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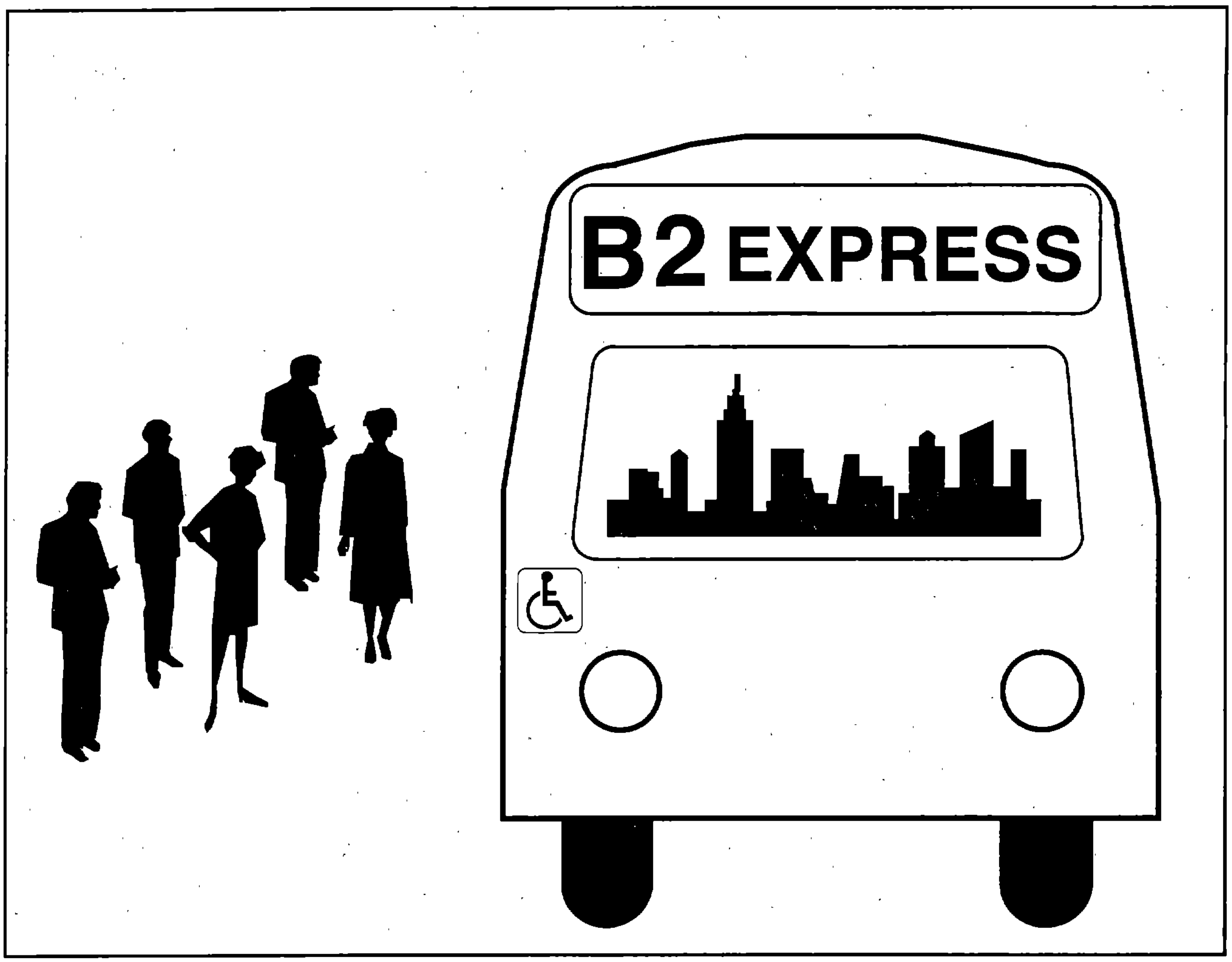
U.S. Department of Transportation

Federal Transit Administration

Bus Signage Guidelines for Persons with Visual Impairments

May 1998

Final Report



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The purpose of this handbook is to provide a reference source for transit agencies about visual communications-related regulations and guidelines contained within the Americans With Disabilities Act (ADA) of 1990 and its amendments. It is intended to clarify the responsibilities and choices transit agencies face when improving visual communications to provide accessible transportation to persons with disabilities.

While a transit agency or a manufacturer may choose to meet the minimum regulatory requirements (the "letter of the law") as contained in the ADA regulations, this handbook goes beyond the regulations to help the transit professional understand communications issues from the perspective of the customer. Through this perspective, the handbook will help transit agencies formulate a plan for addressing the communications needs of its customers, and in so doing, satisfy the spirit of ADA.

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Bus Signage Guidelines for Persons With Visual Impairments

Final Report
May 1998

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The "Bus Signage Guidelines for Persons with Visual Impairments," was prepared by a team of bus experts from Booz·Allen & Hamilton with assistance from scientists and researchers from Boston College and the American Foundation for the Blind. The handbook is intended to clarify the responsibilities and choices transit agencies face when improving visual communications to provide accessible transportation to persons with disabilities. Booz·Allen & Hamilton would like to specifically acknowledge the assistance of the following individuals:

- Elga Joffee, M.Ed. MPS—American Foundation for the Blind
- Billie Louise Bentzen, Ph.D.—Accessible Design for the Blind, Boston College

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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC	METRIC TO ENGLISH
LENGTH (APPROXIMATE) 1 inch (in) = 2.5 centimeters (cm) 1 foot (ft) = 30 centimeters (cm) 1 yard (yd) = 0.9 meter (m) 1 mile (mi) = 1.6 kilometers (km)	LENGTH (APPROXIMATE) 1 millimeter (mm) = 0.04 inch (in) 1 centimeter (cm) = 0.4 inch (in) 1 meter (m) = 3.3 feet (ft) 1 meter (m) = 1.1 yards (yd) 1 kilometer (km) = 0.6 mile (mi)
AREA (APPROXIMATE) 1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2) 1 square foot (sq ft, ft^2) = 0.09 square meter (m^2) 1 square yard (sq yd, yd^2) = 0.8 square meter (m^2) 1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2) 1 acre = 0.4 hectares (he) = 4,000 square meters (m^2)	AREA (APPROXIMATE) 1 square centimeter (cm^2) = 0.16 square inch (sq in, sq^2) 1 square meter (m^2) = 1.2 square yards (sq yd, yd^2) 1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2) 1 hectare (he) = 10,000 square meters (m^2) = 2.5 acres
MASS - WEIGHT (APPROXIMATE) 1 ounce (oz) = 28 grams (gr) 1 pound (lb) = 0.45 kilogram (kg) 1 short ton = 2,000 pounds = 0.9 tonne (t)	MASS - WEIGHT (APPROXIMATE) 1 gram (gr) = 0.036 ounce (oz) 1 kilogram (kg) = 2.2 pounds (lb) 1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons
VOLUME (APPROXIMATE) 1 teaspoon (tsp) = 5 milliliters (ml) 1 tablespoon (tbsp) = 15 milliliters (ml) 1 fluid ounce (fl oz) = 30 milliliters (ml) 1 cup (c) = 0.24 liter (l) 1 pint (pt) = 0.47 liter (l) 1 quart (qt) = 0.96 liter (l) 1 gallon (gal) = 3.8 liters (l) 1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3) 1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)	VOLUME (APPROXIMATE) 1 milliliter (ml) = 0.03 fluid ounce (fl oz) 1 liter (l) = 2.1 pints (pt) 1 liter (l) = 1.06 quarts (qt) 1 liter (l) = 0.26 gallon (gal) 1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3) 1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)
TEMPERATURE (EXACT) [(x - 32) (5/9)]°F = y°C	TEMPERATURE (EXACT) [(9/5)y + 32]°C = x°F

QUICK INCH-CENTIMETER LENGTH CONVERSION

INCHES	0	1	2	3	4	5	6	7	8	9	10

CENTIMETERS 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

25.40

QUICK FAHRENHEIT-CELCIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and/or other conversion factors, see NBS Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50. SD Catalog No. C13 10286.

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FOREWORD

The purpose of this handbook is to provide a reference source for transit agencies about visual communications-related regulations and guidelines contained within the Americans With Disabilities Act (ADA) of 1990 and its amendments. It is intended to clarify the responsibilities and choices transit agencies face when improving visual communications to provide accessible transportation to persons with disabilities.

While a transit agency or a manufacturer may choose to meet the minimum regulatory requirements (the "letter of the law") as contained in the ADA regulations, this handbook goes beyond the regulations to help the transit professional understand communications issues from the perspective of the customer. Through this perspective, the handbook will help transit agencies formulate a plan for addressing the communications needs of its customers, and in so doing, satisfy the spirit of ADA.

EXECUTIVE SUMMARY

Persons having visual impairments are particularly dependent on public transportation since their visual status may render them ineligible for a driver's license. Impaired vision can often make reading difficult by reducing the amount of light that enters the eye, blurring the retinal image, or damaging the central portion of the retina. Although persons *without* visual impairments need to be able to read signs identifying transit vehicles, it is particularly important for persons *with* visual impairments. Many persons with visual impairments regard public transportation as their "lifeline" to employment and the community, and consider impediments to the readability of transit signage to be one of the principle obstacles to accessible bus transportation.

PROJECT OBJECTIVES

The purpose of this handbook is to provide a reference source for transit agencies about visual communications-related regulations and guidelines contained within the Americans With Disabilities Act (ADA) of 1990 and its amendments. It is intended to clarify the responsibilities and choices transit agencies face when improving visual communications to provide accessible transportation to persons with disabilities.

While a transit agency or a manufacturer may choose to meet the minimum regulatory requirements (the "letter of the law") as contained in the ADA regulations, this handbook goes beyond the regulations to help the transit professional understand communications issues from the perspective of the customer. Through this perspective, the handbook will help transit agencies formulate a plan for addressing the communications needs of its customers, and in so doing, satisfy the spirit of ADA.

METHODOLOGY

The handbook is organized in two parts. Part I contains information to help the transit professional understand and address the needs of customers to improve visual communications and provide accessible transportation to persons with disabilities. Part I also reviews the current regulatory mandates, discusses current transit sign technology, and provides an in-depth discussion of factors to consider when selecting an ADA-compliant sign.

For those interested in the research project, the second part of this handbook summarizes the results of the human factors testing and focus group research. The reasons for complementing human factors testing with focus group studies were to:

- Determine the extent to which the experiences of the focus group participants with transit bus signage were consistent with the human factors testing

- Learn about the factors that persons with visual impairments believe affect the readability of signs in dynamic transit environments

- Explore additional factors that persons with visual impairments believe are related to reading changeable message signs.

SUMMARY OF CONCLUSIONS

The results of this research project, obtained through human factors testing and focus group discussions, led to some general conclusions about the readability of transit bus signage:

- There are specific signage characteristics for both conventional and electronic signs that enhance readability for persons with low vision.
- The specific signage characteristics that enhance readability by persons who are visually impaired, also enhance sign readability for persons who report having normal sight.
- Other variables exist in the transit environment that can enhance or detract from sign readability.

SUMMARY OF RECOMMENDATIONS

The results of this research project, obtained through human factors testing and focus group discussions, led to some general recommendations to improve the readability of transit bus signage:

Character Specifications

Print-type signs should have a minimum character height of 6 inches in the front and a minimum of 2 inches to 4 inches on the side sign; intercharacter spacing should be 1.5 to 2.0 times the stroke width; the character width-to-height ratio should be at least 3.5:5 to 1:1; and the character stroke width-to-height ration should be at least 1:7 to 1:5.

CMS-type signs should have a minimum character height of 5.5 inches in the front and a minimum of 4 inches on the side sign; intercharacter spacing should be 1.5 to 2.0 times the stroke width; the character width-to-height ratio should be at least 3.5:5 to 1:1; and the character stroke width-to-height ration should be at least 1:7 to 1:5.

Contrast

High contrast should be maintained on all destination signs. White characters on a black background are recommended.

Glare

Materials that cover the destination sign should be designed to minimize glare. All destination signs should be positioned at an angle to minimize glare.

Sign Placement of Vehicle

Destination signs should be located at the bottom of the side passenger window that is closest to the entrance door.

Visual Clutter

Competing numerical information should not be displayed in proximity to bus route display on the designation sign, where it may confuse passengers with visual impairments. Text messages should be limited to destination information only. Messages such as "Have a Nice Day" are confusing to persons with visual impairments.

Message Display Capabilities

- Display route number continuously
- Display route number in larger size than text
- Display only upper case characters
- Display single line text messages
- Display 8-inch route numbers on 2-line messages
- Display 8-inch route numbers on signs with alternating or changing messages.

Chapter 1
INTRODUCTION

1.1 BACKGROUND

Persons having visual impairments are particularly dependent on public transportation since their visual status may render them ineligible for a driver's license. According to the National Eye Institute, about 1 in every 20 persons has partial sight—sight that cannot be corrected by ordinary eyeglasses, contact lenses, or by surgery. Impaired vision can often make reading difficult by reducing the amount of light that enters the eye, blurring the retinal image, or damaging the central portion of the retina. Light reduction and blurring reduce the contrast of text, while central retinal damage impairs the ability to see small print and to make the proper eye movements crucial to reading.

Although persons *without* visual impairments need to be able to read signs identifying transit vehicles, it is particularly important for persons *with* visual impairments. Many persons with visual impairments regard public transportation as their "lifeline" to employment and the community, and consider impediments to the readability of transit signage to be one of the principle obstacles to accessible bus transportation.

1.2 CURRENT TRANSIT BUS SIGNAGE REGULATIONS

Transit bus signage specifications were developed by the Architectural and Transportation Barriers Compliance Board (Access Board) and first issued in the Americans with Disabilities Act Accessibility Guidelines (ADAAG) Section 4.30.2 in July 1991. After a period of public comment, these specifications were adopted by the U.S. Department of Transportation and incorporated in Part 1192 of the Americans with Disability Act (ADA) Accessibility Guidelines for Transportation Vehicles in September 1991. In summary, the regulations require:

- Illuminated signs on the front and boarding side of a vehicle to display destination or route information
- A minimum character height of 1-inch for boarding side signs and 2-inches for front signs

- Character width-to-height ratio between 3:5 and 1:1 and stroke width-to-height ratio between 1:5 and 1:10

- "Wide" spacing between characters (generally, the space between letters shall be 1/16 the height of upper case letters)

- Characters that contrast with the background—either dark-on-light or light-on-dark.

1.3 ISSUES/CONCERNS THAT THE TRANSIT BUS SIGNAGE REGULATIONS DID NOT ADDRESS

Many questions and issues arose during and after the period of public comment on the regulation. Most of the questions and concerns focused on the "legibility" of transit signs. Legibility of transit signs is a function of several factors. Some factors are inherent in the physical characteristics of the sign, such as:

- Character height
- Character width-to-height ratio and stroke width-to-height ratio
- Character case (upper or mixed upper and lower case)
- Inter-character, inter-word, and inter-line spacing
- Contrast
- Font
- Message content.

Some factors are inherent in electronic signs, which are widely used in the transit environment:

- Direction of message progression (right-to-left; bottom-to-top)
- Nature of message change (all characters change at once; scrolling characters)
- Rate of message change.

Environmental factors also affect transit sign legibility:

- Lighting conditions (daylight or night time lighting)
- Glare (off the windshield or off the glass in front of the sign)
- Obstructions

- Dirt
- Location of the sign on a vehicle and the angle of the rider to the sign.

Finally, transit signs must be readable in the dynamic transit environment—in which either the passenger or the vehicle is moving. Rapidly changing viewing angles as a vehicle approaches a passenger are particularly significant—and are determined by the location of the sign on a vehicle. Characters on side signs appear closer together and thinner when the vehicle is far away, and the sign is difficult to read until the vehicle is close. Conversely, characters on front signs appear closer together and thinner when the vehicle is about to pass a passenger.

In summary, the questions and issues that were not addressed by the regulations included:

- ❑ Do the ADA specifications for vehicle signage adequately address the needs of persons with visual impairments?

- ❑ Is the new electronic signage technology, with its capability to provide multiple messages by alternating text, usable by persons who are visually impaired?

- ❑ Is the minimum character height of 1-inch for side signs and 2-inches for front signs adequate for persons with visual impairments? If not, what size character is both readable and appropriate for placement on vehicles?

- ❑ Should letters used for vehicle signage be upper case or mixed upper and lower case?

- ❑ How can the best contrast on vehicle signs be achieved?

- ❑ Is sign readability enhanced by using a wide character width?

- ❑ Is the "wide" spacing between letters cited in the ADA regulations associated with improved readability by persons who have visual impairments?

1.4 SUMMARY OF ADDITIONAL FTA-SPONSORED RESEARCH

As a result of this initial research, the Federal Transit Administration (FTA) recognized that more research was needed on factors affecting the legibility of transit signs for individuals with visual impairments. The FTA funded a research project—with scientists from Boston College and the American Foundation for the Blind, and bus technology experts from Booz·Allen & Hamilton—to identify and explore factors associated with the readability of conventional print and electronic signs when both the individuals and/or signs are in motion (the vehicle is in motion and the sign is alternating messages), as is typically found in the transit bus environment.

The results of this research project, obtained through human factors testing and focus group discussions, led to some general conclusions about the readability of transit bus signage:

- There are specific signage characteristics for both conventional and electronic signs that enhance readability for persons with low vision.
- The specific signage characteristics that enhance readability by persons who are visually impaired, also enhance sign readability for persons who report having normal sight.
- Other variables exist in the transit environment that can enhance or detract from sign readability.

The research project results were then used to develop the recommendations contained in this handbook.

1.5 HOW TO USE THIS HANDBOOK

The handbook is organized in two parts. Part I contains information to help the transit professional understand and address the needs of customers to improve visual communications and provide accessible transportation to persons with disabilities. Part I reviews the current regulatory mandates, discusses current transit sign technology, and provides an in-depth discussion of factors to consider when selecting an ADA-compliant sign. For those interested in the research project, the second part of the handbook summarizes the results of the human factors and focus group research.

Chapter 2
CURRENT TRANSIT BUS SIGNAGE REGULATIONS

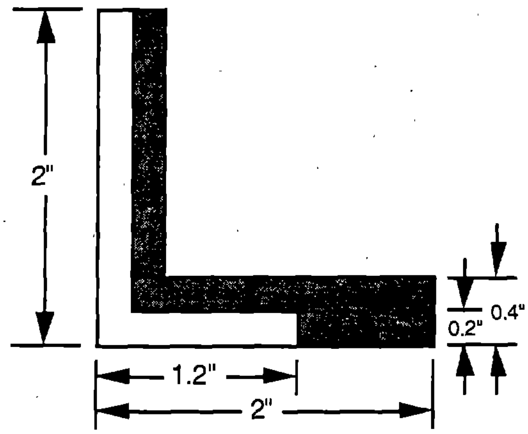
The regulations for transit bus signage were developed by the Architectural and Transportation Barriers Compliance Board (Access Board) and first issued in the Americans with Disabilities Act Accessibility Guidelines (ADAAG), Section 4.30.2, in July 1991. After a period of public comment, these regulations were adopted by the U.S. Department of Transportation and were published in the Federal Register, Volume 56, Number 173, pages 45757-45760, dated Friday, September 6, 1991.

Transit bus signage regulations are referenced in Title 49, Code of Federal Regulations; Part 38 Americans With Disabilities Act (ADA) Accessibility Specifications for Transportation Vehicles; Subpart B–Buses, Vans and Systems; Section 38.39, Destination and Route Signs. The text of the regulation citation is as follows:

> § 38.39 **Destination and route signs.**
>
> (a) Where destination or route information is displayed on the exterior of a vehicle, each vehicle shall have illuminated signs on the front and boarding side of the vehicle.
>
> (b) Characters on signs required by paragraph (a) of this section shall have a width-to-height ratio between 3:5 and 1:1 and a stroke width-to-height ratio between 1:5 and 1:10, with a minimum character height (using an upper case "X") of 1 inch for signs on the boarding side and a minimum character height of 2 inches for front "head signs", with "wide" spacing (generally, the space between letters shall be 1/16 the height of upper case letters), and shall contrast with the background, either dark-on-light or light-on-dark.

Figure 2-1 shows a graphical representation of the current regulations—an example of character dimensions and inter-character spacing.

Character Dimension Example



Current Regulations

Width-to-Height Ratio
3:5 and 1:1

Stroke-to-Height Ratio
1:5 and 1:10

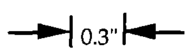
H ≥ 1" Boarding Side Signs

H ≥ 2" Front Headsigns

	Gray Letter "L"	White Letter "L"
Width-to-Height Ratio	3:5	1:1
Stroke-to-Height Ratio	1:10	1:5

Inter-Character Spacing Example

Current Regulations



Calculation

Letter Width 0.2"
x 1.5
Inter-Char. Sp. 0.3"

FIGURE 2-1. GRAPHIC REPRESENTATION OF ADA TRANSIT BUS SIGNAGE REGULATIONS

The Access Board issued a Technical Assistance Manual in October 1992, entitled, "Buses, Vans, and Systems," which recommended that signage characters contrast with the background by 70 percent. The manual provided a specific formula for determining contrast percentages:

$$\text{Contrast} = [(B_1 - B_2)/B_1] \times 100$$

where B_1 = light reflectance value of the lighter area

and

B_2 = light reflectance value of the darker area

Chapter 3
REVIEW OF CURRENT TRANSIT BUS SIGN TECHNOLOGIES

3.1 BACKGROUND

The transit bus destination sign market is currently dominated by two technologies—the conventional printed roller curtain sign and the more recently developed electromagnetic painted flip dot and split flap signs. While the roller curtain sign has been in use since the turn of the century, the electromagnetic signs were not commonplace until the early 1980s.

Each technology offers distinct advantages and disadvantages. The roller curtain sign has a limited number of destination displays, but offers substantially lower cost, a wide variety of colors and logos, and very good readability of its printed characters. The flip dot and split flap signs offer a large number of programmable destination displays, but are considerably more expensive. In addition, the reflective surface area-to-size ratio of their characters is less than printed signs due to the intra-character spaces between the dots and flaps.

This section of the handbook examines each of these currently used technologies as well as some emerging and evolving technologies (such as light emitting diode and liquid crystal display signs) that may be of interest to transit operators. The point of this section is to help transit operators make informed decisions when specifying signage for bus procurements or retrofits, which are also responsive to the needs of persons with visual impairments.

3.2 CONVENTIONAL ROLLER CURTAIN PRINT SIGNS

The traditional cloth or mylar roller curtain print signs have been used successfully for many years in a wide variety of transit applications. However, there are two constraints on their use:

- The number of destinations the signs can display
- The effort required to change or add a destination display.

In addition, the overhead compartment that bus manufacturers provide for the front and side destination signs does not accommodate the diameter of the mylar roll that is needed for very large numbers of destinations. For example, large operators like the New York City Transit Authority, with its fleet of 2,800 buses, found it very costly to maintain and update curtain sign rolls two or three times per year. On the other hand, small operators with less than 150 destinations and who make few permanent changes to their fixed route service, continue to find the curtain destination signs very attractive—both economically and functionally. Table 3-1 lists the advantages and disadvantages of conventional roller curtain signs.

TABLE 3-1. ADVANTAGES AND DISADVANTAGES OF CONVENTIONAL ROLLER CURTAIN SIGNS

Advantages	**Disadvantages**
• Large character sizes are available up to 11 inches high	• The 150 exposure limit may be insufficient for large properties
• A broad spectrum of colors and designs are available	• Route changes require new or spliced curtain rolls
• Front and side signs can be linked to move simultaneously	• Curtain rolls are subjected to tearing and jamming
• Signs are capable of about 150 different exposures each	
• Driver can verify correct sign selection on LED readout or through a peep hole from the interior of the vehicle	
• Signs are back-lit resulting in good nighttime visibility	

3.3 ELECTROMAGNETIC FLIP DOT AND SPLIT FLAP SIGNS

The electromagnetic flip dot and split flap signs have captured an increasingly large share of the transit bus market over the past 15 years. The signs consist of matrices of dots or split flaps with an electromagnet behind each dot that reverses polarity on a signal from a central microprocessor (controlled from the driver's console). This causes the dot to flip over or the split flap to open thereby exposing either the painted or the black side. Typically, the dots or flaps are painted with a highly reflective, fluorescent yellow paint, though other colors are available.

Recent advances in this technology include the ability to display as many as six colors on a split flap type of sign and the use of fiber-optics to channel high intensity light through miniature holes in the flaps to the surface of the sign. Table 3-2 lists the advantages and disadvantages of electromagnetic flip dot and split flap signs.

TABLE 3-2. ADVANTAGES AND DISADVANTAGES OF ELECTROMAGNETIC FLIP DOT AND SPLIT FLAP SIGNS

Advantages	Disadvantages
• Signs can accommodate a large number of destinations—stored in the microprocessor memory • Front and side signs are linked to change simultaneously—one controller drives all the signs • Driver can verify correct sign selection on LED readout • Sign can be linked to a voice annunciation system • Character size is limited only by height of sign • Characters can be "double stroked" to increase legibility • Proven technology in industry use	• Expensive, relative to roller curtain signs • Reduced character reflective area compared to print signs • Mechanical device—subject to dust, vibration, and moisture

3.4 SEVEN-SEGMENT ELECTROMAGNETIC SIGN

The seven-segment electromagnetic sign is a recent innovation in the electromagnetic sign market. With only seven reflective areas, the seven segment sign may improve the visual clarity of the route number characters since it has a relatively large reflective surface area-to-size ratio. Table 3-3 lists the advantages and disadvantages of the seven-segment electromagnetic sign.

TABLE 3-3. ADVANTAGES AND DISADVANTAGES OF THE SEVEN-SEGMENT ELECTROMAGNETIC SIGN

Advantages	Disadvantages
• Large surface area-to-size ratio improves numeral legibility • Relatively low cost, changeable route number technology • Signs are available with 9-inch high numerals	• Requires a separate destination sign • Only capable of displaying numeric characters • Alphanumeric route numbers, such as B10 cannot be displayed • Mechanical device—subject to dust, vibration and moisture

3.5 LIGHT EMITTING DIODE SIGNS

Light Emitting Diode (LED) sign technology has found increasing acceptance in transit environments because it offers several advantages over mechanical signs. LEDs are not light bulbs in the traditional sense but rather solid state devices consisting of chemically-treated silicon crystals that emit light when electrical current flows through them. LEDs come in various sizes, measured by the diameter of their "luminous point," and can be arranged in matrices of any size depending on the specific application.

Recent advances in LED technology include the development of high intensity LEDs, which overcome the problem earlier LEDs had with visibility in bright sunlight. Also, new "flat view" LEDs have increased the viewing angle to as wide as

165°—thus substantially improving the side angle readability of LED signs. Finally, multi-color LEDs have been developed whose colors help to differentiate types of information within a sign. Table 3-4 lists the advantages and disadvantages of LED signs.

TABLE 3-4. ADVANTAGES AND DISADVANTAGES OF LIGHT EMITTING DIODE SIGNS

Advantages	Disadvantages
• Solid state device with no mechanical parts to fail	• Operating costs higher than dot/flap systems
• Lifetime average of 100,000 hours (more than 10 years of nonstop use)	• Light output may decrease substantially with angle of view
• Displays graphics with great flexibility in programming	• Contrast ratios typically not as high as dot/flap systems
• Can display up to three colors (red, green, orange) in addition to black	
• Character size is limited only by height of sign	
• Drive voltage and wattage requirements are relatively low	
• Can link state-of-the-art transit communication systems	

3.6 LIQUID CRYSTAL DISPLAY SIGNS

Liquid crystal display (LCD) is the newest type of sign technology currently used in public transit. There are three basic types of LCD signs:

- Reflective LCDs, which reflect ambient light
- Transmissive LCDs, which permit light to pass through from behind
- Transflective LCDs, which can both reflect and transmit light.

The transflective LCDs may be useful for bus destination signs since they allow light to pass through from a rear light source at night and make use of sunlight during the day.

LCDs function like a light valve, allowing light to pass through or reflect off tiny crystals suspended in liquid contained between sheets of glass as voltage supplied to the liquid is varied. The LCD segments in the glass can be arranged as dot matrices, mosaics, or combinations of straight and curved border lines resulting in sharply defined and precise character outlines that can be easy to read. Figure 3-1 is an example of what an LCD display looks like.

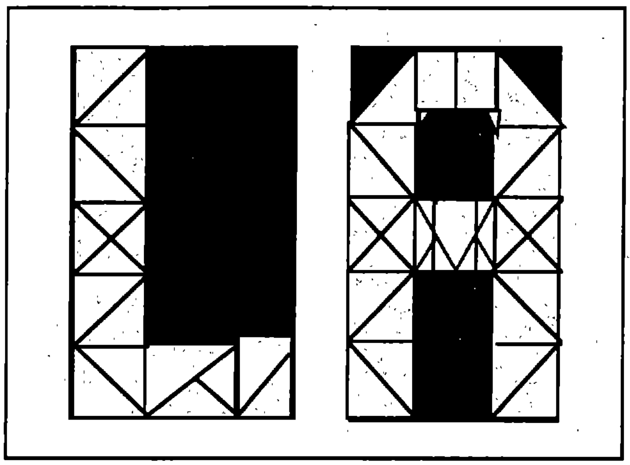


FIGURE 3-1. LCD DISPLAY EXAMPLE

Table 3-5 lists the advantages and disadvantages of LCD signs.

TABLE 3-5. ADVANTAGES AND DISADVANTAGES OF LIQUID CRYSTAL DISPLAY SIGNS

Advantages	**Disadvantages**
• Solid state device with no moving parts • LCD performance does not degrade over time • Character quality is high, with curved segment design • Character size is limited only by height of sign • Can display various colors using dyes or filters	• Requires rear light source in dim light and at night • Tendency to have "ghosts" as characters change • Contrast ratios typically not as high as dot/flap systems

Chapter 4
FACTORS TO CONSIDER WHEN SELECTING TRANSIT BUS DESTINATION SIGNS

4.1 OVERVIEW—MAKING A DECISION

The real assignment of the transit professional is to decide how to apply their own experience and the knowledge gained from the contents of this handbook to select transit bus destination signs. Each transit agency must consider many factors before a decision is made, but generally the following questions need to be answered:

- *What sign technology is best for us?* Basically, a transit manager must choose between conventional printed roller curtain or changeable message sign (CMS) technologies. The general advantages and disadvantages of each technology must be weighed by a transit agency in light of a specific vehicle, service, or modal application. For example, if roll curtain technology is selected, then cloth or mylar rolls are available, and split curtains (two curtains side by side along a vertical axis) can increase destination sign display flexibility. If CMS technology is selected then flip dot or slip flap is available, as well as one of the emerging technologies, such as LED or LCD.

- *What capital or operating funds are available?* The additional purchase price of changeable message sign (CMS) technology over roll curtain technology may limit a transit manager's choices.

- *What are our maintenance capabilities/strategies? Is destination sign equipment standardization an issue?* Such things as labor agreements, subcontracting provisions, maintenance employee skill levels, and types of equipment already in use may influence technology choices.

- *What are the equipment supplier issues?* Items such as adaptability, reliability, durability, maintainability, service, parts, and warranty may influence technology choices. In addition, determine the life expectancy of the destination sign equipment. Too often, the destination sign system is sold or scrapped along with the sale of vehicles that are being retired and new destination sign systems are ordered with the purchase of new vehicle. With the advent of more sophisticated and expensive destination sign equipment, consideration should be given to re-using the destination sign system in replacement vehicles.

- ❑ *What do our riders want?* Customer and employee preferences for readability, operation, and types of messages should also be considered. Before selecting a specific supplier's destination sign system, evaluate the product to ensure that the system meets the minimum ADA requirements; and just as important, that the system will satisfy the needs of your customers and is compatible with your transit operations.

4.2 OTHER FACTORS THAT AFFECT THE LEGIBILITY OF TRANSIT DESTINATION SIGNS FOR INDIVIDUALS WITH VISUAL IMPAIRMENTS

However, as important as the questions are, the main objective of this section is to identify the important factors affecting the legibility of transit destination signs for individuals with visual impairments. Results of the FTA-sponsored research project, obtained through human factors research and focus group discussions, led to some general conclusions about the readability of transit bus signage:

- There are specific signage characteristics for both conventional and electronic signs that enhance readability for persons with low vision.
- The specific signage characteristics that enhance readability by persons who are visually impaired, also enhance sign readability for persons who report having normal sight.
- Other variables exist in the transit environment that can enhance or detract from sign readability.

Based on the research project results, additional factors that should be evaluated when deciding on the "right" destination sign system for your transit agency are discussed in the following paragraphs.

- **Route Number.** The route number is the most important element on a destination sign. Display the route number first—on the left of the destination sign—and make it as big as possible. If two lines of text are required, the route number should be separate and distinct, and measure the full height of the sign display (twice the text height), as shown in Figure 4-1.

FIGURE 4-1. ROUTE NUMBER DISPLAY WITH TEXT

- **Character Size.** Go beyond the character size dimension requirements of the ADA regulations. The **"bigger the letter—the better."** The limiting factor on character size is most often the vehicle destination sign compartment and/or the selected destination sign supplier's technology. Rely on **these** size restricting dimensions to specify the largest possible character readings, and avoid relying on the legal "minimum" character dimensions. Generally, a 1-inch increase in character size produces another 50 feet in distance readability.

- **Visual Clutter.** Identification markings—such as a bus number, or advertisements that are mounted on the vehicle near the destination sign—can clutter the destination display and confuse the reader. Avoid marketing, public service, or goodwill messages in the destination sign reading (an shown in Figure 4-2). Instead, place these types of messages in the advertising spaces provided on transit vehicles for such information. This issue is more common with CMS systems, where a marketing message is programmed to alternate with a destination reading. Passengers are more interested in where the bus is going when looking at the destination sign. Vehicle identification numbers, radio station call numbers, and service telephone numbers should not be displayed in proximity to route number signs.

FIGURE 4-2. AN EXAMPLE OF HOW OTHER MESSAGES ADD TO VISUAL CLUTTER

- **Standard Destination Sign Locations.** Location of destination signs on the vehicle warrants careful consideration. When purchasing new vehicles, the transit professional should work with the vehicle manufacturer during design review meetings to ensure that destination signs are placed in a location that is consistent and standard with the existing fleet. Although a preference for positioning destination signs at "eye level" was identified during the research study, this preference must be evaluated in light of other factors that can influence destination sign location on the vehicle. For example, the vehicle destination sign compartment may be costly to reconfigure or relocate on a particular vehicle design. Also, readings at eye level may be blocked by crowds or may not be feasible because of the arrangement of passenger stations or bus stops. Finally, "eye level" is not a precise location and varies among individuals.

- **Standard Destination Sign Configuration.** The number of destination signs per vehicle and the layout of those signs is important. To satisfy the basic ADA regulations for a 22-foot or longer vehicle, a basic destination sign system requires a front destination sign (head sign), a boarding side sign, and an audible and visual "Stop Request" indicator.

The Stop Request is activated when the passenger chime is activated. The destination sign configuration and location on each vehicle should be standardized within the entire fleet—so that customers will instinctively know where to look for destination information.

- **Glare.** Minimize glare to the extent possible by selecting nonreflective materials for the destination sign hardware and by positioning glazing surfaces in a manner to avoid reflective glare.

- **Cleanliness.** To enhance readability, keep destination sign glazing and reading display surfaces clean by scheduling this cleaning activity during the maintenance department's major vehicle cleaning program. Many designs make it difficult to access the inside of the destination sign compartment for cleaning. Access improvements should be considered when buying new equipment.

- **Maintenance.** Maintain the destination sign system by following the manufacturer's recommended preventive maintenance intervals and repair practices, such as replacing burnt bulbs.

- **Fog.** Utilize a defogger, fresh air blower or electric strip, on the destination sign glass surface to reduce fogging and improve the readability of the destination sign display.

- **Optional Signage.** Beyond the regulatory requirements, optional signage can be added. Route/run number signs can be included on up to all four sides of the vehicle. Also auxiliary destination signs can be mounted on the vehicle dash, in the rear window, over the passenger aisle near the driver's compartment, or on either side of the vehicle.

- **Operator Announcement.** To enhance communications, destination signs can be supplemented by audible destination information announcements. To meet ADA requirements, at a minimum, major intersections, major stops and destinations requested by passengers must be announced. Typically, a vehicle operator, properly trained in the ADA regulations, will make an approaching stop announcement over the PA System. For example, "Next Stop, Third and Main, connecting service, Routes 2 and 3."

- **Automatic Announcement.** Technological advancements now permit automatic stop announcements—through the use of electronic equipment. On a very basic system, the operator may be required to activate an audio device each time the vehicle approaches the next stop. The device is usually programmed to announce the stops in sequence. Coupled with an automatic vehicle location (AVL) system, inductive loop system, or similar vehicle/route identification system, the audio device can be activated automatically with limited driver intervention.

- **Bus Hailer.** An inexpensive and less sophisticated approach to helping those who are visually disabled board the correct bus is the bus hailer system. Very simply, a passenger stands at the bus stop holding a card in the direction of approaching traffic so a transit vehicle operator can read the card that prominently displays the desired route number. The operator must be trained to recognize this card and if the route corresponds with the route number on the card, the operator pulls over to pick up the passenger.

- **Correct Readings.** Proper employee training and supervision are important to ensure that the proper destination sign readings are displayed on transit vehicles. Typically, a vehicle must change displays several times a day—each time at the end of the line, for the return trip, and when the vehicle is "out of service." AVL equipment can also be utilized to automatically change destination sign readings at appropriate points along the route, such as at the end of the line or in the center of town.

- **Unique and Distinct Readings.** Each destination sign reading should be unique for that particular destination, especially the route number designation. Routes that have the same number designation, but that go to different final destinations, tend to confuse the transit rider.

- **Destination Sign Readings Inventory.** The entire list of destinations for a transit system's route network, "the destination sign readings inventory," must be kept up to date on each vehicle. Service changes often require the creation of new readings. Thoughtful preparation must go into this process. Destination sign readings by their very nature must be concise and communicate the final destination with no room for ambiguity. This task is usually the responsibility of the Marketing and Planning staff, but it is worth the effort to involve others, such as the operator, the customer and the scheduler.

- **New Transit Service Destinations.** Once the destination sign readings inventory is complete, adequate lead time before the new service is implemented must be given to install the new readings on each vehicle. For CMS systems the process of updating the inventory is usually accomplished electronically by downloading new readings from a portable memory transfer unit (MTU) to the programmable memory chips in the controller for the sign system. Changes to roll curtains may require completely new curtains, splicing in sections with new readings, or silk screening or stenciling new readings onto blank spaces on the curtain.

4.3 TRANSIT BUS DESTINATION SIGN CHECKLIST

Using ADA requirements as the benchmark, field testing has shown some factors that should be considered to benefit the visually impaired. These are shown in the checklist in Figure 4-3. This checklist is designed to help transit agencies choose a sign system.

Part I. "Specific" Sign Factors

- **Character Height**
  - ✓ Front Signs: 6-inch minimum height for print and 5.5-inch for CMS
  - ✓ Side Signs: 2- to 4-inch for print and 4-inch minimum for CMS
- **Character Width-to-Height Ratio**
  - ✓ Should be 3.5:5 to 1:1 (width 70% to 100% of height)
- **Character Stroke Width-to-Height Ratio**
  - ✓ Should be between 1:7 and 1:5 (width 14% to 20% of height)
- **Inter-character Spacing**
  - ✓ Should be between 1.5 and 2.0 times stroke width
- **Contrast**
  - ✓ High contrast should be maintained (white on black preferred)
- **Message Display Capabilities**
  - ✓ Displays route number continuously
  - ✓ Displays route number in larger size than text
  - ✓ Displays only upper case characters
  - ✓ Displays single line text messages
  - ✓ Displays 8-inch route numbers on 2-line messages
  - ✓ Displays 8-inch route number on signs with changing messages

Part II. "External" Sign Factors

- **Glare Abatement**
  - ✓ Signs are positioned at an angle to minimize unavoidable glare
  - ✓ Sign covering material is designed to minimize glare
- **Sign Placement on Vehicle**
  - ✓ Side destination signs are located at the bottom of the side passenger window that is closest to the entrance door.
- **Visual Clutter Abatement**
  - ✓ Competing numerical information is not displayed in proximity to bus route and destination signs where it may confuse passengers with visual impairments.
  - ✓ Message content of destination signs is limited to route and destination information since messages like "Have a Nice Day" are confusing to persons with visual impairments.

FIGURE 4-3. TRANSIT BUS DESTINATION SIGN CHECKLIST

Chapter 5
SUMMARY OF RECOMMENDATIONS

The results of this research project, obtained through human factors testing and focus group discussions, led to some general recommendations to improve the readability of transit bus signage:

Character Specifications

Sign Type	Character Height	Inter-Character Spacing	Character Width-to-Height Ratio	Character Stroke Width-to-Height Ratio
Print	Front: 6-inch minimum Side: 2-inch to 4-inch minimum	1.5 to 2.0 times stroke width	3.5:5 to 1:1 (with 70% to 100% of height)	1:7 to 1:5 (width 14% to 20% of height)
CMS	Front: 5.5-inch minimum Side: 4-inch minimum	1.5 to 2.0 times stroke width	3.5:5 to 1:1 (width 70% to 100% of height)	1:7 to 1:5 (width 14% to 20% of height)

Contrast

High contrast should be maintained on all destination signs. White characters on a black background are recommended.

Glare

Materials that cover the destination sign should be designed to minimize glare. All destination signs should be positioned at an angle to minimize glare.

Sign Placement of Vehicle

Destination signs should be located at the bottom of the side passenger window that is closest to the entrance door.

Visual Clutter

Competing numerical information should not be displayed in proximity to bus route display on the designation sign, where it may confuse passengers with visual impairments. Text messages should be limited to destination information only. Messages such as "Have a Nice Day" are confusing to persons with visual impairments.

Message Display Capabilities

- Display route number continuously
- Display route number in larger size than text
- Display only upper case characters
- Display single line text messages
- Display 8-inch route numbers on 2-line messages
- Display 8-inch route numbers on signs with alternating or changing messages

PART II

For those interested in the research project, the second part of this handbook summarizes the results of the human factors testing and focus group research. The reasons for complementing human factors testing with focus group studies were to:

- Determine the extent to which the experiences of the focus group participants with transit bus signage were consistent with the human factors testing

- Learn about the factors that persons with visual impairments believe affect the readability of signs in dynamic transit environments

- Explore additional factors that persons with visual impairments believe are related to reading changeable message signs.

Subjects for this research project included individuals with visual impairments whose best corrected visual acuities range from 20/70 to 20/400, as well as individuals who reported normal vision. Subjects reported that they were regular and frequent users of bus and subway public transportation.

Subjects for human factors testing were recruited through newsletters, telephone information tapes, radio broadcasts, medical service providers, agencies providing services to persons with visual impairments, and churches and social service agencies in close proximity to Boston College. Subjects were paid $20.00 for their time and efforts.

Subjects for focus groups were recruited through low vision clinics, agencies providing services to persons with visual impairments, and a consumer membership organization. Five focus group sessions were conducted in four different cities—New York, Atlanta, San Francisco, and Washington, D.C.

Although this research project was very comprehensive, and new information about the characteristics of conventional and electronic signage that are associated with sign readability was gathered, there are area where future research could be directed. Some proposed topics for future research are:

- Identify the characteristics associated with readability of conventional and changeable message signs in night viewing conditions.

- Identify the characteristics associated with readability of alternating CMS messages in dynamic conditions for day and night viewing.

- Compare the various available CMS technologies (LED, LCD, flip dot) to determine which are the most readable

- Identify the optimum distance of a vehicle sign from a viewer for readability

- Test the efficacy of the strong recommendation from the focus group participants that the route number be placed on each message presented on the front and side signs.

Chapter 6
HUMAN FACTORS TESTING—SUMMARY OF RESULTS

Human factors testing was divided into two phases. Phase I research tested persons in a laboratory-type setting to examine the readability of conventional print signs; Phase II studied the readability of electronic changeable message signs (CMS).

6.1 PHASE I TESTING—CONVENTIONAL PRINT SIGNS

Phase I research tested persons with and without visual impairments in a laboratory-type setting to examine the readability of conventional print signs. The signs contained 6-letter, 2-syllable names that were not associated with transit destinations in the city where the testing was conducted (Boston, Massachusetts). Names not associated with transit were chosen to control for familiarity and anticipation. The signs were printed in Helvetica Bold font, with an inter-character spacing of 1.25 times stroke width, in white letters on a black background. Three different character heights were tested (2-inch, 4-inch, and 6-inch) and two case levels (all upper case and mixed case).

6.1.1 Test Materials

Two, 16-millimeter motion pictures were made of print signs in four movement conditions:

1. Sign stationary/observer stationary
2. Front sign moving/observer stationary
3. Side sign moving/observer stationary
4. Side sign stationary/observer moving.

For the stationary condition (1), the stationary camera was directly in front of the signs, which were mounted on the fence, 5-feet above the ground. Viewing time in the stationary condition was 10 seconds.

For the two dynamic conditions (front sign moving and side sign moving), signs were mounted at a height of 8 feet on top of a vehicle that entered the filming area at 25 mile per hour and slowed to a stop within 400 feet over 20 seconds. There was a 5 mph deceleration for every 80 feet traveled until the last 80 feet, where a speed of 5 mph was maintained. Filming was done with the camera held in a position to simulate the viewing position of a person at a bus stop. Viewing time was 20 seconds.

For the condition in which the observer was moving (4), the signs were mounted on a fence at a height (to the center line) of 5 feet. The camera was inside the vehicle and the vehicle was driven so as to stop just as the camera was even with the sign. Viewing time was 20 seconds.

Filming took place on an overcast, winter day when there were no leaves on the trees and the film was then edited to keep glare to a minimum. The signs that were filmed also did not have a protective (and possibly reflective) surface in front of them. Thirty-two experimental and eight practice signs were filmed. Each of the two films contained four blocks of five signs, one block for each movement condition. The order of the blocks was counterbalanced across the two films to control for learning or fatigue. Each block began with a practice trial, which was followed by four randomized experimental trials that represented one each of the character height/case conditions.

6.1.2 Test Participants

Sixty participants were recruited for Phase I testing—17 males and 43 females. Participants had visual acuities between 20/20 and 20/400. For this project, persons having acuities better than 20/70 (in the range from 20/20 to 20/64) were considered to have normal vision; persons having vision less than 20/64 but better than 20/200 were considered to have low vision; and persons having 20/200 or less (in the range from 20/200 to 20/400) were considered to be legally blind. Persons were included in the experiment only if they reported being able, at least sometimes, to read large, high contrast, well-lighted signs from a distance of approximately 10 feet. Participants' visual acuities were confirmed using the Lighthouse Distance Visual Acuity Test (a standard visual acuity screening test). Participants were also screened for contrast sensitivity using the Vistech Vision Contrast Test System. Contrast sensitivity is a measure of the ability to see small differences in lightness and is a necessary component of being able to discriminate shapes (like letters). Table 6-1 shows the characteristics of the Phase I test participants.

Table 6-1. Phase I Test Participant Characteristics

Vision Group	Number of Subjects	Age Range	Age Average	Acuity Range	Acuity Average	Number of Subjects Using Telescopic Aid
Normal	24	20-73	43.7	20/20-20/64	20/34.1	1
Low	13	20-86	57.6	20/80-20/160	20/124.8	3
Legally Blind	23	28-83	54.1	20/200-20/400	20/289.6	0

6.1.3 Test Procedure

After visual acuity and contrast sensitivity were completed, the test procedures were explained to the participants. The participants were seated in a laboratory, 8 feet from a high quality projection surface where the sign images projected were actual size (i.e., the projected image of a sign have 6-inch characters was 6 inches high when the sign was at its closest distance to the camera). A viewing distance of 8 feet was used because observation and questioning of persons with visual impairments indicated that they were unlikely to stand closer than 8 feet to the sign on a moving vehicle because they would feel unsafe.

Signs were projected at approximately eye level for all participants in all conditions. The four movement conditions were explained and participants were told that as each sign came into view and became legible, they were to read the sign aloud. First, the participants viewed the practice sequence in each movement condition and could ask questions or have the instructions repeated. Then, the participants were asked to read each sign as it became legible. A digital counter was used to time responses—it was started as soon as each sign appeared on the screen and was stopped as soon as the participant began to say the name of the sign. Response times in seconds were recorded for correctly read signs.

6.2 PHASE I TESTING RESULTS—CONVENTIONAL PRINT SIGNS

The responses of the participants were tabulated and analyzed by researchers using the statistical tools Analysis of Variance (ANOVA) and Chi Square. The appropriate statistical procedure that is used when testing differences between a number of means (which in this research project were either response times or legibility distances) is ANOVA. It results in a statistic called "F." The value of "F" is located on a standard probability table, which indicates the probability that the observed differences in means occurred by chance. If the probability is less than 5%, it means that there is less than a 5% likelihood that the differences in means occurred by chance. This is called a *significant* difference. A Chi Square test is a "goodness of fit" technique, which permits the researcher to determine whether or not a significant difference exists between an observed number of cases falling into categories and the expected number of cases, based on a hypothesis of no differences. Both techniques were used to ensure that test data were accurately interpreted. After these statistical analyses were completed, some general conclusions were made.

6.2.1 Summary of Results for Stationary Conditions

In summary, signs having 6-inch letters were read fastest by all acuity groups; and for signs having 4-inch or 6-inch letters, signs in mixed case letters were read as rapidly as signs in all uppercase. In addition, persons who are legally blind could not read signs having 2-inch letters in 58% of the trials. Figure 6-1 shows the mean response times to stationary signs by signage type and vision group.

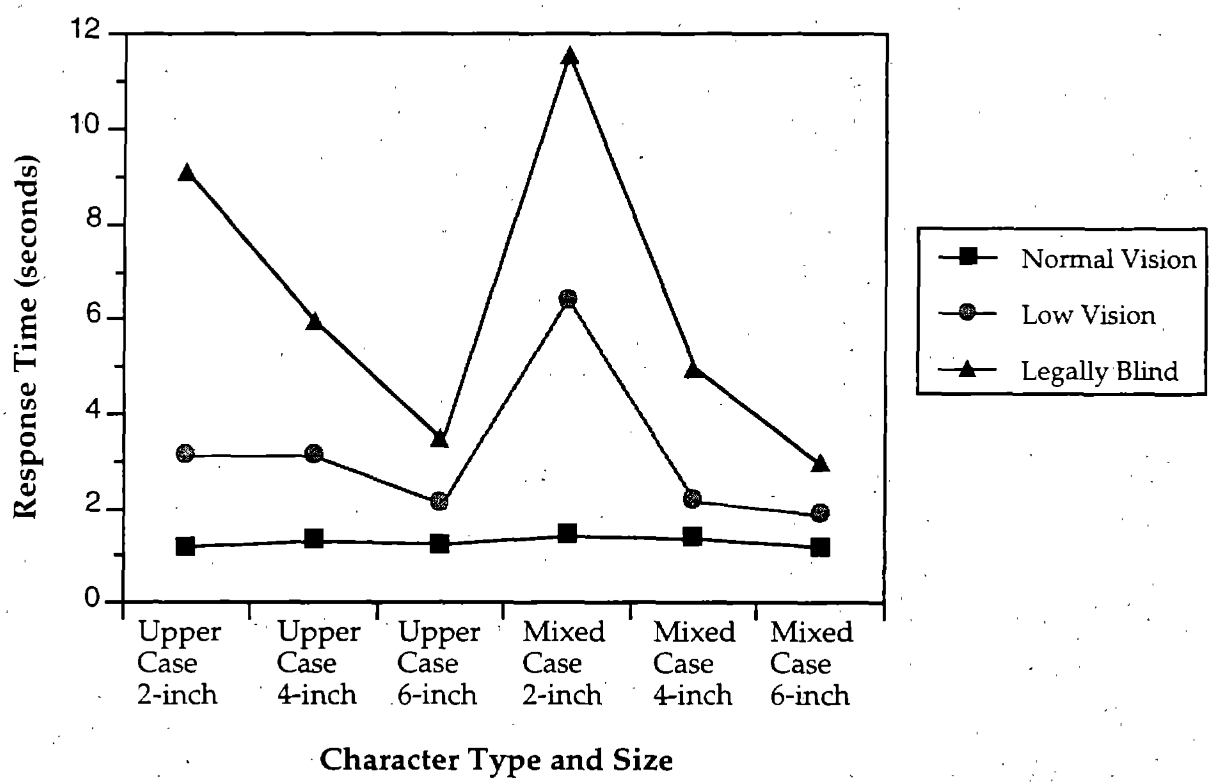


Figure 6-1. Mean Response Times for Stationary Conventional Print Signs

6.2.2 Summary of Results for Dynamic Conditions

The results from Phase I testing under dynamic conditions can be summarized as follows:

- Front and side signs that have 6-inch letters can be read at significantly greater distances by all acuity groups
- Front and side signs that use all uppercase letters can be read at significantly greater distances by all acuity groups.

Figure 6-2 shows the mean legibility distances in feet for dynamic signs (by signage type and vision group).

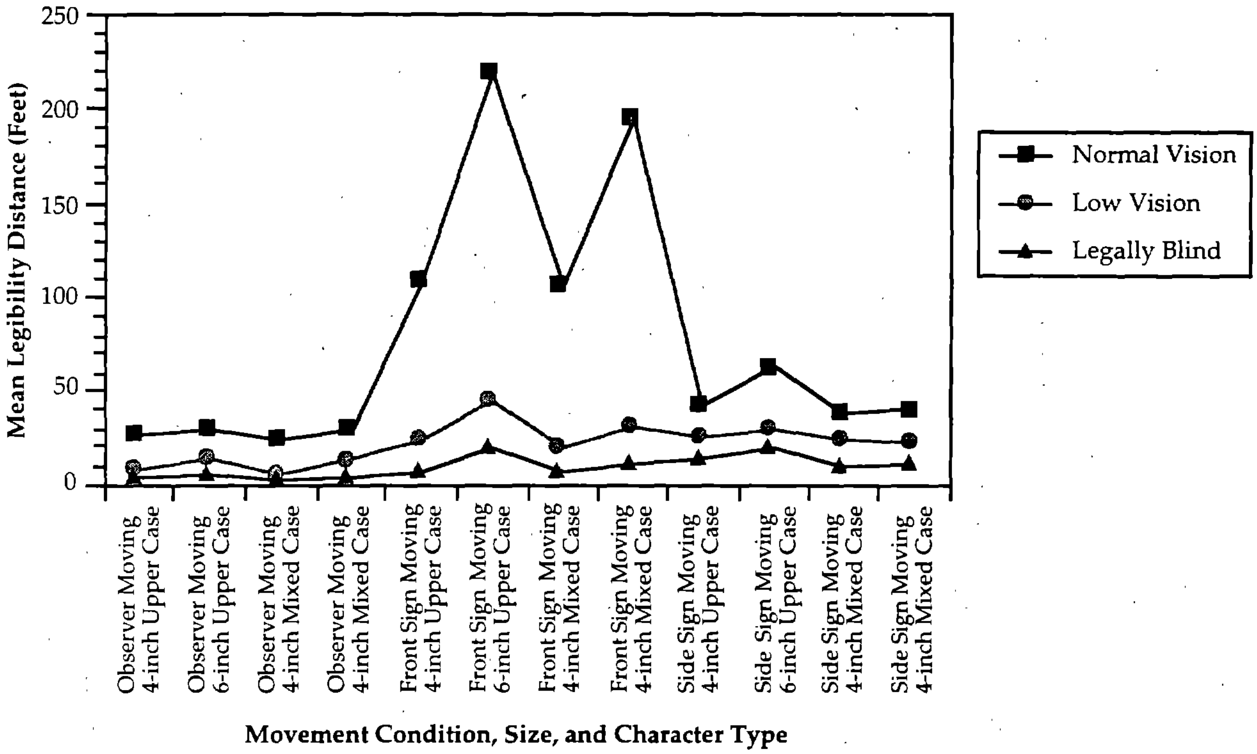


Figure 6-2. Mean Legibility Distances for Dynamic Conventional Print Signs

In addition, there were some differences in legibility of the front sign versus the side sign. In general, persons with normal vision read front signs at much greater distances than side signs. For persons with low vision, there was little difference in legibility distance between the front and side signs. However, persons who are legally blind read moving side signs at greater distances than moving front signs.

6.3 PHASE II TESTING—CHANGEABLE MESSAGE SIGNS

Phase II research tested persons with and without visual impairments in a laboratory-type setting to examine the readability of electronic changeable message signs (CMS). Electronic signs utilizing flip-dot technology were selected for Phase II. Flip-dot signs were chosen over other types of CMS technologies (such as light emitting diode–LED, and liquid crystal display–LDC) because flip-dot signs are currently in use for transit vehicles identification and were readily available for the research project.

The signs contained 6-letter common names that were neither associated with transit destinations nor names that were used in Phase I. In Phase II, the following factors were tested:

- Character height—4-inch, 6-inch and 8-inch. The 8-inch character height was included because some transit agencies are purchasing signs that can produce 8-inch (or 9-inch) characters. The 4-inch and 6-inch characters were produced on a sign with a display area of 44.8 inches wide by 6.4 inches high (small sign); and 6-inch and 8-inch characters were produced on a sign with a display area of 67.8 inches wide by 9.5 inches high (large sign).

- Character and stroke proportions for signs with 6-inch high characters. The signs used in Phase II were all double stroke (two dots wide).

- Inter-character spacing—1.5 times the stroke width (3 dots between characters) and 2.0 times the stroke width (4 dots between characters).

6.3.1 Test Materials

Two, 16-millimeter motion pictures were made of changeable message signs in three movement conditions:

1. Sign stationary/observer stationary
2. Front sign moving/observer stationary
3. Side sign moving/observer stationary

The "sign moving/observer moving" condition that had been tested in Phase I was omitted from Phase II. Phase I results for this condition were very similar to the front and side sign moving/observer stationary conditions, and it was anticipated that nothing new would be learned by including this motion condition for CMSs. In addition, omission of this motion condition permitted testing of an additional character height in all motion conditions.

The signs were mounted on top of the vehicle for all movement conditions. All other filming procedures were that same as Phase I. Phase II films were made in daytime conditions. The signs had a reflective protective surface in front of them and film editing kept glare to a minimum. Forty-eight experimental and eight practice signs were filmed. The films were then blocked and randomized in a manner similar to Phase I.

6.3.2 Test Participants

Fifty-nine participants were recruited for Phase I testing—25 males and 34 females. Efforts were made to recruit as many subjects as possible from those who participated in Phase I—28 persons participated in both phases. Again, participants had visual acuities between 20/20 and 20/400. Participants' visual acuities were confirmed and contrast sensitivities were measured. Table 6-2 shows the characteristics of the Phase II test participants.

Table 6-2. Phase II Test Participant Characteristics

Vision Group	Number of Subjects	Age		Acuity		Number of Subjects Using Telescopic Aid
		Range	Average	Range	Average	
Normal	20	21-76	54.4	20/20-20/64	20/36.2	1
Low	21	20-86	52.4	20/80-20/160	20/121.7	3
Legally Blind	18	21-77	49.2	20/200-20/400	20/291.7	0

6.3.3 Test Procedure

Test procedures were identical to Phase I. The participants were seated in a laboratory, 8 feet from a high quality projection surface where the sign images projected were actual size. Signs were projected at approximately eye level for all participants in all conditions. The three movement conditions were explained and participants were told that as each sign came into view and became legible, they were to read the sign aloud. A digital counter was used to time responses—it was started as soon as each sign appeared on the screen and was stopped as soon as the participant began to say the name of the sign. Response times in seconds were recorded for correctly read signs.

6.4 PHASE II TESTING RESULTS—CHANGEABLE MESSAGE SIGNS

The responses of the Phase II participants were tabulated and analyzed by researchers using the statistical tools Analysis of Variance (ANOVA) and Chi Square, similar to Phase I.

6.4.1 Summary of Results for Stationary Conditions

In summary, for stationary conditions:

- Signs with 8-inch characters were read faster than signs with 4-inch characters by all acuity groups. The mean response times for signs with 8-inch versus 6-inch characters and 6-inch versus 4-inch characters were not significantly different.

- Signs with wide character and stroke width-to-height proportions were read more slowly by persons having normal and low vision than signs with narrow character and stroke width-to-height proportions.

- There was no difference in response times attributable to wide versus narrow inter-character spacing for any acuity group.

Figure 6-3 shows the mean response times to stationary signs by signage type and vision group.

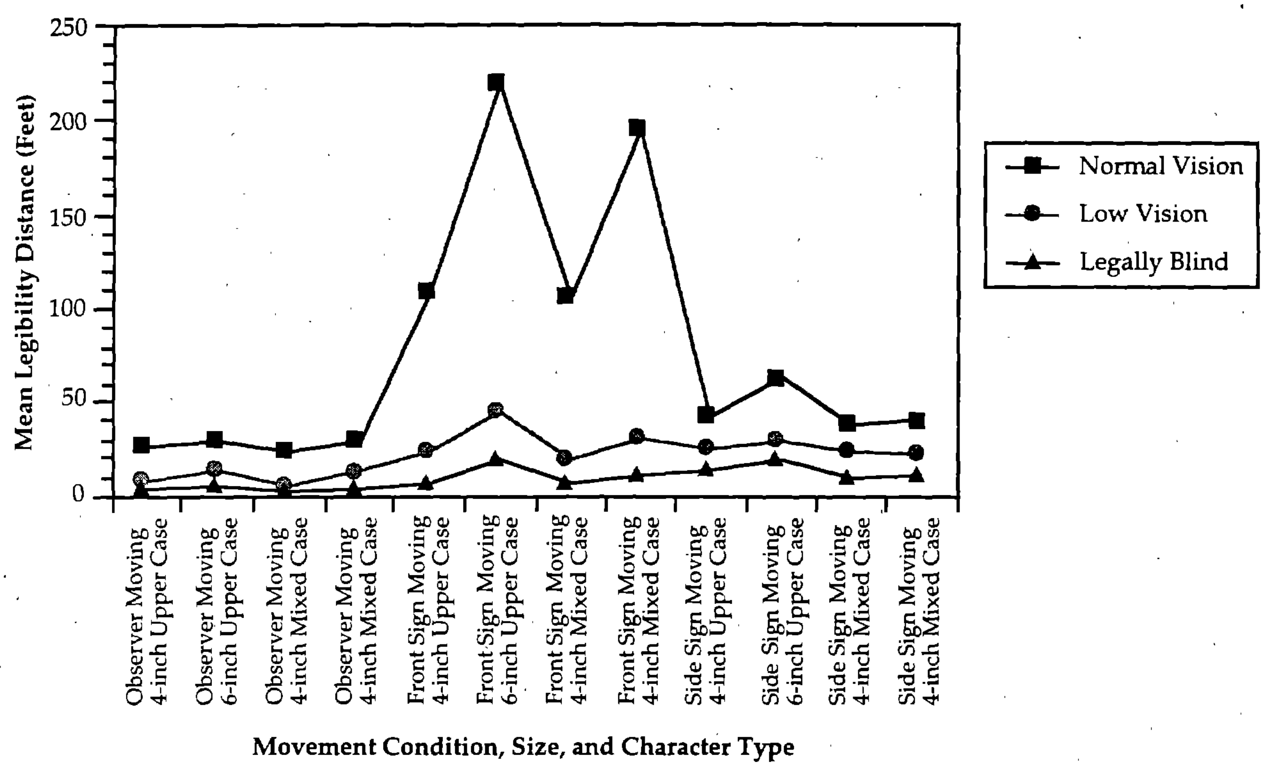


Figure 6-3. Mean Response Times for Stationary Changeable Message Signs

6.4.2 Summary of Results for Dynamic Conditions

The results from Phase II testing under dynamic conditions can be summarized as follows:

- Signs with 8-inch characters were read at greater distances than signs with 6-inch characters (which were read at greater distances than 4-inch characters) by persons with normal or low vision. However, for persons with low vision and reading front signs with wide inter-character spacing (4 dots), there was no different between 6-inch and 8-inch character signs.

- There was no difference in legibility distance attributable to wide versus narrow inter-character spacing (4 dots versus 3 dots) for any acuity group.
- Signs with wide character and stroke width-to-height proportions were read at significantly greater distances by persons having normal or low vision.
- The greatest advantage of large letter size was for front signs.
- Persons who are legally blind were unable to read front and side signs on 76.2% of the trials.

Figure 6-4 shows the mean legibility distances in feet for dynamic signs by signage type and vision group.

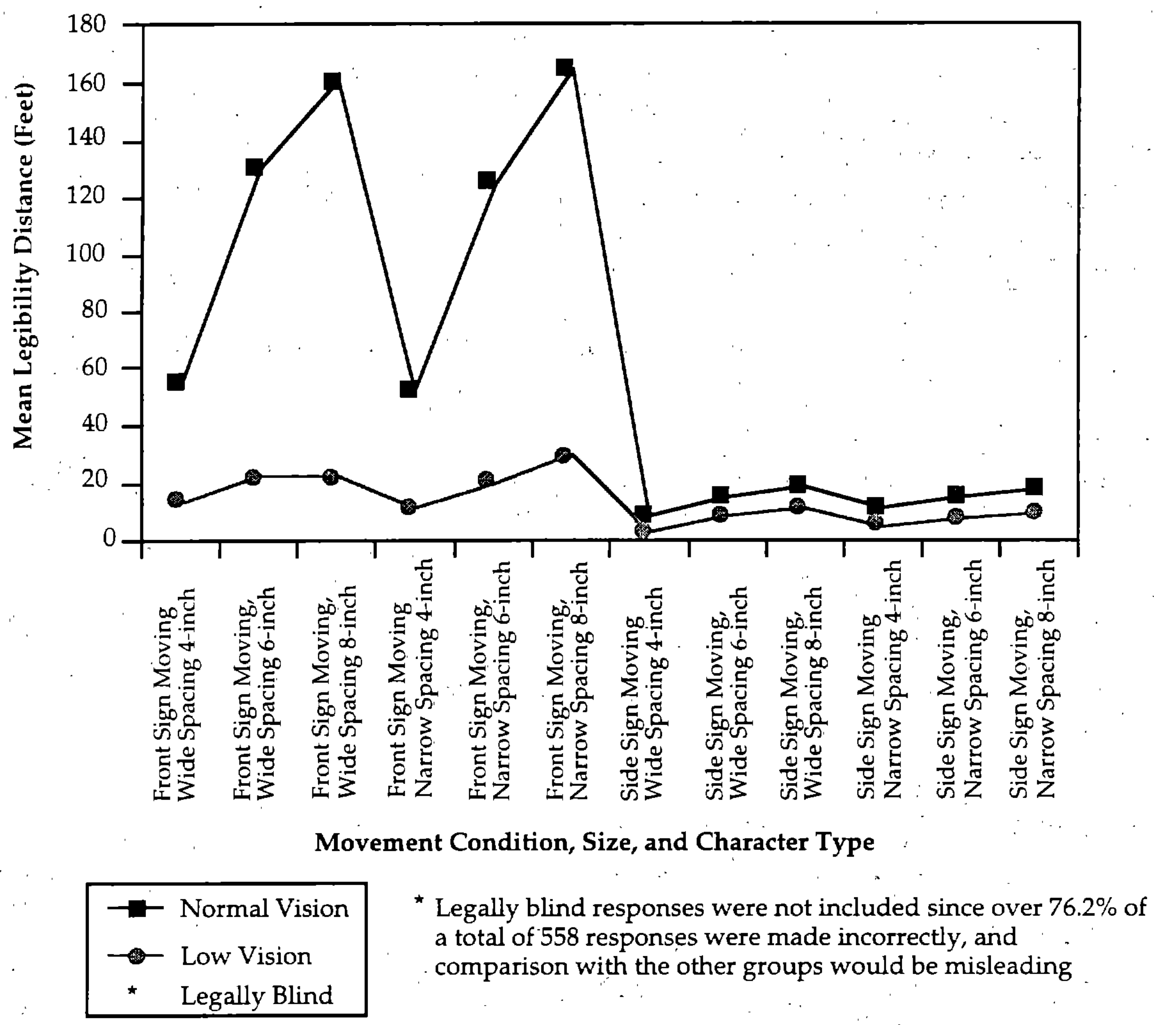


Figure 6-4. Mean Legibility Distances for Dynamic Changeable Message Signs

6.5 SUMMARY OF PHASE I AND PHASE II RESULTS

This project is the first research to investigate signage characteristics in dynamic conditions in which signs are moving towards observers. After reviewing the data from Phase I (conventional print signs) and Phase II (changeable message signs), it was found that motion type interacts with character factors of height, case, and character and stroke width-to-height ratios. Probably because of the foreshortening that limits the legibility distance of side signs, increased legibility distances attributable to these factors were greatest for front signs. Therefore, the greatest benefit for increasing legibility distances can probably be achieved by optimizing front signs.

This is also the first research to investigate the legibility of signs in any dynamic condition for persons with visual impairments. While there were differences in the speed and distance at which signs could be read by persons with different visual acuities, the pattern of results was essentially the same for all three groups—normal vision, low vision, and legally blind. Therefore, making signs more legible to persons with visual impairments also makes them more legible to persons with normal vision.

Chapter 7
FOCUS GROUP RESEARCH—SUMMARY OF RESULTS

Phase III of this project was focus group research. Five focus groups, made up of persons with visual impairments (reported visual acuities in the range of 20/70 to 20/400), were conducted in four areas of the country. Focus groups were conducted in New York City; Washington, D.C.; Atlanta, Georgia; and San Francisco, California (where two sessions were held). Each focus group session lasted for approximately 2 hours.

All focus group participants were either working or currently seeking employment, generally well educated, and reported using buses daily or weekly. In each focus group, 8 to 12 visually impaired participants discussed their general perceptions about transit bus travel, their experiences using both conventional and electronic bus signage, offered suggestions for enhancing bus signage, and reacted to paired comparisons of stationary changeable message signs and conventional print signs. Focus group participants also offered their reactions to CMS messages that utilized more than one line of text by alternating the message display (i.e., the first part of the message is displayed and then is replaced by the second part of the message). A moderator was present in each focus group to guide the discussion and to ensure that all relevant topics were addressed.

The discussion was broken down into two major areas—**direct factors** that pertain to the sign as a discrete entity, and **peripheral factors** that pertain to the sign as one element in the larger transit environment.

7.1 DIRECT FACTORS

The following are direct factors that pertain to the sign as a discrete entity:

- Character Size
- Upper and Lower Case
- Contrast
- Stationary versus Flashing or Alternating Messages

- Solid versus "Digital" Lettering
- Message Presentation
- Undesirable Message Content.

Character Size. Participants generally felt that sign characters should be as large, that is both as tall and wide, as possible. Participants expressed disappointment with the CMSs that are programmed with letters that are a single dot wide. The signs used in the focus groups had character widths of 2 dots and the participants felt that these were much more readable.

Participants universally noted that the bus route number was the most critical bit of information on a bus sign. In fact, they frequently suggested that this was the only piece of information required, assuming non-contradictory and unambiguous route numbering systems. Therefore, all focus groups stated a preference for signs to display the route number as large as possible.

Upper and Lower Case. Since this factor was not raised at all in the New York, Atlanta, or San Francisco focus groups and was not discussed at length in Washington, it could be concluded that case is not a significant factor in the readability of signs by persons who are visually impaired. [However caution is suggested with this conclusion, because of the results of the Human Factors Research discussed in section 6 of this handbook, where a clear preference for upper case letters was identified.]

Contrast. Participants felt that contrast was an important factor in bus sign legibility and expressed an almost unanimous preference for white characters on a black background. Where colors were used, they expressed a preference ranking of yellow, green, and red—in that order.

Since the above preferences reflect the actual experiences of the participants, and since the vast majority of participants avoid riding the buses at night, these comments on color and contrast may not be of value with regard to night viewing conditions.

Stationary versus Flashing or Alternating Messages. Participants preferred to have all critical information contained in a single display. Flashing or alternating messages reduce the time available for riders who are visually impaired to read and understand the messages. In addition, some eye conditions such as cataracts could make it difficult to read flashing or alternating messages.

Solid versus "Digital" Lettering. Participants expressed an almost universal preference for lettering in solid line strokes. Many noted that a common problem with the dot matrix signs is their tendency to become "messed up," that is, to fail to flip properly or become scrambled.

Message Presentation. Again, participants felt that the most important information on a bus sign is the route or line number. Other information such as destination or itinerary is less important. Where it is essential to present a lengthy message in more than one line of display, participants felt that each display panel should always contain the bus route or line number.

Undesirable Message Content. Some concern was expressed over the potential of the CMSs to display "extraneous matter" such as commercial advertising, which make it more difficult to read and understand destination sign information.

7.2 PERIPHERAL (ENVIRONMENTAL) FACTORS

The following are direct factors that pertain to the sign as one element in the larger transit environment:

- Glare
- Location of Sign on Bus
- Imprecise Bus Stops
- Bus Line Numbering Systems
- Bus Stop Information Signs
- Visual Clutter
- Driver Inability to Recognize Hidden Disabilities
- Awareness of Destination.

Glare. Participants felt that this was one of the most important obstacles to bus sign readability. Glare is defined as light from the sun, overhead street lamps, oncoming headlights, or other sources that reflects off the protective shielding of the destination sign and makes it difficult for a viewer to see the destination sign characters.

Location of Sign on Bus. Participants felt that the location of signs on the bus is also a very important factor. Front and side signs mounted high on the bus are difficult for persons with visual impairments to read—even at relatively short distances. In areas where multiple bus systems operate, another important issue is that there is no standard for the location of signs on buses. The result is frustration and lost time locating and deciphering the sign.

Imprecise Bus Stops. Participants in every focus group stated they had difficulty reading signs at bus stops where several bus lines intersect. These "hub" stops are often larger than normal and buses may stop at any point along a lengthy curb line. Also, buses typically form a long, tightly packed line at these stops, blocking the front signs and making them unreadable to anyone—regardless of visual condition.

Bus Line Numbering Systems. Participants in the New York and San Francisco groups expressed their concern with the confusion created by buses bearing identical line numbers that are bound for different destinations.

Bus Stop Information Signs. All participants felt that the information provided at bus stop signs was printed in characters that were too small to read. Also, the signs are generally placed on poles, at heights that make it difficult for the visually impaired to read them.

Visual Clutter. Participants felt that the tendency of bus authorities to load their buses with "visual clutter" is a significant problem. Bus identification numbers, dashboard run number signs, and bus advertising signs (particularly those with numerical information like radio station frequencies or telephone numbers), are very confusing when placed in the vicinity of the bus route number. The effect is to make it difficult for persons with visual impairments to sort out the critical sign messages.

Driver Inability to Recognize Hidden Disabilities. Participants felt that bus drivers tend to assume that persons without a cane or guide dog are equally capable of reading a sign.

Awareness of Destination. Participants in each focus group noted that disembarking at the proper stop is just as important as boarding the correct bus. Since some passengers with normal vision find it difficult to read small street signs as they ride by in the bus, the visually impaired have an even more difficult time identifying their correct stop. Thus, it is critical to the visually impaired that stops are announced.

GLOSSARY

The glossary of terms is provided to assist the reader understand terms or technical definitions that are used in this handbook. Although some of these terms may be defined differently than those in the Code of Federal Regulations, the reader should note that the definitions are consistent with the intentions of the American With Disabilities Act (ADA).

Accessible. With respect to vehicles and equipment that are compliant with the requirements of the ADA regulations.

Bus. Means any of several types of self-propelled vehicles, other than over-the-road buses, generally rubber-tired, intended for use on city streets, highways, and busways, including but not limited to minibuses, 40-, 35- and 30-foot transit buses, articulated buses, double-deck buses, and electric powered trolley buses, used to provide designated or specified public transportation services. Self-propelled, rubber tire vehicles designed to look like antique or vintage trolleys or streetcars are considered buses.

Central Field Loss. A loss of vision in the central portion of the field of view that reduces an individual's ability to see items in detail, read at near point, or recognize faces at close range. Items viewed at a distance become difficult, or impossible, to see at near point.

Demand responsive system. A system of public transportation of individuals, such as paratransit, which is not a fixed route system.

Disability. With respect to an individual, a physical or mental impairment that substantially limits one or more of the major life activities of such individual.

Discussion Guide. The outline used by the moderator to lead the focus group discussion.

DOT. The United States Department of Transportation.

ed route system. Public ground transportation on which a vehicle is operated along a prescribed route according to a fixed schedule.

Focus group. A qualitative research technique in which a group of 8 to 12 carefully selected participants engage in discussion of a particular topic under the direction of a moderator; such groups normally run for no more than two hours.

FTA. Federal Transit Administration, an agency of DOT.

Legal Blindness. A term describing visual loss that is used to establish eligibility for government or other benefits. An individual who is legally blind has a visual acuity of 20/200 in the better eye with the best correction or a visual field of no more than 20 degrees.

Light Rail. A streetcar-type vehicle railway operated on city streets, semi-private right-of-way, or exclusive private rights-of-way. Service may be provided by step-entry vehicles or by level-boarding.

Low Vision. A clinical diagnostic term used to describe an impaired visual condition that cannot be improved by conventional glasses, medication, or surgery. Low vision was operationally defined for this project to include individuals whose acuities ranged from 20/70 to 20/199.

Moderator. An individual skilled in qualitative research techniques generally and whose responsibility it is to implement the focus group research process; the moderator prepares a focus group discussion guide, facilitates discussion during the course of the focus group, and analyzes the content of the focus group discussion following its completion.

New vehicle. A vehicle which is offered for sale or lease after manufacture without any prior use.

Paratransit. Comparable transportation service required by the ADA for individuals with disabilities who are unable to use fixed route transportation systems.

Peripheral Field Loss. A loss of vision at the outer portions of the field of view which reduces the ability to see objects that are to an individual's right and left sides, or above and below the central line of sight. Peripheral field losses are associated with "tunnel vision" and night blindness.

Purchaser. The recipient.

Public transportation. Public transportation provided by a public entity, other than a school, typically by bus or rail, that provides the general public with general or special service, including charter service, on a regular and continuing basis.

Recipient. A receiver of Federal financial assistance from the FTA.

Revenue Service. The operation of vehicles for the transportation of passengers as anticipated by the recipient.

Rolling Stock. Transit vehicles, such as buses, vans, cars, railcars, locomotives, trolley cars and buses, ferry boats, and vehicles used on guide ways and incline planes.

Severe Visual Impairment. A loss of sight that results in the inability to read ordinary newsprint even with correction.

Total Blindness. The complete absence of sight.

Visual Acuity. The ability of the eye to resolve detail or form an image in high-contrast or detail. Visual acuity is expressed as a fraction, where the numerator is the distance in feet an individual is from a visual target, and the denominator is the size of the target an individual can see at that distance. Target size is expressed in units of 5, up to 25 and then in units of 10 with lower numbers describing smaller targets. A target size of 10 is smaller than a target size of 25. A target size of 20 is the target normal eye sees from a distance of 20 feet, and a visual acuity of 20/20 is considered to be normal vision. Poor visual acuity results in blurred and/or distorted vision.

Visual Field. The area or extent of physical space that is visible to the eye, measured in degrees as an angle.