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16. Abstract

Design guidelines and information are offered for static signage and handout information to assist transit riders in route planning and guidance. An earlier version of this manual was published in 1994. The manual now incorporates Americans with Disability (ADA) design guidelines, and also has an Appendix which is comprised of a digest of ADA Accessibility Guidelines applicable to bus and light transit stop design. The manual provides concise and explicit advice on how to design signs at stops, transfer points, and terminals for street and system maps, route maps and timetables, route and direction designation, and locator signs. Information is also given for the design of timetables and system maps for distribution to riders. 100 transit companies were surveyed by mail and telephone of which 65 sent specimens of their route guidance material. This material helped the authors arrive at these suggestions, however in some cases the authors had to rely upon their Human Factors and Ergonomics backgrounds to provide guidance in the absence of consensus.

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BUS ROUTE GUIDANCE INFORMATION DESIGN

A Manual for Bus and Light Rail Transit Systems

Rodger J. Koppa
Laura L. Higgins

Southwest Region University
Transportation Center

Texas Transportation Institute
The Texas A&M University System
College Station, Texas 77843

Second Edition
Incorporates ADA Guidelines

December 1996

DISCLAIMER

ACKNOWLEDGMENT

FOREWORD TO SECOND EDITION

The original *Bus Route Guidance Information Design* was developed under funding from the Federal Transit Administration through the Southwest Region University Transportation Center at the Texas Transportation Institute. This revised and expanded edition of the manual provides an update to incorporate currently accepted interpretations of the Americans with Disabilities Act of 1990 (ADA), as these regulations apply to bus system signage and other related topics. In addition, Appendix 1 has been added to present a concise review of the applicable ADA regulations and design information for bus stops. This edition of the manual has also been sponsored by the Federal Transit Administration through the Southwest Region University Transportation Center.

The suggestions and approaches presented in this manual represent the authors' best understanding of current practice and of the research literature. In some cases, where relevant research or practices were not available, the authors have not hesitated to use their best judgement on approaches to information design, particularly in the area of color coding and its uses. References in the text to sources for the design approaches have not been given, in keeping with the use intended for this manual: a first resource in designing or redesigning guidance information, rather than as a research report. Additional resources are summarized in Appendix 2.

In the course of development of the original manual, 100 transit companies and operations were contacted by mail and telephone. Ultimately, 65 of these operations very kindly sent route guidance materials for us to study. SmartMaps of Knoxville, Tennessee was very helpful to us at various stages in the development , as was Brazos Valley Transit, our local bus system.

The contents of this manual, however, reflect the views of the authors, who are responsible for the facts and accuracy of the information presented herein. This manual is disseminated under the sponsorship of the Department of Transportation, University Transportation Centers Program, in the interest of information exchange. The U.S. Government assumes no liability for the contents or the use thereof.

Rodger J. Koppa
Laura L. Higgins

Texas Transportation Institute
College Station, December 1996

TABLE OF CONTENTS

BUS ROUTE GUIDANCE INFORMATION DESIGN

This design guide is for bus systems or light rail systems in locales in which a substantial number of riders are expected to be infrequent users, tourists, or transients. Fulfilling route information needs for those who are not daily commuters are of primary concern, but even commuters have to start somewhere!

All the design suggestions in this booklet are for the least costly methods of imparting *route planning and guidance* information to the would-be rider: static signs and printed material. Transit operations may well have call-in services, sophisticated changeable message signs both in terminals and even on vehicles. Riders may even talk to drivers or operators! Even with such information available, the baseline of signs, maps, and timetables will almost always be used as well. Fare structures vary so widely that no attempt has been made to integrate fare information into these suggestions.

What Does the "Beginning" Rider Need to Know?

This question is at the heart of information design, together with a idea of who that beginning rider is:

- o   They are elderly
- o   They are children
- o   They are people of any age without a car in a strange town
- o   They are people of modest means
- o   They are people curious to try a "new" mode of transportation
- o   They are disabled or disadvantaged
- o   They have little or no familiarity with English

A given beginning rider may be any one of these or a combination of several. What needs do all these diverse kinds of people have in common?

1.   "The primary need of all prospective riders is to be able to determine if transit provides a reasonable connection between a planned trip origin and destination"

2.   Beginning riders need to have *positive guidance* in all aspects of route planning and during the actual trip. The powerful concept of positive guidance, developed under Federal Highway Administration auspices for highway drivers, has application to transit as well. Translated into transit terms, positive guidance means giving the rider the maximum amount of visual information that is:

- o   useful
- o   prioritized in importance
- o   uniform, consistent, and without surprises
- o   easily visible under as many riding conditions as possible

INFORMATION TYPE	Street Map	Street Map Sign	System Map	System Map Sign	Route Map/Timetable	Single Route Sign	Terminal Designation	Bus Stop Designation	Exterior Bus Route/Direction	Interior Bus Rt/Dir/Destination	Remote Stop Location
	A	B	C	D	E	F	G	H	I	J	K
INFORMATION NEED:											
1. Area Geography	X	X									
2. Places Served	X	X	X	X	X	X				X	
3. Closest Approach	X	X	X	X	X	X					X
4. Identification/Location	X	X	X	X	X	X					
5. Route Service Hours					X	X				X	X
6. Schedules					X	X					
7. Trip Distances/Times	Distance				Times	Times					
8. Stop Designation							X	X			X
9. Vehicle Identification									X		
10. Enroute Guidance										X	

Information that fulfills these four descriptions will not let the rider "get lost." It is crucial that the rider always knows where he or she is going to go or is going.

Specific route guidance information that is needed include (at least) the following:

1. Area geography, the "lay of the land"
2. Places and areas served by the bus system
3. How far closest approach of the bus route(s) is from actual trip origin or destination
4. Identification and location of terminals, transfer points, stops, and routes
5. Hours of service on route(s)
6. Schedules and/or headways/waiting times
7. Trip distances and times
8. Designation of terminals, transfer points, stops with what routes are accommodated
9. Vehicle identification signs, route numbers
10. Guidance information enroute

Some of these needs must be met before the rider leaves their point of origin - their home, hotel, or terminal for another mode of travel. Other needs arise at the terminal, transfer point, or bus stop. Information is also needed during the travel period, when the rider is in the bus. When the rider disembarks from the bus, confirmatory information is required that the rider has actually accomplished the trip they planned.

These needs can be satisfied by appropriately designed information classified as:

A. Street Map
B. Wall Map Sign
C. System Map
D. Route Map and Timetable
E. Single Route Sign
F. Terminal Designation/Location Sign
G. Transfer Point and Bus Stop Designation/Location Sign
H. Exterior Bus Route and Direction Sign
I. Interior Bus Route/Direction/Destination Information
J. Bus Stop/Terminal Location Sign (Remote)

The relationship of needs to information is shown in matrix form in this Table.

Bus Route Coding Strategies and Colors

You can design effective route guidance information without using multiple colors or complicated (and expensive) graphics. Researchers agree that the use of more than one color (black is a color, too) is not necessary, but may be desirable, especially for systems which have more than seven or eight routes, and routes that overlap or are in close proximity. Color is a powerful tool for quickly locating information of interest, highlighting items, and separating background "nice to know" information from "need to know" information. Colored guidance information, whether signs or printed material, is undeniably more attractive in appearance and bespeaks quality as well as concern for the prospective user.

Although color reproduction is getting less expensive every day, it still is substantially more expensive than single color (i.e., monochromatic) reproduction. Each additional color means an additional cycle through the printing process.

Single Color Route Coding

1.   Use the darkest shade lines and letters for your system-specific information. All other information should be medium to light saturation.

2.   Never use "reverse polarity" (light lines and letters on a dark background) for either printed materials or for route and timetable information. Such presentation will result in poorer and slower reading for many people, especially under low lighting conditions.

3.   Use patterns for different routes if they will otherwise be confused. Some of the many possibilities for line patterns are shown on the facing page.

Color	Munsell Identification
Red	5R 3/14
Green	2.5G 5/12
Yellow	2.5Y 8/16
Violet-blue	7.5PB 3/12
Orange	10R 5/18 (MAX)
Purple	10P 4/12
Brown	5YR 4/4
Lt. Blue	5B 6/8
Black	- -

Color for Route Coding

Color coding is recommended for distinguishing route lines on the system map. Color has been shown to be a valuable aid for locating items on a display, particularly as the number of items increases. To maximize accuracy and speed, however, the number of colors should be kept at or below 9.

Include a legend showing the route numbers with their colors.

Option 1: Partial Color Coding

A partial color code, in which each color is used for several items in the display, significantly reduces search time by guiding the user's eye to a smaller number of targets. For example, if a map contains 30 different route lines printed in three different colors, a user looking for Route 10 (Red) would scan only those lines that are printed in red, ignoring the other two colors and shortening the search.

Keep the number of routes per color approximately equal.

Arrange the color coding so that adjacent routes are in different colors, to help the reader distinguish between them (see the system map example on page 20).

Recommended colors: Red
Green
Yellow
Blue
Orange
Purple
Brown
Lt. Blue
Black

0	30	60
1	31	61
2	32	62
3	33	63
4	34	64
5	35	65
6	36	66
7	37	67
8	38	68
9	39	69
10	40	70
11	41	71
12	42	72
13	43	73
14	44	74
15	45	75
16	46	76
17	47	77
18	48	78
19	49	79
20	50	80
21	51	81
22	52	82
23	53	83
24	54	84
25	55	85
26	56	86
27	57	87
28	58	88
29	59	89
	90	95
	91	96
	92	97
	93	98
	94	99
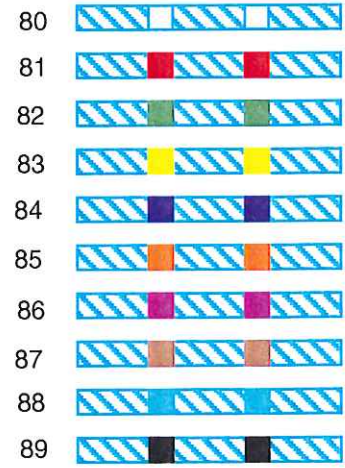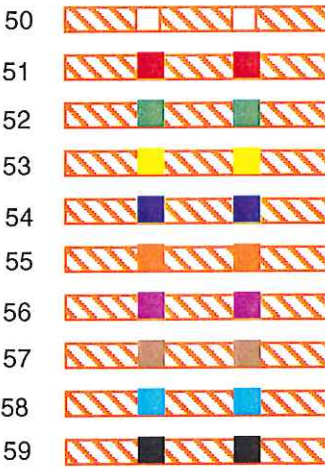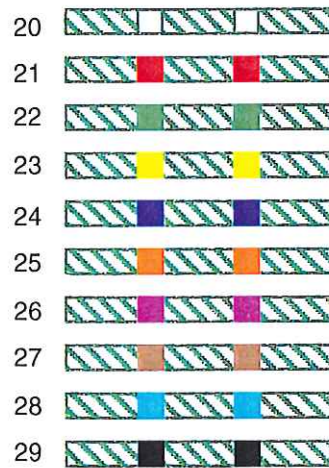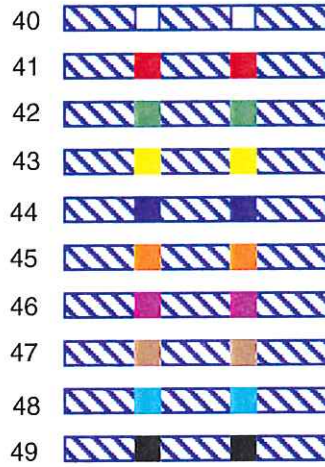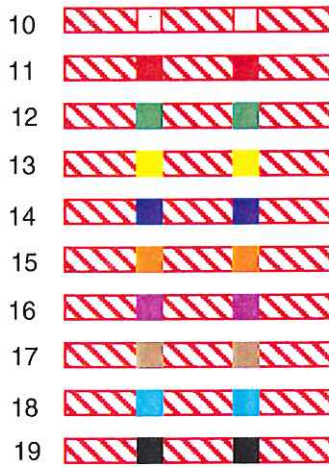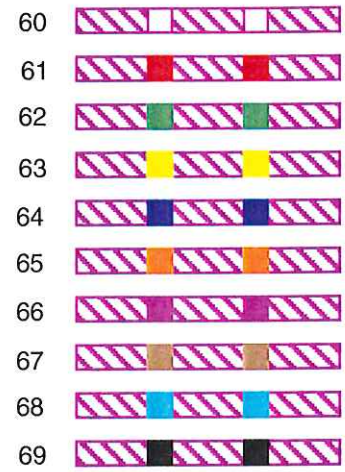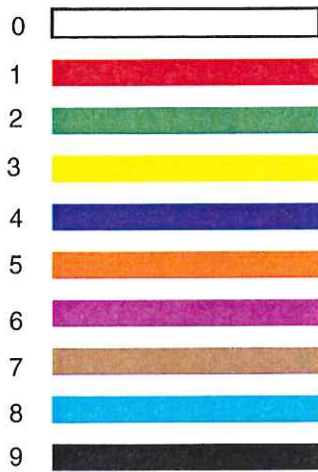
Color codes for routes numbered 1 through 99.
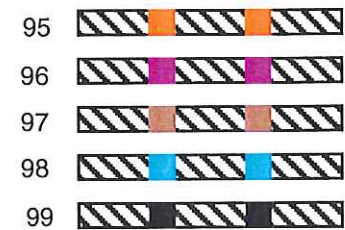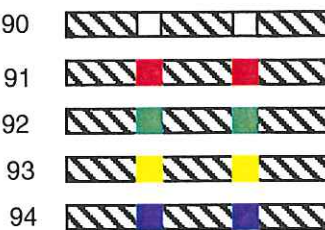
Color for Route Coding

Option 2: Complete Color Coding
A complete color code uses a different color or combination of colors for each item (e.g., route line) in the display.

This color code groups every ten routes under a different line color to reduce the user's search field, and individually codes each route within the groups. The code uses a maximum of nine colors.

Each digit from 0 to 9 has a unique color:

0	White	5	Orange
1	Red	6	Violet
2	Green	7	Brown
3	Yellow	8	Lt. Blue
4	Violet-blue	9	Black

For routes number 1 through 9, the route lines are printed in solid colors.

For routes 10 through 99, the first digit of the route number is indicated by slash-marked route lines (red slash marks for routes 10 through 19, green slash marks for routes 20 through 29, and so forth).

The second digit is indicated by equally spaced squares of solid color on the slash-marked lines. For instance, route number 14 is shown as a red slash-marked line (first digit=1) with squares of violet-blue (second digit=4). The color codes for route numbers 1 through 99 are shown here.

Half-tone or "hash-marked"
background color for first digit

Solid color for
second digit
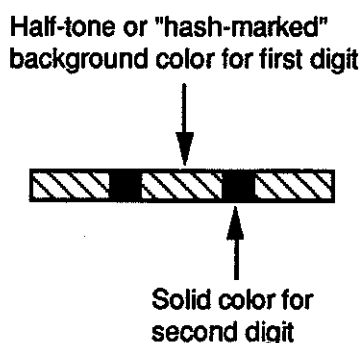
Note: Always mark each route with its number. Do not identify routes by color only.

If fewer colors are used, this coding system can still be used. For example, if only four colors are used (red, green, yellow, and violet-blue) up to 24 routes can be color coded according to the chart by selecting codes as follows:

	10	20	30	40
1	11	21	31	41
2	12	22	32	42
3	13	23	33	43
4	14	24	34	44

10

TERMINALS

BROOKS CENTER

Directional arrows

Always black

TRANSFER POINTS

Always black

12 — THOMAS

6 — SMITH

JACKSON AND PEABODY

STOPS

Route number on every stop on route

6 — JACKSON

DE KALB

Circles same color as route line

If bus stops at every intersection :

6 — JACKSON

DE KALB

Minor intersections

Major intersection

COMPASS DIRECTIONS

Preferred:

N
W   E
S

OK:

N
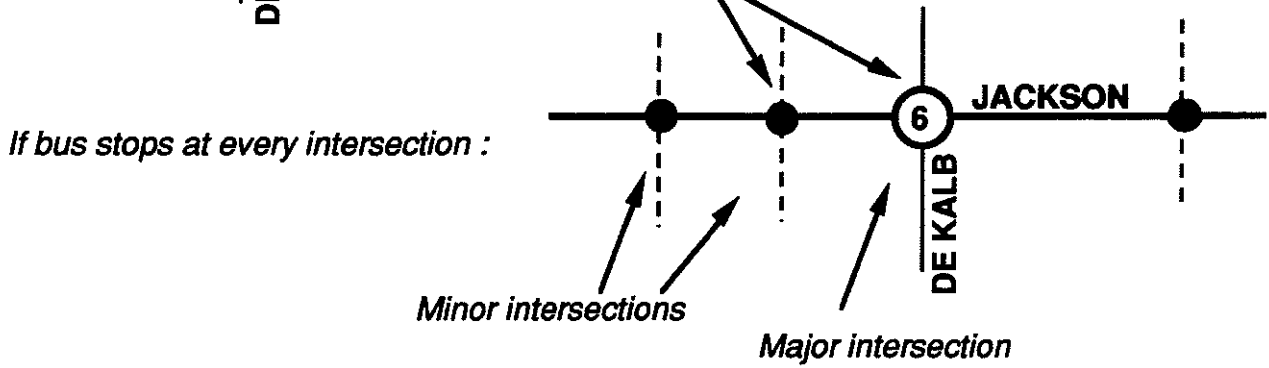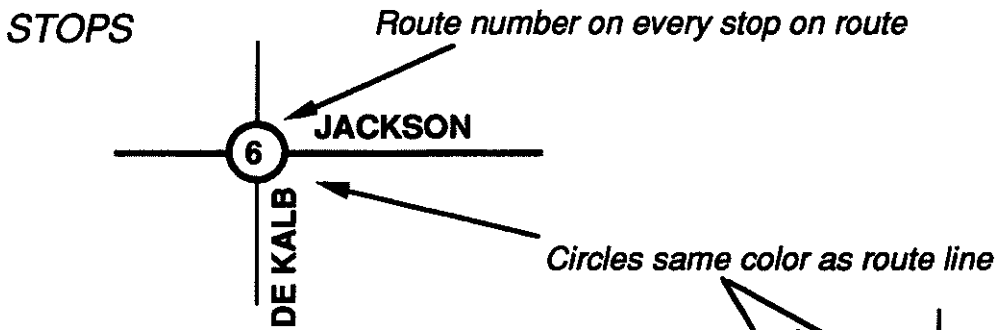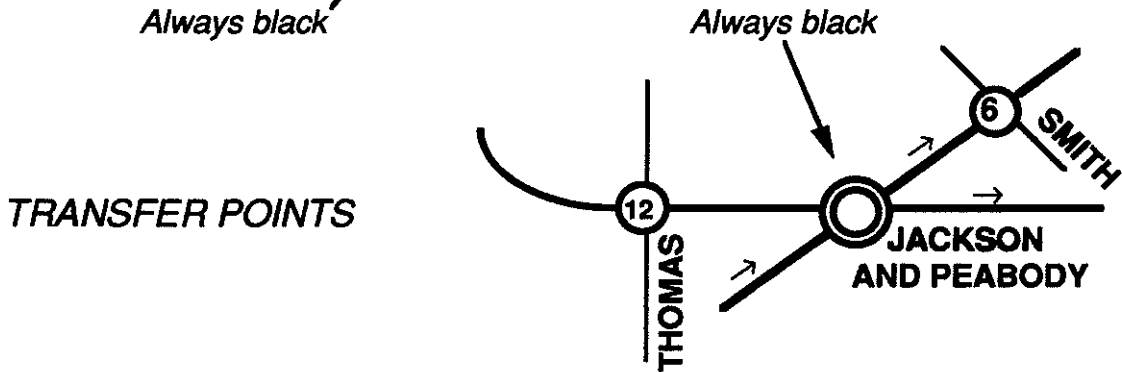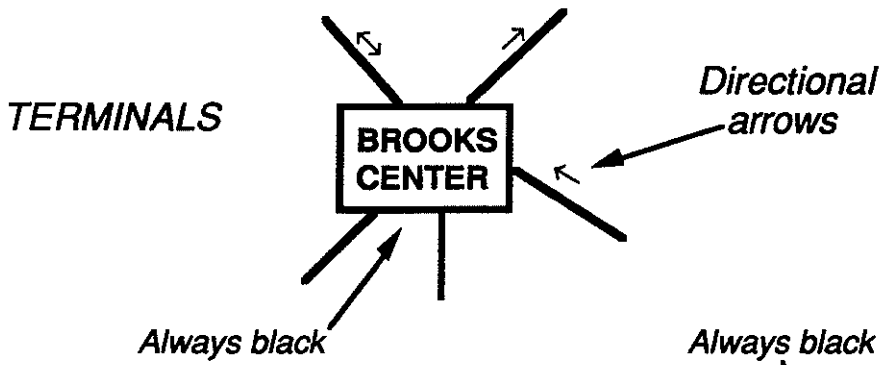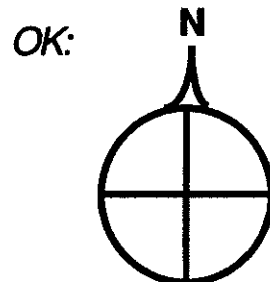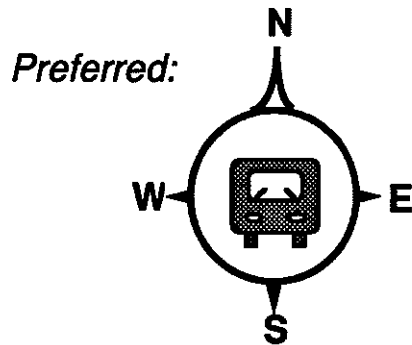
Coding of Other System-Related Features

In this booklet we make specific recommendations for denoting terminals, transfer points, bus stops, direction of travel on a route, compass directions, and route designation. These are summarized on the facing page, with illustrations. But these coding conventions are not necessarily supported by research or evaluation. Other coding can and is being used throughout United States and abroad.

Research has established that a system *must be consistent* in the use of coding techniques. Sign should not have different coding than printed materials, other than whether or not different colors are used. If colors are *specifically* associated with routes or other features of a system, then colors must also be carried in a consistent manner throughout all route guidance material. If, for example, Route 6 is coded purple in a system map, and referred to as the "Purple Route" or "Purple 6", then the color is more than an aid to easy readability of a map; it has become part of the name.

Even if a system does not specifically associate color codes with routes or other features, you must be careful never to change colors from, say, the wall map in transfer points to printed maps. Unless the color and the route or feature are specifically associated by name, it is permissible to reproduce otherwise identical material in one color, preferably one not used for color coding. If all information on the sign or printed item is in one color, it will be obvious to most readers that the color is irrelevant to the information being presented.

Names of other verbal designations of terminals, transfer points, stops, and other system-relevant features must also be consistent from one item of information to another. If a stop is at the intersection of Church Street and Dekker Avenue, near the Public Library, all guidance information must say "CHURCH and DEKKER" as a minimum. If the extra information, PUBLIC LIBRARY, is placed only on certain kinds of information (e.g., a Route/Timetable), the stop must still be primarily designated by CHURCH and DEKKER - every time. The material would read:

CHURCH and DEKKER - PUBLIC LIBRARY.

LEGEND

─────── ROUTE 1

▪ ▪ ▪ ▪ ▪ ▪ ROUTE 2

━ ━ ━ ROUTE 3

ZZZZZZZ ROUTE 4

‖‖‖‖‖‖‖‖‖‖‖‖‖ ROUTE 5

─────── MAJOR STREETS

─ ─ ─ ─ ─ MINOR STREETS

▭ TERMINAL

◎ TRANSFER POINT

④ BUS STOP -
Major intersection
showing route number

● BUS STOP - Minor
Intersection

Map Legend

The map legend for the system map should list:

- the numbers of all routes shown on the map, with their color codes or line patterns.

- coding for any streets/highways

- symbols for landmarks

- symbols for stops, transfer points, terminals

The map legend for the street map should list:

- coding for streets/highways

- symbols for landmarks

- symbols for stops, transfer points, terminals

Character Size: Minimum character size should be at least as large as the minimum character size for the body of the map.

Remarks: Legend should be placed at an edge of the map where it will not obscure any relevant map information. If there is an existing "break" in the map with no relevant streets, route lines, etc. the legend may be inset there, space permitting. Otherwise, the legend should be placed outside the body of the map.

If the map is a schematic, state in the legend that the map is not to scale.

If only transfer points and not all stops are shown on a system map, state that fact in the legend.

Box the legend and label it "Legend".

Background color of the legend should be white. Symbols, etc. shown in the legend must follow the color scheme that is used in the body of the map.

MARVIN GARDENS Marvin Gardens Helvetica

MARVIN GARDENS Marvin Gardens Helvetica Narrow

MARVIN GARDENS Marvin Gardens Gothic Book

MARVIN GARDENS Marvin Gardens Symbol

MARVIN GARDENS Marvin Gardens Times Roman

MARVIN GARDENS Marvin Gardens Times Roman Bold

MARVIN GARDENS Marvin Gardens Palatino Italic

Compare the legibility of these various typefaces by placing this page of the book 12 feet distant. At that distance, the letters look the same size as those on an eye chart 20/20 line. Walk toward the page and watch which line becomes clear first. You will see Helvetica and Gothic Book clearly before you see the others. Narrow letters such as Helvetica Narrow and Bold (thick stroke) letters are less legible than the normal typeface, and probably Palatino Italic is the hardest to see of all.

All of these typefaces meet ADA Guidelines, but Helvetica and Gothic Book families will work best for all transit users.

BUS ROUTE GUIDANCE INFORMATION DESIGN

TYPEFACE RECOMMENDATIONS

"serifs" are fine end strokes on letters, such as those on this *times Roman* typeface:

Route 6 to Marvin Gardens

Studies have shown that letters without serifs are easier to read

o   At a distance

o   By people with visual impairments

o   By children and those with limited education

This Design Guide is printed in the Helvetica typeface family. Helvetica is only one of a number of typefaces suitable for a transit system. Other typefaces to consider include Folio Book, News Gothic, Trade Gothic, Futura Medium, Spartan Gothic, and Optima. The letter styles used by traffic engineers for street signing are similar to those listed here.

The letter stroke width to height ratio should be 1:6 (minimum 1:10) for dark letters on a white background. Since white or light letters on a dark background tend to "bleed" they are *not recommended* for route guidance information. Letter height to width ratio should be between 5:3 and 3:2, and never less than 1:1. Letter spacing should be at least 1 stroke width. Line spacing should be at least 3 stroke widths.

Use capital letters (upper case) for stop designations (usually street intersections), terminals, and other short labels. Use capital and lower case letters (with extenders) for extended legends and instructions.
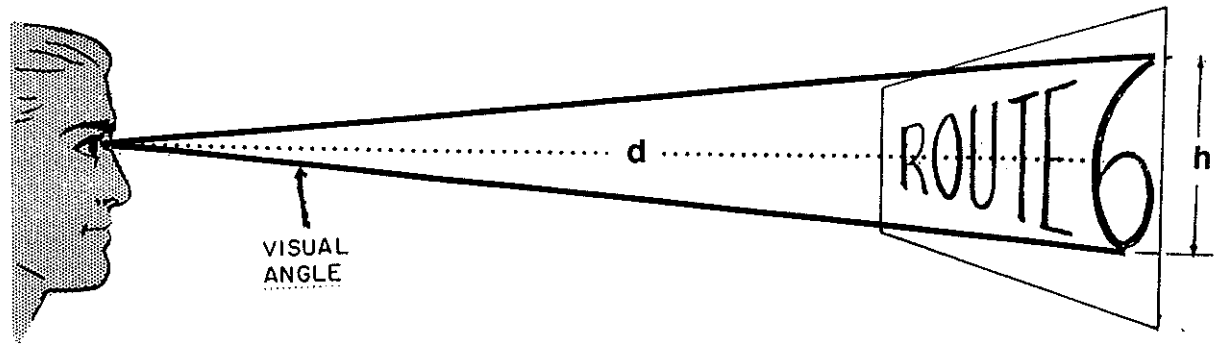
(for angles less than 5 degrees)

$$VA_{degree} = \arctan \frac{h}{12d}$$

or

$$VA_{radians} = \frac{h}{12d}$$

Where VA = Visual Angle
       h   = Height of character, inches
       d   = Viewing distance, feet

$$Contrast(\%) = \left(\frac{L_c - L_b}{L_b}\right) x\ 100$$

Where L_c = Luminance (brightness) of character
       L_b = Luminance (brightness) of background

"Luminance" is measured in ft-lamberts or in candela/meter^2

NOTE: If you know the reflectances (in percent) of the characters and the sign background, you can substitute those values for the L_c and L_b in the equation above to find the contrast. Black type has a reflectance of 10 %, and white paint has a reflectance of 90 %. Substituting in the equation above, the contrast would be

Contrast = ((10 - 90)/90) x 100 = -88.9%

BUS ROUTE GUIDANCE INFORMATION DESIGN

VISUAL ANGLE AND CONTRAST REQUIREMENTS

Visual Angle

Since we don't know what distances your riders may be standing away from a sign when they read it, we have specified most sign character sizes in terms of *visual angle*. This is expressed either in degrees or in radians. The visual angle is the angle that the letter or other object makes up in the visual field of the rider. For example, suppose that a letter (upper case) is six inches (0.5 ft) high. At a distance of 75 feet, such a letter will appear to make an angle of 0.38 degrees (22.9 minutes of arc or 0.0067 radian). A sign with letters 12 inches high will look twice as large in terms of visual angle at 75 ft, and *will look the same size* as the 6 inch letters at 150 ft. The visual angle in that case will be the same. The formulas that you can use to compute the visual angle are shown at the left.

A person with "normal" vision (20/20) will just be able to make out letters that are 5 minutes (0.00145 radian) of arc. ADA requirements call for the major route designators and other essential information to be visible from 30 ft away by low-vision people. "Low vision" means those with 20% of of normal vision under proper lighting and high contrast. This translates into a requirement for approximately 1 degree letters (0.017 radian).

In the following pages of this manual, esssential information and supplementary information design requirements under ADA guidelines will be identified.

Contrast

"Contrast" refers to the brightness difference between letters or symbols and their background. The defining formula is given at the left, plus some hints as to calculating it for design purposes. This formula produces "negative" contrast for signs and publications when the letters are dark against a light background, and "positive" contrast otherwise. Contrast for all signs, schedules, and publications should be at least - 70%, i.e., always dark characters against a lighter background.

To enhance visibility under all conditions, sign characters and backgrounds must be flat, matte, or "eggshell" in finish. No glossy paint or paper! Gloss produces shiny glare points under certain types of lighting and lighting angles that will limit legibility drastically.
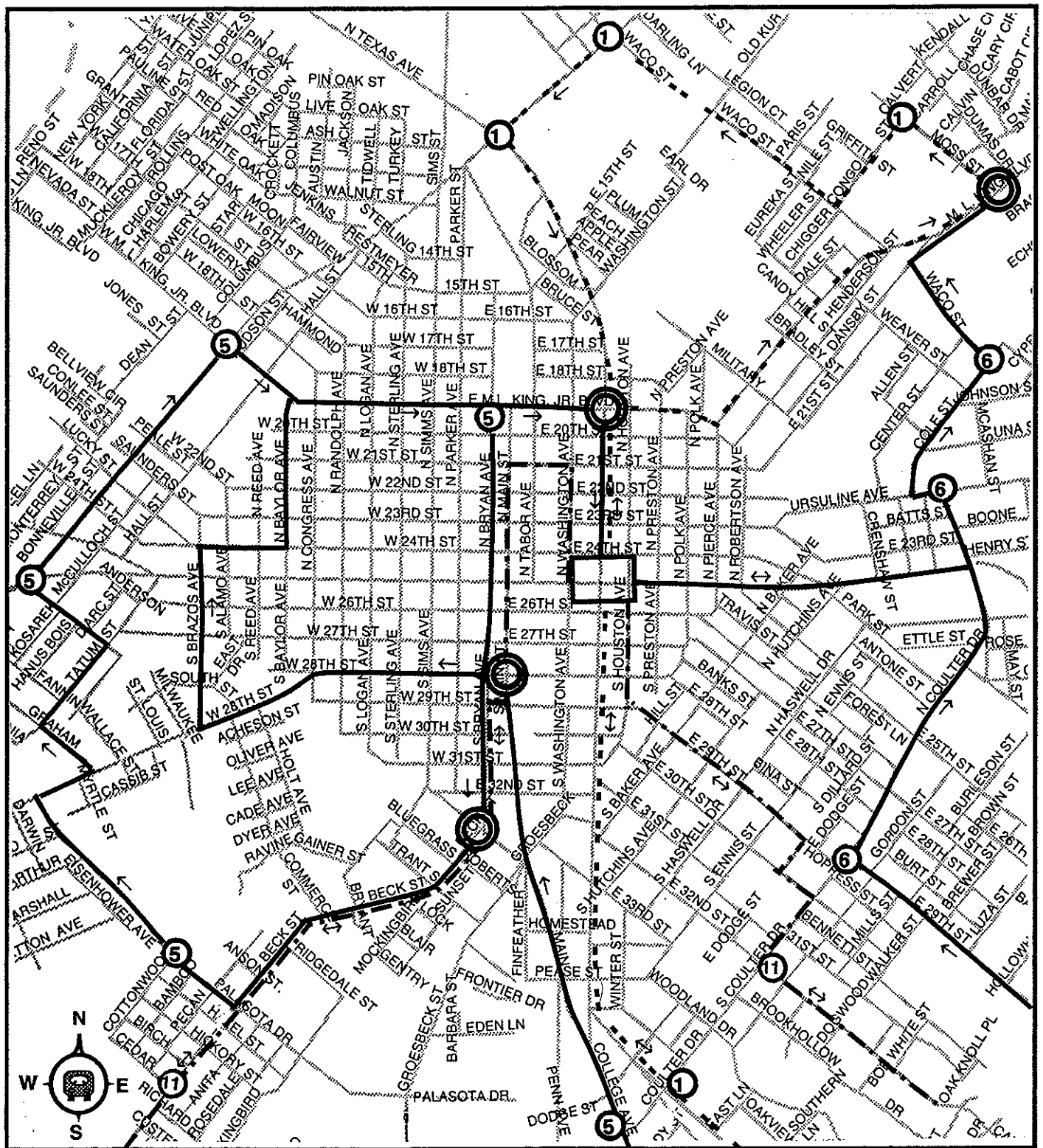
TYPE OF GUIDANCE INFORMATION: Street Map

APPLICATION: Information for distribution to passengers

TYPE OF PRESENTATION: Pictorial (small and medium cities)
Simplified Pictorial (large cities, regions)

FEATURES: Grid overlay to aid street location finding
Vertical axis - numbers
Horizontal axis - letters
Provide street landmark location index
Bus terminals - designate with box
Transfer points - designate with 2 concentric circles
Stops at major intersections - designate with a circle containing
the route number
Include compass directions at prominent location
Pictorial maps - show all streets and highways
Simplified maps - show major arterials, highways, landmarks
all major routes followed by buses

PHYSICAL DESIGN CHARACTERISTICS:

Background Size: 36x36 inches (77x77 cm) maximum, unfolded

Character Sizes: 10 point type, minimum

Typefaces: See page 15 for route guidance. System logos, other non-route
guidance related information may be in other *legible* typefaces

Other Codes, Colors, Distinguishing Features:
One color: Streets, highways on routes - black overlay
Different shading if two or more routes overlap
Two colors: Streets, highways on routes - colored, rest background
Terminals and transfer points - black
More than two colors:
Streets, highways on routes - different colors
Terminals and transfer points - black

Remarks: If the serviced region is too large to display on one side of a page of
maximum size while maintaining minimum typeface size requirements,
divide map into sections, two to a side, with index on each page.
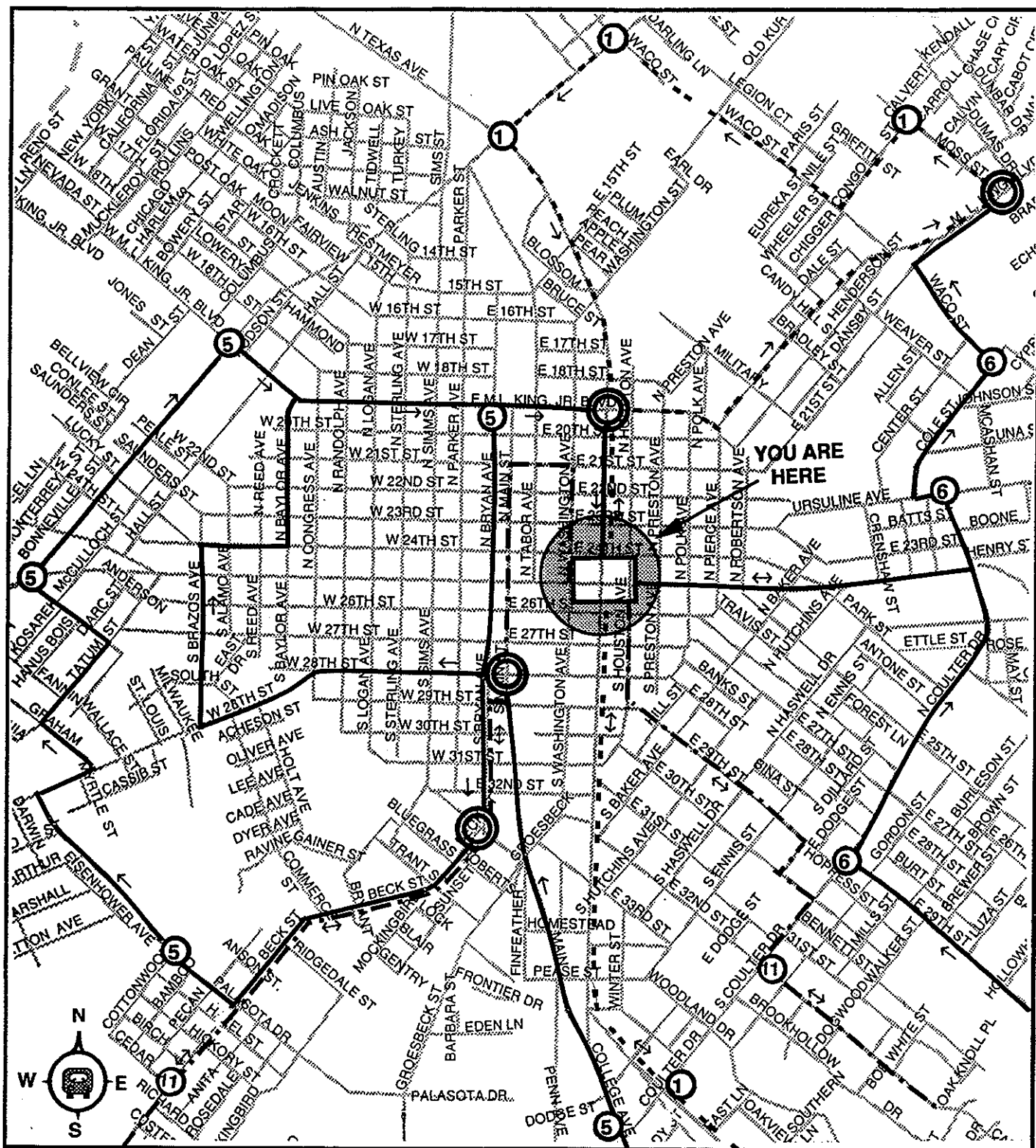
TYPE OF GUIDANCE INFORMATION: Wall Map

APPLICATION: Bus Terminals, possibly stops with shelters

TYPE OF PRESENTATION: Pictorial (small and medium cities)
    Simplified Pictorial (large cities, regions)

FEATURES: Grid overlay to aid street location finding
    Vertical axis - numbers
    Horizontal axis - letters
    Provide street landmark location index
    Bus terminals - designate with large star
    Transfer points - designate with small star
    Include compass directions at prominent location
    Pictorial maps - show all streets and highways
    Simplified maps - show major arterials, highways, landmarks
    all routes followed by buses
    Locator - use circle with "YOU ARE HERE"

PHYSICAL DESIGN CHARACTERISTICS:

Background Size: Any size consistent with user capability to approach to easy viewing distance, but top edge should be no more than 70 inches from floor, and bottom edge no less than 41 inches from floor

Character Size: Subtend vertical 15 minutes of arc (0.00436 radian) at design closest viewing distance (See page 17 for how to calculate viewing distance from visual angle)

Typefaces: See Page 15 for design information. System logos, other non-route guidance related information may be in other *legible* typefaces

Other Codes, Colors, Distinguishing Features:
    One color: Streets, highways on routes - shaded overlay
    Different shading if two or more routes overlap
    Route identification - white circle with number on overlay
    Two colors:Streets, highways on routes - colored, rest background
    Terminals and transfer points - colored
    More than two colors:
    Streets, highways on routes - different colors
    Terminals and transfer points - unique color

Remarks: 1. If area of service too large to depict on one map, use sectional displays keyed to a large-scale map of area. Index of streets and landmarks should be located next to each section and pertain ONLY to that section.
2. Wall maps must be the same as maps for individual distribution, except for locator and size
3. Do not mount where map board or case can be a protruding object for disabled people. See Appendix.

SAN JACINTO & WACO — **1**

SAN JACINTO & TEXAS — **1**

San Jacinto

CONGO & MOSS — **1**

Waco

Congo

Moss

Texas Ave.

M.L. KING & MOSS

SAN JACINTO & 19TH — **5**

San Jacinto

M.L. KING & BRYAN — **5**

TEXAS & M.L. KING

Waco

COLE & WACO — **6**

GRAHAM & SAN JACINTO — **5**

M.L. King

M.L. King Dr.

Cole

Graham

Bryan St.

Texas Ave.

COULTER & URSULINE — **6**

28th

MAIN AVE. & 28TH

W.J. Bryan

WJ BRYAN TERMINAL

Coulter

COULTER & 29TH — **6**

PALASOTA & COTTONWOOD — **5**

29th St.

29th

COULTER & 32ND — **11**

32nd

SIMS & BRYAN

COULTER & 32ND

BECK & CEDAR — **11**

TEXAS & COULTER — **1**

Beck

TABOR & COULTER — **5**

Tabor

Texas Ave.

N
W — E
S
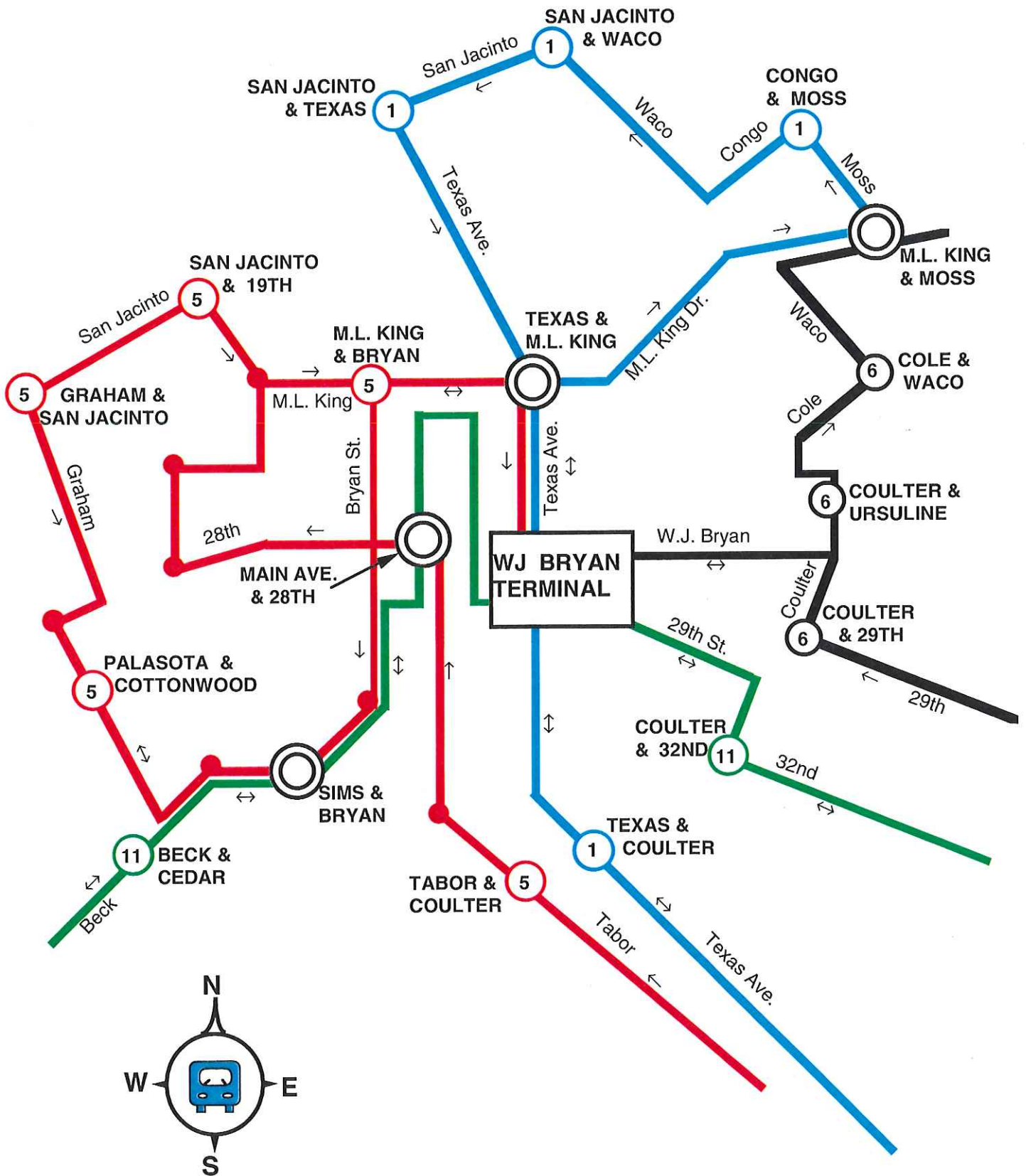
TYPE OF GUIDANCE INFORMATION: System Map

APPLICATION: Information for distribution to passengers, visitor publications

TYPE OF PRESENTATION: Schematic (Exception: small systems with six routes or less may use pictorial maps (See p.17))

FEATURES: Bus terminals - box with terminal name inside
Transfer points - 2 concentric circles on route line and name of stop
Bus stops - Circle on route line containing route number and labeled with the name of the intersection. If bus stops at every corner, designate major intersections with this circle and route number and minor intersections with a small solid unlabeled circle on the route line
Include compass directions at prominent location

PHYSICAL DESIGN CHARACTERISTICS:

Background Size: maximum 36 x 36 inches (77x77 cm), smaller the better

Character Sizes: 10 point type, minimum

Typefaces: See page 15 for route guidance. System logos, other non-route guidance related information may be in other *legible* typefaces

Other Codes, Colors, Distinguishing Features:
One color: Streets, highways necessary for clarity: medium to light gray
Routes in black where no overlap or close proximity
Routes in patterned black where overlap or close proximity
Pattern guidance: see page 5
Two colors: Same as one color, except:
Routes in one color or patterned color (Pattern guidance: see page 5)
Bus Stops - same colors as routes
Terminals, transfer points - black
Landmarks, all other details on schematic in other color
More than two colors:
Routes - different colors and patterns (Color combinations: see page 9)
Bus Stops - same colors as routes
Terminals, transfer points - black

Remarks: Should show geographic location of routes and spatial relationships and intersections among these routes, with routes appearing as straight lines, angles and simple curves

Should look identical to Wall-Mounted System Map, except possibly number of colors used.

SAN JACINTO & WACO
(1)

SAN JACINTO & TEXAS
(1)

San Jacinto

CONGO & MOSS
(1)

Waco

Congo

Moss

M.L. KING & MOSS

Texas Ave.

SAN JACINTO & 19TH
(5)

San Jacinto

(5)

GRAHAM & SAN JACINTO

M.L. KING & BRYAN
(5)

TEXAS & M.L. KING

M.L. King

Graham

M.L. King Dr.

Waco

Cole

COLE & WACO
(6)

YOU ARE HERE

Bryan St.

28th

COULTER & URSULINE
(6)

MAIN AVE. & 28TH

WJ BRYAN TERMINAL

W.J. Bryan

Coulter

PALASOTA & COTTONWOOD
(5)

29th St.

COULTER & 29TH
(6)

29th

SIMS & BRYAN

COULTER & 32ND
(11)

32nd

(11) BECK & CEDAR

Beck

TEXAS & COULTER
(1)

TABOR & COULTER
(5)

Tabor

Texas Ave.

N
W E
S

BUS ROUTE GUIDANCE INFORMATION DESIGN

TYPE OF GUIDANCE INFORMATION: Wall-Mounted System Map

APPLICATION: Bus Terminals, Bus Stop Shelters

TYPE OF PRESENTATION: Schematic (Exception: small systems with six routes or less may use pictorial maps (See p. 21))

FEATURES: Bus terminals - box with terminal name inside
Transfer points - 2 concentric circles on route line and name of stop
Bus Stops - Solid circle on route line (unless bus stops at every corner - then show only transfer points, see next line)
Include compass directions at prominent location
Locator - circle with "YOU ARE HERE"

PHYSICAL DESIGN CHARACTERISTICS:

Background Size: Any size consistent with user capability to approach to easy viewing distance, but top edge should be no more than 70 inches from floor, and bottom edge no less than 41 inches from floor

Character Sizes: Subtend vertical 15 minutes of arc (0.00436 radian) at design closest viewing distance (See p. 17 for how to calculate viewing distance from visual angle)

Typefaces: Helvetica for route guidance, system logos, other non-route guidance related information may be in other *legible* typefaces

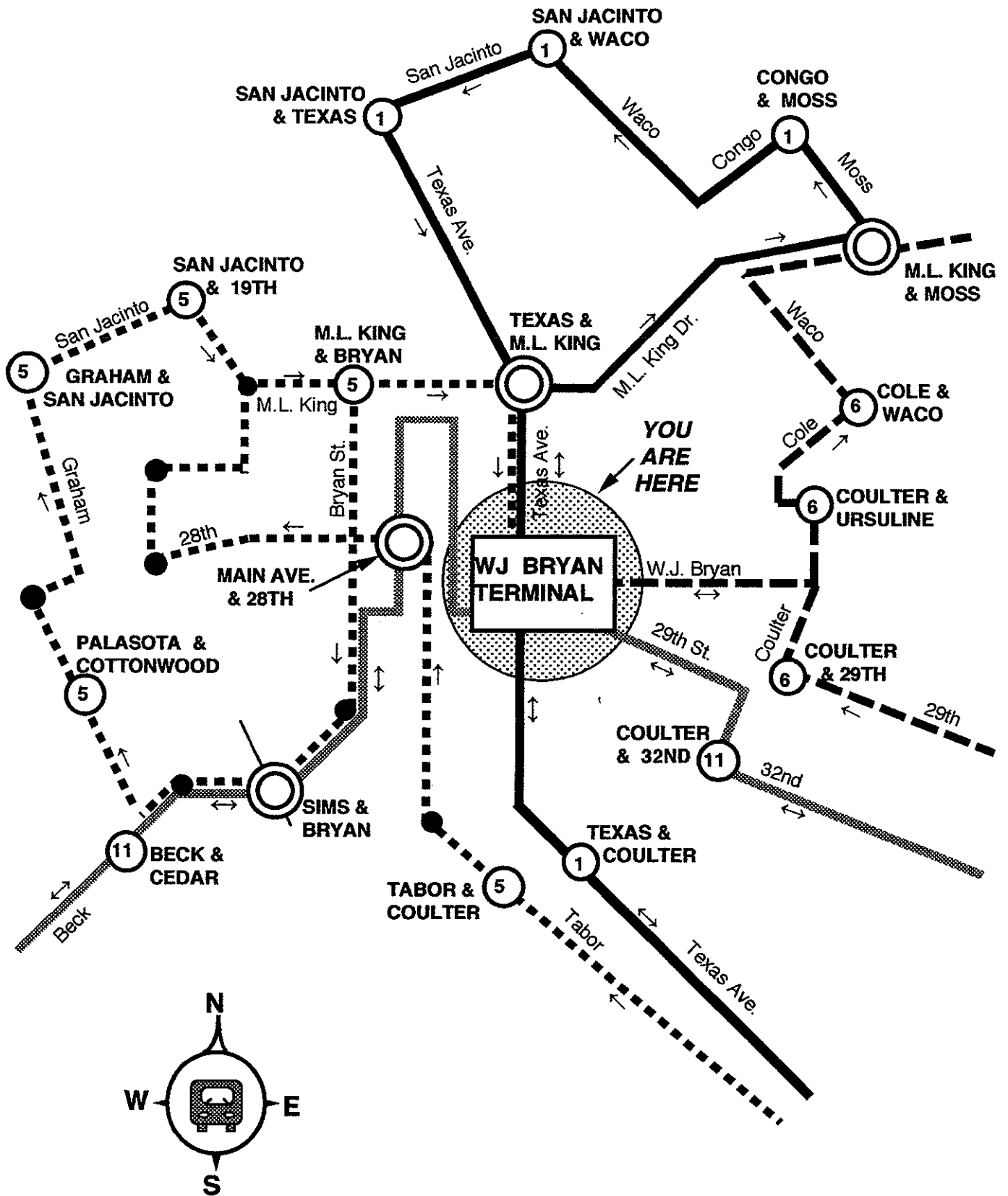## Other Codes, Colors, Distinguishing Features:

One color: Streets, highways necessary for clarity: medium to light gray
Routes in black where no overlap or close proximity
Routes in patterned black where overlap or close proximity (Pattern guidance: See page 5)

Two colors: Same as One Color, except:
Routes in one color or patterned color (Pattern guidance: see Page 5)
Terminal and transfer points - colored
Landmarks, all other details on schematic in other color

More than two colors:
Routes - different colors and patterns (Color combinations: see Page 9)
Terminals and transfer points - black

Remarks: 1. Should show geographic location of routes and spatial relationships and intersections among these routes, with routes appearing as straight lines, angles, and simple curves
2. Wall maps must be the same as maps for individual distribution, except for locator and size
3. Do not mount where map board or case can be a protruding object for disabled people. See Appendix.

ROUTE 16

OAK VALLEY
FROM DOWNTOWN

ROUTE 16
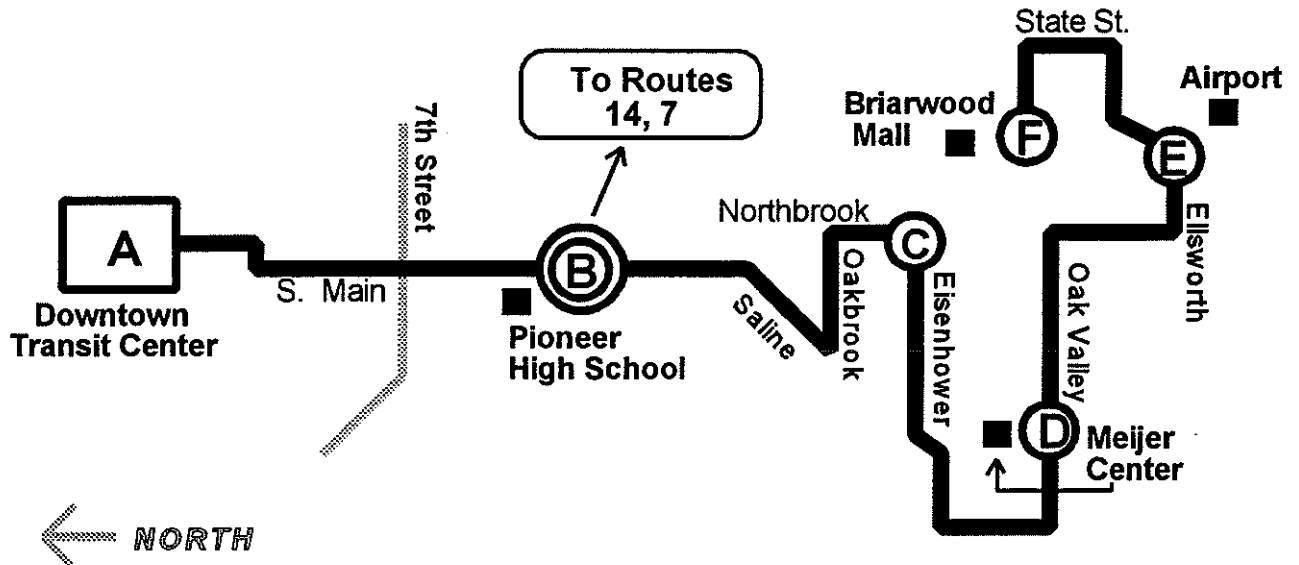
	A	**B**	**C**	**D**	**E**	**F**
	BUS STARTS at Downtown Transit Center	BUS ARRIVES at Pioneer High School	BUS ARRIVES at corner of Northbrook and Eisenhower	BUS ARRIVES at Meijer Center	BUS ARRIVES at Airport	BUS ARRIVES at Briarwood Mall
A.M.	7:00	7:06	7:10	7:15	7:22	7:30
	7:30	7:36	7:40	7:45	7:52	8:00
	8:00	8:06	8:10	8:15	8:22	8:30
	8:30	8:36	8:40	8:45	8:52	9:00
	9:00	9:06	9:10	9:15	9:22	9:30
	9:30	9:36	9:40	9:45	9:52	10:00
	10:00	10:06	10:10	10:15	10:22	10:30
	10:30	10:36	10:40	10:45	10:52	11:00
	11:00	11:06	11:10	11:15	11:22	11:30
	11:30	11:36	11:40	11:45	11:52	12:00
P.M.	12:00	12:06	12:10	12:15	12:22	12:22
	12:30	12:36	12:40	12:45	12:52	12:52
	1:00	1:06	1:10	1:15	1:22	1:30
	1:30	1:36	1:40	1:45	1:52	2:00
	2:00	2:06	2:10	2:15	2:22	2:30

Adapted from Ann Arbor Transit Authority Route 16 Schedule; Smart Maps Standard Design

BUS ROUTE GUIDANCE INFORMATION DESIGN

TYPE OF GUIDANCE INFORMATION: Route Map/Timetable

APPLICATION: Information for distribution to passengers, visitor publications

TYPE OF PRESENTATION: Schematic

FEATURES: Horizontal orientation of route, stop progression from left to right
Under each terminal, stop, transfer point list times for that point in a column, plus timepoint bus stop designator (A, B, C, etc.)
Make up different Map/Timetable for each route direction or variation
Provide route number at top left corner of map
Bus terminals - box with terminal name label
Transfer points - 2 concentric circles on route line and name of stop
Bus Stops - Solid white circle on route line
Include compass direction of route; if direction changes, show new compass direction as well

PHYSICAL DESIGN CHARACTERISTICS:

Background Size: Scale to be no larger than standard page

Character Sizes: 10 point type, minimum; Route number 30 point type

Typefaces: See page 15 for route guidance, system logos, other non-route guidance related information may be in other *legible* typefaces

Other Codes, Colors, Distinguishing Features:
One color: Use black on white or other background color consistent with system map coding
Streets, highways necessary for clarity: medium to light gray
Route in black, stops in solid white circle with designator for timepoints
Two colors:Same as one color, except:
Route in one color or patterned color (Pattern guidance: see Page 5); bus stops in same color
Terminal and transfer points - black
Landmarks, all other details on schematic in other color
More than two colors:
Route - colors and/or patterns (Color combinations: see Page 9); bus stops in same colors
Terminals and transfer points - black

Remarks: Should show geographic location of route and spatial relationships and intersections along the route, with route appearing as straight lines, angles, and simple curves

Coding, symbols, names, etc. should be consistent with System Map, except possibly number of colors used, e.g., if route is coded yellow on system map, print route map/timetable in black on yellow paper

ROUTE 12

TO HOLLY SQUARE

N ⟶

YOU ARE HERE

College

CHURCH ST.

17TH ST.

⑫

Nagle St.

Inlow

⑫

REDBUD

3rd Ave.

To Route 6

Main

Anderson

HOLLY SQUARE
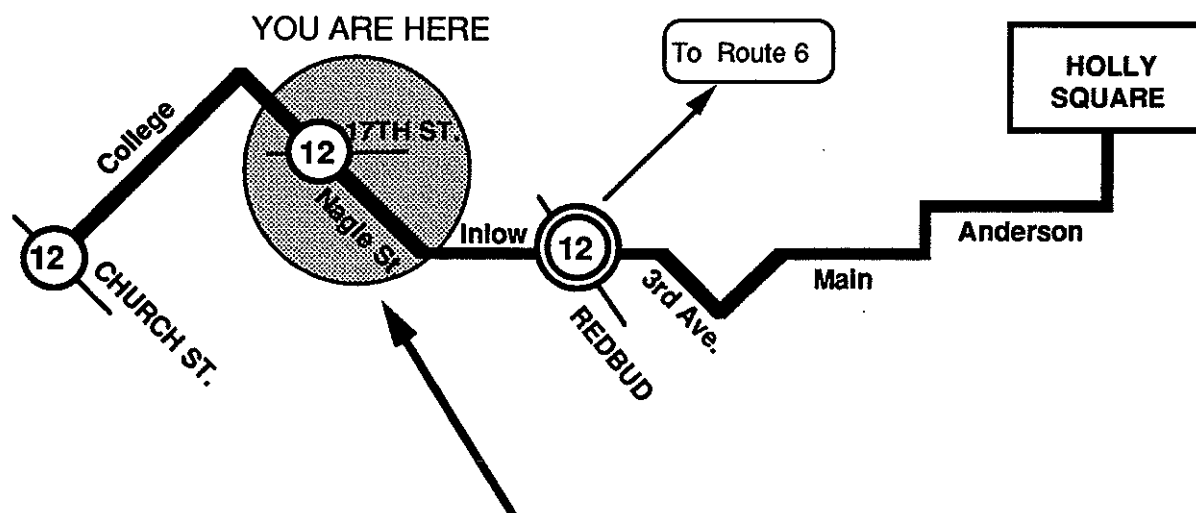
BUS ARRIVES
at
Nagle St. and 17 th St.

A.M.	P.M.
5:57	12:07
6:27	12:38
6:57	1:13
7:27	1:43
7:57	2:19
8:27	2:57
8:57	3:30
9:27	4:04
9:57	4:31
10:27	
11:02	
11:32	

BUS ROUTE GUIDANCE INFORMATION DESIGN

TYPE OF GUIDANCE DESIGN: Single Route Map

APPLICATION: Bus Stops, Transfer Points

TYPE OF PRESENTATION: Schematic

FEATURES: Horizontal orientation of route, stop progression from left to right
List times in a box under the stop designation, as shown
Make up different Map/Timetable for each route direction or variation
Provide route number at top left corner of map
Bus terminals - box with terminal name inside
Transfer points - 2 concentric circles on route line and name of stop
Bus stops - solid white circle on route line with route number
Include compass direction of route; if direction changes, show new compass direction as well
Locator - circle with "YOU ARE HERE"

PHYSICAL DESIGN CHARACTERISTICS:

Background Size: Depends on surfaces available at stop, but top edge should be no more than 70 inches (150 cm) from street level and bottom edge no less than 41 inches (88 cm) from street level

Character Sizes: Subtend vertical 15 minutes of arc (0.00436 radian) at design closest viewing distance (see p. 17 for how to calculate viewing distance from visual angle)

Typefaces: See p. 15 for route guidance. System logos, system logos, other non-route guidance related information may be in other *legible* typefaces.

Other Codes, Colors, Distinguishing Features:

One color: Streets, highways necessary for clarity: medium to light gray
Routes in black where no overlap or close proximity
Routes in patterned black where overlap or close proximity
(Pattern guidance: See page 5)

Two colors:Same as One Color, except:
Routes in one color or patterned color (Pattern guidance: see Page 5)
Terminal and transfer points - colored
Landmarks, all other details on schematic in other color

More than two colors:
Routes - different colors and patterns (Color combinations: see Page 9)
Terminals and transfer points - black

Remarks: 1. Should show geographic location of route and spatial relationships and intersections along the route, with route appearing as straight lines, angles, and simple curves.
2. Colors, symbols, names, etc. should be consistent with System Map (p.23) except possibly number of colors used.
3. Mount where visual impaired rider could approach to within 3 inches to read the sign, but not where it can be a protruding object or obstacle (See Appendix).

COLLEGE AVE.
AT
CHURCH ST.
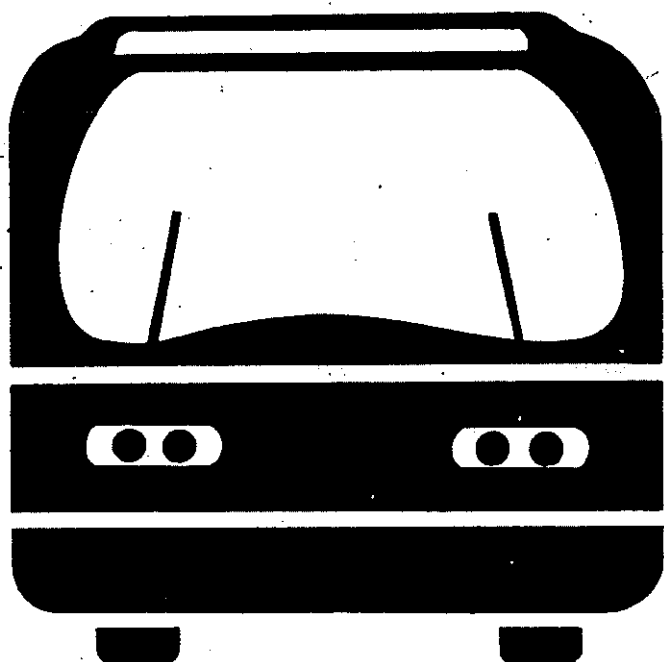
TRANSIT COMPANY NAME

ROUTE **6, 15**

BUS ROUTE GUIDANCE INFORMATION DESIGN

TYPE OF GUIDANCE INFORMATION: Bus Stop Designation/Location

APPLICATION: Bus Stops and Transfer Points

TYPE OF PRESENTATION: Static Signage

FEATURES: Sign 1: Transit system logo/symbol/name
Identification - Names of streets or landmarks
Route - Numbers of routes serving stop
Sign 2: Location - Route map/times (See Page 29)

PHYSICAL DESIGN CHARACTERISTICS: Sign 1

Background Size: Background size consistent with area required for character sizes to meet requirements (below)

Character Sizes: Transit Identifier and Route Number(s) must be legible to person with low vision (20/200), daylight conditions, at 30 ft, which is 6 inch high characters and/or symbols

Names of streets or landmarks must subtend at least 15 minutes of arc (0.00436 radian) at the design viewing distance (half a block or across the intersection, whichever is further away--see page 17 for how to calculate viewing distance from visual angle)

Typefaces: Transit Identifier: Consistent with maps and other system information
Other Information: See page 15

Other Codes, Colors, Distinguishing Features:

Remarks:
- Signs should be mounted to be conspicuous against other signs, advertising, and other visual clutter. Consideration must also be given to local ordinances and for protection against vandalism
- Sign 1 must be visible to bus passengers inside bus when bus is at stop
- If the stop is a transfer point, route map signs should be installed for each route (sign 2), but only a single sign 1 need be installed
- If more than 3 routes share a bus stop, the stop is a **terminal** (See Page 33)
- Consider use of duplicate sign 1 with 3 inch raised letters/symbols in location suitable for approach to within 3 inches, Grade II Braille under each character

CHURCH STREET TERMINAL
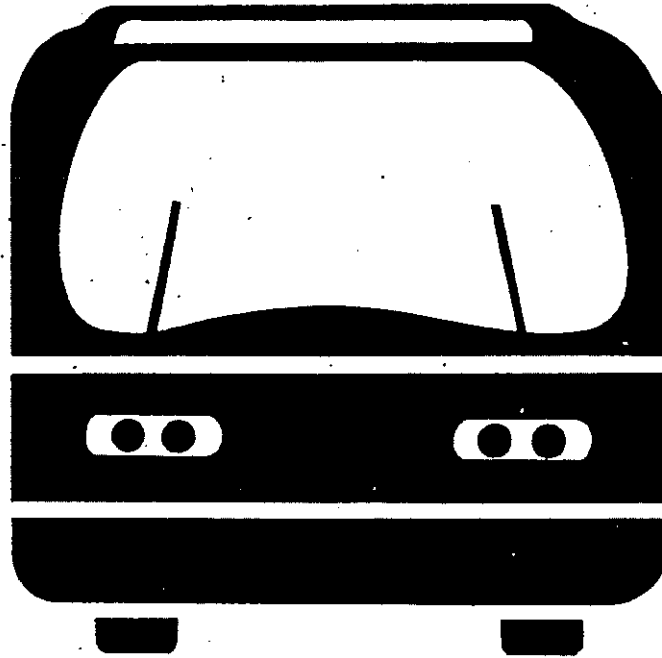
TRANSIT COMPANY NAME

ROUTES
6,15,23,40

TYPE OF GUIDANCE INFORMATION: Bus Stop Designation/Location

APPLICATION: Terminals (3 or more Route Intersections or Origins)

TYPE OF PRESENTATION: Static Signage

FEATURES: Sign 1: Transit system logo/symbol/name
Identification - Names of streets or landmarks
Designation as "Terminal"
Route - Numbers of routes serving Terminal
Sign 2: Location - Route map/times (See Page 29)

PHYSICAL DESIGN CHARACTERISTICS: Sign 1

Background Size: Background size consistent with area required for character sizes to meet requirements (below)

Character Sizes: Transit Identifier and Route Number(s) must be legible to person with low vision (20/200), daylight conditions, at 30 ft, which is 6 inch high characters and/or symbols

"Terminal" and names of streets or landmarks must subtend at least 15 minutes of arc (0.00436 radian) at the design viewing distance (half a block or across the intersection, whichever is further away--see page 17 for how to calculate viewing distance from visual angle)

Typefaces: Transit Identifier: Consistent with maps and other system information
Other Information: See page 15

Other Codes, Colors, Distinguishing Features:

Remarks:
- Signs should be mounted to be conspicuous against other signs, advertising, and other visual clutter. Consideration must also be given to local ordinances and for protection against vandalism
- If buses for different routes stop at designated locations in or around Terminal, Route Maps/Times should be posted at those locations PLUS at a central location in Terminal
- Sign 1 must be visible to bus passengers inside bus so they can plan transfer to other routes prior to leaving bus; if not feasible, place signs with name of Terminal and "Terminal" above Route Maps/Times signs at location where buses stop
- Consider use of duplicate sign 1 with 3 inch raised letters/symbols in location suitable for approach to within 3 inches, Grade II Braille under each character

ROUTE 6

TO HOLLY SQUARE

TYPE OF GUIDANCE INFORMATION: Bus Route and Direction

APPLICATION: Outside of Bus - Front/Rear/Sides

TYPE OF PRESENTATION: Alphanumeric signage

FEATURES: Route - Number display
Direction - Keyed to route map direction, cardinal direction should be
spelled out: NORTH, EAST, WEST, SOUTH, NORTHEAST, etc.

PHYSICAL DESIGN CHARACTERISTICS:

Background Size: Background size and dimensions consistent with area required for
character sizes to meet requirements (below)

Character Sizes: Route Number(s) and Route Designators must be legible to
person with low vision (20/200), daylight conditions, at distance of
30 ft, which is 6 inch high characters and/or symbols, preferably
larger

Typefaces: See page 15

Other Codes, Colors, Distinguishing Features:

Remarks: Placement should be high on the bus body, above window line
Display may be by changeable message sign. Back illumination or flood
illumination should be provided for nighttime operations. Minimum
background luminance should be 25 ft-lamberts (86 nits)for negative
contrast signs (dark letters on white background) For other types of sign
elements, consult the current edition of the *IES Lighting Handbook* in the
section on lighting for advertising

ROUTE 6

TO HOLLY SQUARE

ROUTE 12

TO HOLLY SQUARE

N →

To Route 6

HOLLY SQUARE

College

17TH ST.

Nagle St.

Inlow

CHURCH ST.

REDBUD

3rd Ave.

Main

Anderson

BUS ROUTE GUIDANCE INFORMATION DESIGN
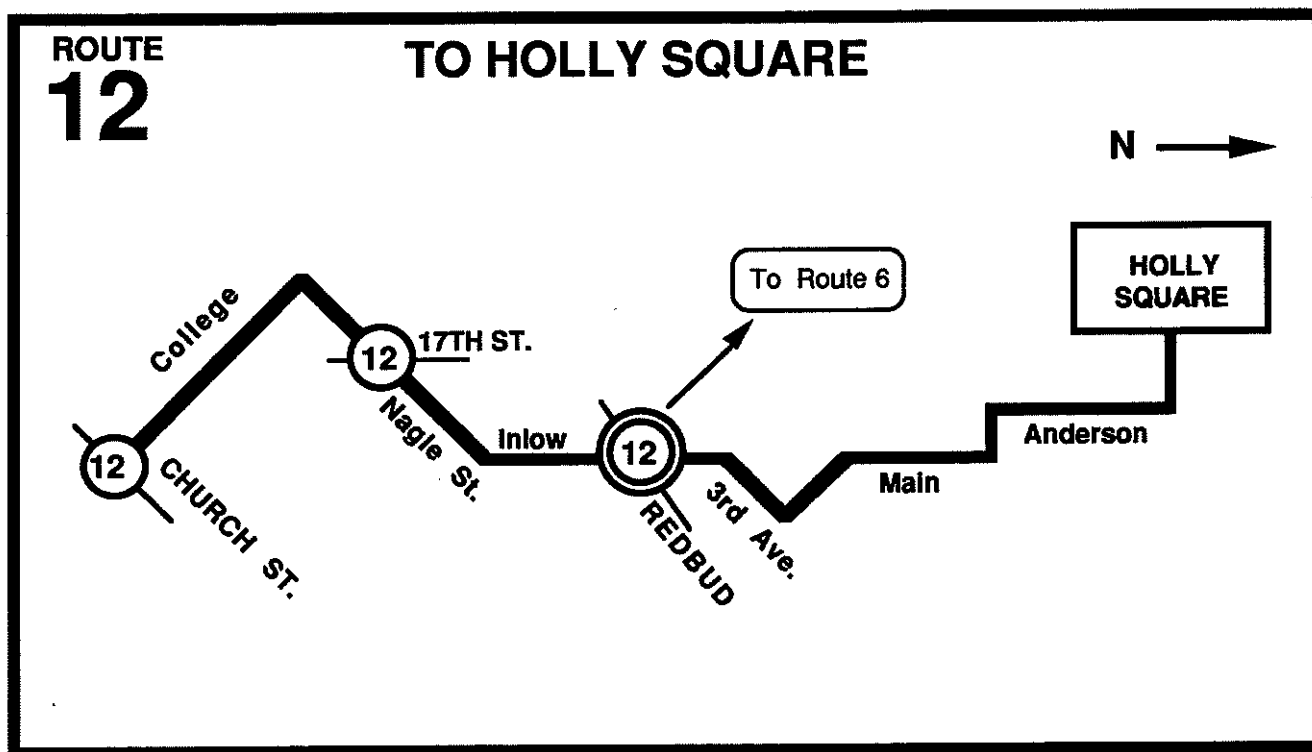
TYPE OF GUIDANCE INFORMATION: Bus Route, Direction, Destination

APPLICATION: Inside Bus

TYPE OF PRESENTATION: Alphanumeric, schematic signs, auditory displays
Front and rear of bus, over window line
Route map: Front, Back, Center of Bus, each side

FEATURES: Route - Number display
Direction - If route is unidirectional or circular, no direction is required. If route is bidirectional, and not circular, display end stop

Destination (next stop) - changeable message sign or illuminated stop markers on route map (if technology available) otherwise by operator or automated announcement

Route Map - See Page 28. Should be enlarged versions of single route maps designed for distribution

PHYSICAL DESIGN CHARACTERISTICS:

Background Size: Background size and dimensions consistent with area required for character sizes to meet requirements (below)

Character Sizes: Route Number and direction must be legible to person with 20/60 vision, daylight conditions, at distance of 20 ft, a character height of 1 inch (vertical character dimension must subtend at least 15 minutes of arc (0.00436 radian)). Riders with low vision should be able to approach sign to within 3 inches to read at least route number, and direction
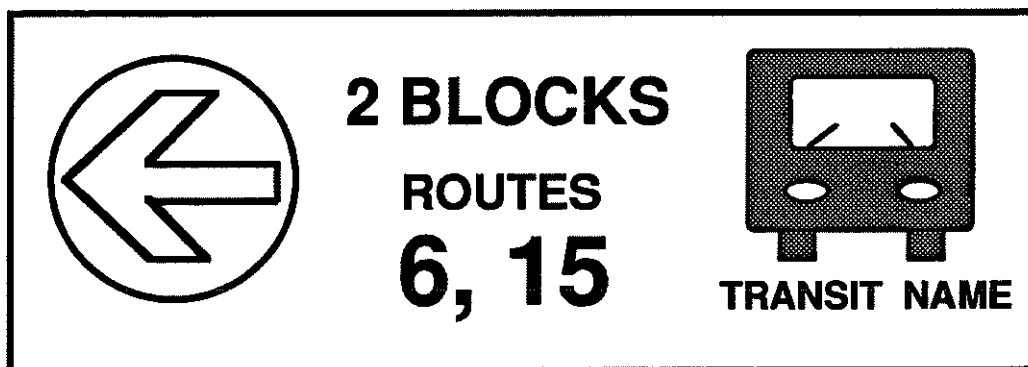
Typefaces: See page 15

Other Codes, Colors, Distinguishing Features:

Remarks: Display may be by changeable message sign or other dynamic presentation

Display of all information except route map may be by auditory announcement with the following recommended format (example):

ROUTE 20 TO HOLLY SQUARE
NEXT STOP MARVIN GARDENS

2 BLOCKS
ROUTES
6, 15

TRANSIT NAME

TYPE OF GUIDANCE INFORMATION: Bus Stop/Terminal Location

APPLICATION: On Street, remote from Stop or Terminal
Use at least every other block, all major streets or arterials, six block radius
Mount in conjunction with street signs at intersections

TYPE OF PRESENTATION: Static signage

FEATURES: Transit Logo or Identifier
Direction of Stop of Station
Distance of Stop or Location
Routes served

PHYSICAL DESIGN CHARACTERISTICS:

Background Size: Consistent with area required for character sizes as specified below

Character Sizes: 6 inches (15.24 cm) Transit Logo/Identifier
Routes served
2 inches (5 cm) Distance (in blocks)

Other Codes, Colors, Distinguishing Features:

Arrows

Remarks: Background should be different color than street signs

APPENDIX 1

Those sections of Reference 3 that pertain to bus stop design and are summarized in the discussion preceding have been excised from the *Accessibility Guidelines* for reference purposes.   They are presented in the same order as in the text. Where material not pertaining to bus stops has been excised in the guidelines provided, three vertical dots appear. Signage issues are covered in Section 4.30, Page 67

Implications of Americans with Disabilities Act of 1990 for Bus Stop Design

The Americans with Disabilities Act (ADA) of 1990 supplants a patchwork of previous accessibility and barrier-free legislation with a comprehensive set of requirements and guidelines for providing *reasonable* access to and use of buildings, facilities, and transportation. The purposes of ADA are to:

*   To provide a clear and comprehensive national mandate for the elimination of discrimination against individuals with disabilities

*   To provide clear, strong, consistent, enforceable standards addressing discrimination against individuals with disabilities

*   To ensure that the Federal Government plays a central role in enforcing the standards established in the Act on behalf of individuals with disabilities

*   To invoke the sweep of congressional authority...to address the major areas of discrimination faced day-to-day by people with disabilities (1)

The key language that governs access to transportation and transportation facilities is contained in 49 CFR Part 37 (2). The Appendix (3) to these rules is a set of design guidelines that are invoked by 49CFR37. Most of these design guidelines are nearly identical to the well-established American National Standards Institute (ANSI) A117.1 - 1980 which has been invoked by all previous legislation governing access for people with disabilities. There are, however, a number of new sections added to ANSI A117.1 for the express purposes of ADA. The transportation-specific section of the ADA Appendix (first promulgated in 1994) is Section 10, "Transportation Facilities." However, the first paragraph of Section 10 calls out "applicable provisions" of any of the previous sections of the Appendix, specifically 4.1 through 4.35, then all of Sections 5 - 9, in addition to the provisions of Section 10 (thus invoking itself, a somewhat circular procedure). The previous editions of the Appendix (3) did not contain any language in Section 10, and handbooks such as that referenced (1) made do with the general provisions of the first 9 sections.

A short guide written expressly for bus stop accessibility (4) makes the valuable point that it may not be within the power of a public entity to ensure that ADA guidelines are met in configuring a bus stop or appurtenances. If private organizations take the responsibility for the provision of stops for the convenience of shoppers, homeowners, etc. it may be unclear whether or not they must comply with ADA. Most transit agencies do not have legal control over the right-of-way where bus stops are located, according to this source. However, as a rule, some public entity (local government, State DOT) does, and they are thus tasked with ensuring ADA compliance. As a matter of practicality, almost any transit system will have accessible bus stops.

Specific Requirements for Bus Stop Design from Accessibility Guidelines

Although much of the Guidelines (3) with regard to transportation seem aimed at fixed rail systems (both light and heavy rail) there are numerous paragraphs scattered throughout the document that have import for bus stop design. Each call out will be discussed in the same order it appears in the Guidelines. The term "building" is defined by the Guidelines as "any structure used and intended for supporting or *supporting* any use or occupancy (italics added)." By this definition, shelters at bus stops would qualify as buildings, and will be so treated here.

The bus stop designer should also be alert to accessibility considerations other than those associated with wheelchairs. Many of the provisions relate to sensory disabilities, especially blind and partially-sighted individuals, and make sense only when the designer considers those types of disabilities.

10. TRANSPORTATION FACILITIES

10.1 **General**

This subsection refers to "applicable provisions" of 4.1 through 4.35 of the Appendix, and also Sections 5 through 9. Sections 5 through 9 have no provisions applicable to bus stop design and will not be discussed in this review. The discussion will branch to the applicable provisions of Section 4, and then take up the specific transportation-related provisions of Section 10.

4.1.2 **Accessible Sites and Exterior Facilities: New Construction**

This subsection calls for at least one accessible route within the boundary of a site from public transportation stops. This means that the bus stop must be designed so that a person who is disabled could proceed unimpeded to an accessible building or facility served by that stop (Detail design in 4.3). It also calls for elimination of obstacles protruding into circulation pathways (Detail design in 4.4). Ground surface design is covered in 4.5. Signage requirements are referenced to applicable sections of 4.30. Public pay phone requirements are in 4.31.2 through 4.31.8 if they are provided for by the bus operation. Curb ramps must meet a 1:12 slope criterion, unless the stop is an alteration of an existing (non-accessible) facility. In such a case a steeper slope may be permissible (six-inch rise, 1:10 to 1:12; three-inch rise, 1:8 to 1:10).

Thus this subsection is the top-level set of general requirements applicable to bus stops. Actual design information is contained in the subsections called out in this subsection.

4.2   Space Allowance and Reach Ranges

This section gives basic anthropometric data for wheelchair usage, All of these data should be used in bus stop layout.

4.3   Accessible Route

The accessible route within the boundary of the site should be the same as that for everybody else.   In other words, the path to and from the stop to other facilities or from the stop pad to other appurtenances such as a shelter should be designed to be accessible.   For a bus stop used as a part of a park-and-ride, an accessible route to the parking lot would be required.

This subsection has callouts for path width, passing space, head room (clearance) (Subsection 4.4.2), surface textures, slope, and level changes.   These data can be directly used for bus stop design purposes.

4.4   Protruding Objects

Objects projecting from walls (or equivalent vertical surfaces at a bus stop) with their leading edges between 27 and 80 inches must not protrude more than 4 inches into an accessible route.   Objects below that range have no restrictions on protrusions.   An object mounted on a post or pylon within the critical range of 27 to 80 inches can protrude as much as 12 inches into an accessible path.   Any protrusion in these situations, however, cannot reduce the minimum path widths and other dimensions mandated by 4.2 and 4.3.

4.5   Ground and Floor Surfaces

Surfaces along accessible routes must be stable, firm, and slip-resistant.   This subsection gives some guidance as to how to achieve these characteristics at a bus stop.   If level changes are less than 1/4 inch, no special treatment is necessary.   Between 1/4 and 1/2 inch, a bevel must be provided with a slope of at least 1:2, and angle of 26.5 degrees.   Any drop greater than that requires a ramp (4.7 or 4.8).   If gratings are in the accessible route, then they must have openings in the direction of travel no greater than 1/2 inch wide.

4.7   Curb Ramps

If curb ramps are part of a bus stop design, this subsection gives explicit guidelines for their location and detail design.

4.8   Ramps

In order to achieve compliance with 4.5 above, ramps other than curb ramps

may be necessary at a bus stop or leading to a bus stop. This subsection gives the guidelines. Note that an accessible route because of terrain may involve a slope greater than 1:20. If it does, then these provisions apply.

4.30 Signage

This subsection gives design guidelines for signs and information about accessible locations within the bus stop site. These include the familiar wheelchair logo that is the international symbol of accessibility. In addition, signs providing route designators (names, numbers, symbols, colors, or any combination of these), bus numbers, or stop designators are included in these requirements for character proportions, character heights, raised characters, braille, pictograms, finish and contrast, mounting location and height. Special provision is made for those who are visually disabled; users must be able to approach to within 3 inches of the sign, assuming that the centerline of the sign is 60 inches off the ground. This would suggest that stop identification signs, route designators, etc. placed for maximum visibility for the general public would have to be duplicated to meet ADA guidelines.

4.31 Telephones

There is nothing in ADA that requires public pay telephones to be placed at bus stops, but if they are, at least one must comply with these provisions for clear floor and ground space, mounting height, and protrusion into an accessible route or space. In addition, this pay telephone must be equipped to be hearing aid compatible with a volume control, be pushbutton operated where the telephone company can accommodate such a telephone. If a directory is provided, it must also be accessible as defined in 4.2.5 and 4.2.6.

10.   TRANSPORTATION FACILITIES (Resumed)

10.2 Bus Stops and Terminals

10.2.1 New Construction

New bus stop pads built to interface with vehicle ramps or lifts must meet the design guidelines provided in this paragraph.   Bus stop shelters must connect to the boarding area or stop pad by an accessible path as described in Section 4.   The mobility aid user must enter from the public way to reach an area 30 by 48 inches entirely under the shelter.

This paragraph calls out the signage provisions commented on in Subsection 4.30, however sizes and proportions of characters and symbols that meet the maximum local, state or federal regulations are considered in compliance with 10.2.1. An important exception is noted here:

"EXCEPTION: Bus schedules, timetables, or maps that are posted at the bus stop or bus bay are not required to comply with this provision."

10.2.2 Bus Stop Siting and Alterations

This paragraph merely states that bus stop sites must be chosen to comply with the previous paragraph to the maximum extent practicable.

CONCLUSION

ADA provisions important to bus stop design are heavily oriented to accommodation for wheelchair users, with some provisions for sensorily disabled persons mixed in. The basic design guidelines take a comparatively small number of pages in the standards, but a fair amount of interpretation is necessary to make the "reasonable" accommodations that ADA calls for in a bus stop layout. One of the more challenging aspects may be defining and designing the "accessible path" identified in many of the paragraphs summarized here, especially if that path is also as much as possible the same as the path for general public. Appendix 1 provides the applicable pages (with some reorganization and excising) of the *Accessibility Guidelines* (3).

EXCERPTS FROM *GUIDELINES* (3)

10.   TRANSPORTATION FACILITIES.

10.1   General. Every station, bus stop, bus stop pad, terminal, building or other transportation facility, shall comply with the applicable provisions of 4.1 through 4.35, sections 5 through 9, and the applicable provisions of this section. The exceptions for elevators in 4.1.3(5), exception 1 and 4.1.6(1)(k) do not apply to terminal, depot, or other station used for specified public transportation, or an airport passenger terminal, or facilities subject to Title II.

4.   ACCESSIBLE ELEMENTS AND SPACES: SCOPE AND TECHNICAL REQUIREMENTS.

4.1   Minimum Requirements

4.1.1* Application.

(1) General. All areas of newly designed or newly constructed buildings and facilities required to be accessible by 4.1.2 and 4.1.3 and altered portions of existing buildings and facilities required to be accessible by 4.1.6 shall comply with these guidelines, 4.1 through 4.35, unless otherwise provided in this section or as modified in a special application section.

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(5) General Exceptions.

(a) In new construction, a person or entity is not required to meet fully the requirements of these guidelines where that person or entity can demonstrate that it is structurally impracticable to do so. Full compliance will be considered structurally impracticable only in those rare circumstances when the unique characteristics of terrain prevent the incorporation of accessibility features. If full compliance with the requirements of these guidelines is structurally impracticable, a person or entity shall comply with the requirements to the extent it is not structurally impracticable. Any portion of the building or facility which can be made accessible shall comply to the extent that it is not structurally impracticable.

4.1.2   Accessible Sites and Exterior Facilities: New Construction. An accessible site shall meet the following minimum requirements:

(1) At least one accessible route complying with 4.3 shall be provided within the boundary of the site from public transportation stops, accessible parking spaces, passenger loading zones if provided, and public streets or sidewalks, to an accessible building entrance.

(2) At least one accessible route complying with 4.3 shall connect accessible buildings, accessible facilities, accessible elements, and accessible spaces that are on the same site.

(3) All objects that protrude from surfaces or posts into circulation paths shall comply with 4.4.

(4) Ground surfaces along accessible routes and in accessible spaces shall comply with 4.5.

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(7) Building Signage. Signs which designate permanent rooms and spaces shall comply with 4.30.1, 4.30.4, 4.30.5 and 4.30.6. Other signs which provide direction to, or information about, functional spaces of the building shall comply with 4.30.1, 4.30.2, 4.30.3, and 4.30.5. Elements and spaces of accessible facilities which shall be identified by the International Symbol of Accessibility and which shall comply with 4.30.7 are:

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(b) Accessible passenger loading zones:

(c) Accessible entrances when not all are accessible (inaccessible entrances shall have directional signage to indicate the route to the nearest entrance):

4.1.3   Accessible Buildings: New Construction. Accessible buildings and facilities shall meet the following minimum requirements:

(1) At least one accessible route complying with 4.3 shall connect accessible building or facility entrances with all accessible spaces and elements within the building or facility.

(2) All objects that overhang or protrude into circulation paths shall comply with 4.4.

(3) Ground and floor surfaces along accessible routes and in accessible rooms and spaces shall comply with 4.5.

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4.2   Space Allowance and Reach Ranges.

4.2.1* Wheelchair Passage Width. The minimum clear width for single wheelchair passage shall be 32 in (815 mm) at a point and 36 in (915 mm) continuously (see Fig. 1 and 24(e)).

4.2.2   Width for Wheelchair Passing. The minimum width for two wheelchairs to pass is 60 in (1525 mm) (see Fig. 2).

4.2.3* Wheelchair Turning Space. The space required for a wheelchair to make a 180-degree turn is a clear space of 60 in (1525 mm) diameter (see Fig. 3 (a)) or a T-shaped space (see Fig. 3(b)).
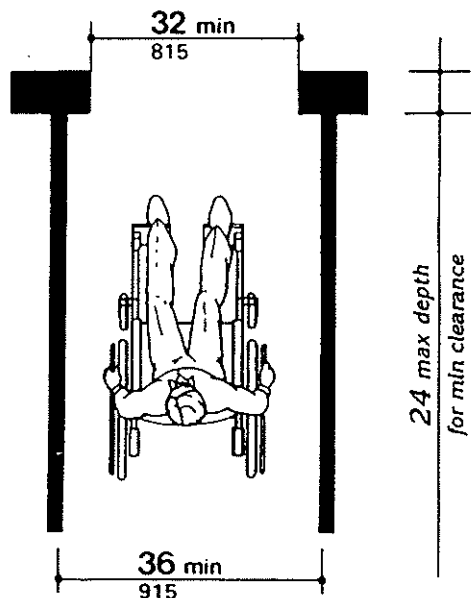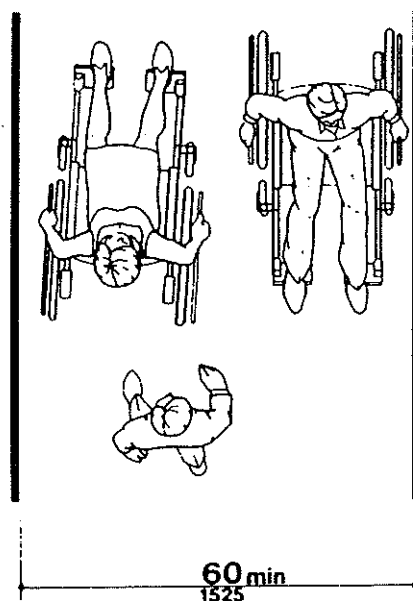
Fig. 1
Minimum Clear Width
for Single Wheelchair

Fig. 2
Minimum Clear Width
for Two Wheelchairs

4.2.4* Clear Floor or Ground Space for Wheelchairs.

4.2.4.1 Size and Approach. The minimum clear floor or ground space required to accommodate a single, stationary wheelchair and occupant is 30 in by 48 in (760 mm by 1220 mm) (see Fig. 4(a)). The minimum clear floor or ground space for wheelchairs may be positioned for forward or parallel approach to an object (see Fig. 4(b) and (c)). Clear floor or ground space for wheelchairs may be part of the knee space required under some objects.

4.2.4.2 Relationship of Maneuvering Clearance to Wheelchair Spaces. One full unobstructed side of the clear floor or ground space for a wheelchair shall adjoin or overlap an accessible route or adjoin another wheelchair clear floor space. If a clear floor space is located in an alcove or otherwise confined on all or part of three sides, additional maneuvering clearances shall be provided as shown in Fig. 4(d) and (e).

4.2.4.3 Surfaces for Wheelchair Spaces. Clear floor or ground spaces for wheelchairs shall comply with 4.5.

4.2.5* Forward Reach. If the clear floor space only allows forward approach to an object, the maximum high forward reach allowed shall be 48 in (1220 mm) (see Fig. 5(a)). *The minimum low forward reach is 15 in (380 mm).* If the high forward reach is over an obstruction, reach and clearances shall be as shown in Fig. 5(b).

4.2.6* Side Reach. If the clear floor space allows parallel approach by a person in a wheelchair, the maximum high side reach allowed shall be 54 in (1370 mm) and the low side reach shall be no less than 9 in (230 mm) above the floor (Fig. 6(a) and (b)). If the side reach is over an obstruction, the reach and clearances shall be as shown in Fig 6(c).

4.3   Accessible Route.

4.3.1* General. All walks, halls, corridors, aisles, skywalks, tunnels, and other spaces that are part of an accessible route shall comply with 4.3.

4.3.2. Location.

(1) At least one accessible route *within the boundary of the site* shall be provided from public transportation stops, accessible parking, and accessible passenger loading zones, and public streets or sidewalks to the accessible building entrance they serve. *The accessible route shall, to the maximum extent feasible, coincide with the route for the general public.*

(2) At least one accessible route shall connect accessible buildings, facilities, elements, and spaces that are on the same site.

(3) At least one accessible route shall connect accessible building or facility entrances with all accessible spaces and elements and with all accessible dwelling units within the building or facility.

(4) An accessible route shall connect at least one accessible entrance of each accessible dwelling unit with those exterior and interior spaces and facilities that serve the accessible dwelling unit.

4.3.3   Width. The minimum clear width of an accessible route shall be 36 in (915 mm) except at doors (see 4.13.5 and 4.13.6). If a person in a wheelchair must make a turn around an obstruction, the minimum clear width of the accessible route shall be as shown in Fig. 7(a) and (b).

4.3.4   Passing Space. If an accessible route has less than 60 in (1525 mm) clear width, then passing spaces at least 60 in by 60 in (1525 mm by 1525 mm) shall be located at reasonable intervals not to exceed 200 ft (61m). A T-intersection of two corridors or walks is an acceptable passing place.

4.3.5   Head Room. Accessible routes shall comply with 4.4.2.

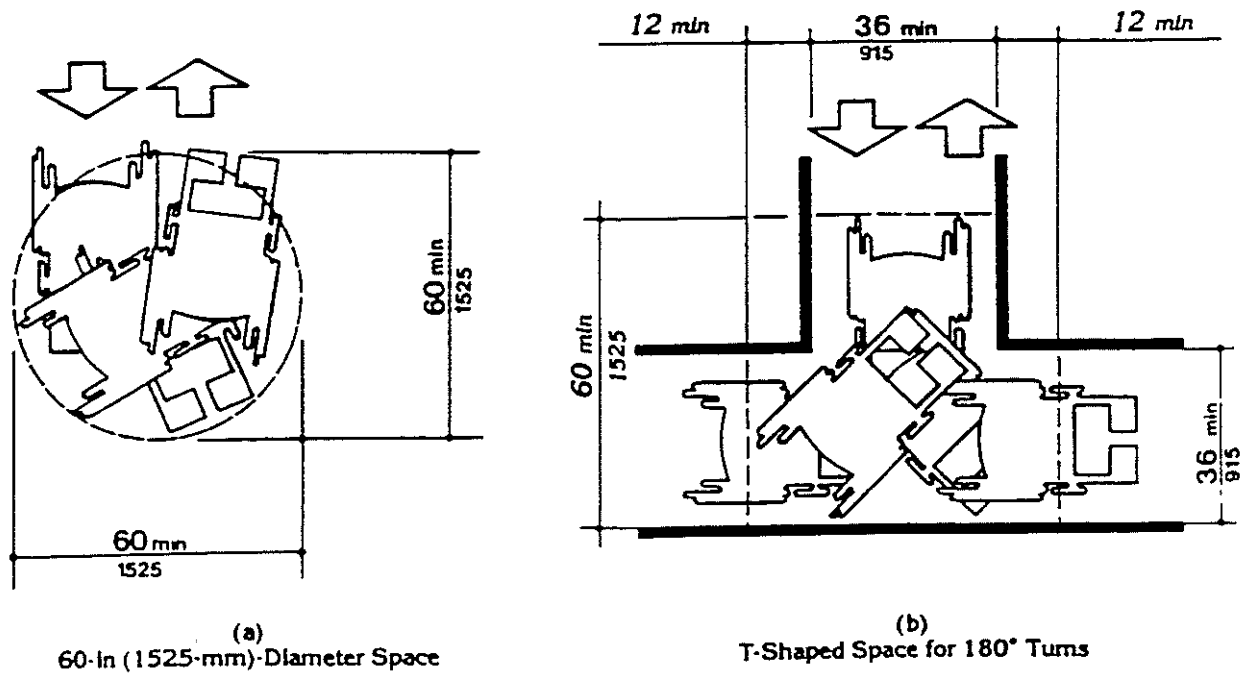**4.3.6   Surface Textures.** The surface of an accessible route shall comply with 4.5.

(a)
60-ln (1525-mm)-Diameter Space

(b)
T-Shaped Space for 180° Turns

Fig.3
Wheelchair Turning Space

(a)
Clear Floor Space

(b)
Forward Approach

(c)
Parallel Approach

NOTE: x ≤ 24 in (610 mm).

NOTE: x ≤ 15 in (380 mm).

(d)
Clear Floor Space in Alcoves

NOTE: If x > 24 in (610 mm), then an additional maneuvering clearance of 6 in (150 mm) shall be provided as shown.

NOTE: If x > 15 in (380 mm), then an additional maneuvering clearance of 12 in (305 mm) shall be provided as shown.
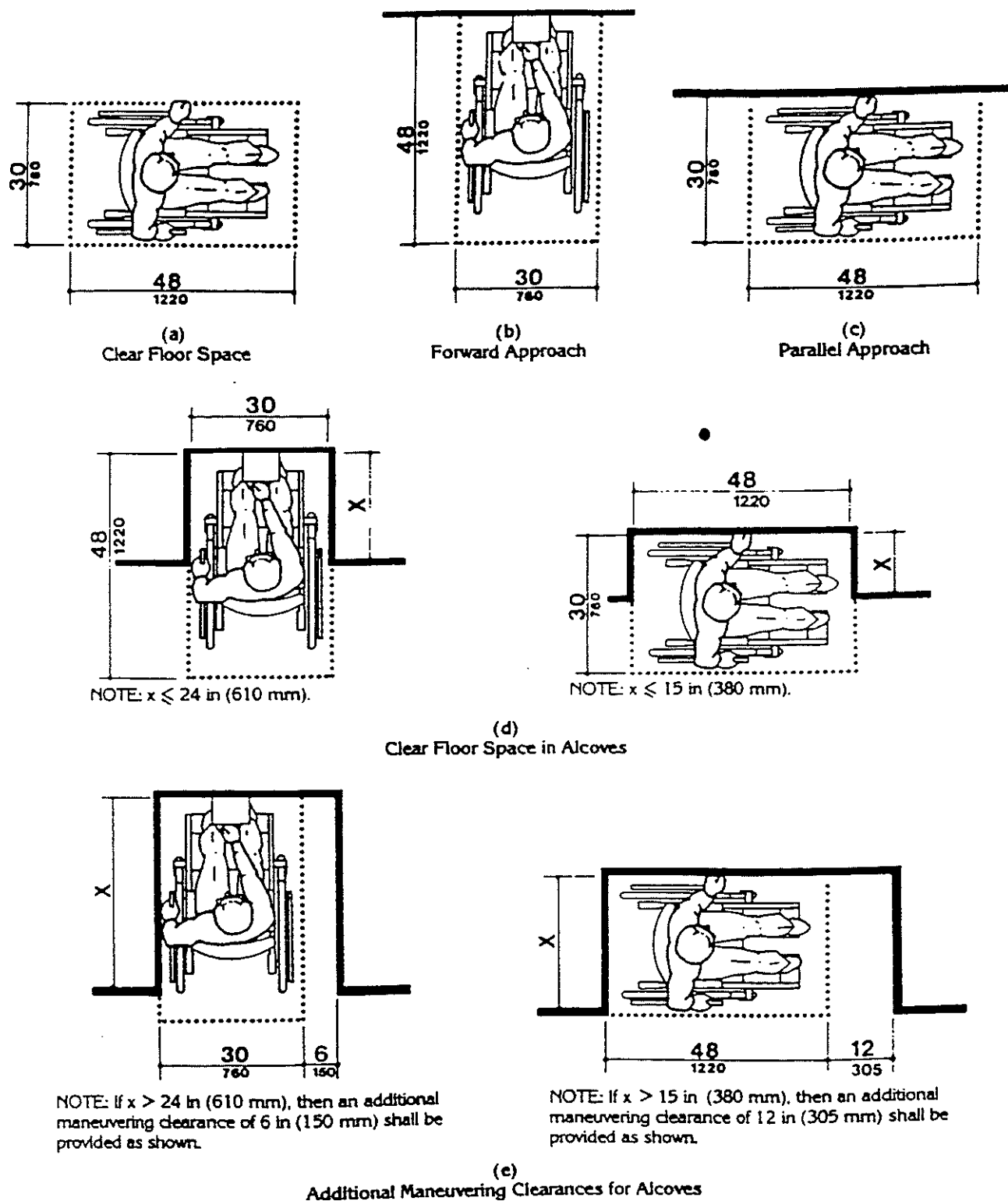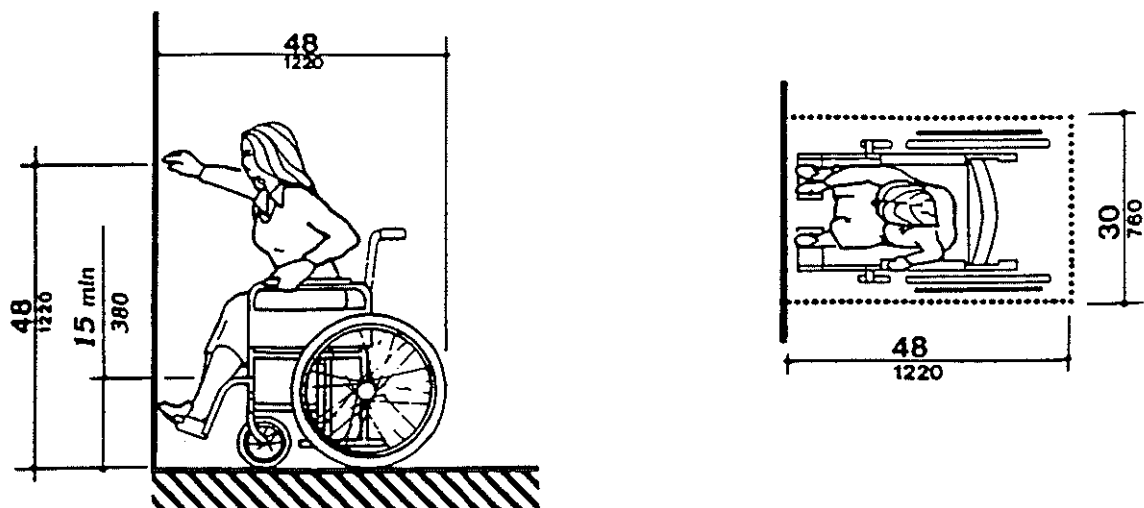
(e)
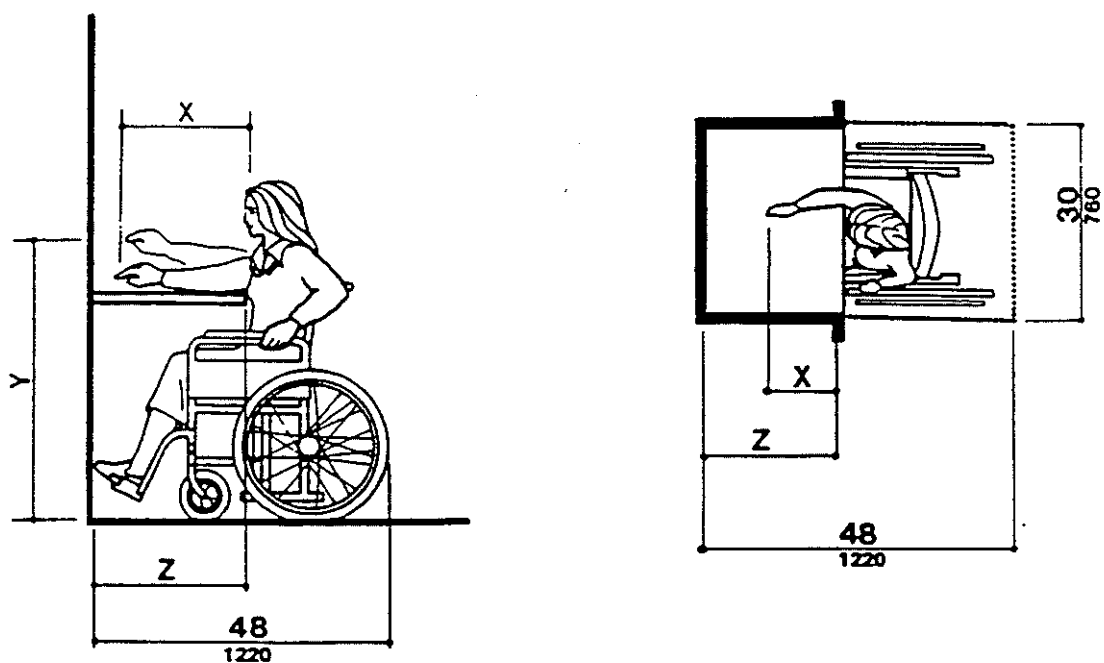Additional Maneuvering Clearances for Alcoves

Fig. 4
Minimum Clear Floor Space for Wheelchairs

(a)
High Forward Reach Limit

NOTE: x shall be ≤ 25 in (635 mm); z shall be ≥ x. When x < 20 in (510 mm), then y shall be 48 in (1220 mm) maximum. When x is 20 to 25 in (510 to 635 mm), then y shall be 44 in (1120 mm) maximum.

(b)
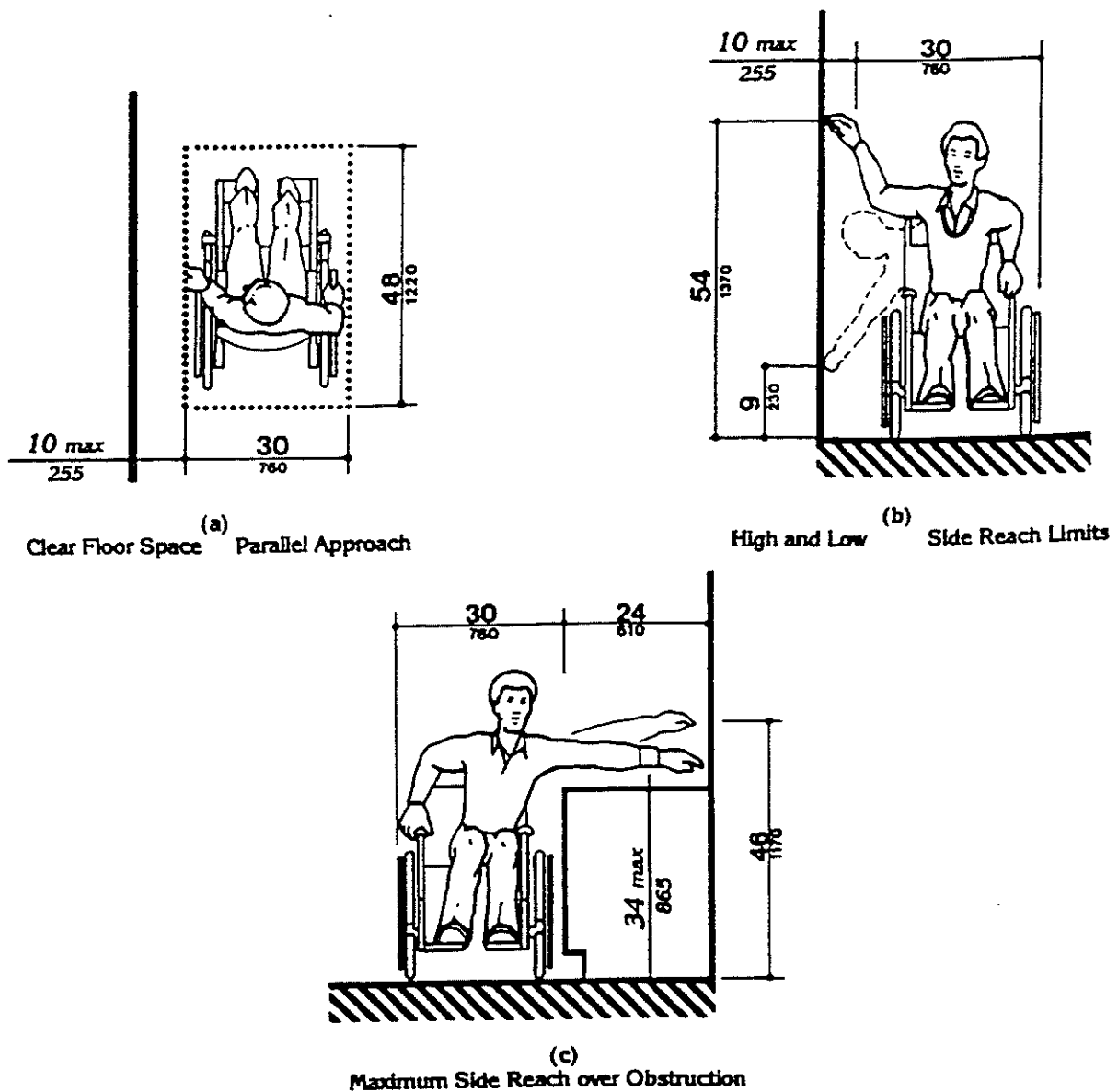Maximum Forward Reach over an Obstruction

Fig. 5
Forward Reach

(a)
Clear Floor Space **Parallel Approach**

(b)
High and Low **Side Reach Limits**

(c)
Maximum Side Reach over Obstruction

Fig. 6
Side Reach

4.3.7 Slope. An accessible route with a running slope greater than 1:20 is a ramp and shall comply with 4.8. Nowhere shall the cross slope of an accessible route exceed 1:50.

4.3.8 Changes in Levels. Changes in levels along an accessible route shall comply with 4.5.2. If an accessible route has changes in level greater than 1/2 in (13 mm), then a curb ramp, ramp, elevator, or platform lift (*as permitted in 4.1.3 and 4.1.6*) shall be provided that complies with 4.7, 4.8, 4.10, or 4.11, respectively. An accessible route does not include stairs, steps, or escalators. See definition of "egress, means of" in 3.5.
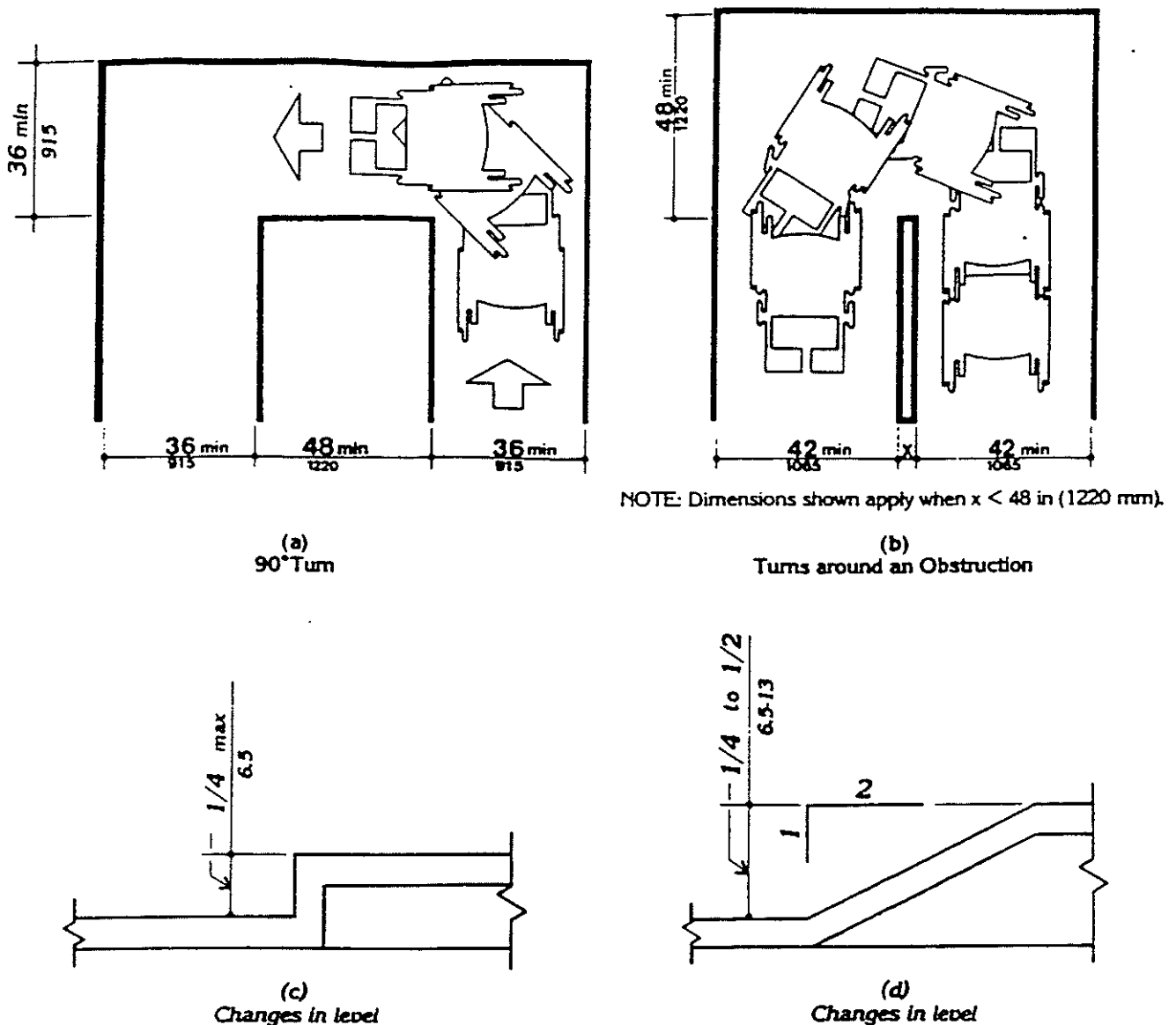
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-
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(a)
90°Turn

(b)
Turns around an Obstruction

NOTE: Dimensions shown apply when x < 48 in (1220 mm).

(c)
Changes in level

(d)
Changes in level

Fig. 7
Accessible Route

4.4 Protruding Objects.

4.4.1* General. Objects projecting from walls (for example, telephones) with their leading edges between 27 in and 80 in (685 mm and 2030 mm) above the finished floor shall protrude no more than 4 in (100 mm) into walks, halls, corridors, passageways, or aisles (see Fig. 8(a)). Objects mounted with their leading edges at or below 27 in (685 mm) above the finished floor may protrude any amount (see Fig. 8 (a) and (b)). Free-standing objects mounted on posts or pylons may overhang 12 in (305 mm) maximum from 27 in to 80 in (685 mm to 2030 mm) above the ground or finished floor (see Fig. 8(c) and (d)). Protruding objects shall not reduce the clear width of an accessible route or maneuvering space (see Fig. 8(e)).

4.4.2. Head Room. Walks, halls, corridors, passageways, aisles, or other circulation spaces shall have 80 in (2030 mm) minimum clear head room (see Fig. 8(a)). *If vertical clearance of an area adjoining an accessible route is reduced to less than 80 in (nominal dimension), a barrier to warn blind or visually-impaired persons shall be provided (see Fig. 8(c-1)).*
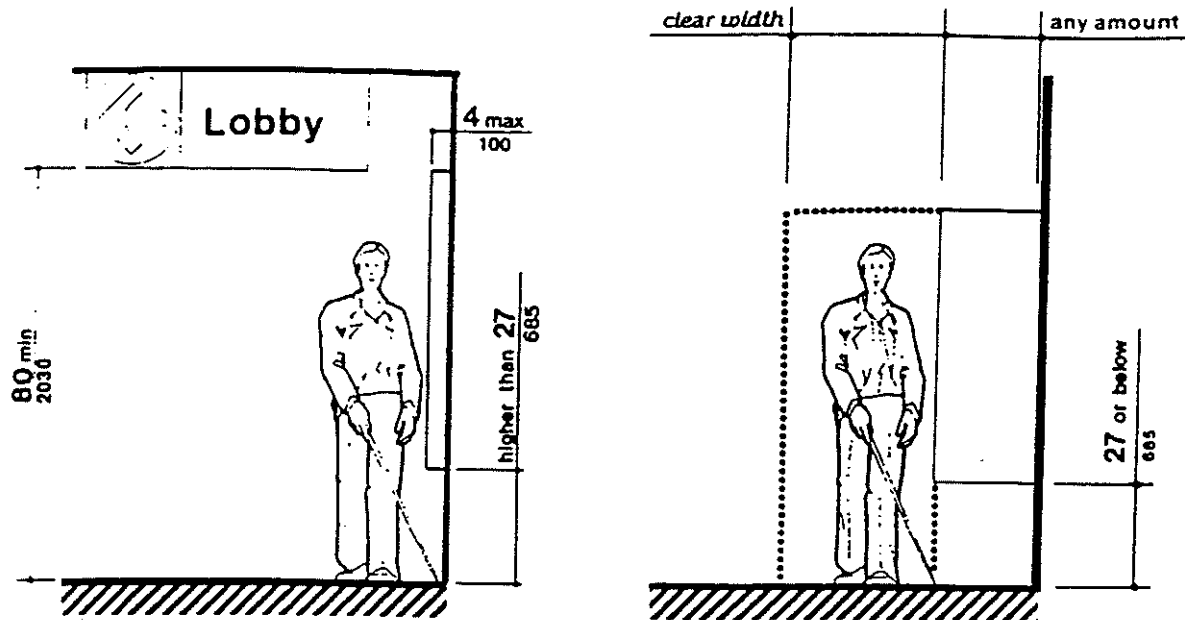

Fig. 8 (a)
Walking Parallel to a Wall
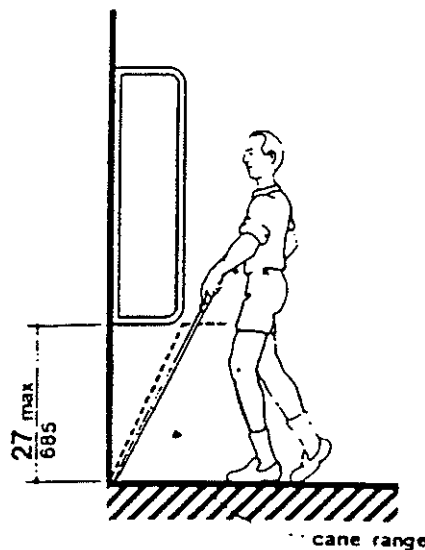
Fig. 8 (b)
Walking Perpendicular to a Wall

greater than 12
305

Plan

greater than 12
305

27 max
685

Elevation
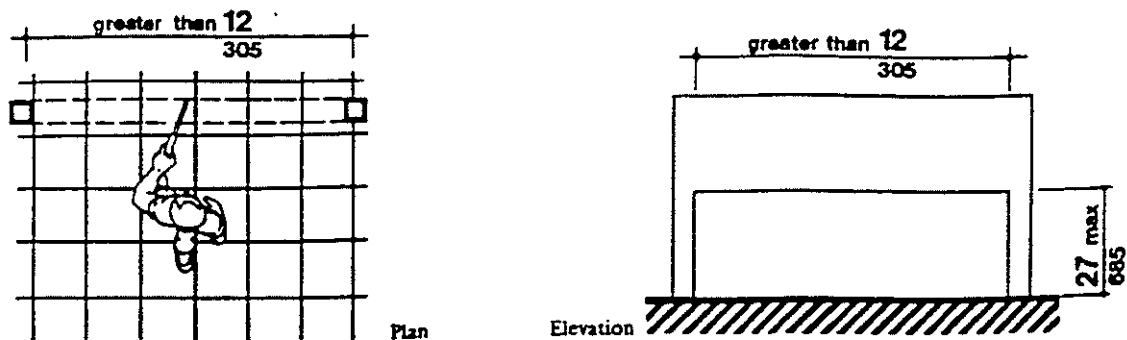
Fig. 8 (c)
Free-Standing Overhanging Objects

protect shaded
area from
cross-traffic

27
685

80

2030

CANE
DETECTION
AREA

Fig. 8 (c-1)
Overhead Hazards

12 max
305

this overhang can be
greater than 12 [305]
because no one can
approach the object
from this direction

Plan

greater than 27
685

cane hits post or pylon
before person hits object

Elevation

12 max
305

cane range

Fig. 8 (d)
Objects Mounted on Posts or Pylons

Fig. 8 (e)
Example of Protection around Wall-Mounted Objects and Measurements of Clear Widths

4.5 Ground and Floor Surfaces.

4.5.1* General. Ground and floor surfaces along accessible routes and in accessible rooms and spaces including floors, walks, ramps, stairs, and curb ramps, shall be stable, firm, slip-resistant, and shall comply with 4.5.
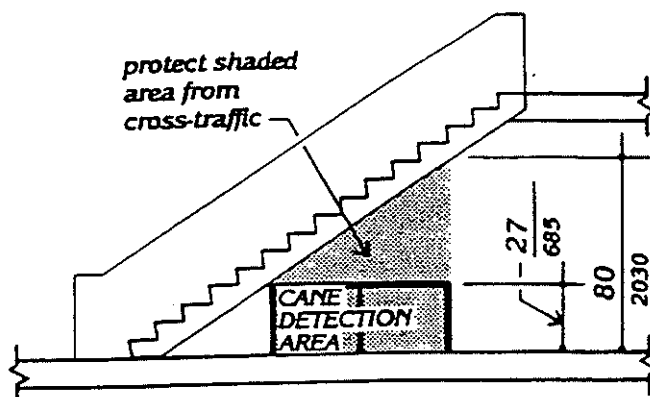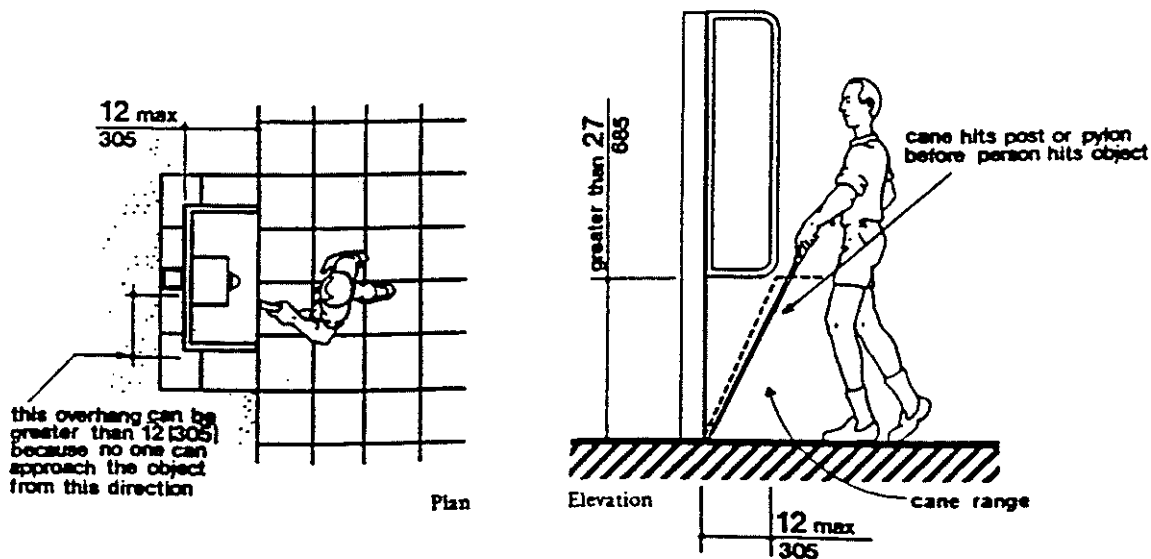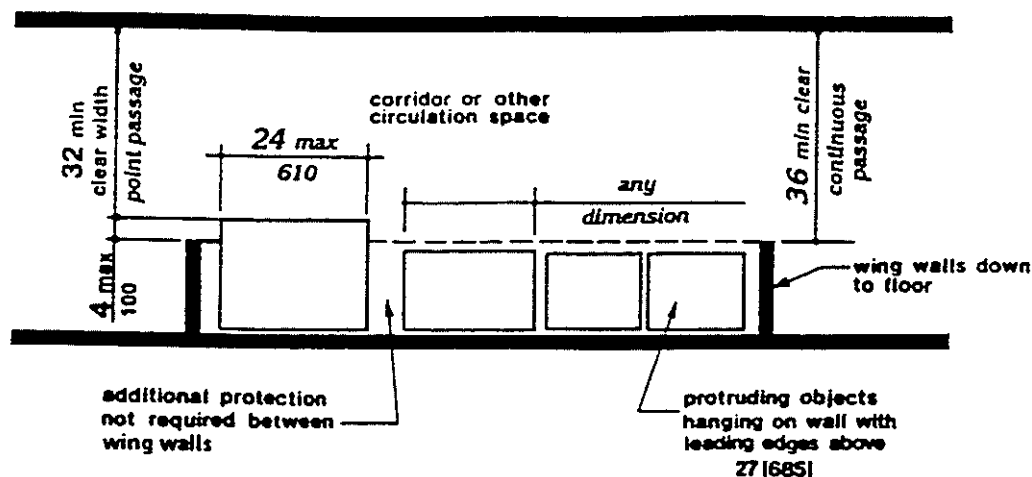
4.5.2 Changes in Level. Changes in level up to 1/4 in (6 mm) may be vertical and without edge treatment *(see Fig. 7(c))*. Changes in level between 1/4 in and 1/2 in (6 mm and 13 mm) shall be beveled with slope no greater than 1:2 (see Fig. 7(d)). Changes in level greater than 1/2 in (13 mm) shall be accomplished by means of a ramp that complies with 4.7 or 4.8.

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4.5.4 Gratings. If gratings are located in walking surfaces, then they shall have spaces no greater than 1/2 in (13 mm) wide in one direction *(see Fig. 8(g))*. If gratings have elongated openings, then they shall be placed so that the long dimension is perpendicular to the dominant direction of travel *(see Fig. 8(h))*.

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4.29.2* *Detectable* **Warnings on Walking Surfaces.** *Detectable warnings shall consists of raised truncated domes with a diameter of nominal 0.9 in (23 mm), a height of nominal 0.2 in (5 mm) and a center-to-center spacing of nominal 2.35 in (60 mm) and shall contrast visually with adjoining surfaces, either light-on-dark, or dark-on-light.*

The material used to provide contrast shall be an integral part of the walking surface. Detectable warnings used on interior surfaces shall differ from adjoining walking surfaces in resiliency or sound-on-cane contact.

4.7 Curb Ramps.

4.7.1   Location. Curb ramps complying with 4.7 shall be provided wherever an accessible route crosses a curb.

4.7.2   Slope. Slopes of curb ramps shall comply with 4.8.2. The slope shall be measured as shown in Fig. 11. *Transitions from ramps to walks, gutters, or streets shall be flush and free of abrupt changes. Maximum slopes of adjoining gutters, road surface immediately adjacent to the curb ramp, or accessible route shall not exceed 1:20.*

4.7.3 Width. The minimum width of a curb ramp shall be 36 in (915 mm), exclusive of flared sides.

4.7.4   Surface. Surfaces of curb ramps shall comply with 4.5.

4.7.5   Sides of Curb Ramps. If a curb ramp is located where pedestrians must walk across the ramp, or *where it is not protected by handrails or guardrails*, it shall have flared sides; the maximum slope of the flare shall be 1:10 (see Fig. 12(a)). Curb ramps with returned curbs may be used where pedestrians would not normally walk across the ramp (see Fig. 12(b)).

4.7.6   Built-up Curb Ramps. Built-up curb ramps shall be located so that they do not project into vehicular traffic lanes (see Fig. 13).

4.7.7   *Detectable Warnings.* A curb ramp shall have a *detectable* warning complying with 4.29.2. The *detectable warning shall extend* the full width and depth of the curb ramp.

4.7.8   Obstructions. Curb ramps shall be located or protected to prevent their obstruction by parked vehicles.

4.7.9   Location at Marked Crossings. Curb ramps at marked crossings shall be wholly contained within the markings, excluding any flared sides (see Fig. 15).

4.7.10 Diagonal Curb Ramps. If diagonal (or corner type) curb ramps have returned curbs or other well-defined edges, such edges shall be parallel to the direction of pedestrian flow. The bottom of diagonal curb ramps shall have 48 in (1220 mm) minimum clear space as shown in Fig. 15(c) and (d)). If diagonal curb ramps are provided at marked crossings, the 48 in (1220 mm) clear space shall be within the markings (see Fig. 15(c) and (d). If diagonal curb ramps have flared sides, they shall also have at least a 24 in (610 mm) long segment of straight curb located on each side of the curb ramp and within the marked crossing (see Fig. 15(c)).
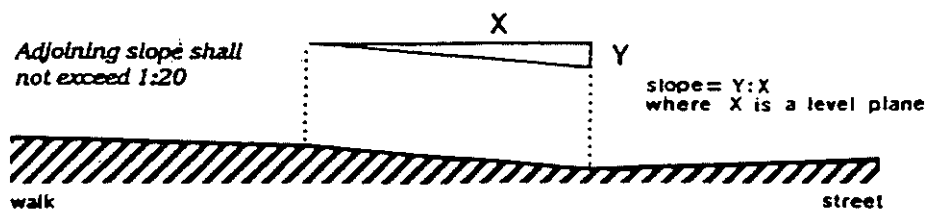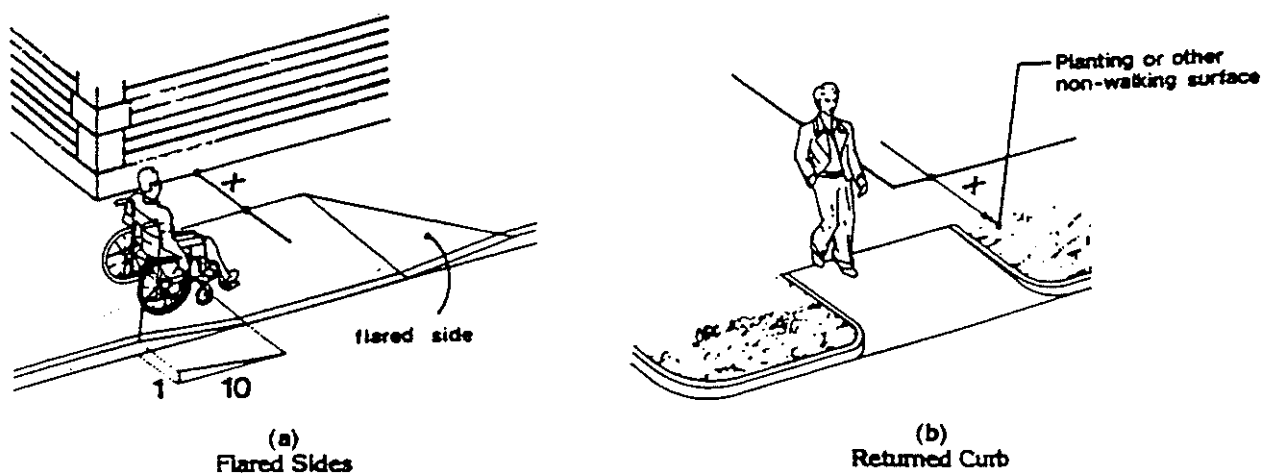
Fig. 11
Measurement of Curb Ramp Slopes

If X is less than 48 in,
then the slope of the flared side
shall not exceed 1:12.
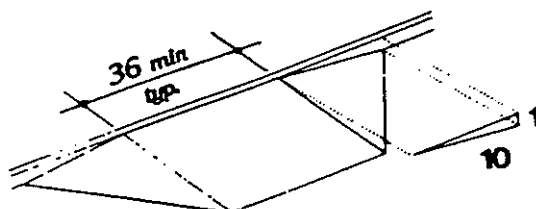
Fig. 12
Sides of Curb Ramps

Fig. 13
Built-Up Curb Ramp

(a)

(b)

segment of
straight curb

48min
1220

segment of
straight curb
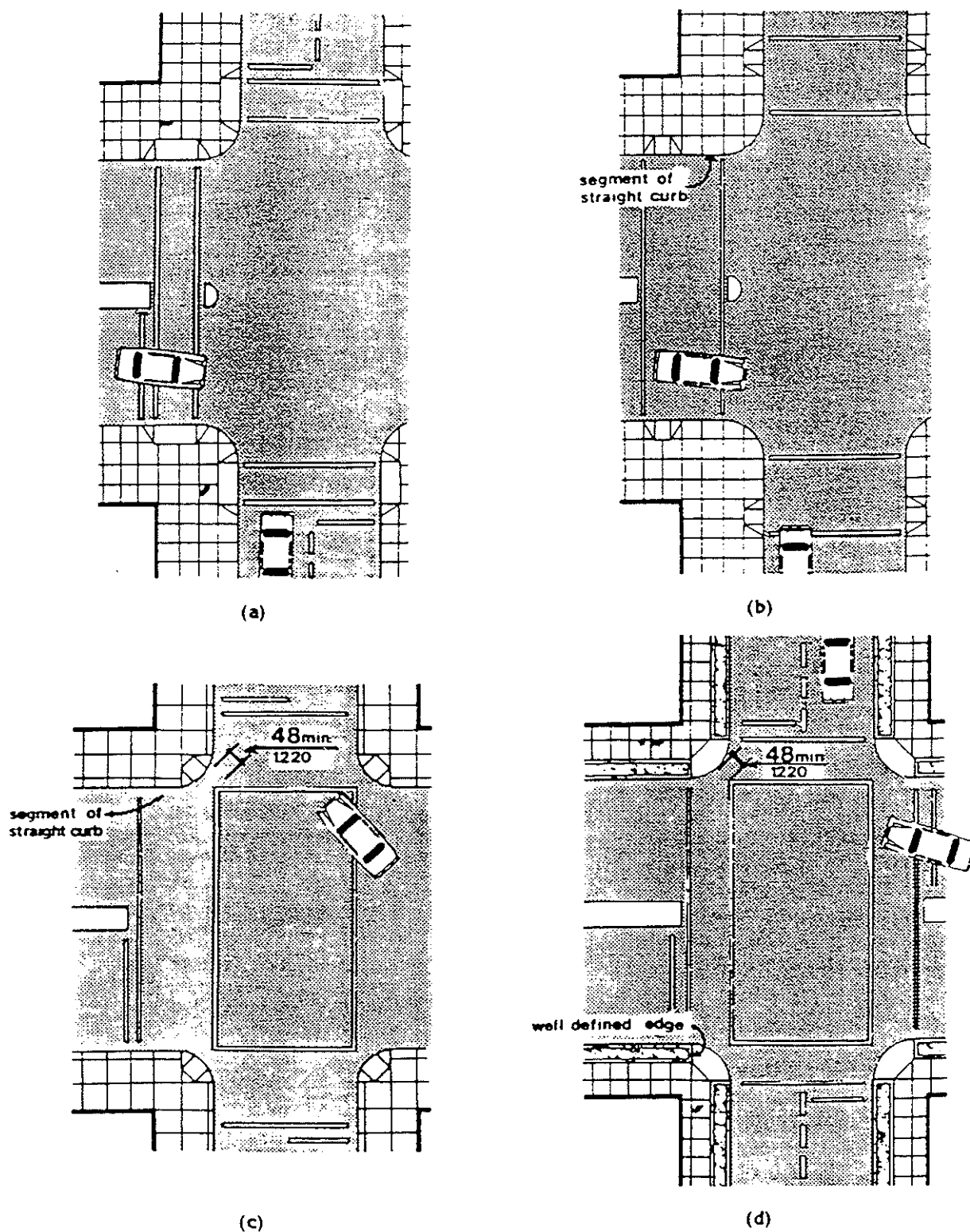
48min
1220

well defined edge

(c)

(d)

Fig. 15
Curb Ramps at Marked Crossings

4.7.11 Islands. Any raised islands in crossings shall be cut through level with the street or have curb ramps at both sides and a level area at least 48 in (1220 mm) long between the curb ramps in the part of the island intersected by the crossings (see Fig. 15(a) or (b)).

4.8 Ramps.

4.8.1* General. Any part of an accessible route with a slope greater than 1:20 shall be considered a ramp and shall comply with 4.8.

4.8.2* Slope and Rise. The least possible slope shall be used for any ramp. The maximum slope of a ramp in new construction shall be 1:12. The maximum rise for any run shall be 30 in (760 mm) (see Fig. 16). Curb ramps and ramps to be constructed on existing sites or in existing buildings or facilities may have slopes and rises as allowed in 4.1.6(3)(a) if space limitations prohibit the use of a 1:12 slope or less.

4.8.3 Clear Width. The minimum clear width of a ramp shall be 36 in (915 mm).

4.8.4* Landings. Ramps shall have level landings at bottom and top of each ramp and each ramp run. Landings shall have the following features:

(1) The landing shall be at least as wide as the ramp run leading to it.

(2) The landing length shall be a minimum of 60 in (1525 mm) clear.

(3) If ramps change direction at landings, the minimum landing size shall be 60 in by 60 in (1525 mm by 1525 mm).

(4) If a doorway is located at a landing, then the area in front of the doorway shall comply with 4.13.6.

4.8.5* Handrails. If a ramp run has a rise greater than 6 in (150 mm) or a horizontal projection greater than 72 in (1830 mm), then it shall have handrails on both sides. Handrails are not required on curb ramps or adjacent to seating in assembly areas. Handrails shall comply with 4.26 and shall have the following features:

(1) Handrails shall be provided along both sides of ramp segments. The inside handrail on switchback or dogleg ramps shall always be continuous.

(2) If handrails are not continuous, they shall extend at least 12 in (305 mm) beyond the top and bottom of the ramp segment and shall be parallel with the floor or ground surface (see Fig. 17).

(3) The clear space between the handrail and the wall shall be 1 - 1/2 in (38 mm).

(4) Gripping surfaces shall be continuous.

(5) Top of handrail gripping surfaces shall be mounted between 34 in and 38 in (865 mm and 965 mm) above ramp surfaces.

(6) Ends of handrails shall be either rounded or returned smoothly to floor, wall, or post.

(7) Handrails shall not rotate within their fittings.

4.8.6 Cross Slope and Surfaces. The cross slope of ramp surfaces shall be no greater than 1:50. Ramp surfaces shall comply with 4.5.

4.8.7   Edge Protection. Ramps and landings with drop-offs shall have curbs, walls, railings, or projecting surfaces that prevent people from slipping off the ramp. Curbs shall be a minimum of 2 in (50 mm) high (see Fig. 17).

4.8.8   Outdoor Conditions. Outdoor ramps and their approaches shall be designed so that water will not accumulate on walking surfaces.

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4.26   Handrails, Grab Bars, and Tub and Shower Seats.

4.26.1*General. All handrails, grab bars, and tub and shower seats required to be accessible by 4.1, 4.8, 4.9, 4.16, 4.17, 4.20 or 4.21 shall comply with 4.26.

4.26.2*Size and Spacing of Grab Bars and Handrails. The diameter or width of the gripping surfaces of a handrail or grab bar shall be 1-1/4 in to 1-1/2 in (32 mm to 38 mm), or the shape shall provide an equivalent gripping surface. If handrails or grab bars are mounted adjacent to a wall, the space between the wall and the grab bar shall be 1-1/2 in (38 mm) (see Fig. 39(a), (b), (c), and (e)). Handrails may be located in recess if the recess is a maximum of 3 in (75 mm) deep and extends at least 18 in (455 mm) above the top of the rail (see Fig. 39(d)).

4.26.3 Structural Strength. The structural strength of grab bars, tub and shower seats, fasteners, and mounting devices shall meet the following specification:

(1) Bending stress in a grab bar or seat induced by the maximum bending moment from the application of 250 lbf (1112N) shall be less than the allowable stress for the material of the grab bar or seat.

65

elevation
section

12 min
305

12 min
305

36min
915

2min
50

curb

<27
685

36min
915

wall

34·38
865·965

36min
915

vertical guard rail

12 min
305

36min
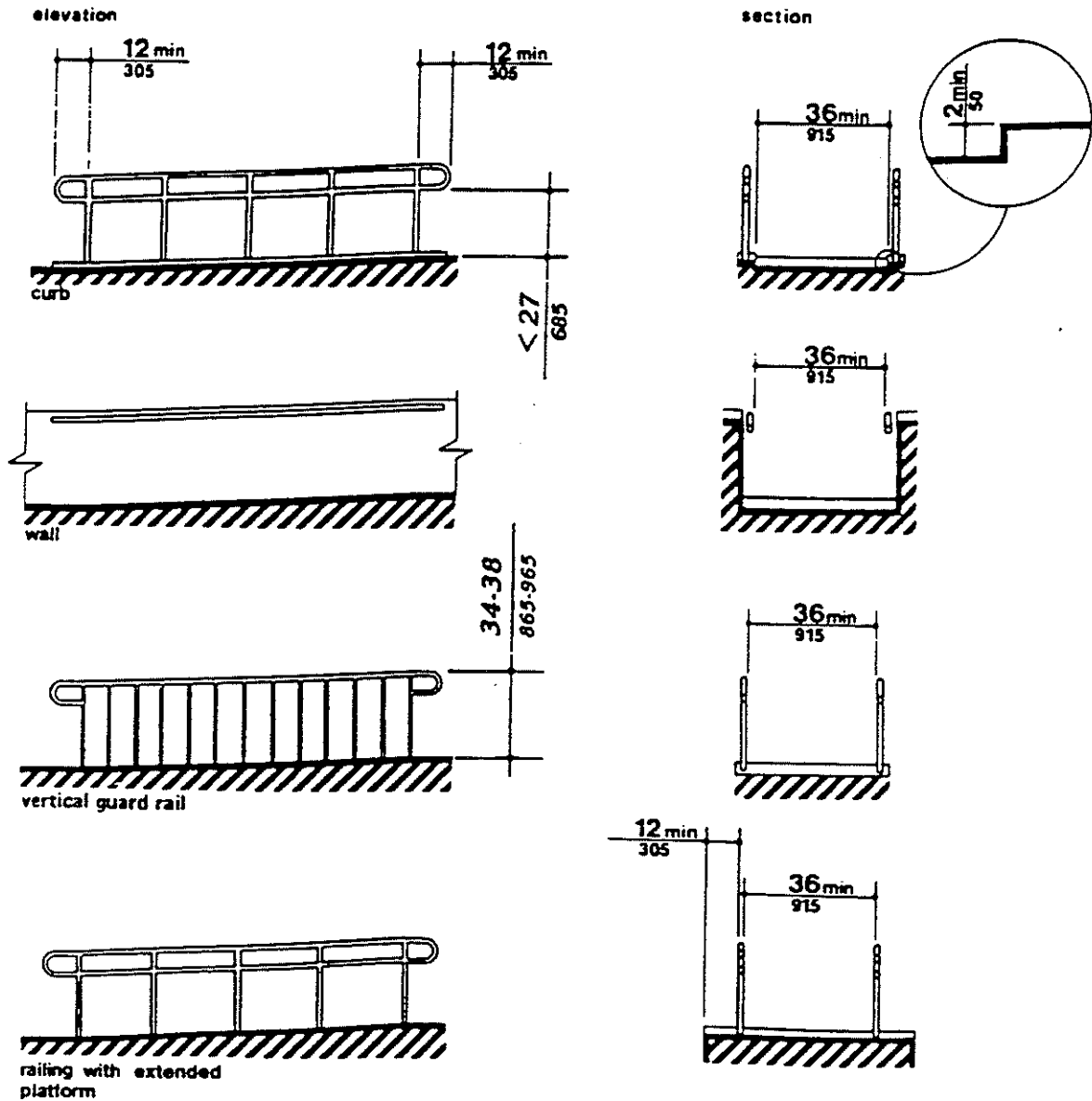915

railing with extended
platform

Fig. 17
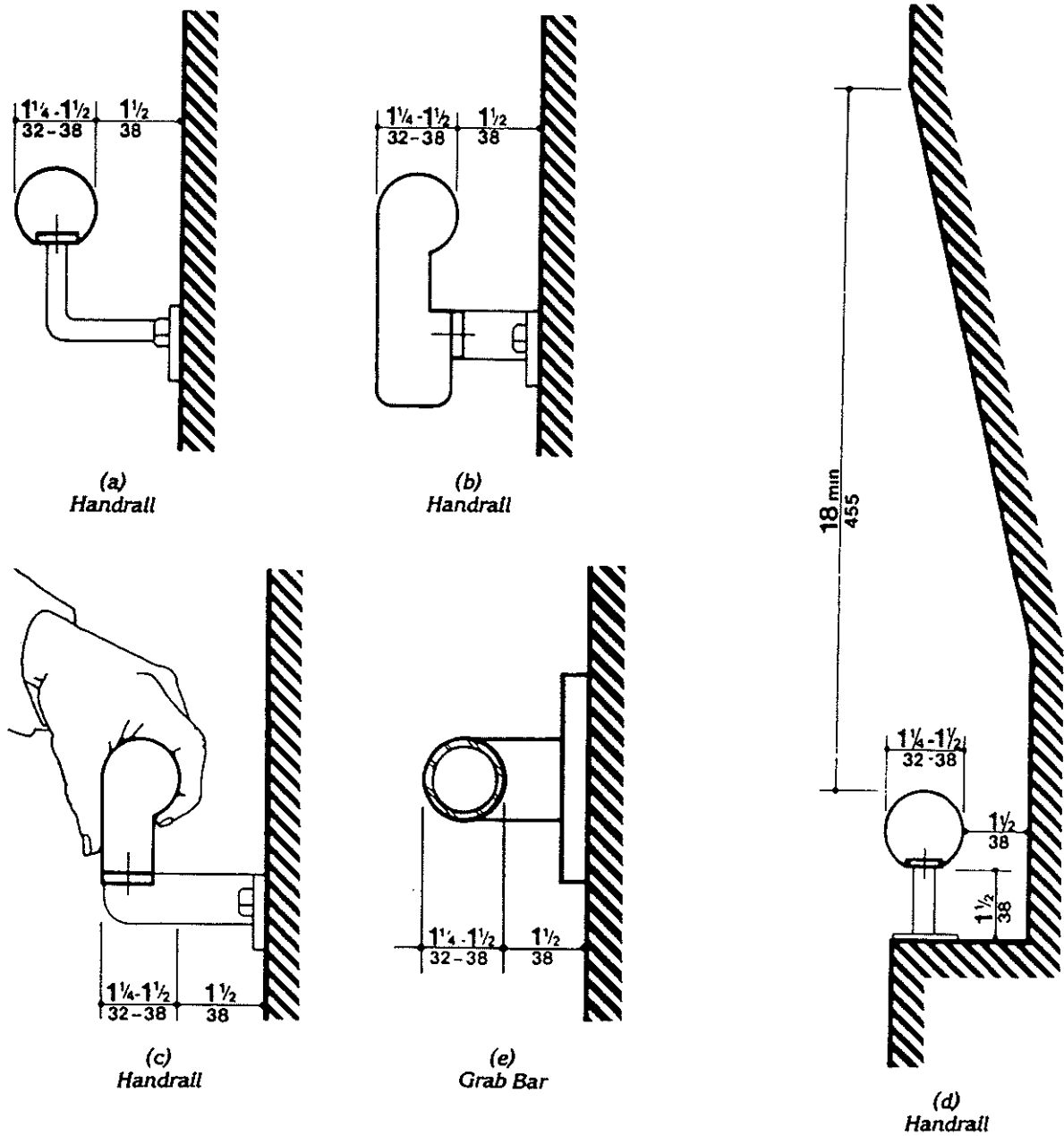Examples of Edge Protection and Handrail Extensions

Fig. 39
Size and Spacing of Handrails and Grab Bars

(2) Shear stress induced in a grab bar or seat by the application of 250 Ibf (1112N) shall be less than the allowable shear stress for the material of the grab bar or seat. If the connection between the grab bar or seat and its mounting bracket or other support is considered to be fully restrained, then direct and torsional shear stresses shall be totaled for the combined shear stress, which shall not exceed the allowable shear stress.

(3) Shear force induced in a fastener or mounting device from the application of 250 Ibf (1112N) shall be less than the allowable lateral load of either the fastener or mounting device or the supporting structure, whichever is the smaller allowable load.

(4) Tensile force induced in a fastener by a direct tension force of 250 Ibf (1112N) plus the maximum moment from the application of 250 Ibf (1112N) shall be less than the allowable withdrawal load between the fastener and the supporting structure.

(5) Grab bars shall not rotate within their fittings.

4.26.4 Eliminating Hazards. A handrail or grab bar and any wall or other surface adjacent to it shall be free of any sharp or abrasive elements. Edges shall have a minimum radius of 1/8 in (3.2 mm).

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4.30 Signage.

4.30.1*General. Signage required to be accessible by 4.1 shall comply with the applicable provisions of 4.30.

4.30.2*Character Proportion. Letters and numbers on signs 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.

4.30.3 Character Height. Characters and numbers on signs shall be sized according to the viewing distance from which they are to be read. The minimum height is measured using an upper case X. Lower case characters are permitted.

| Height Above Finished Floor	Minimum Character Height
Suspended or Projected Overhead in compliance with 4.4.2	3 in. (75 mm) minimum

4.30.4*Raised and Brailled Characters and Pictorial Symbol Signs (Pictograms). Letters and numerals shall be raised 1/32 in (0.8 mm) minimum, upper case, sans serif or simple serif type and shall be accompanied with Grade 2 Braille. Raised characters shall be at least 5/8 in (16 mm) high, but no higher than 2 in (50 mm). Pictograms shall be accompanied by the equivalent verbal description placed directly below the pictogram. The border dimension of the pictogram shall be 6 in (152 mm) minimum in height.

4.30.5*Finish and Contrast. The characters and background of signs shall be eggshell, matte, or other non-glare finish. Characters and symbols shall contrast with their background - either light characters on a dark background or dark characters on a light background.

4.30.6 Mounting Location and Height. Where permanent identification is provided for rooms and spaces, signs shall be installed on the wall adjacent to the latch side of the door. Where there is no wall space to the latch side of the door, including at double leaf doors, signs shall be placed on the nearest adjacent wall. Mounting height shall be 60 in (1525 mm) above the finish floor to the centerline of the sign. Mounting location for such signage shall be so that a person may approach within 3 in (76 mm) of signage without encountering protruding objects or standing with in the swing of door.

4.30.7*Symbols of Accessibility.

(1) Facilities and elements required to be identified as accessible by 4.1 shall use the international symbol of accessibility. The symbol shall be displayed as shown in Fig. 43(a) and (b).
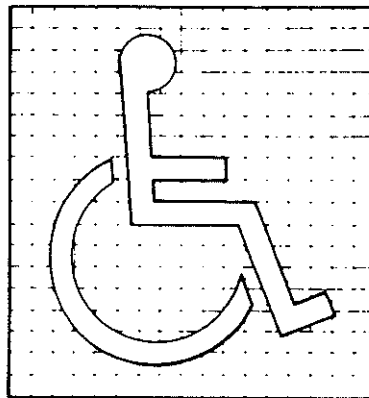
(a)
Proportions
International Symbol of Accessibility

(b)
Display Conditions
International Symbol of Accessibility

4.31 Telephones.

4.31.1 General. Public telephones required to be accessible by 4.1 shall comply with 4.31.

4.31.2 Clear Floor or Ground Space. A clear floor or ground space at least 30 in by 48 in (760 mm by 1220 mm) that allows either a forward or parallel approach by a person using a wheelchair shall be provided at telephones (see Fig. 44). The clear floor or ground space shall comply with 4.2.4. Bases, enclosures, and fixed seats shall not impede approaches to telephones by people who use wheelchairs.

4.31.3*Mounting Height. The highest operable part of the telephone shall be within the reach ranges specified in 4.2.5 or 4.26.

4.31.4 Protruding Objects. Telephones shall comply with 4.4.

10.2 Bus Stops and Terminals.

10.2.1 New Construction.

(1) Where new bus stop pads are constructed at bus stops, bays or other areas where a lift or ramp is to be deployed, they shall have a firm, stable surface; a minimum clear length of 96 inches (measured from the curb or vehicle roadway edge) and a minimum clear width of 60 inches (measured parallel to the vehicle roadway) to the maximum extent allowed by legal or site constraints; and shall be connected to streets, sidewalks or pedestrian paths by an accessible route complying with 4.3 and 4.4. The slope of the pad parallel to the roadway shall, to the extent practicable, be the same as the roadway. For water drainage, a maximum slope of 1:50 (2%) perpendicular to the roadway is allowed.

(2) Where provided, new or replaced bus shelters shall be installed or positioned so as to permit a wheelchair or mobility aid user to enter from the public way and to reach a location, having a minimum clear floor area of 30 inches by 48 inches, entirely within the perimeter of the shelter. Such shelters shall be connected by an accessible route to the boarding area provided under paragraph (1) of this section.

(3) Where provide, all new bus route identification signs shall comply with 4.30.5. In addition, to the maximum extent practicable, all new bus route identification signs shall comply with 4.30.2 and 4.30.3. Signs that are sized to the maximum dimensions permitted under legitimate local, state or federal regulations or ordinances shall be considered in compliance with 4.30.2 and 4.30.3 for purposes of this section.

EXCEPTION: Bus schedules, timetables, or maps that are posted at the bus stop or bus bay are not required to comply with this provision.

10.2.2 Bus Stop Siting and Alterations.

(1) Bus stop sites shall be chosen such that, to the maximum extent practicable, the areas where lifts or ramps are to be deployed comply with section 10.2.1(1) and (2).

(2) When new bus route identification signs are installed or old signs are replaced, they shall comply with the requirements of 10.2.1(3).

References

1.   Balog, J.N., Chia, D., Schwartz, A.N., and Gribbon, R.B.   (1992) *Accessibility Handbook for Transit Facilities* Ketron Division of Bionetics Corp for U.S. Dept. Of Transportation, Federal Transit Administration, Washington, DC Report FTA-MA-06-0200-92-1.

2.   U. S. Dept of Transportation, "Transportation for People with Disabilities" 49 CFR 37, Docket 47483, Notice 91-14, Final Rule, effective October 7, 1991..

3.   United States Access Board (1994) *Americans with Disabilities Act: Accessibility Guidelines for Buildings and Facilities, Transportation Facilities, and Transportation Vehicles* U.S. Architectural and Transportation Barriers Compliance Board, 1331 F Street, NW, Suite 1000, Washington, DC 20004-1111

4.   CGA Consulting Services, Inc. (1992) *Bus Stop Accessibility: A Guide for Virginia Transit Systems for Complying with the Americans with Disabilities Act of 1990.* Prepared for the Virginia Dept. Of Rail and Public Transportation. CGA was associated with EG&G/Dynatrend and Katherine McGuinness and Associates.

APPENDIX 2

BUS ROUTE INFORMATION AND MAPPING - BIBLIOGRAPHY

The resources on the following pages address various elements of bus route information, instructional text and graphics, map design and map learning, and cognitive mapping

BUS ROUTE INFORMATION AND MAPPING - BIBLIOGRAPHY

Bus Route Information

Bartram, D. The presentation of information about bus services. *Information Design*,
  edited by R. Easterby & H. Zwaga, John Wiley & Sons Ltd., 1984; p.299-320.

> A "legible" bus system is defined as one in which a passenger can plan
> and execute a trip without outside assistance and without fear of getting
> lost. Two types of information that have been studied are route maps and
> timetables. This article reviews some of the studies performed by the
> author and by others concerning map color-coding and schematization,
> maps versus lists of bus stops, timetable formats, and information displays
> at bus stops and on buses. Suggested improvements include breaking a
> large bus system into smaller systems with their own area-maps,
> improving in-transit information on bus stop signposts and increasing the
> information presented on the outsides and insides of buses.

Batelle Memorial Institute, Transit user information aids: an evaluation of consumer
  attitudes. Department of Transportation, Urban Mass Transit Adminstration,
  Office of Transit Management, Feb. 1976.

> The overall purpose of the Transit User Information Project has been to
> identify the necessary components (both currently used and potential) of
> an effective transit information program which will provide the appropriate
> types and levels of information for persons to successfully use a transit
> system. A major output of this project is a handbook of transit user
> information aids which will provide transit operators with guidelines for
> developing an effective set of information aids. This handbook is based
> on an extensive inventory of currently used user information aids,
> interviews with a selected sample of transit operators, development of new
> potential information aids (form, design, etc.), and evaluation of existing
> and proposed transit user information aids through a series of laboratory
> group activity sessions. The laboratory evaluation was a means of
> objectively studying the impacts of the alternative techniques for providing
> transit information. As stated in the proposal for this project, the
> evaluation goals are "to determine what user information aids and
> dissemination techniques work best to satisfy existing and potential rider
> needs, physical and psychological, in specific test situations considering

multiple influence forces". In short, the laboratory sessions have been a primary mechanism for testing how accurately information aids and techniques reflect the perceived information needs of transit users. More specific objectives of the laboratory evaluations have been to test: 1. degrees of information levels required by specific information aid types to supply necessary information; 2. the level of information and design content at which complexity and mass becomes unclear, confusing, and counterproductive to purpose; 3. importance of specific information aids and dissemination techniques and their ability to satisfy rider needs and stimulate ridership; 4. user information's ability to satisfy certain psychological, as well as physical, components of the urban transportation trip, specifically: treatment, predictability, individualization, security, and accessibility; and 5. the effect that brief exposure to information aids may have on attitudes and/or propensity to ride transit. (Author)

Ellson, P.B. and Tebb, R.G.P., Requirements, design and comprehensibility of leaflets to promote existing bus services. Supplementary Report 371, Transport and Road Research Laboratory; Berkshire, Great Britain, 1978.

An information leaflet was devised during the course of an experiment in the generation of passenger traffic in an existing bus network. The requirements to be met by the leaflet were investigated and are set out in detail in the Report. The ways in which these requirements dictated the design of the leaflet are discussed and a copy of the final design is included at the back of this Report. Production costs of the leaflet are quoted and the successful methods adopted for distribution are described.

Following the distribution of the leaflets, a survey of a sample of recipients was made in order to assess the comprehensibility of various features incorporated in the leaflet. The numerical and statistical results of the survey are given in detail, and conclusions are drawn on the comprehensibility of the various features that figured in the leaflets. (Author)

Ellson, P.B. and Tebb, R.G.P. Costs and benefits of a bus-service leaflet. TRRL Laboratory Report 825, Transport and Road Research Laboratory; Berkshire, Great Britain, 1978.

TRRL has studied the effects of distribution of bus service information leaflets, to determine whether expenditure on such activities can be justified by resultant increases in traffic. A well-established network of eight rural services in South and West Yorkshire was chosen for the study.

Principal findings were that the extra revenue attributable directly to the information leaflet was some four times the cost of production and

distribution. Patronage on the bus services in the area covered by the information leaflet was up by 13 per cent four weeks after distribution and was still detectably above the pre-distribution level 17 weeks after distribution. Additionally, extra rural interchange traffic was generated at points where the services connected. (Author)

Ellson, P.B. and Tebb, R.G.P., Leaflets giving information about existing urban public transport services: requirements, design and comprehensibility. TRRL Laboratory Report 990, Transport and Road Research Laboratory; Berkshire, Great Britain, 1981.

Leaflets giving travel information were needed for use in a further experiment on the generation of passenger traffic on an existing group of public transport services. The group comprised all buses and trains serving and urban area. The requirements to be met by the leaflet were investigated and are set out in detail in the Report. One requirement was that they should fit into standard display cases at bus stops in the area.

The ways in which this and other requirements dictated the design of the leaflet are discussed. Production costs are indicated, and the methods adopted for free distribution are described and are shown to have been assessed.

After issue of the travel information, a survey was made to assess the comprehensibility of various features incorporated in the leaflet. The numerical and statistical results of the survey are given detail, and conclusions are drawn from these and from previous survey results. Details of the effect of the information dissemination on traffic levels and modal choice are given in a companion report, LR 991. (Author)

Fruin, J.J. Passenger information systems for transit transfer facilities. Report #7, *Synthesis of Transit Practice*, Transportation Research Board, National Research Council, Washington, D.C., 1985.

Elements of a passenger information program are discussed. Four categories of information aids include visual communication (wall maps, directional signing, route and timetable displays), oral communication (telephone informtion services, transit personnel), distributed information (maps, brochures), and automatic passenger interactive systems (electric guidance maps, computer-generated trip information).

The type and content of passenger information aids should reflect user needs, the complexity of the transit system, and the size of the transfer facility. Factors to be considered in designing information aids include rehearsal, simplicity, continuity, consistency, and repetition. More

research is needed in the areas of transit signing, changeable message signing, and interactive information systems.

Kaeser & Wilson Design, Ltd. User survey of surface transit information systems. Final report prepared for the New York City Department of Transportation, Bureau of Planning and Research; October, 1981.

The purpose of this study was to design the best graphic method for presenting on-street bus transit information to public transit users. Phase I of the study tested six existing graphic formats: three "basic" route coverage designs and three "detailed" designs (including transfers, schedules, landmarks, and fare information). Phase II compared the existing "Guide-a-Ride" detailed format with the "Simplified" and "Topographical formats" developed for this study. User performance was measured using sample route-finding problems on written questionnaires. Phase I results indicated that "basic" designs, with less detail, produced better performance. In Phase II, the three formats produced approximately equal performance, with the exception of the timetables. Here, the Topographic format,which shows bus arrival times (in hours and minutes) in vertical columns showed significantly better performance in most trials.

Sperling, D., Goralka, R. Demand for intercity bus by the rural elderly. Transportation Research Record 1202, Transportation Research Group, University of California, Davis, California, 1990.

What role could and should the intercity bus play in serving the growing elderly population in rural areas? Telephone and on-board surveys were conducted in a corridor in Northern California to learn who used intercity buses and who did not, and why. It was found that only a tiny number of elderly riders were "captive"; the remainder had similar demographic, socioeconomic, and auto accessibility characteristics to those who did not use intercity buses. This finding implies that the potential for expanding ridership may be significant, but also implies that the intercity bus does not provide an essential public service to elderly people. To understand and predict ridership, future studies of intercity bus demand should focus on the particular circumstances and lifestyles of individuals living in differing sociocultural environments, not on traditional demographic, socioeconomic, and auto accessibility indicators. (Author)

Sprent, N., Bartram, D., Crawshaw, C.M. Intelligibility of bus timetables. *Human Factors in Transport Research,* Edited by D.J. Osborne and J.A. Levis; Academic Press, 1980, Vol.1, p.319-327.

> Four commonly used styles of timetable, each conveying the same travel information and containing identical alphabetical and numerical material, were compared.
>
> Ninety-six people were given one of the four timetables, and asked to complete a questionnaire which required them to consult the timetable and use its information in a number of ways.
>
> The results indicated that the most important factor in ease and speed of reading the timetables was the twelve-hour clock system. Subjects completed the questionnaire significantly faster and made significantly fewer errors when consulting a timetable which used the twelve-hour (am/pm) system. (Author)

Map Design and Map Learning

Bronzaft, A.L., Dobrow, S.B., O'Hanlon, T.J. Spatial orientation in a subway system. *Environment and Behavior,* Vol. 8 No. 4, 1976, 575-594.

> A subway rider's cognitive map of the subway system is highly dependent on the graphic and/or verbal information provided to him. The effectiveness of a map or guidebook can be judged by how well its information can direct the user's actions to successfully travel from origin to destination. To test the effectiveness of the New York Metropolitan Transit Authority's subway guide, volunteer subjects were asked to use this guide to travel assigned routes through the subway system. Poor performance by most of the subjects, along with their comments on an accompanying questionnaire, indicated a need to redesign graphics and organization of information in the guide as well as to increase the amount of information displayed at stations and concourses.

Garland, H.C., Haynes, J.J., Grubb, G.C. Transit map color coding and street detail: effects on trip planning performance. *Environment and Behavior,* Vol. 11 No.2, 1979, 162-184.

> The effects of two map-related variables on trip-planning performance were investigated. Presence or absence of color-coding and level of street detail were varied to produce four styles of transit maps: (1) color-coded routes, high street detail; (2) no color-coding, high detail; (3) no color-coding, low street detail (only streets that intersect bus routes are depicted); (4) no color-coding, low street detail (only major city streets

depicted). Starting and two destination points were presented on a street map, and subjects planned a bus trip through these points using one of the four transit maps. Color coding in a high-detail map was shown to improve planning accuracy, reduce frustration, and improve the users' confidence in the correctness of their plan. In the absence of color coding, lower levels of street detail produced better accuracy than high street detail. There was no significant difference in trip planning time between the four map types.

Hollands, J.G., Carey, T.T., Matthews, M.L., McCann, C.A. Presenting a graphical network: a comparison of performance using fisheye and scrolling views. *Designing and Using Human-Computer Interfaces and Knowledge Based S ystems*, edited by G. Salvendy and M.J. Smith; Elsevier Science Publishers B.V., Amsterdam, 1989, p.313-320.

This experment investigated the impact of a fisheye view on graphical presentations for topographic networks. Subjects selected optimal routes between stations on a fictional subway network, using either a scrolling view or a fisheye view. Performance using a fisheye view was superior when the destination station was not visible in the initial display; performance with scrolling was superior when both stations were visible and when more complex itineraries were required. Scrolling performance improved over time with two-station routes; the fisheye performance improved in the (later) itinerary task. (Author)

Kovach, R.C., Surrette, M.A., Aamodt, M.G. Following informal street maps: effects of map design. *Environment and Behavior*, Vol. 20 No.6, 1988, p. 683-699.

To study the effectiveness of map style and map complexity on street map-following performance, drivers utilized one of six informal street maps to drive to a destination in an unfamiliar location. Using a 2x3 factorial, 78 undergraduates were randomly assigned to one of six map design conditions: two levels of style (written verbatim or graphic illustration) and three levels of complexity. The low-complexity map contained a direct route, including relational (left-right) directions. The medium complexity map contained a direct route, relational directions, five adjacent streets, and major mileage estimates. The high-complexity map contained a direct route, relational directions, 16 adjacent streets, major mileage estimates, and seven landmarks. Map style significantly affected driving time, as written verbatim maps resulted in less total driving time than graphic maps. Subjects with higher cognitive abilities (as measured by the Wonderlic Personnel Inventory) took less time to reach the final destination than did those with lower cognitive abilities. Neither the effects for map complexity nor the style by complexity interaction were significant. Also, male and female performance did not significantly differ. (Author)

Streeter, L.A, Vitello, D. A profile of drivers' map-reading abilities. *Human Factors,*
1986, 28(2), 223-239.

> To create better aids for everyday surface navigations, people's
> navigational preferences, habits, experiences, abilities, and route-selection
> strategies were examined. Self-described good navigators like and use
> maps, and they differentially value landmarks, such as rivers, railroads,
> and houses, whereas poor navigators tend not to use maps, prefer verbal
> instructions, and tend to rate all landmarks as equally valuable for route-
> finding.
>
> Routes selected by people with varying degrees of familiarity with an area
> were compared with routes generated by standard graph-search
> procedures. A shortest-path, breadth-first route characterized half of the
> "expert" routes, whereas none of the graph-search procedures matched
> "intermediate" and "novice" routes. A good predictor of whether people
> chose a particular road was whether the sum of A+B+C (where A equals
> the straight-line distance from the start to the road, B equals the distance
> traveled on the road, and C equals the straight-line distance from the
> departure point on the road to the destination) did not exceed the straight-
> line distance between start and destination by more than about 20%.
> (Author)

Van der Kooi, H. Case study -- designing new maps for the Municipal Transit Company
of Amsterdam. *Information Graphics,* by Peter Wildbur; Van Nostrand Reinhold
Co., New York, 1989, p. 74-77.

> Design of Amsterdam's new public transport maps began with a study of
> other maps to identify elements that improved clarity and ease of use. For
> a pocket-sized leaflet, a schematized map was designed which used 30-,
> 60-, and 90-degree angles to portray routes and used only the well-known
> canals and other bodies of water as landmarks. Preliminary tests showed
> improved rate of route-finding work over the old, more detailed map as
> people learned how to use the leaflet.
>
> A larger map, showing all public transport in Amsterdam (train, metro, bus,
> etc.) was designed for placement in public transit shelters. Both the leaflet
> and the large map use color coding, and the large map includes more
> landmarks, such as main roads and city parks. User reactions to both
> forms of the map were favorable.

Wildbur, P. *Information Graphics*; Van Nostrand Reinhold, New York, 1989, p. 90-103 and p. 14.

> Network maps emphasize the stages and relationships of travel routes rather than the physical layout of the terrain they cover. This arrangement may present a distorted view of a geogrpahical area, but simplifies the pertinent transit information. Examples of well-known network maps include those for the London Underground, the Teito Rapid Transit Authority in Tokyo, and the TWA network diagram.

> Timetable information is complex and may be better understood and used if user aids are incorporated into the format. Analogue clock faces instead of 24-hour digital times, spacing and breaks that aid visual searching, and a printed example of timetable use are some ways of improving timetable legibility.

Instructional Text and Graphics

Booher, H.R. Relative comprehensibility of pictorial information and printed words in proceduralized instruction. *Human Factors*, 1975, 17(3), 266-277.

> A study was conducted to compare the relative comprehensibility of pictorial information and printed words in instructions. Six picture-word formats were examined using 24 procedural problems on three types of tasks. The formats were print-only, pictorial-only, pictorial-related print, print-related pictorial, pictorial-redundant print, and print-redundant pictorial. The results showed pictorial information important for speed but print information necessary for accuracy. Comprehension of instructions on all three tasks was most efficient with the pictorial-related print and pictorial-redundant print formats but could not be shown to be simply a function of number of visual information channels used or the degree of redundancy between channels. The type of information displayed in the visual channels was found to be important. (Author)

Christ, R.E. Research for evaluating visual display codes: an emphasis on color coding. *Information Design*, edited by R. Easterby & H. Zwaga, John Wiley & Sons Ltd., 1984; p. 209-228.

> Problems of display design studies include (1) selecting criteria for evaluating displays, (2) considering the task that the user is expected to perform using the display, and (3) determining the design and objectives of an experiment. A literature search was conducted for studies that evaluate color coding in displays based on its compatibility with human perceptual-cognitive processing capabilities. Performance on identification and search tasks compared the use of color as the only identifying attribute of a target with the use of color as one of several

attributes of a target; further, when color was one of several target attributes, distinctions were made between the uses of color as an independent or a redundant attribute.

Based on the generally favorable performance of color coding in the literature data, experiments were conducted to test color coding versus achromatic coding in three simple tasks and one complex task. Results indicated that while color is as effective as other, achromatic coding techniques, it is not significantly more effective. Color is recommended to call attention to a particular signal in a display or to identify less than ten (preferably six or fewer) values or categories.

Jones, M.R. Color coding. *Human Factors*, 1962, 4(12), p.355-365.

Research published in the last decade on color as a coding device is discussed. The method of absolute judgment yielded similar findings with respect to identifications of surface and luminous hues. These findings suggest that reliable unidimensional hue code should not contain more than about eight optimally spaced stimuli. Variations in purity and luminance in addition to wavelength can significantly increase the number of usable code categories. However, criteria for code selection in a given situation should depend not only upon the number of visual objects to be differentially identified but also upon the type of task for which the code functions. In particular, color codes do not appear to be suited for situations that demand rapid and precise identification, whereas they are valuable in decreasing search-time with locate-type tasks. (Author)

Reynolds, L. The legibility of printed scientific and technical information. *Information Design*, edited by R. Easterby & H. Zwaga, John Wiley & Sons Ltd., 1984; p. 187-208.

The initial visual impression given to a reader by an information display has been shown to affect the reader's assessment of the complexity and the value of the information as well as his or her reading speed and accuracy. Legibility of printed information and the effectiveness of text structuring can be measured by reader eye movements, rate of work, and, to some extent, readers' preferences. Legibility considerations include recognition of individual letters, numerals, and punctuation marks; character variations such as typeface, upper versus lower case letters, and character size and weight; page and line formats; and the type of paper and ink used. Modern technology has brought new kinds of equipment and methods for producing information displays, and research is needed to apply existing knowledge about legibility to these new mediums.

Saenz, N.E. and Riche, C.V. Shape and color as dimensions of a visual redundant code. *Human Factors*, 1974, 16(3), p.308-313.

> Studies have been conducted which indicate that redundant coding is effective in facilitating the locating of a target among other objects. This study examines that hypothesis for a range of the shape and color variables. All possible combinations of four shapes and four colors were used as targets in the experiment. The times to locate six each of the targets among 36 background objects for 16 displays in each of three coding conditions of the experiment were determined for 24 subjects. The targets could be differientiated from the background objects on the basis of color only, shape only, and redundant color/shape. The results indicate a difference among the coding conditions, the colors, and the shapes, and in the code-by-shape and code-by-color interactions. An important finding is that the redundant code and the color code conditions did not differ. The data are examined for possible explanations of this result and some implications are suggested. (Author)

Shontz, W.D., Trumm, G.A., Williams, L.G. Color coding for information location. *Human Factors*, 1971, 13(3), p. 237-246.

> Visual search performance was investigated as a function of color-coded and uncoded information location, number of categories coded, number of objects per category, and background clutter. Thirty-three subjects searched 12 areas of modified sectional aeronautical charts for a total of 48 checkpoints. Identification of checkpoints was established with labels plus geographical context information. Color served as a partially redundant code for information location. In general, the findings indicate that color coding for information location is most when: (1) many categories of information can or must be coded, (2) colors highly discriminable in peripheral vision are used, and (3) the number of objects per category is kept reasonably small. (Author)

Smith, S.L. Letter size and legiblility. *Information Design*, edited by R. Easterby & H. Zwaga, John Wiley & Sons Ltd., 1984; p. 171-186.

> Letter size is the legibility factor which most influences display design. Ten minutes of arc is the visual angle recommended by two writers for easy reading, and other studies indicate preferred letter subtending 12, 15, even 23 minutes of arc, with additional safety factors for low luminance, long viewing distances, and other poor visual conditions. MIL-STD-1472B recommends 12 to 37 minutes of arc, depending on the criticality of the material being read and on viewing conditions.
>
> This study was conducted to compare the distribution of legilibility measures with current standards. Visual angle measurements were

obtained from subjects' self-reported farthest reading distance from a display. Minimum visual angles ranged from .5 mrad (1.7 minutes of arc) to 12.7 mrad (43.7 minutes of arc) under good viewing conditions, with a mean of 1.9 mrad and a median of 1.7 mrad (both close to 6 minutes of arc). Addtional measures, varying the display material, illumination, and viewing distance supported the current standards for letter size.

Smith, S.L. Color coding and visual separability in information displays. *Journal of Applied Psychology*, 1963, 47(6), p. 358-364.

Twelve experimental subjects performed both visual search and class counting tasks, viewing displays containing 20, 60, or 100 items. Each item consisted of a vector, letter, and 3-digit number grouped together, and was presented as white-on-black in some displays, or 1 of 5 colors. The color code was redundant with the 5 class-designator letters that were used. Average search and counting time, and counting errors, increased with increasing display density (number of items). None of these measures varied significantly among the 5 different target classes (colors). Addition of the redundant color code resulted in an average time reduction of 65% in the visual search task and 69% in the counting task, with a reduction of 76% in counting errors. (Author)

Cognitive Mapping

Garling, T., Book, A., Lindberg, E. Cognitive mapping of large-scale environments. *Environment and Behavior*, Vol. 16, No.1, 1984, 3-34.

A theory about the acquisition and use of cognitive maps of large-scale everyday environments is presented. The basic assumptions of the theory are (1) people's behavior in social and physical environments is determined by action plans, and, if the execution of such action plans requires traveling, plans for how to travel, termed travel plans, are formed and executed; (2) the cognitive maps of large-scale and medium-scale environments acquired are adapted to facilitate movement and travel, and contain information about destinations for travel, spatial information, and travel instructions; (3) cognitive maps are initially acquired in connection with the formation of travel plans and , at the later stages of acquisition, the execution of travel plans (requiring active monitoring) constitutes a more important set of conditions for acquisition. The principles of internal representation of the cognitive map are also discussed. (Author)

Kirasic, K.C., Mathes, E.A. Effects of different means for conveying environmental information on elderly adults' spatial cognition and behavior. *Environment and Behavior,* Vol. 22 No. 5, 1990, 591-607.

> Verbal description, verbal description with imagery instruction, videotape observation, and map study were compared as different means for providing elderly adults with information needed for a series of spatial tasks in a large-scale environment. Verbal description and map study led to greater efficiency on a route execution task, but the four means did not lead to differences on scene recognition, route planning, or map placement tasks. A simple classification of behaviors revealed that walking while scanning and standing while scanning were most common during route execution. Standing without scanning during route execution was correlated with poor performance in that task. Psychometric measures of spatial abilities, imagery abilities, and internal-external locus of control did not correlate highly with performance measures from the environmental tasks. (Author)

Light, L. L., Zelinski, E.M. Memory for spatial information in young and old adults. *Developmental Psychology* , 1983, Vol. 19 No. 6, 901-906.

> This study evaluates the claim that memory for spatial information is automatic. Young and older adults studied a map containing 12 structures. Half of the people in each age group were asked to remember both the structures and their locations (intentional learning) and the remaining half were led to believe they would be tested only on the structures (incidental learning). Both age and test expectations affected memory for the locations of structures, with older people and people in the incidental groups performing more poorly. It was concluded that memory for spatial information is not automatic. (Author)

Lloyd, R. Cognitive maps: encoding and decoding information. *Annals of the Association of American Geographers,* 79(1), 1989, 101-124.

> The experiences of learning a city by direct experience or navigating through it and studying a map of it provide people with different types of information. Navigation is thought to provide procedural knowledge, which is stored as verbal coding, and map reading is thought to provide survey knowledge, which is stored as imagery coding. Subjects who learned a city primarily through years of navigation and subjects who learned a city by studying a cartographic map for several minutes were asked to perform the simple experimental task of locating familiar landmarks relative to reference points. Distortions in the cognitive maps of subjects were analyzed to determine significant differences in patterns of distance and direction errors. Patterns of absolute distortion are explained by theories

related to the use of alignment and rotation heuristics for encoding information and an implicit scaling process for decoding information. Subjects who learned the city from studying a cartographic map were significantly more accurate and faster at performing the experimental task than subjects who learned the city through direct experience or navigation. Both groups were significantly more accurate when making their judgments with centrally located reference points than with peripherally located reference points. These results provide knowledge of processes used in cognitive mapping and the distortions caused by these processes. Ultimately such studies lead to an understanding of spatial decision-making behavior. (Author)

Lloyd, R., Heivly, C. Systematic distortions in urban cognitive maps. *Annals of the Association of American Geographers*, 77(2), 1987, 191-207.

Aggregate cognitive maps of urban areas differ from cartographic maps for reasons other than differences in the mobility and idiosyncratic experiences of individuals. Systematic distortions in aggregage urban maps may be caused by the cognitive processes used to code spatial information into memory or to retrieve it from memory and by the way these processes relate to a particular urban area. A purpose of this study was to determine the extent to which systematic distortions are present in aggregate urban cognitive maps and to investigate the causes of such distortions. Subjects from three neighborhoods were asked to provide estimates of distances and directions between 105 pairs of landmarks. Differences between these estimates and true distances and directions were analyzed to determine if the patterns of distortions were significantly different among the three neighborhoods. Differences for the three samples appeared to be related to the scale and orientation of the aggregate cognitive maps. Regressions with aggregate data for the three neighborhoods using cognitive distance as the dependent variable and actual distance as the independent variable indicated a tendency to overestimate shorter distances more than longer distances. Subjects' cognitive locations for landmarks and the actual locations were mapped in the same space using multidimensional scaling and Euclidean regression. The aggregate cognitive maps appeared to be rotated to align major transportation axes with canonical direction axes. Systematic distortions appear to be related to a rotation heuristic and to key reference points used by the subjects to code and access spatial information. (Author)

Naka, M., Minami, K. Memory psychophysics for areas: distortion in natural memory of a school campus. *Perceptual and Motor Skills*, 1991, 73, 995-1003.

As the perceived magnitude of a stimulus is related by power function to the physical magnitude, the remembered visual areas and length are also related by power function to the actual areas and length. The main

purpose of this study is to examine whether the power law is also applicable to remembered areas in natural environment, e.g., a school campus, and to its old memory. 31 junior high students and seven university undergraduates who graduated from the same junior high school seven years before were asked to draw a layout of the school campus. The areas of the school facilities and field, and other features of drawings such as the number of recalled facilities and objects, and direction of the sketch were assessed. Analysis showed that the areas remembered by the junior high subjects followed the power law while those remembered by the undergraduates did not. The divergence of exponents observed for undergraduates was accounted for by reconstruction by schema. (Author)

Pezdek, K. Memory for items and spatial location by young and elderly adults. *Developmental Psychology 1983*, Vol. 19, No. 6, 895-900.

This study examines age differences in the relationship between memory for items and memory for the spatial location of items. Young (M age = 17 years) and elderly (M age = 68 years) adults studied a spatial display that included 16 items in specific locations. The items were either small objects or the one-word verbal label for each. Two tests followed to independently assess free recall of the items and the accuracy of spatial relocation. The young adults were more accurate on both tests. This finding was consistent for both verbal and visual items. The age differences in memory are explained in terms of age differences in encoding and rehearsal strategies. This study resolves, in part, the conflicting results regarding age differences in spatial memory accuracy reported by Perlmutter, Metzger, Nezworski, and Miller (1981) and by McCormack (1982). (Author)

Steinke, T., Lloyd, R. Images of maps: a rotation experiment. *Professional Geographer*, 35(4), 1983, 455-461.

Theories which explain mental imagery are discussed and are related to cognitive maps. An experiment was conducted to illustrate that people can code information about maps as visual images and use map images for a map-reading task. Subjects were shown maps which were rotated at various angles from north-at-the-top. The time needed to decide if a map was a correct or mirror representation was recorded. The results support the notion that people did this task by forming and rotating map images. (Author).

Ward, S.L., Newcombe, N., Overton, W.F. Turn left at the church, or three miles north: a study of direction giving and sex differences. *Environment and Behavior*, Vol. 18 No. 2, 1986, 192-213.

> This study examined how college students give directions from maps, either with maps perceptually available, or after maps had been memorized. Six aspects of direction giving were coded: use of landmarks, use of relational terms, use of cardinal directions, use of mileage estimates, and frequency of omission and commission errors. In accord with predictions, males used more mileage estimates and cardinal directions than did females and made fewer errors. Use of cardinal directions and mileage estimates were rarer, in relation to opportunities to use them, than use of landmarks and relational terms. Correlations among the dependent variables suggested that use of relational terms and use of cardinal directions may trade off, with speakers using one or the other but not both. An individual's choice of direction-giving "method" seems to be a stylistic preference rather than a measure of ability in that method.

Wetherell, A. Some factors affecting spatial memory for route information. *Information Design*, edited by R. Easterby & H. Zwaga, John Wiley & Sons Ltd., 1984; p. 321-338.

> Four studies were conducted concerning the presentation of route-directing information to drivers. The first stucy, designed as a drug trial, tested the effects of anticholinergic drugs on navigation performance; while subjects showed little difference in performance due to drug effects, all subjects (drug, placebo and untreated groups) had difficulty navigating with the provided maps. The second study investigated retroactive inhibition of route memory by the reorientation encountered while traveling the route. Subjects who memorized a route map and then attempted to recall the route while seated in a stationary car recalled the information more accurately than subjects who attempted to recall the route while travelling along it in the car. The third study investigated spatial memory interference with both verbal logical reasoning and graphic (spatial) logical reasoning. Results indicated that spatial memory interferes with spatial reasoning but not with verbal, or "linear" reasoning. The fourth study tested subjects' matching performance with a set of target maps, and showed that subjects tended to learn and memorize a map as a linear series of junctions and turns, instead of as a spatial map.