Signing Design

Kate Hunter-Zaworski, Ph.D., P.E.
Civil and Construction Engineering
Oregon State University
Corvallis, OR

Outline

• Types of Signs
• Legibility
• Comprehension
• Special Case: Nighttime
• Retroreflectivity
• Striping
• Pavement Markings
General Types of Signs by Function

- Regulatory – STOP, YIELD, traffic laws, regulation (red & white; black & white)
- Warning – warn, alert traffic (yellow)
  - Temporary traffic control – alert traffic to work zones (orange)
  - School or Pedestrian – indicate school & ped zones and crossing (fluorescent yellow green)
- Guide & information – provide guidance, directions and information (green, blue, brown, fluorescent pink, purple)

Source: MUTCD

Sign Design (SSD)
**Legibility Distance - Sensory**

- Legibility Distance = Information Presentation Distance – Advanced Placement
- Minimum Letter Height (in)
  - \[ \text{Legibility Distance (ft)} = \frac{\text{Legibility Distance}}{\text{Legibility Index (ft/in)}} \]
- Legibility Index (MUTCD 30 feet per inch)
- Turn to Tutorial 5 on page 22-41

- Example: Driver approaches intersection at 35 MPH (51 ft/s), reads destination sign (D1-1) one word
- Sign is placed 200 feet before intersection and assume legibility index of 30 ft/in

**Solution**

**Basic Reading Time**

- BRT(s) = 0.5X + 1Y
  - X = number of critical words
  - Y = number of symbols
- If more than 4 words
  - Add time based on the BRT
    - 2 < BRT 4 Add 0.75 s
    - 4 < BRT 6 Add 1.50 s
    - 6 < BRT 8 Add 2.25 s
  or
  Reading Time(s) = 0.31 (number of words) + 1.94

**Reading Distance (ft)**

- \[ \frac{1 \text{s/word}^2}{1 \text{word}} + \frac{0.5 \text{s/symbol}^2}{1 \text{symbol}} \times 51 \text{ ft/s} = 77 \text{ ft} \]

Basic Reading Time – Impacted by Cognitive Processing Capabilities
What are the implications for design
**Solution**

### Decision Distance

- 1s for simple maneuvers (stop, reduce speed)
- 2.5 for complex (2 or more choice points)

### Maneuver Distance

<table>
<thead>
<tr>
<th>Operating Speed (mph)</th>
<th>Gap Search Distance (ft)</th>
<th>Lane Change Distance (ft)</th>
<th>Deceleration Distance (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>40</td>
<td>130</td>
<td>77</td>
</tr>
<tr>
<td>35</td>
<td>92</td>
<td>193</td>
<td>574</td>
</tr>
<tr>
<td>40</td>
<td>119</td>
<td>370</td>
<td>377</td>
</tr>
<tr>
<td>45</td>
<td>143</td>
<td>500</td>
<td>393</td>
</tr>
</tbody>
</table>

\[
\text{Decision Distance (ft)} = \left( \frac{1s}{\text{simple decision}} \right) \times (51 ft/s) = 51 \text{ feet}
\]

\[
\text{Maneuver Distance (ft) (using Table 22-8)} = \text{Gap Search + Lane Change + Deceleration} = 92 \text{ ft} + 195 \text{ ft} + 154 \text{ ft} = 441 \text{ ft}
\]

Example of impacts of cognitive processing
.....Distracted driving implications

### Information Presentation Distance

- Total distance from the choice point (intersection) that driver needs information
  \[
  \text{Information Presentation Distance} = 77 \text{ ft} + 51 \text{ ft} + 441 \text{ ft} = 569 \text{ ft}
  \]

### Legibility Distance

\[
\text{Legibility Distance} = 569 \text{ ft} - 200 \text{ ft} = 369 \text{ ft}
\]

Distracted Driving Impacts

Source: NCHRP #600
Solution

Minimum Letter Height (in) = \frac{\text{Legibility Distance (ft)}}{\text{Legibility Index (ft/in)}}

\text{Minimum Letter Height (in)} = \left(\frac{369 \text{ ft}}{30 \text{ ft/in}}\right) = 12 \text{ inches (rounded)}

Sign Design – Legibility

<table>
<thead>
<tr>
<th>Sign Design Characteristic</th>
<th>Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retroreflectivity</td>
<td>Microprismatic retroreflective sheeting provides longer legibility distances than encapsulated retroreflective sheeting by 9.5% (1).</td>
</tr>
</tbody>
</table>
| Legend Color               | Light letters on a dark background  
Better than dark letters on a light background (2)  
Black-on-orange and white-on-green signs are easier to detect than black-on-white signs (3). |
| Symbol Contrast            | Optimal legend to background contrast value is 12:1 (3)  
Positive-contrast signs better than negative-contrast signs |

Source: NCHRP #600
Sign Design – Legibility

<table>
<thead>
<tr>
<th>Sign Design Characteristic</th>
<th>Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Font Size</td>
<td>maximum legibility index of 40 ft/in of letter height should be used (4). MUTCD recommends 30 ft/in. Research indicates that legibility distance increases as letter height increases, although the benefits are not proportional above letter heights of about 8 in. (3)</td>
</tr>
<tr>
<td>Font Style</td>
<td>Increased legibility distance is found with mixed-case text under daytime and nighttime conditions</td>
</tr>
<tr>
<td></td>
<td>MUTCD and FHWA very prescriptive on sign Font, and Style</td>
</tr>
</tbody>
</table>

Source: NCHRP #600

FHWA Standard Alphabets and Highway Sign Word Length Calculator

- Use the Letter Series drop-down to specify and switch between the FHWA Standard Alphabet letter series—B, C, D, E, E (mod), and F.
- Use Letter Height function to specify the initially upper-case letter height. The loop height of the following lower-case letters for mixed-case legends is automatically calculated in accordance with MUTCD criteria.

The Spacing Ratio function allows the spacing between characters can be reduced or expanded. For example, a spacing ratio of 120% increases the letter spacing 20%. A spacing ratio of 80% reduces the letter spacing 20%.

There is no need to re-enter the sign legend if one of the parameters is changed—simply change the entry and click the Calculate button to generate the new result.
Sign Legibility and Older Drivers

- Minimize symbol complexity
- Maximize the distance between symbol sign elements
- Use representational rather than abstract symbols
- Use solid rather than outline figures for design
- Standardize the design of arrowheads, human figures, and vehicles
- Retain maximum contrast between the symbol and the sign background
- Use a larger font when possible
- Follow the MUTCD

Conspicuity – Can I see the sign?

- Conspicuity: how easy to locate and see a visual target
- How to distinguish signs from environmental clutter
- Increase sign brightness relative to its surrounding
- Increase brightness contrast between different aspects of the sign
- Increase the sign’s size relative to other objects in the visual field/environment
- Use a sign hue that contrasts with other noise/background items
- Add flashers to attract attention
**Comprehension – What does it mean?**

- **Legibility**
  - Can the driver see the sign?
  - Is it legible at various distances?
  - Can it be seen under both nighttime and daytime lighting conditions?

- **Recognition**
  - How well do the parts of this sign relate to one another?
  - Does the construction of the sign support accurate recognition?
  - Is it easily confused with other signs?

- **Interpretation**
  - How well does the sign convey the message?
  - Will it be understood when presented in the appropriate context?
  - Does it require special knowledge particular to a culture, language, or driver age?

Source: adapted from Campbell et al. (1)

---

**Design Guidelines for Comprehension**

**Text only**

- Use for highly complex messages
- Use when indicating hazards
- Use for destination information
- Use in areas requiring unexpected or unique driver actions, e.g., frequent lane shifts
Design Guidelines for Comprehension

Graphic/Icon Only
- Use for safety and warning information
- Use for prohibited actions
- Use in visually degraded conditions
- Use in areas with higher posted speeds
- Use diagrammatic graphics when road geometry violates driver expectancies
- Minimize symbol complexity by using few details

Types of Guide & Information Signs
- Advanced Guide
- Conventional Guide
- Exit Directions
- Lane Control
- Tourists
- Service
- Distance
Advanced, Conventional and Exit Guide Signs

Advanced
- Limit route and destination information to 3 lines
- Only use 2 or less destination/street names
- Place intersection streets on top line and distance to intersecting streets on bottom

Conventional
- Limit route and destination information to 3 lines

Exit
- Limit route and destination information to 3 lines
- DO NOT include more than 2 destination/street names

MUTCD Conventional Sign

Figure 2E-3. Overhead Arrow-per-Lane Guide Sign for a Multi-Lane Exit with an Option Lane
Distance

• Limit 3 streets or exits accompanied by distance
• Put shortest distance first

![Image of a sign with distances to exits](image)

Complexity of Sign Information

• Information is calculated in terms of bits and bytes or units
• Signs that require immediate action should only contain 1-2 words
• Navigation 3-4 units max
• Less urgent messages for delayed response up to 7 units
• Example of Units
• 4 units - Road Construction Ahead at Sheepcreek
• 7 units - Road Construction Ahead at Sheepcreek take Highway 22
Effects of Information Complexity

• This is a very important consideration for changeable message signs

Highly complex (over 9 units)
• Processing time over 5 seconds
• Impact on older drivers

Low Complex (3-5 information units)
• Processing time less than 5 seconds

Design Guidelines for Comprehension

Mixed Icon and Text
• Add text when symbols alone are unintuitive
• Keep text to no more than 2-3 words
• Use a clear and simple font for text
**Horizontal Signing**

Reduce speed in curves
- Drivers looking at roadway and already looking at pavement
- Can provide lane specific information
- Lane drops and wrong way movements
- Need good maintenance and high contrast
- May have problems in congested traffic situations

**Retroreflective Signs**

Daytime signing here is complimentary

Nighttime signing here is necessary
**RETROreflection**

Retroreflected light

- Matte or Diffuse Reflection
- Mirror-like Reflection (Specular)

**Retroreflection**

**Informal Definition**

- A ratio of the amount of light returned from a sign versus the amount hitting the sign
- A way to measure the efficiency of a material

\[
\frac{\text{Light OUT of sign}}{\text{Light INTO sign}} = \text{Retroreflectivity}
\]
Retroreflectivity Cone

Reflected light gets dimmer as distance from light axis increases

Reflected light is brighter near light axis

Light Source Direction

Flashlight Demonstration - Cone

More dim

Dimmer

Bright

Demo
Cone Size is Important

Technical Terms

Retroreflective Sign

\( R_A \text{ cd/}lx/m^2 \)

Luminance

\( \text{cd/m}^2 \)

Illuminance

\( lx \)
Basic Angles of Retroreflectivity

• Observation Angle
  – Where in the cone is the measurement made (from the light source)

• Entrance Angle
  – What is the orientation of the sign or pavement marking (is from the light source)

Key Geometry Angles

Observation angle (α)
Between source and receptor (red and blue lines)

Entrance angle (β)
Between source and target axis (blue and green lines)
Key Elements of Visibility

Headlamp Illuminance \times Sign Material Retroreflectivity = \text{Luminance}

...but that’s not all!!

The “Older Driver” Factor

Luminance \times Driver Vision = \text{Perceived Brightness}
Example 2

7 different types of material used on these stop signs

Key Nighttime Visibility Issues

- Sign
  - Location
  - Sheeting materials
- Headlamps
  - Amount and quality of light for signs
- Driver
  - Visual capabilities
  - Comfort level
- Vehicle
  - Size
**Key Issue: Headlamps**

- Out of control of traffic engineers
- Evolving considerably in last decades
- Human Factors Impacts

**Summary – Sign Design**

- Sensory
  - Size, Font, Color contrasts, Retro-reflectivity
- Cognitive
  - Content, bits and bytes, spreading, information processing time (VMS, Work Zones)
- Volition
  - Physical reaction time
Simplicity Rules

• Simple – combination of symbols and words
• Clear – convey only one meaning
• Spaced out over distance
• Good maintenance of signs – retroreflectivity