left Exit Number (E1-5bP) plaque was included in the 2009 edition of the MUTCD to be used at the top left-hand edge of Advanced Guide signs and Exit Directions signs to identify a left exit. An example of the Left Exit Number (E1-5bP) plaque is shown in Figure 10.

Figure 10 Left exit number (E1-5bP) plaque (MUTCD, 2009).

The MUTCD includes the following provisions regarding the use of the Left Exit Number plaque:

- Section 2E.21, paragraph 07, item I: "For numbered exits, the Exit Number (E1-5P) or Left Exit Number (E1-5bP) plaque shall be used at the top of the sign in accordance with Section 2E.31. For unnumbered left exits, the LEFT (E1-5aP) plaque shall be used at the top left edge of the sign."
- Section 2E.22, paragraph 02, item E: "For numbered exits, the Exit Number (E1-5P) or Left Exit Number (E1-5bP) plaque shall be used at the top of the sign in accordance with Section 2E.31. For unnumbered left exits, the LEFT (E1-5aP) plaque shall be used at the top left edge of the sign."
- Section 2E.31, paragraph 08: "Because road users might not expect an exit to the left and might have difficulty in maneuvering to the left, a left exit number (E1-5bP) plaque (see Figure 2E-22) shall be added to the top left-hand edge of the sign for all left-hand exits (see Figures 2E-14 and 2E-15). The word LEFT on the E1-5bP plaque shall be a black legend on a yellow rectangular sign panel and shall be centered above the word EXIT."
- Section 2E.33, paragraph 03: "For numbered exits to the left, a left exit number (E1-5bP) plaque (see Figure 2E-22) shall be added to the top left-hand edge of the sign."
- Section 2E.36, paragraph 03: "For numbered exits to the left, a left exit number (E1-5bP) plaque (see Figure 2E-22) shall be added to the top left-hand edge of the sign."
- Section 2E.44, paragraph 04: "At splits where the off-route movement is to the left, the Left Exit Number (E1-5bP) plaque shall be added at the top left-hand edge of the guide sign (see Section 2E.31)."

As indicated in Section 2E.31 of the MUTCD, the word "LEFT" shall be positioned centered above the word "EXIT" on the Left Exit Number (E1-5bP) plaque. However some agencies have recognized the need to clarify this message and have included the centered inlay and the same-line inlay as a means of improving legibility and providing for reduced wind loads on overhead signs.

Figure 11 Example MUTCD standard (left), example centerline inlay (middle) and example same-line inlay (right).

Moving the Left (E11-2) sign panel to the same line as the Exit Number, as shown in Figure 11, may lead to better readability while also reducing the height of the panel from 54 inches to 30 inches. Though there may be benefits to the reduced height of the panel, such changes would result in an increased panel width; the tradeoffs between panel height/width would need to be discussed among practitioners. Most importantly, the Left panel should be in close proximity to the exit number so that motorists make the connection between the two and ultimately understand that the word "LEFT" is referring to the location of the exit on the roadway. There are no known issues with the current location of the Left panel, and research would be required in order to determine whether the specific location of the "LEFT" plaque relative to the exit number (above or to the left of it) would influence driver comprehension and legibility distance of the plaque.

Recommendation:

Provide outreach to agencies to ensure uniform practices, in accordance with the MUTCD, of left exit panel design and location. Consider adding language in the MUTCD to allow the LEFT (E1-5aP) plaque centered above or on the same line as the Exit Number.

BOTTOM BORDER ON EXIT NUMBER PANEL

Concept:

Some states use a bottom border on exit number panels while others do not.

Discussion:

The MUTCD provides the following language regarding borders:

- Section 2A.14, paragraph 01: “Unless otherwise provided, each sign illustrated in this Manual shall have a border of the same color as the legend, at or just inside the edge.”
- Section 2A.16, paragraph 01: “Signs shall have a border of the same color as the legend in order to outline their distinctive shape and thereby give them easy recognition and a finished appearance.”
- Section 2A.16, paragraph 02: “For guide signs larger than 120 x 72 inches, the border should have a width of 2 inches. For smaller guide signs, a border width of 1.25 inches should be used, but the width should not exceed the stroke width of the lettering of the principal legend on the sign.”
- Section 2A.16, paragraph 03: “Corner radii of sign borders should be 1/8 of the minimum sign dimension on guide signs, except that the radii should not exceed 12 inches on any sign.”
- Section 2A.16, paragraph 04: “The sign material in the area outside of the corner radius may be trimmed.”

Although the MUTCD states that all signs shall have a border unless otherwise provided, the ATSSA Sign Committee recommended that the bottom border on the exit number panel be removed to give extra spacing around the “Left” plaque and border width equal on both panels. Figure 12 provides an example from the MUTCD with the border included (top) and an example with the border removed (bottom).

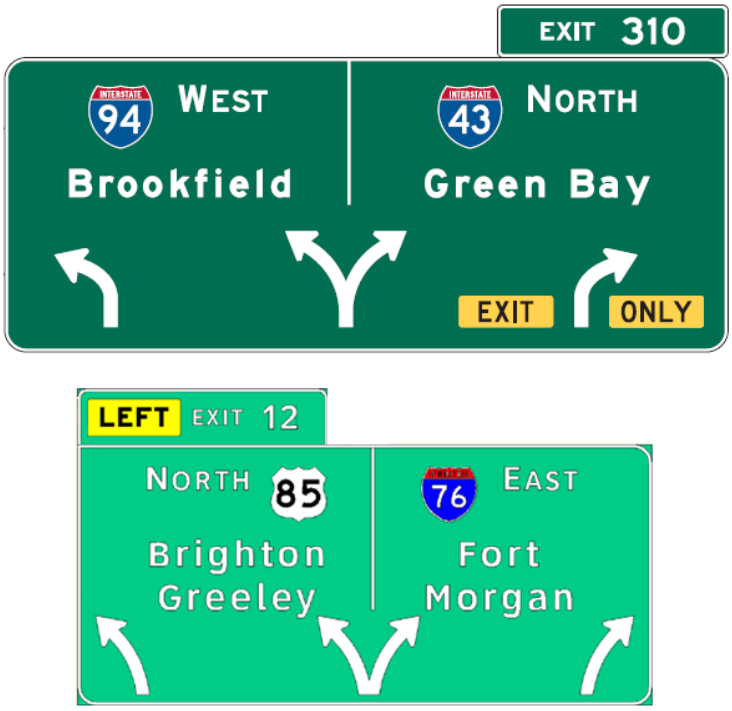

Figure 12 MUTCD example with border included (top) and example with border removed (bottom).

Although the MUTCD does not specifically state that a border must be included on all sides of a sign, section 2A.06 paragraph 07 states, “…Uniformity in design shall include shape, color, dimensions, legends, borders, and illumination or retroreflectivity.” Furthermore, section 2A.14 paragraph 01 indicates that all signs shall have a border “unless otherwise provided” (pg. 36). As guidance for border width varies based upon sign size, borders on adjacent signs may not match,

meaning that removing the bottom border on an exit number plaque would violate 2A.06.07. In such cases, the border width for the exit number plaque would be dependent on the size of the exit number plaque if its border is on all four sides; if the border of the exit number plaque were only on three sides, it would need to match the size of the main sign's top border, as this would function as a de-facto bottom border for the exit plaque. Additionally, because the corners of guide sign borders should be rounded (in accordance with MUTCD section 2A.14, paragraph 02), it would be important to consider whether or not agencies trim the corners of the main sign before deciding to remove the bottom border of the exit number plaque.

Recommendation:

A change to the MUTCD does not appear necessary unless there is a desire to standardize to a no bottom border option.

BORDER WIDTH CONSISTENCY ON SAME SUPPORT

Concept:

Some guide sign installations use different border widths on adjacent panels.

Discussion:

The MUTCD prescribes guidance for border width based on the size of the sign, as shown by the following:

- Section 2A.14, paragraph 03: "A dark border on a light background should be set in from the edge, while a light border on a dark background should extend to the edge of the sign. A border for 30-inch signs with a light background should be from 1/2 to 3/4 inch in width, 1/2 inch from the edge. For similar signs with a light border, a width of 1 inch should be used. For other sizes, the border width should be of similar proportions, but should not exceed the stroke-width of the major lettering of the sign. On signs exceeding 72 x 120 inches in size, the border should be 2 inches wide, or on larger signs, 3 inches wide. Except for STOP signs and as otherwise provided in Section 2E.16, the corners of the sign should be rounded to a radius that is concentric with that of the border."
- Section 2E.16, paragraph 02: "For guide signs larger than 120 x 72 inches, the border should have a width of 2 inches. For smaller guide signs, a border width of 1.25 inches should be used, but the width should not exceed the stroke width of the lettering of the principal legend on the sign."
- Section 2E.16, paragraph 04: "The sign material in the area outside of the corner radius may be trimmed."

Although consistency and uniformity of signs is important, especially for signs on the same approach or support, the border width and radius should be based on the size of the sign, letter height, and other factors individually. If the border is intended to group information and provide additional visual distinction between signs, then it is most important that the border width is appropriate for the sign. Applying a consistent border width and radius to all signs on the same support could result in the border losing its effect or overemphasizes a smaller sign (e.g. drawing

more attention to a smaller sign that may have less important information). If signs are the same width and contiguous, it would make sense to have the same border width and radius for these signs, however smaller signs should have borders controlled by their smaller dimensions.

Recommendation:

There is no reason to believe that border width inconsistency, as long as a visible border exists, would lead to issues with legibility, comprehension, or interpretation. Therefore, no changes in border width requirements are recommended at this time.

ARROW LOCATION WITH EXIT ONLY PANEL

Concept:

There is variation in practice for arrow placement where exit only lanes exist. Furthermore, there is question about whether the arrow should be in the same place on signs without the exit only panel as it is on signs with the exit only panel.

Discussion:

The MUTCD provides a standard to place the arrow within the yellow exit only panel, as shown by the following text and Figure 13:

- Section 2E.24, paragraph 04: "For lane drops, the Exit Direction sign (see Section 2E.36 and Figure 2E-26) shall be of the format shown in Figures 2E-15 and 2E-16. The bottom portion of the Exit Direction sign shall be yellow with a black border and shall include a diagonally upward-pointing black directional arrow (left or right) for each lane dropped at the exit, with the sign designed and placed so that each arrow is located over the approximate center of each lane being dropped. The words EXIT and ONLY shall be positioned to the left and right, respectively, of the arrow on the E11-1d sign panel for a single-lane drop. For a two-lane drop, the words EXIT ONLY shall be located between the two arrows on the E11-1e sign panel. The number of arrows on the sign shall correspond to the number of dropped lanes at the location of the sign."

Figure 13 Example of arrow placement in EXIT ONLY panel in accordance with the MUTCD 2009.

There has been some thought to suggest moving the arrow to the green section of the primary sign. Although there are various practices for arrow placement where exit only signs

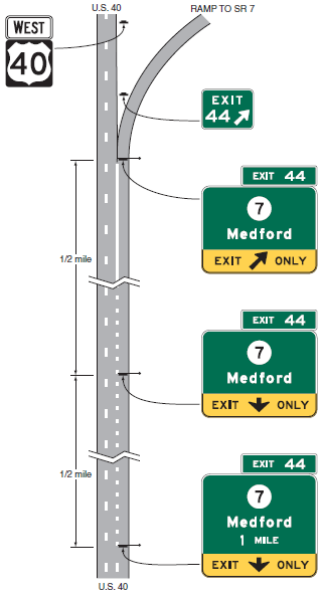

Figure 14 Guide Signs for a single-lane exit to the right with a dropped lane (MUTCD Figure 2E-16).

exist, the 2009 MUTCD included the movement of the arrows from the green section of the sign to within the EXIT ONLY panel to be consistent with the EXIT ONLY panels on the advanced guide signs (with down arrows), as shown in Figure 14. This placement also serves to help road users to better relate the arrow(s) to the lane (i.e. it is the lane that is "exit only") and reduce the likelihood that road users incorrectly interpret the EXIT ONLY message as indicating that the interchange is "exit only" (i.e. there is no re-entry). Figure 15 displays a sign with the arrow placed in the green section of the sign, rather than in the EXIT ONLY panel (left) as well as an illustration of what that same sign might look like if redesigned (right).

Figure 15 Example of different arrow locations.

The placement of the arrow inside the EXIT ONLY panel and centered above the lane and relative to the legend not only provides consistency with advanced guide signs, but also helps to clean the overall appearance of the sign. It should be noted that some variation in practice throughout the country may be attributed to the fact that not all signs have had the time to be changed out through attrition since the new standard that was placed in the 2009 MUTCD.

However, the question still remains as to whether the arrow should be located in the same place on signs that do not have the EXIT ONLY panel, as it is on signs with the EXIT ONLY panel. Figure 16 and Figure 17 provides different examples of arrow placement on signs that do not include an EXIT ONLY panel.

Figure 16 Example arrow placement on signs without EXIT ONLY panel (source: Scott Kuznicki).

Figure 17 Example guide signs for cloverleaf interchange (Source: MUTCD Figure 2E-35).

In areas where an EXIT ONLY panel is used adjacent to a non exit only panel, it does make sense to place the arrow in the same location, such as shown in Figure 18.

Figure 18 Example arrow placement on signs without EXIT ONLY panel (source: Scott Kuznicki).

Recommendation:

As long as either method use similar arrow sizes and avoid placement that makes the sign difficult to interpret, there doesn't seem to be any indication that there would be any issues. No

change to the MUTCD seems necessary at this point; however, if there seem to be any interpretation issues due to the arrow placement, comprehension testing should be considered.

MARGINS BETWEEN OBJECTS

Concept:

Some guide sign implementations use elements that are very closely spaced, making the sign appear very crowded.

Discussion:

Crowding of sign elements can reduce legibility, recognition, and interpretation. The MUTCD provides the following guidance on interline spacing, spacing of elements from borders, and spacing between route shields and other objects:

- Section 2E.15, paragraph 01: "Interline spacing of upper-case letters should be approximately three-fourths the average of upper-case letter heights in adjacent lines of letters."
- Section 2E.15, paragraph 02: "The spacings to the top and bottom borders should be equal to the average of the letter height of the adjacent line of letters. The lateral spacing to the vertical borders should be essentially the same as the height of the largest letter."
- Section 2D.36, paragraph 03: "If Route shields and cardinal directions are included on a Destination sign, the height of the route shields should be at least two times the height of the upper-case letters of the principal legend and not less than 18 inches, and the cardinal directions should be in all upper-case letters that are at least the minimum height specified for these signs."

Signs designed according to these parameters still have the potential to appear over-crowded if appropriate legend grouping is not applied; efforts to cut costs by "cramming" legends into the smallest possible size can lead to ambiguity of sign messages. As discussed previously (and displayed in Figure 2 and Figure 3), the alignment of legend elements and appropriate application of legend grouping can help to clean up the appearance of a sign; a sign that is the same size (or even smaller!) can appear less crowded or less ambiguous if these concepts are properly applied.

Recommendation:

Further guidance and examples of general guide sign layout should be developed to help ensure consistency among practitioners. This could be done within Standard Highway Signs or another guidebook specific to guide sign layout and design.

ARROW SIZE

Concept:

Arrow sizes on consecutive signs should be the same.

Discussion:

The MUTCD provides guidance for arrow size based on the height of the upper case letters:

- Section 2D.08, paragraph 23: "The width across the arrowhead for the Types A, B, and C directional arrows should be between 1.5 and 1.75 times the height of the upper-case letters of the principal legend on the sign. The width across the arrowhead for the Type D directional arrow should be at least equal to the height of the upper-case letters of the principal legend on the sign. For down arrows used on overhead signs, the width across the arrowhead should be approximately two times the height of the upper-case letters of the principal legend on the sign."

It is important for arrows to be legible from adequate distance, and in some cases, overhead signs might not have the same requirements as ground mounted signs.

Recommendation:

Further guidance on arrow size practices on guide signs of various types and sizes should be developed to help ensure consistency among practitioners.

MATCHING ARROW ANGLES

Concept:

Arrow angles on successive signs should be the same.

Discussion:

Arrows are an important tool for conveying messages on guide signs. Directional arrows pointed upward at an angle are used on Exit Direction signs and Exit Gore signs to provide motorists with information on the direction and alignment of the exit roadway. Although drawings of such signs in the Standard Highway Signs and Markings book typically include a standard 45 degree angle arrow, the MUTCD indicates that, though the standard design may not be modified, the orientation of symbols can be changed to better reflect the direction of travel. More specifically, the MUTCD provides the following language related to arrow angles on guide signs:

- Section 2D.08, paragraph 04: "Where a roadway is leaving the through lanes, a directional arrow shall point upward at an angle that approximates the alignment of the exit roadway."
- Section 2D.08, paragraph 18: "Arrows used on guide signs to indicate the directions toward designated routes or destinations should be pointed at the appropriate angle to clearly convey the direction to be taken. A horizontally oriented directional arrow design should be used at right-angle intersections."
- Section 2E.37, paragraph 03: "The arrow should be aligned to approximate the angle of departure. Each gore should be treated similarly, whether the interchange has one exit roadway or multiple exits."

Kuznicki and Katz (2015) also provide the following guidance, based on observed consistency in practice, regarding the use of discrete arrows for signing freeway lanes:

- A Down Arrow always indicates a lane that continues on along the mainline, even if that lane terminates downstream in a service interchange
- The degree of the angle of installation of a Down Arrow, when not 0° off the vertical, indicates the curvature of the mainline movement or primary movement(s) within an interchange, used only on signs placed at the decision point
- Down Arrows may be used on more than one sign at a junction if the additional movements are considered primary movements, such as at a major split of two marked routes of equal importance along a freeway corridor
- Angled Down Arrows are only applied in conjunction with overhead Exit Direction Signs
- The upward angle Type A or Type B arrow installation is indicative of the severity of the exiting movement
- Type A and Type B arrows never point down into a lane from an overhead sign
- Type A and Type B arrows are typically restricted to use on Exit Direction Signs at service interchanges

Many of the problems currently being experience with overhead guide sign installations could be mitigated by the consistent use of arrows in the MUTCD.[12] As consistency and uniformity are critical in the design of guide signs, the angles of arrows used on the Exit Direction sign should match that of the Exit Gore sign, where appropriate. In some cases, however, matching the angles exactly between the two signs is not suitable and may cause additional confusion for motorists. For example, although the Exit Gore sign typically uses a standard 45 degree angle arrow, it can be angled horizontally for severe/right-angle departures. In such cases, it would not necessarily make sense for the arrow angle of the Exit Direction sign to match that of the Exit Gore sign, as Exit Direction signs are placed in advance of the gore and typically over, or in advance of, an auxiliary lane. Therefore relative, rather than exact, consistency is important when matching arrow angles of Exit Direction signs and Exit Gore signs.

Recommendation:

Further guidance on angles of arrows on guide signs showing examples to consider would be helpful to practitioners to ensure consistency and could be incorporated in other supplementary materials for sign designers, as discussed previously.

CONCLUSION

Guide signs must be designed to meet both operational and safety needs. The guide sign design process begins with careful examination and consideration of the geometric design of the roadway and other external factors (e.g. control destinations). The next step involves determining the arrangement or layout of the sign legend; in order to effectively address the needs of drivers, legend design must incorporate appropriate human factors and design principles.

Although some elements of sign design can be prescribed by employing basic design concepts such as those outlined in this paper, other elements require more information to help designers make decisions. Furthermore, some designers and traffic engineers (especially inexperienced ones) need additional guidance on design principles in general. Ultimately, the MUTCD and SHS are not enough; designers, whether experienced with established methods or new and inexperienced, need to understand WHY these design concepts are important in order to promote technical growth and uniformity. Therefore, the project team recommends a combination of guidance, training and exercises be developed to educate and promote good sign design principles.

The project team believes that a general sign design manual would be helpful to ensure uniformity and consistency. This manual would include general guidance for the sign design from top to bottom, and would provide designers with a step-by-step process for designing signs. This guidance could be presented as a stand-alone document, or could be included in the SHS; the project team recommends that FHWA work with research contractors, software developers, and sign fabricators to begin identifying the best way to disseminate information about good design practices.

In addition to providing step-by-step guidance through the sign design process, training and exercises regarding the design and layout of legend elements would be useful, particularly to traffic engineers who have little to no experience. In addition to certification programs, new or inexperienced designers should also have access to good mentors who can continue to help them in their technical growth. This could be achieved through a peer/mentor program that encourages or requires state sign designers to meet with a mentor.

Finally, the concept of peer-reviewed signing between states, which would be beneficial to designers of all experience levels, could be useful in getting states as a whole out of sign design “ruts” or bad habits, while promoting sign design uniformity across the country.

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