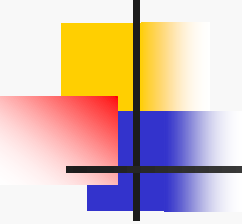
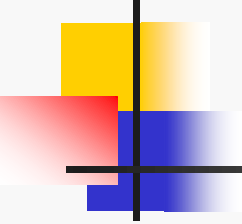


CE 4640: Transportation Design



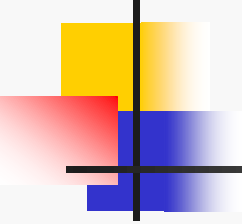
Volume Studies

- Intersection Studies
 - All movements in all possible directions at an intersection – most complex
- Small Network Studies
 - Amount and pattern of traffic flow over a network of street links and intersections
 - Size may vary from a community CBD to a large city CBD
 - Vehicle Miles of Travel (VMT) estimated



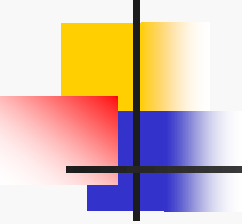
Volume Studies

- Statewide and Other Areawide Studies
 - Performed through ongoing traffic-counting program
 - Vehicle Miles of Travel (VMT) estimated
- Cordon Studies
 - Considering an imaginary boundary around a study area of interest, generally, a CBD
 - Data from all streets and highways crossing the cordon are collected



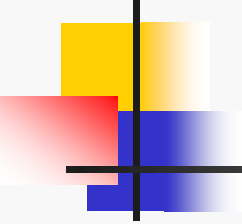
Volume Studies

- Origin-Destination Studies
 - Where the vehicles are coming from and where they are going to
 - Useful for the following:
 - **Freeway interchanges**
 - **Weaving areas**
 - **Major activity centers**
 - **Regional planning studies**



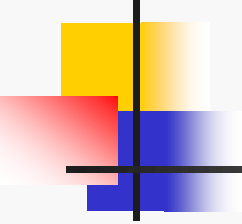
Traffic Volume

- Number of vehicles passing a given point or a section of a roadway during a specified time
- Data collected by
 - Manual counting
 - Electro-mechanical devices



Traffic Demand

- Number of vehicles that desire to traverse a particular section of roadway during a specified period of time
 - at present
 - in future



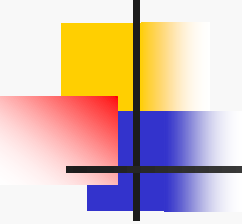
Traffic Demand at Various Situations

- Bottlenecks

- Traffic volume reaches the capacity of the highway and queues develop behind such bottleneck

- Alternative Routes

- In case of congestion in main route, drivers seek an alternative route, which does not give a true demand of the main



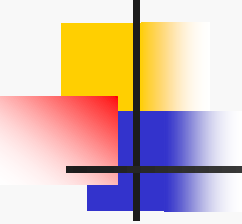
Traffic Demand at Various Situations

- Latent Demand

- Due to extremely high congestion, driver chooses to either stay home or find an alternative destination or mode for the same purpose

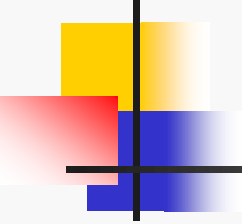
- Future Growth

- Changes in travel behavior and available facilities with respect to time



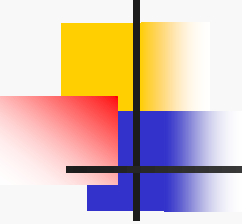
Various Types of Traffic Volumes

- Daily Volume
 - Average Annual Daily Traffic (AADT)
 - Average Annual Weekday Traffic (AAWT)
 - Average Daily Traffic (ADT)
 - Average Weekday Traffic (AWT)
- Hourly Volume
- Subhourly Volume



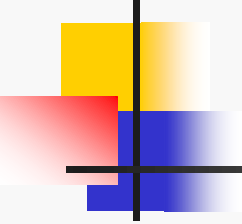
AADT and AAWT

- Average Annual Daily Traffic (AADT)
 - Average 24-hour traffic volume at a location over a full 365-day year, which is the total number of vehicles passing the location divided by 365
- Average Annual Weekday Traffic (AAWT)
 - Average 24-hour traffic volume on weekdays over a full year, which is the total weekday traffic volume divided by 260



ADT and AWT

- Average Daily Traffic (ADT)
 - Average 24-hour traffic at a location for any period less than a year (e.g. six months, a season, a month, a week or even two days)
- Average Weekday Traffic (AWT)
 - Average 24-hour traffic volume on weekdays for any period less than a year



DDHV/PHV

- Directional Design Hourly volume (DDHV) $\sim$ Peak Hourly Volume

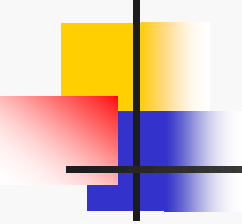
$$\text{DDHV (veh/hour)} = \text{AADT} \times K \times D$$

where AADT = Average Annual Daily Traffic (veh/day)

**K = Proportion of daily traffic occurring in
peak hour (decimal)**

**D = Proportion of peak hour traffic traveling
in the peak direction (decimal)**

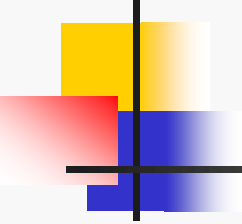
Contd...



DDHV/PHV

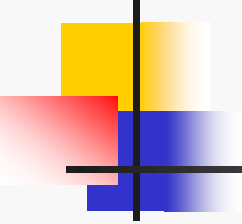
- For design purposes, K factor is generally chosen as 30 HV and D factor as the percentage of traffic in predominant direction during the design hour
- General ranges for K and D factors

Facility Type	K Factor	D Factor
Rural	0.15 – 0.25	0.65 – 0.80
Suburban	0.12 – 0.15	0.55 – 0.65
Urban	0.07 – 0.12	0.50 – 0.60



Sub-Hourly Volume

- Sub-hourly Volume $\sim$ 15-min Volume
Suppose, the peak 15-min volume observed
= 750 veh
So, the Hourly Volume =
15-min volume $\times$ 4
= 750 $\times$ 4
= 3000 veh/hour



Peak Hour Factor

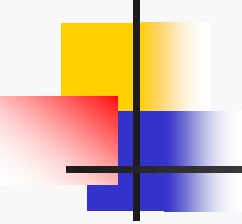
- Relationship between hourly volume and maximum rate of flow within the hour

For intersection:

$$PHF = \frac{\text{Hourly Volume}}{\text{Max. Rate of Flow}} = \frac{HV}{4 \times V_{15}}$$

where HV = Hourly volume (veh/hour)

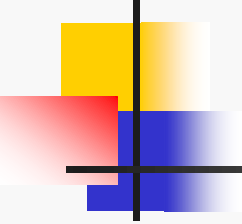
V_{15} = max. 15-min volume within the hour (veh)



Example of PHF Calculation

- Data collected are as follows:

Time Interval	Volume (veh)
4:00-4:15 pm	950
4:15-4:30 pm	1100
4:30-4:45 pm	1200
4:45-5:00 pm	1050
Hourly Volume	4300



Example of PHF Calculation

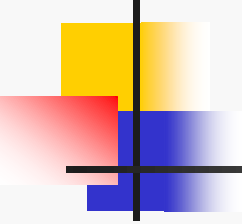
We find from the table,

$HV = 4300$ veh/hour

$V_{15} = 1200$ veh

Therefore,

$$PHF = \frac{HV}{4 \times V_{15}} = \frac{4300}{4 \times 1200} = 0.90$$



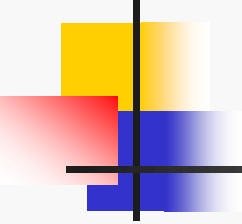
Peak Hour Factor

For freeway/expressway:

$$PHF = \frac{HV}{12 \times V_5}$$

where HV = Hourly volume (veh/hour)

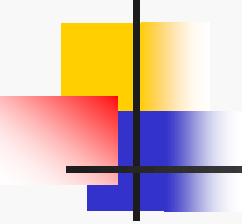
V_5 = max. 5-min volume within the hour (veh)



Traffic Control Devices

Communication of traffic laws and regulations to drivers by means of control devices:

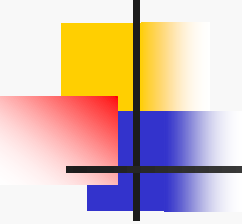
- **Signs**
- **Signals**
- **Markings**



Standards and Guidelines

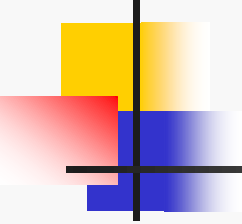
Manual of Uniform Traffic Control Devices (MUTCD)

- Federal MUTCD
- State MUTCD



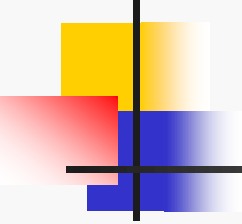
Requirements of a Traffic Control Device

- Fulfill a need
- Command attention
- Convey a clear, simple meaning
- Command respect of road users
- Give adequate time for proper response



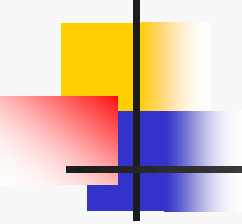
Considerations to insure the requirements

- Design
- Placement
- Operation
- Maintenance
- Uniformity



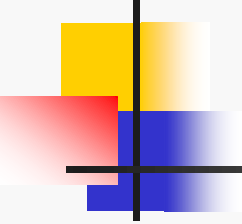
Using the Manual

- Manual provides the standards and guidelines, but it is not a substitute for engineering judgment
- Definitions need careful attention:
 - **Shall – mandatory condition**
 - **Should – advisory condition**
 - **May – permissive condition**



General Color Coding

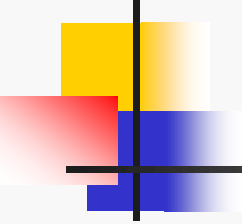
- **Yellow – general warning**
- **Red – stop or prohibition**
- **Blue – motorist services guidance and evacuation route**
- **Green – Direction guidance**
- **Brown – recreational and cultural interest guidance**
- **Orange – construction and maintenance warning**
- **Black – regulation**
- **White – regulation**



Signs

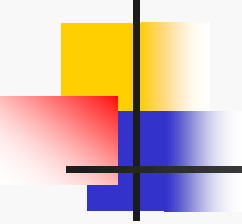
Three major categories:

- **Regulatory** – give notice of traffic laws or regulations
- **Warning** – call attention to conditions that are potentially hazardous
- **Guide** – show route designations, destinations, directions, distances, services, and such information



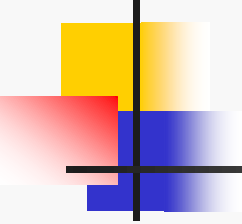
Regulatory Signs

- Right-of-way – STOP, YIELD
- Speed Control
- Movement Control
- Parking
- Pedestrian
- Miscellaneous



Warning Signs

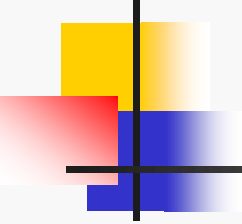
- Changes in horizontal alignment
- Intersections
- Advance warning of control devices
- Converging traffic lanes
- Narrow roadways
- Changes in highway design
- Grades
- Roadway surface conditions
- Railroad crossings
- Miscellaneous others

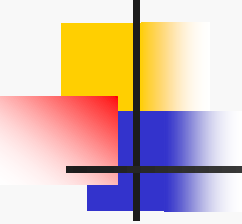


Guide Signs

- Route marker assemblies
- Directional information signs
- Services information signs
- Cultural information signs

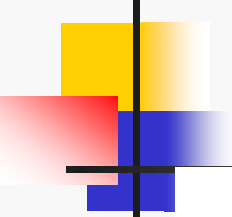
Construction and Maintenance Signs

- 
- Warning signs in black on an orange background
 - Directional signs and street names in conjunction with a detour in black on an orange background



Changeable Message Signs

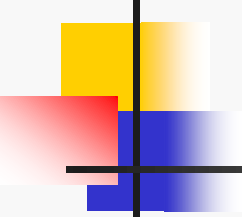
- Designed to display variable messages
 - **Accident**
 - **Congestion**
 - **Detour**
 - **Enforcement and Public Safety Information**
 - **Approx. time to reach a destination**
 - **Other temporary warnings**



Sign Illumination

Table 2A-1. Illumination of Sign Elements

Means of Illumination	Sign Element to be Illuminated
Light behind the sign face	• Symbol or message • Background • Symbol, message, and background (through a translucent material)
Attached or independently-mounted light source designed to direct essentially uniform illumination onto the sign face	• Entire sign face
Other devices, or treatments that highlight the sign shape, color, or message at night: Luminous tubing Fiber optics (shaped to the lettering or symbol) Patterns of incandescent light bulbs Luminescent panels	• Symbol or message • Entire sign face



Retroreflection

Table 2A-2. Retroreflection of Sign Elements

Means of Retroreflection	Sign Element
Reflector "buttons" or similar units	Symbol Word message Border
A material that has a smooth, sealed outer surface over a microstructure that reflects light	Symbol Word message Border Background

Shape of Signs

Table 2A-3. Use of Sign Shapes

Shape	Signs
Octagon	* Stop
Equilateral Triangle (1 point down)	* Yield
Circle	Highway-Rail Grade Crossing (Advance Warning) Emergency Evacuation Route Marker
Pennant Shape / Isosceles Triangle (longer axis horizontal)	* No Passing
Pentagon (pointed up)	* School Crossing Series * County Route Sign
Crossbuck (two rectangles in an "X" configuration)	* Highway-Rail Grade Crossing
Diamond	Warning Series
Rectangle	Regulatory Series ** Guide Series Warning Series
Trapezoid	* Recreational Series

* Indicates exclusive use

** Guide series includes general service, specific service, and recreation signs

Sign Colors

Table 2A-4. Common Uses of Sign Colors

Type of Sign	Legend					Background								
	Black	Green	Red	White	Yellow	Black	Blue	Brown	Green	Orange	Red	White	Yellow	FYG*
Regulatory	X		X	X		X					X	X		
Prohibitive			X	X							X	X		
Permissive		X										X		
Warning	X												X	
Pedestrian	X												X	X
Bicycle	X												X	X
Guide				X					X					
Interstate Route				X			X				X			
State Route	X											X		
US Route	X											X		
County Route					X		X							
Forest Route				X				X						
Evacuation Route				X			X							
Information				X			X		X					
Milepost Signs				X					X					
Road User Service				X			X							
Recreational				X				X	X					
Street Name				X					X					
Destination				X					X					
Temporary Traffic Control	X									X				
School	X												X	X

*FYG is fluorescent yellow-green

Regulatory Sign



R1-1



R1-3



R1-4



R1-2



R3-1



R3-2



R3-3



R3-4



R2-1

OR



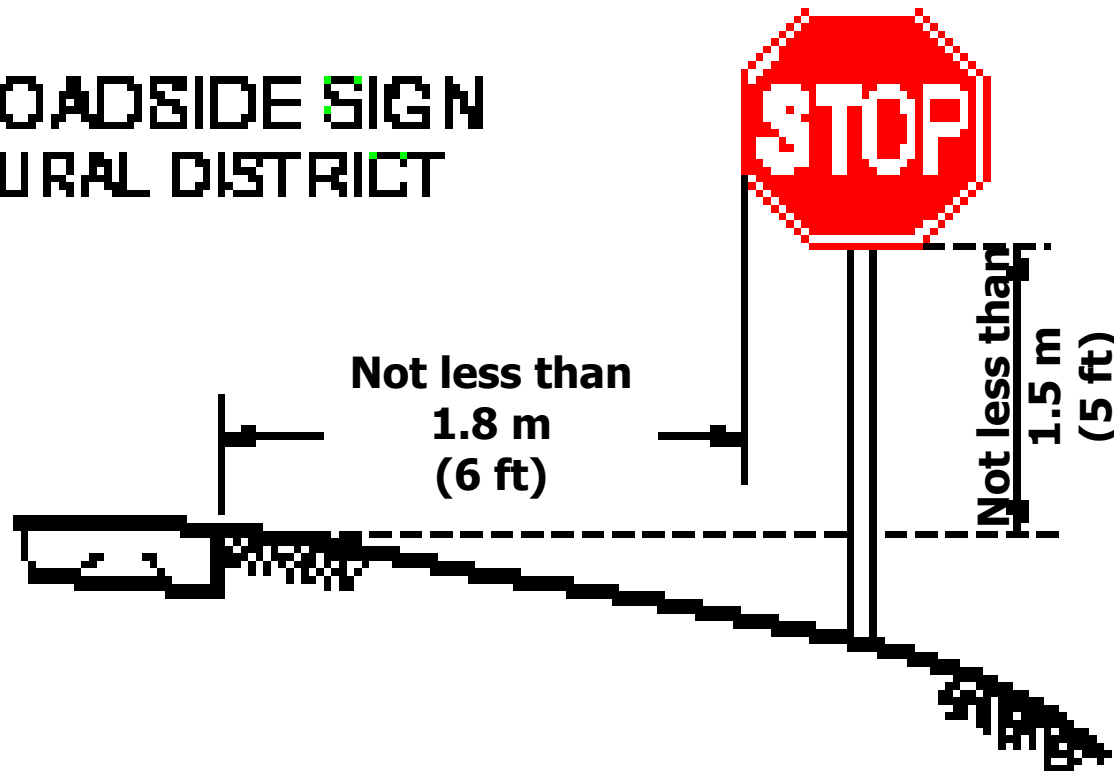
R2-2

OR

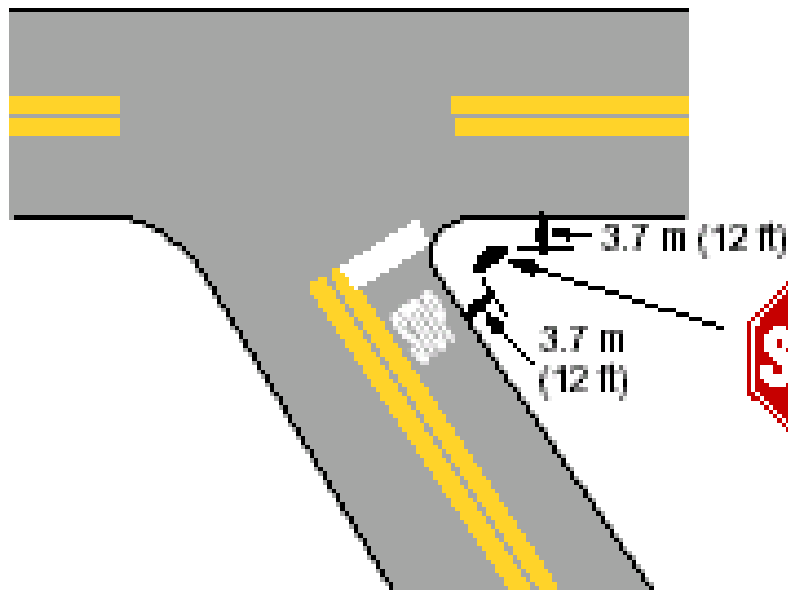


STOP Sign

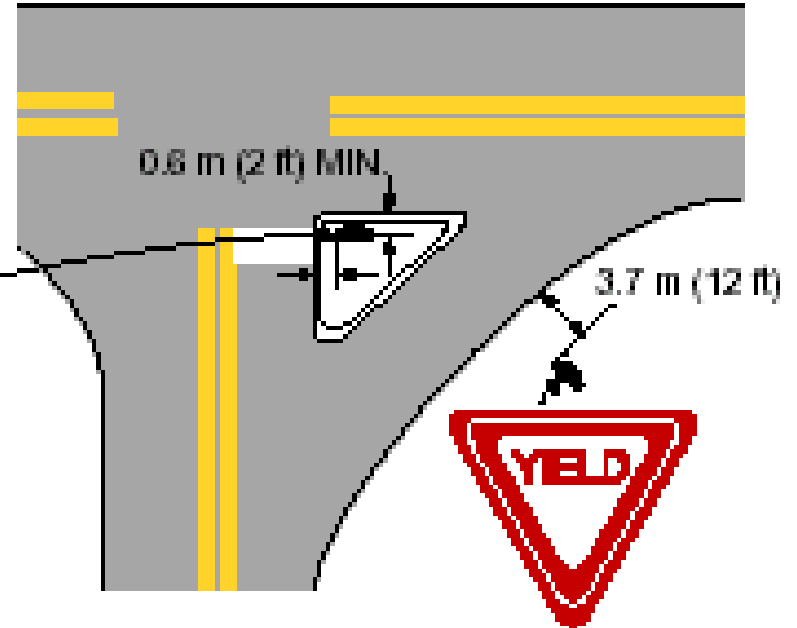
ROADSIDE SIGN
RURAL DISTRICT



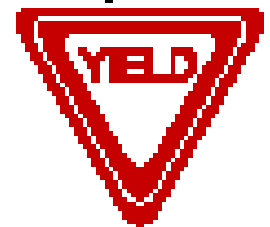
Location of STOP and YIELD Sign



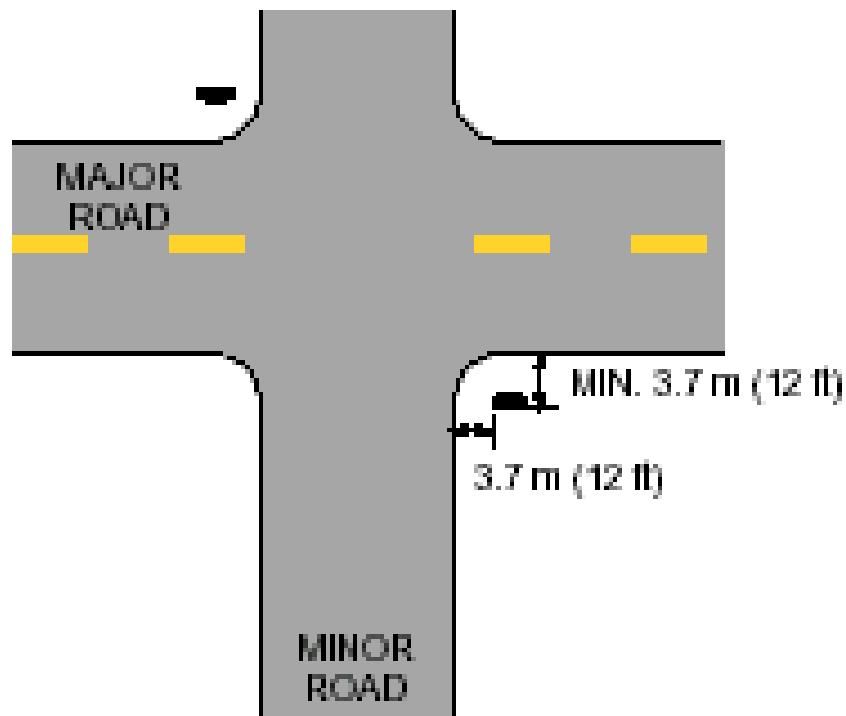
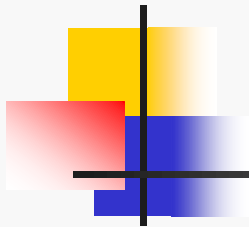
ACUTE ANGLE INTERSECTION



CHANNELIZED INTERSECTION

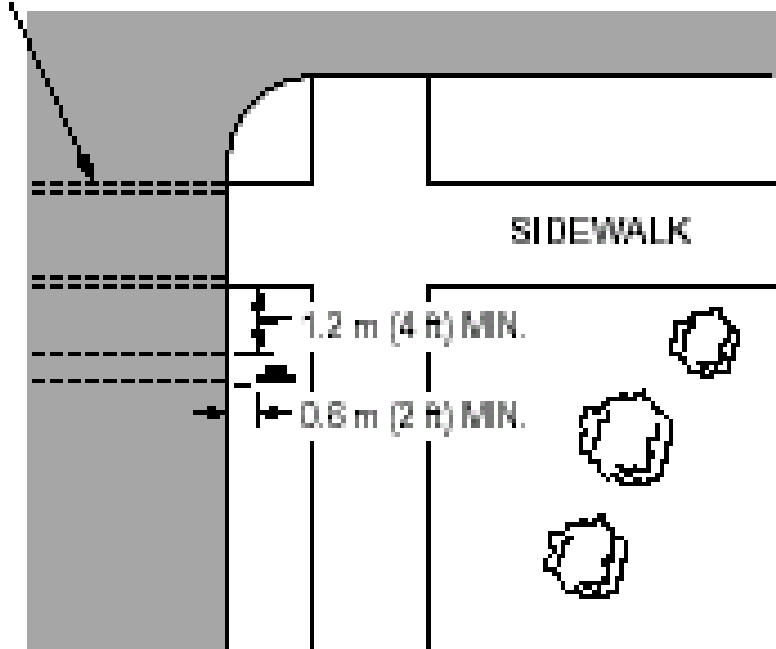


Location of STOP Sign



MINOR CROSSROAD

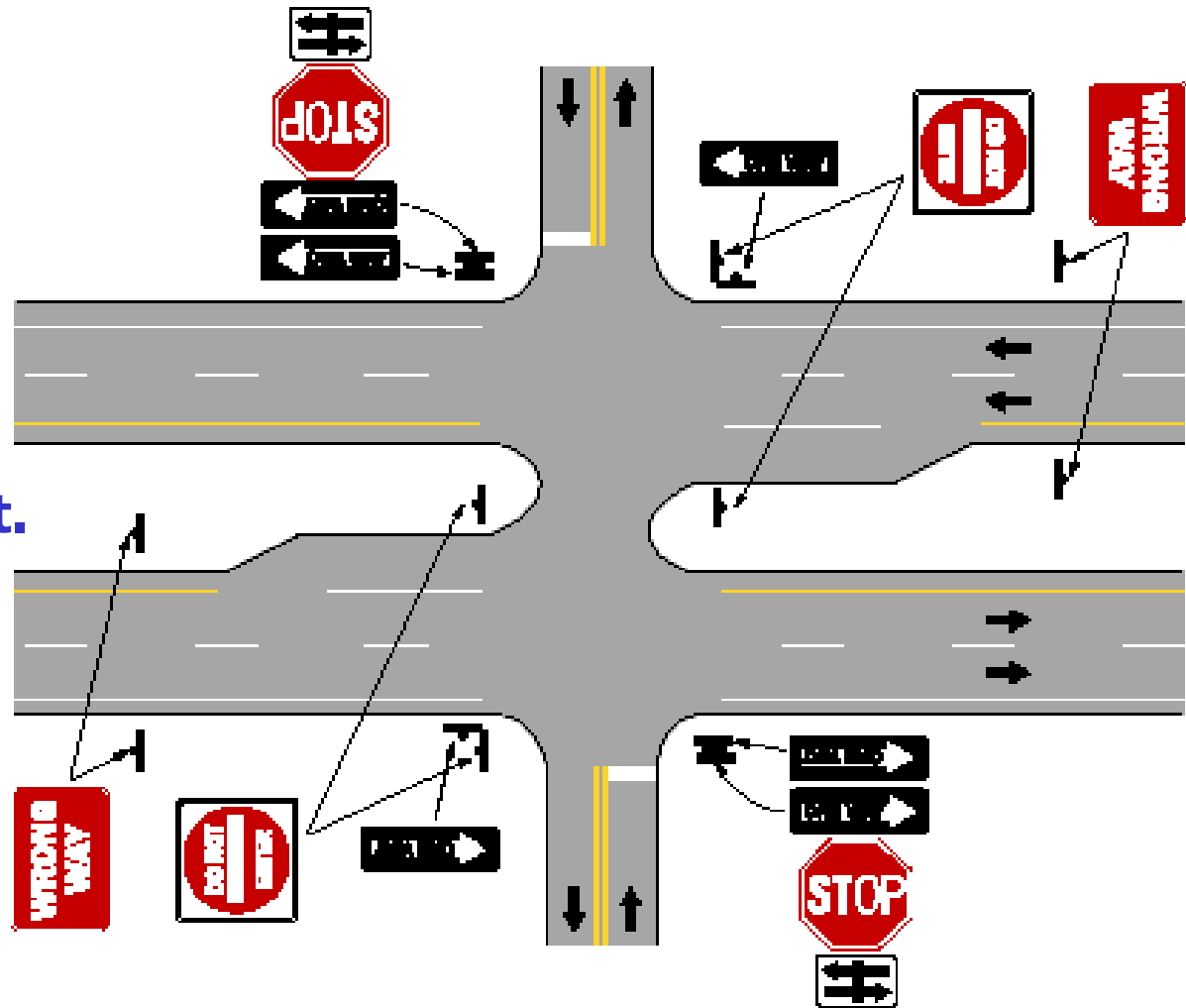
MARKED OR
UNMARKED
CROSSWALK



URBAN INTERSECTION

Typical One Way Signing for Divided Highways

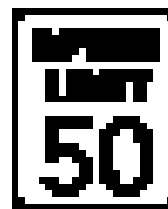
Median < 30 ft.



Speed Limit Sign

ROADSIDE SIGN
BUSINESS OR
RESIDENCE DISTRICT

Not
less
than
0.6 m
(2 ft)



Not less than
2.1 m
(7 ft)



Warning Signs



W1-1



W1-2



W1-3



W1-4



W1-5



W1-6



W1-8



W1-9



W1-10

Warning Signs



W8-1



W8-2



W8-3



W8-4



W8-5



W8-9



W8-9a



W8-11



W17-1



W3-1a



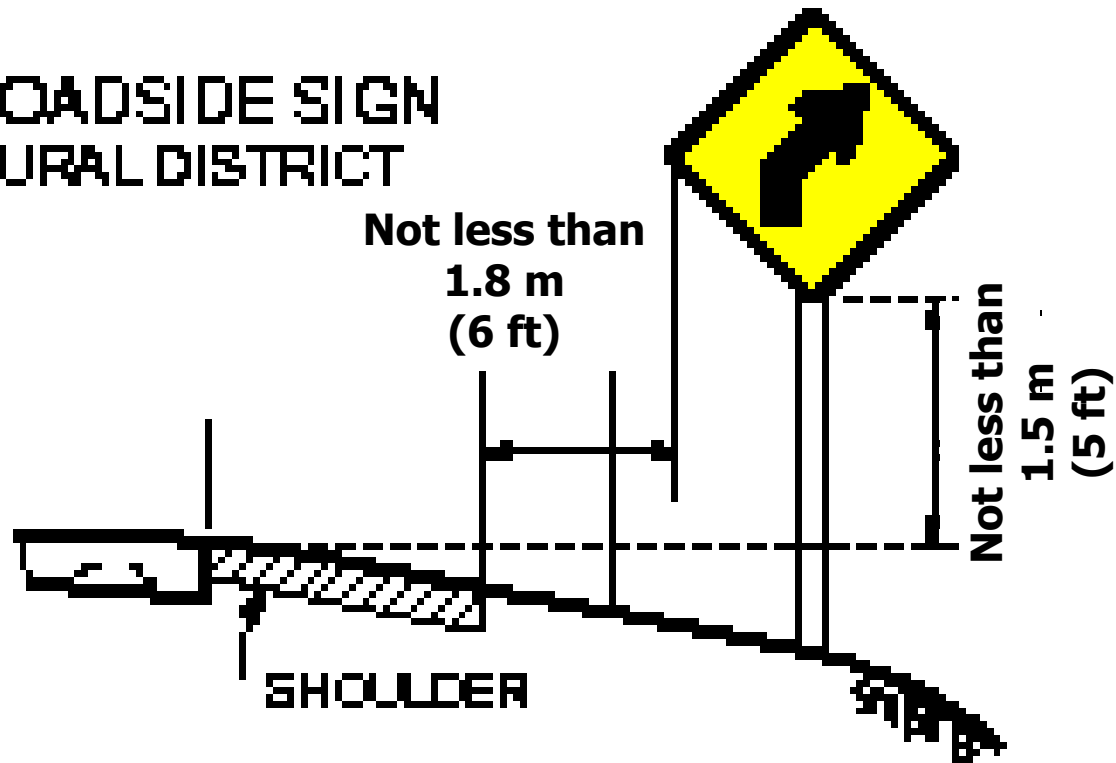
W3-2a



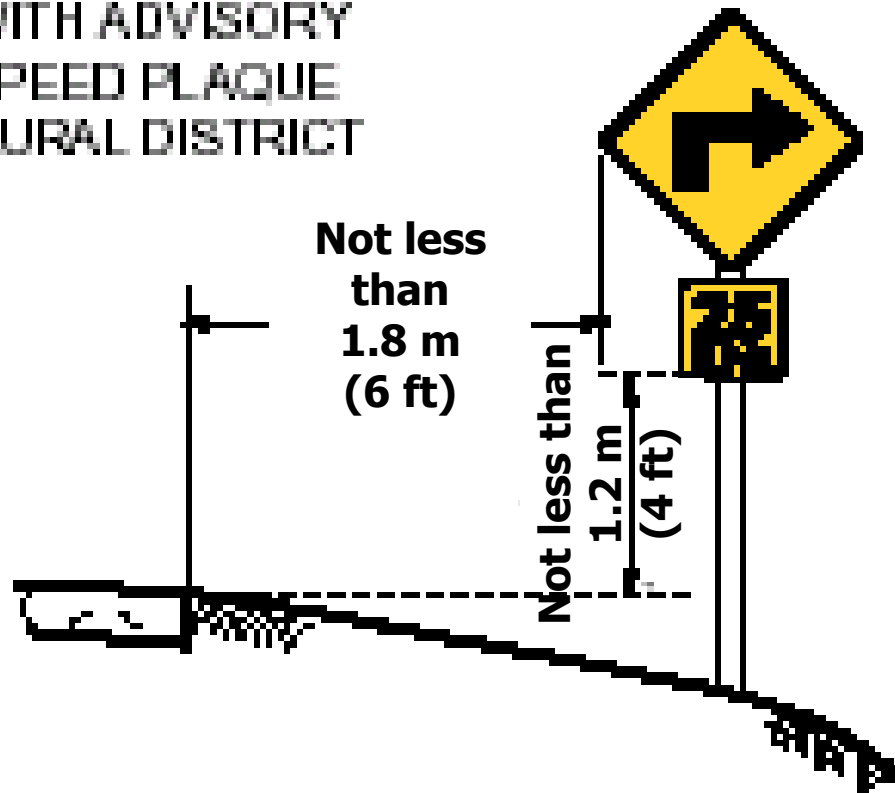
W3-3

Curve Warning Sign

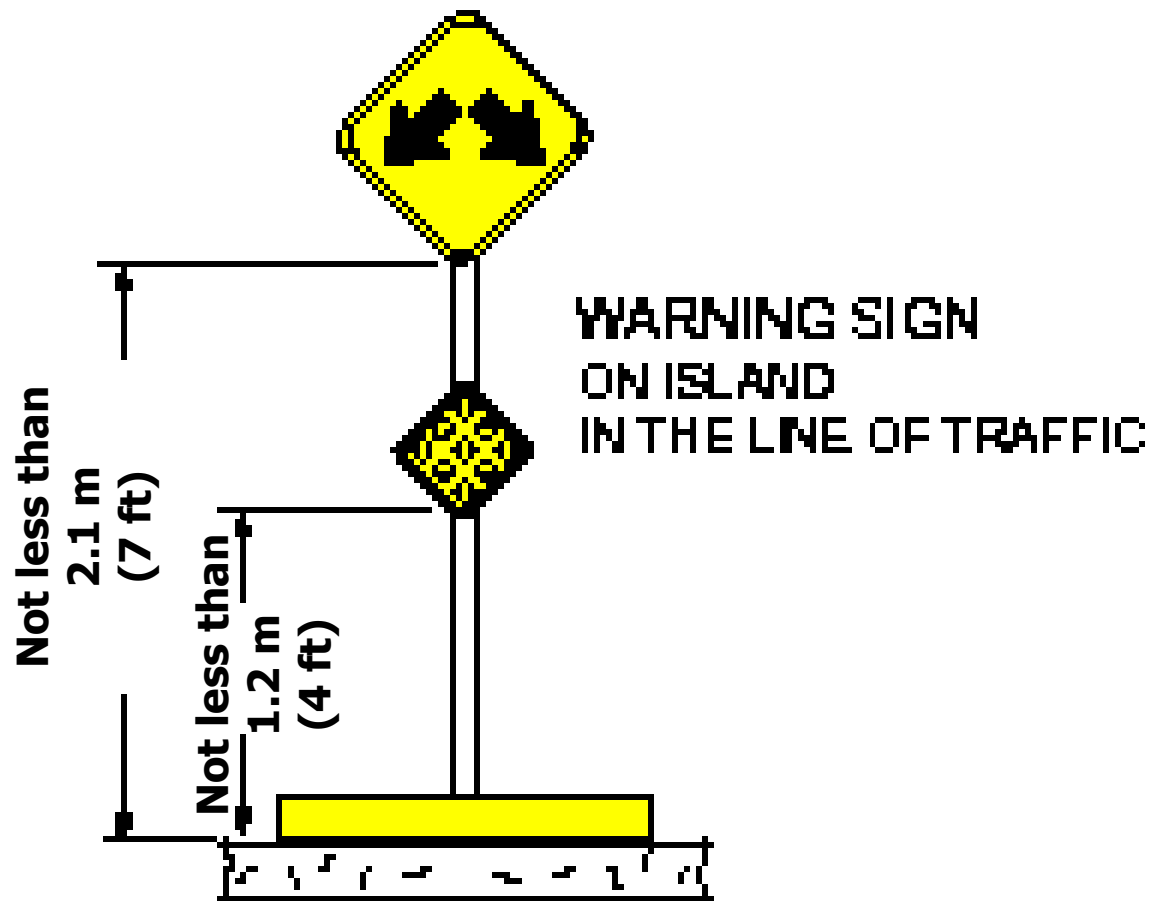
ROADSIDE SIGN
RURAL DISTRICT



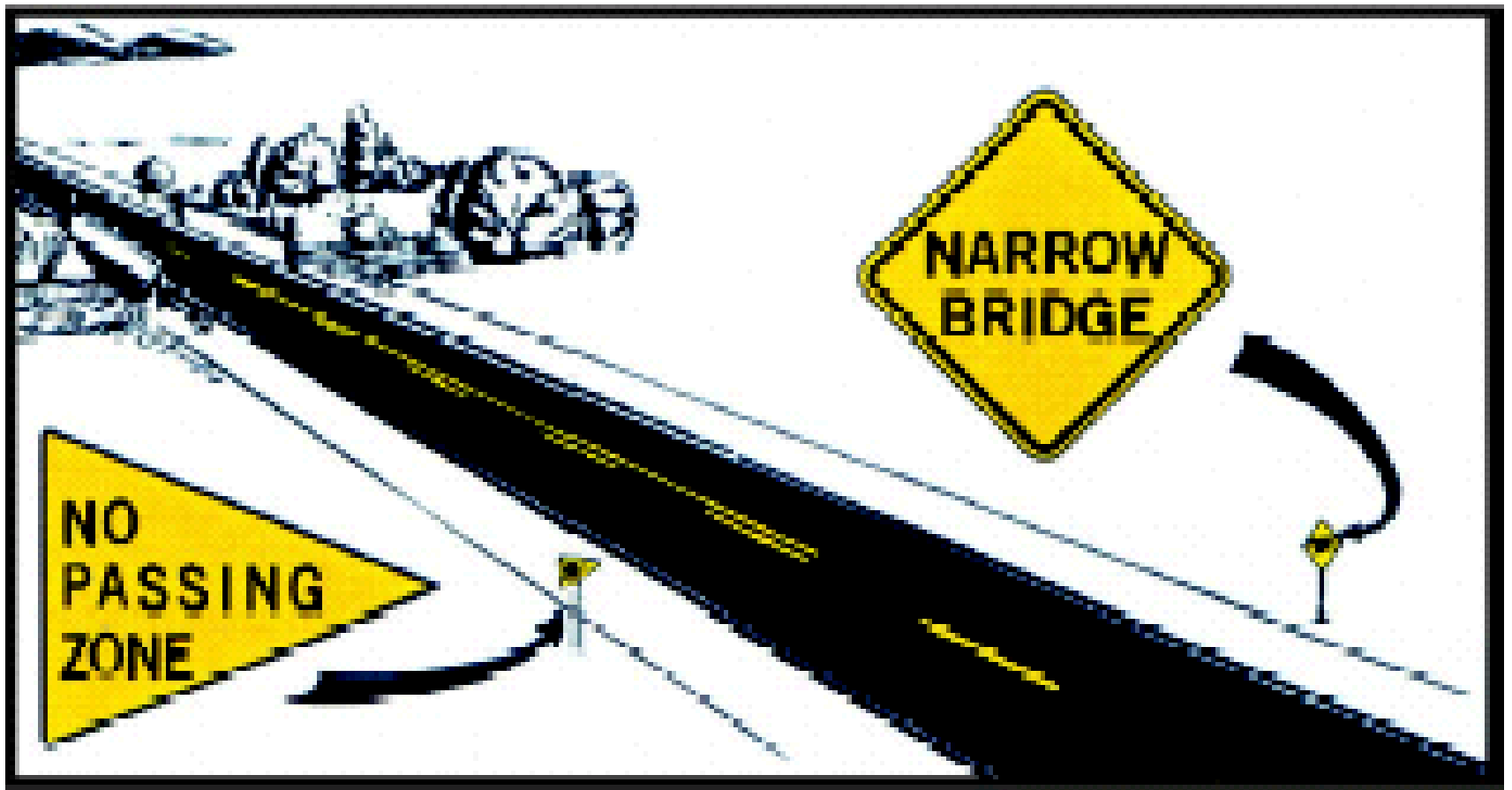
**WARNING SIGN
WITH ADVISORY
SPEED PLAQUE
RURAL DISTRICT**



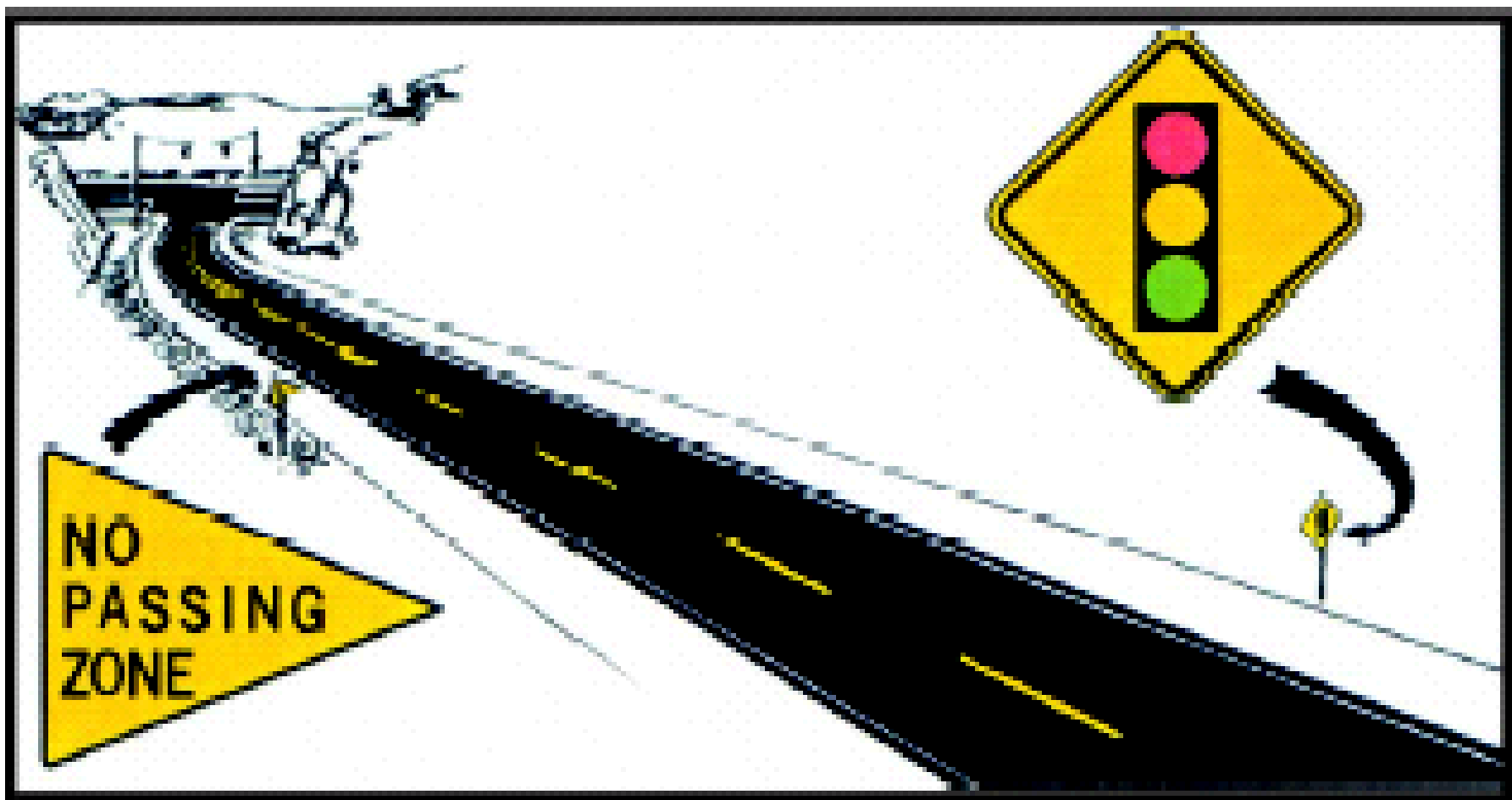
Island Warning Sign



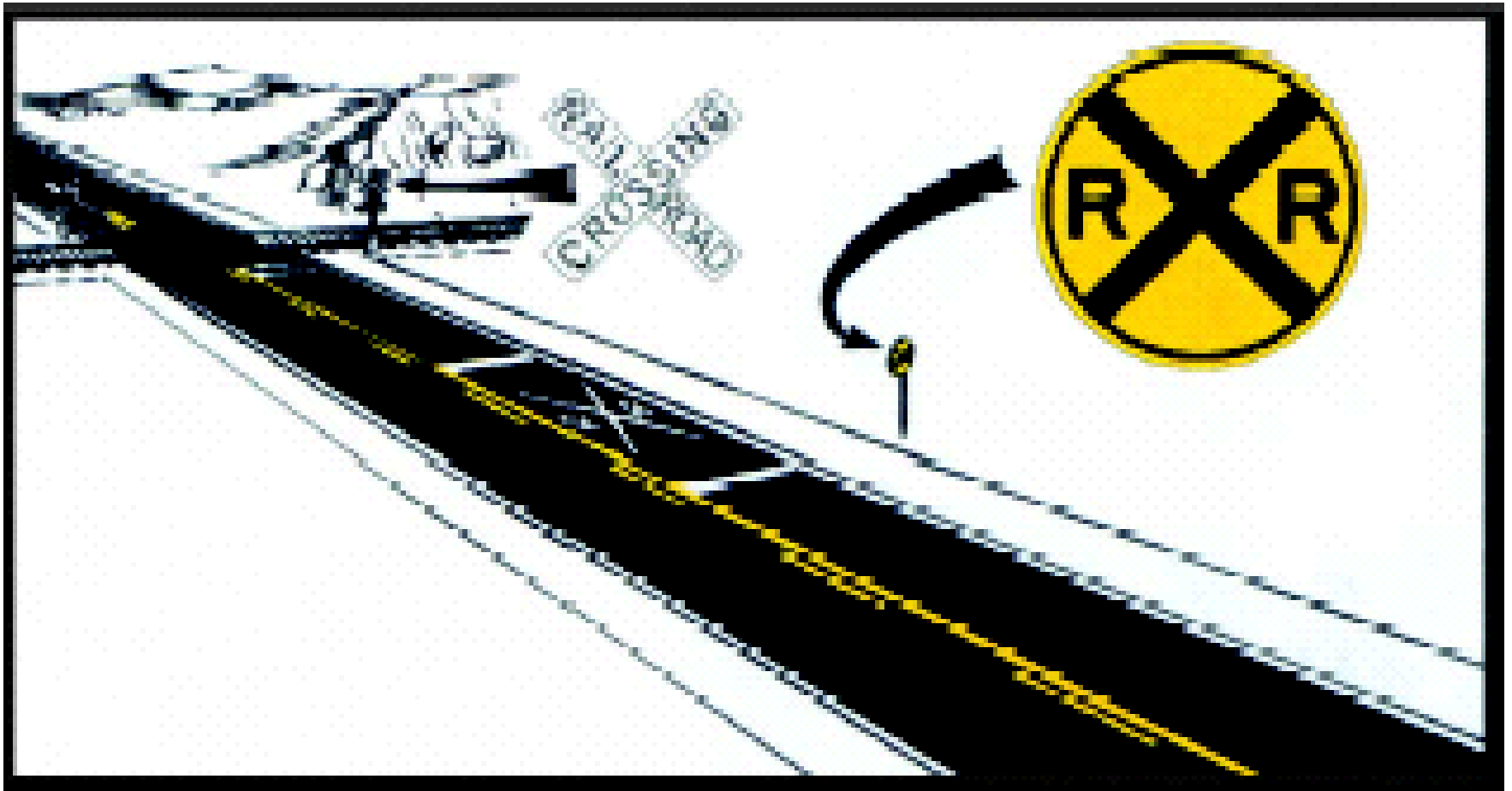
Application of Warning Signs



Application of Warning Signs



Application of Warning Signs



Guide Signs



Interstate Route Sign
M1-1



Off-Interstate Business Route Sign
M1-2 (Loop)
M1-3 (Spur)



U.S. Route Marker
M1-4



State Route Marker
M1-5



County Route Marker
M1-6



Forest Route Marker
M1-7

Guide Signs



D3



D4-1



D4-2



D5-1



D5-2



D5-3



D6-1



D6-2



D6-3



D9-1



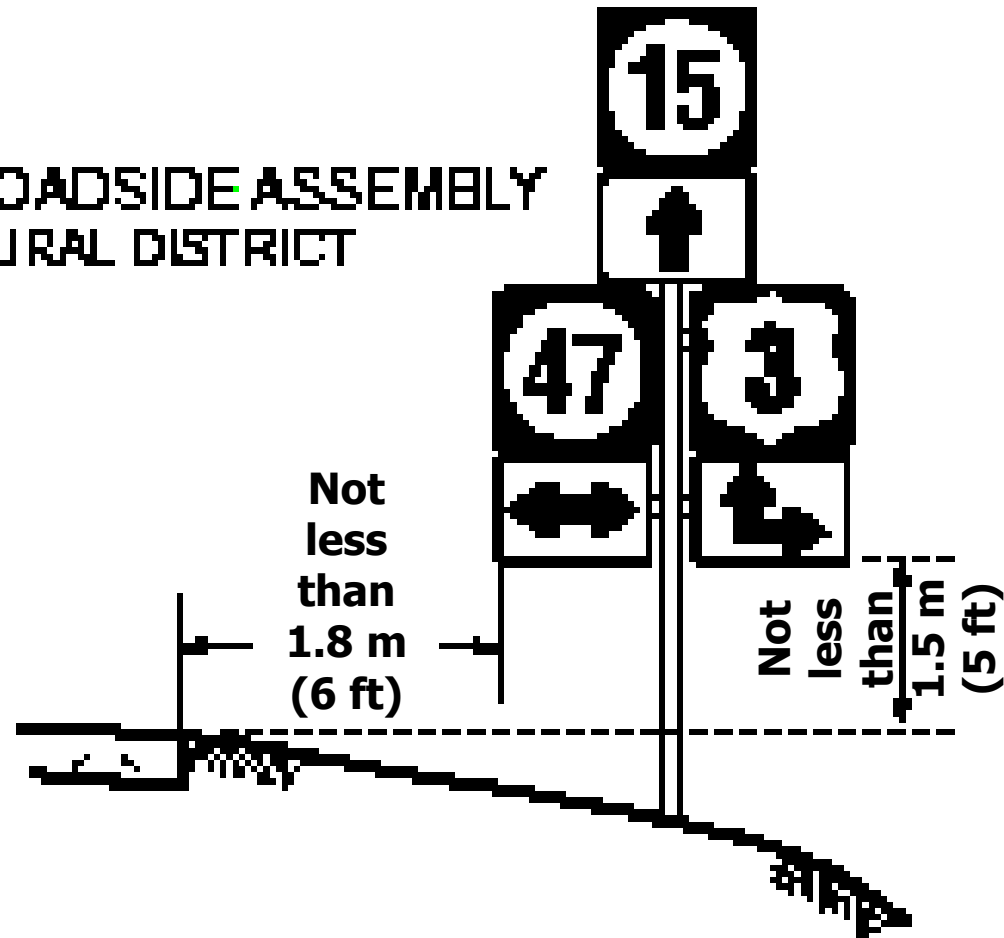
D9-2

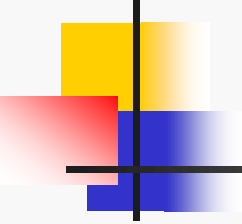


D9-3

Guide Signs

ROADSIDE ASSEMBLY
RURAL DISTRICT

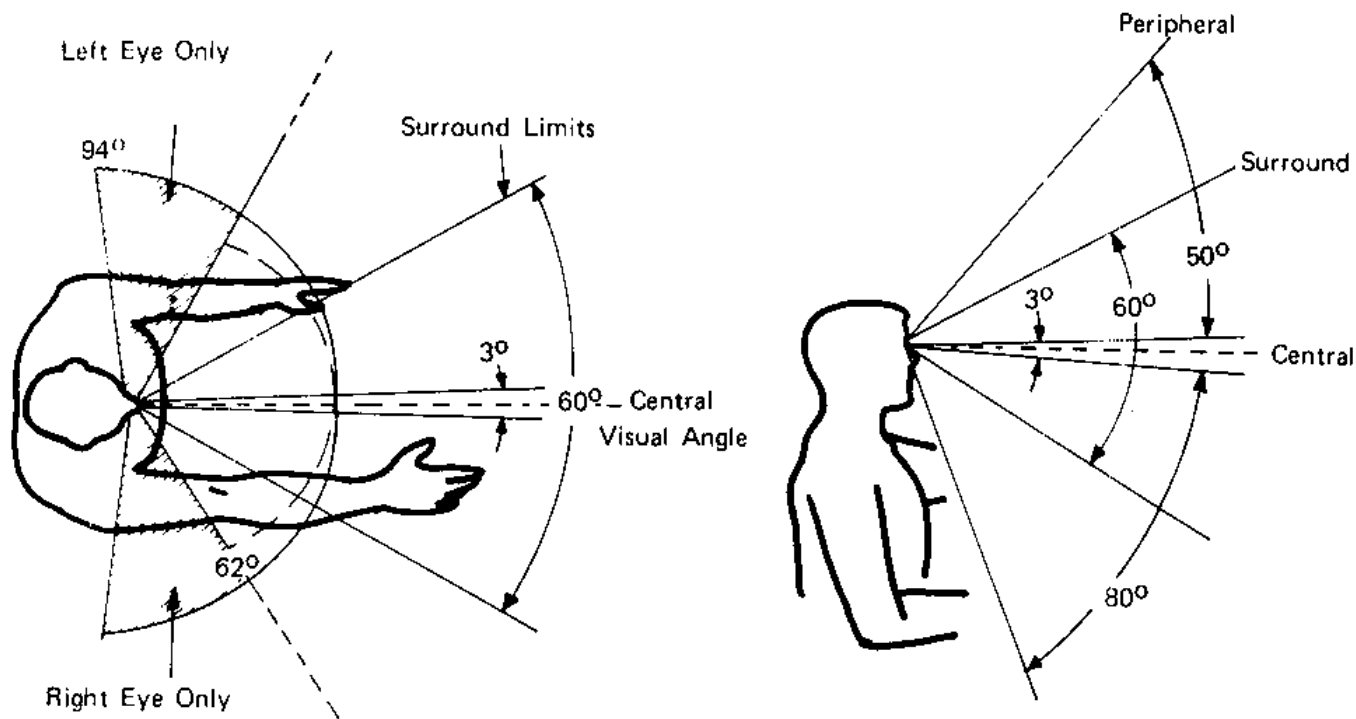




What is Positive Guidance?

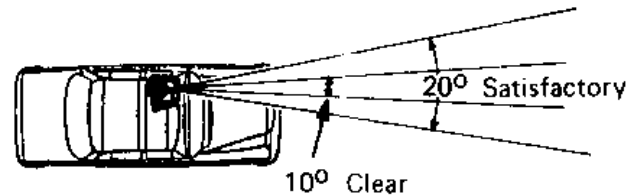
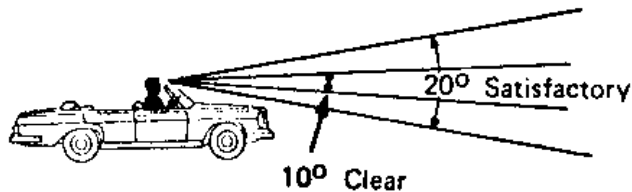
- A guideline prepared by Federal Highway Administration (FHWA)
- Joins the highway engineering and human factors technologies to produce an information system matched to the facility characteristics and driver attributes
- Based on the premise that the drivers can be given sufficient information where they need it and in the form that they can best use to avoid hazards

Human Visual Factors



Visual Angles

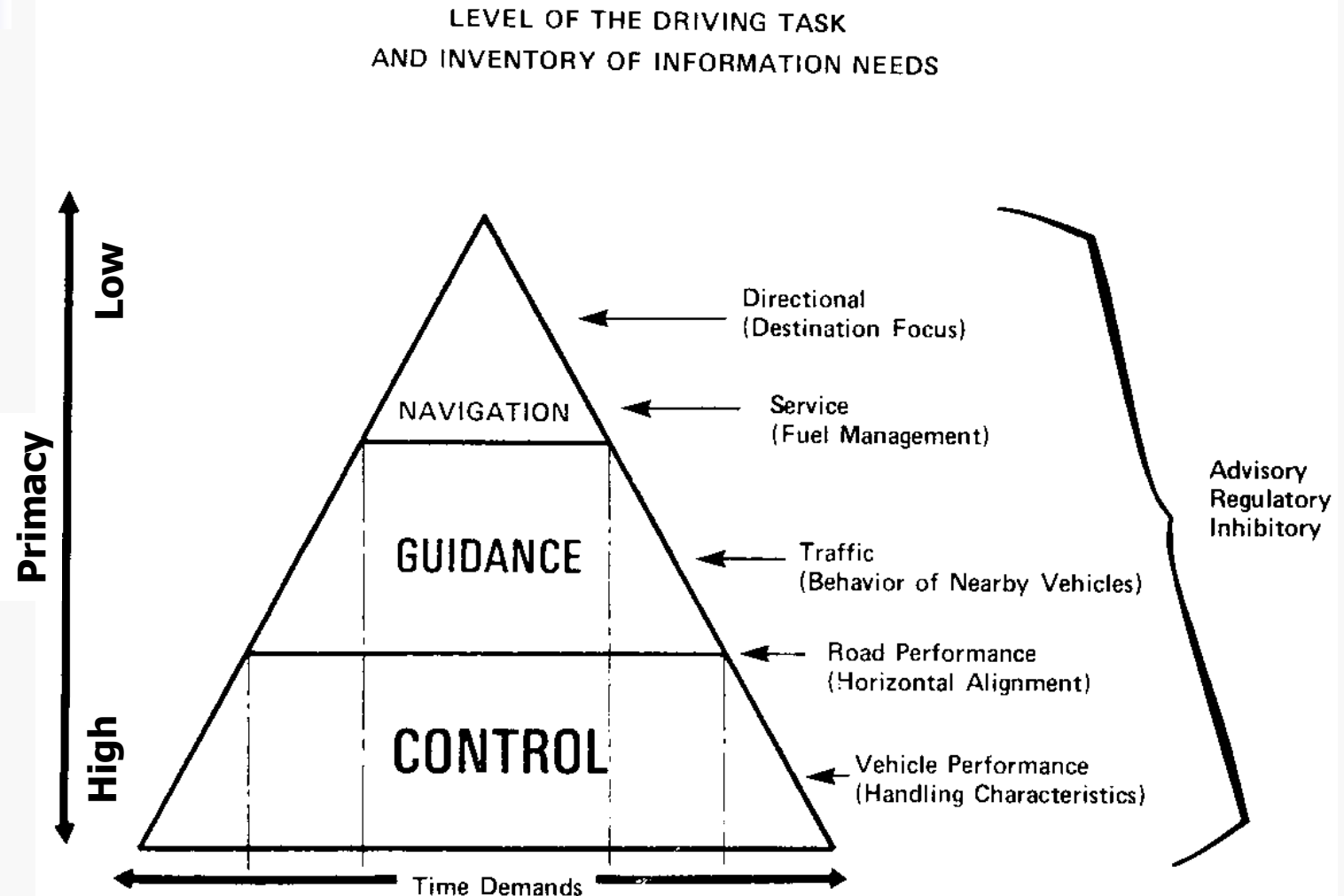
Human Visual Factors

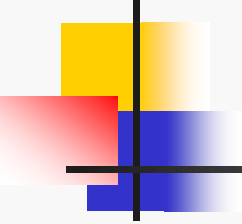


Visual Acuity Factors:

- 20° cone of satisfactory vision
- 10° cone of clear vision (traffic signs and signals should be within this cone)
- 3° cone of optimum vision

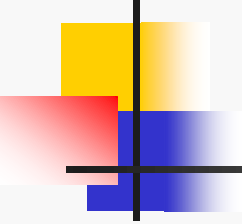
Information Needs





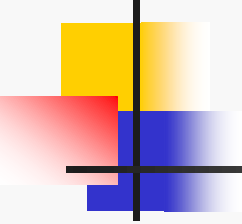
Primacy

- Relative importance of information needed by or presented to the driver.
- Information associated with the control level has the highest primacy, while the same associated with the navigation level has the lowest.
- Failure at the control and guidance level can be an accident, and thus considered higher primacy than navigation.



Driver Expectancy

- Relates to the readiness of the driver to respond to events, situations, or presentation of information.
- Primarily a function of the driver's experience.
- When an expectancy is violated, longer response time and incorrect behavior usually result.



Sign Legibility

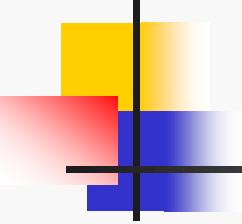
A sign should be legible at a sufficient distance in advance so that the motorist gets time to perceive the sign, its information and perform any required maneuver.

Rule of thumb:

$$LD = H * 50$$

Where, LD = Legibility distance (ft)

H = Height of letters on the sign (inch)



Motorist Information Needs: Aiding Concepts

■ Informal Aiding

- vehicle condition and operation
- visual impact of the road ahead
- topography, cultivation and landscape patterns
- climatological conditions

■ Quasi-Formal Aiding

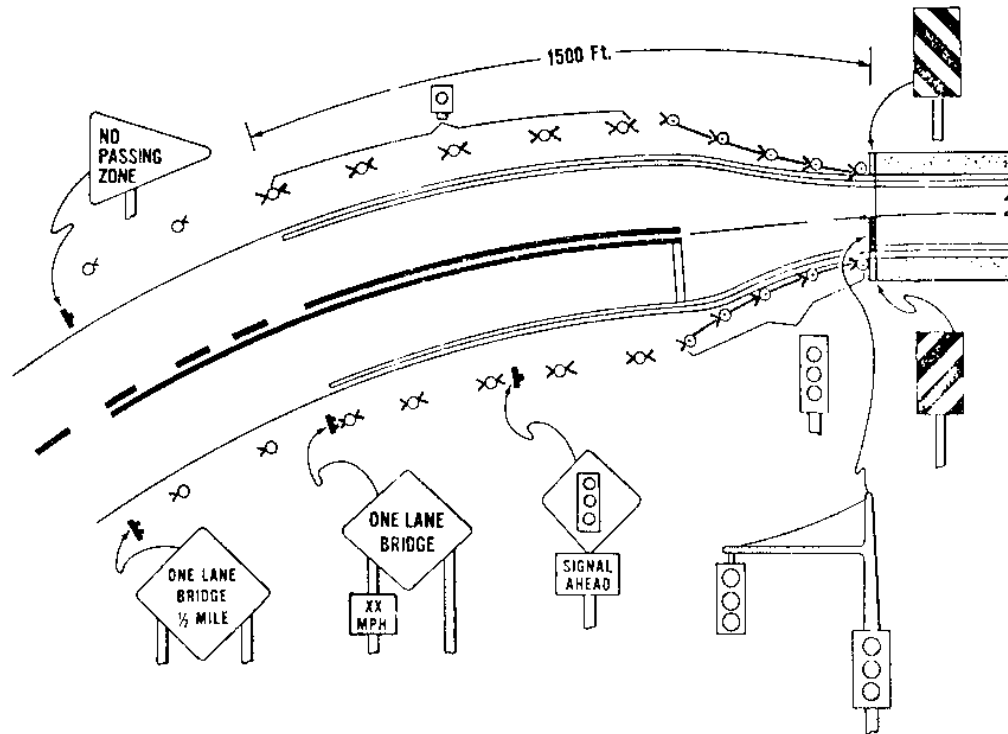
- pavement joints
- highway landscaping
- commercial radio
- roadside advertising

■ Formal Aiding

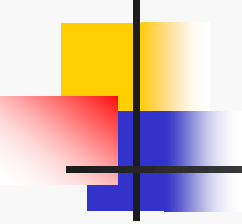
- Pavement markings and delineators
- Regulatory and warning signs
- signals

Standard Traffic Control Devices

USE OF STANDARD TRAFFIC CONTROL DEVICES —ONE LANE BRIDGE ON CURVE—



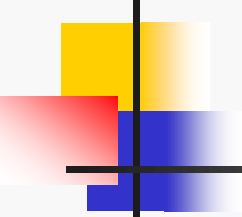
Source: AASHO Highway Design and Operational Practices Related to Highway Safety Washington, D.C., 1974.



Information System Deficiencies

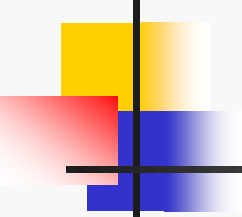
- Needed information is not displayed
 - **Blind driveways, on curves, screened by trees**
 - **Off-road hazards, culverts without guardrail**
- Information displayed is inadequate
 - **Advance warning change in horizontal alignment**
 - **Service signs at off-ramp terminus**
 - **Advance route change without left exit indication**
- Information displayed is erroneous
 - **Temporary lane closures**
 - **Construction ahead**

Information System Deficiencies (continued)

- 
- Ambiguous or confusing information
 - **Pavement marking changes**
 - **Marking of long deceleration lane confused with added lane**
 - Information displayed is in poor form
 - **Use of words “Divided Intersection Ahead” vs symbolic display**
 - **RR X-buck sign only vs full treatment with advance RR warnings**
 - Information overloading - too much information displayed
 - **Mix of route sign, speed limits and warning**

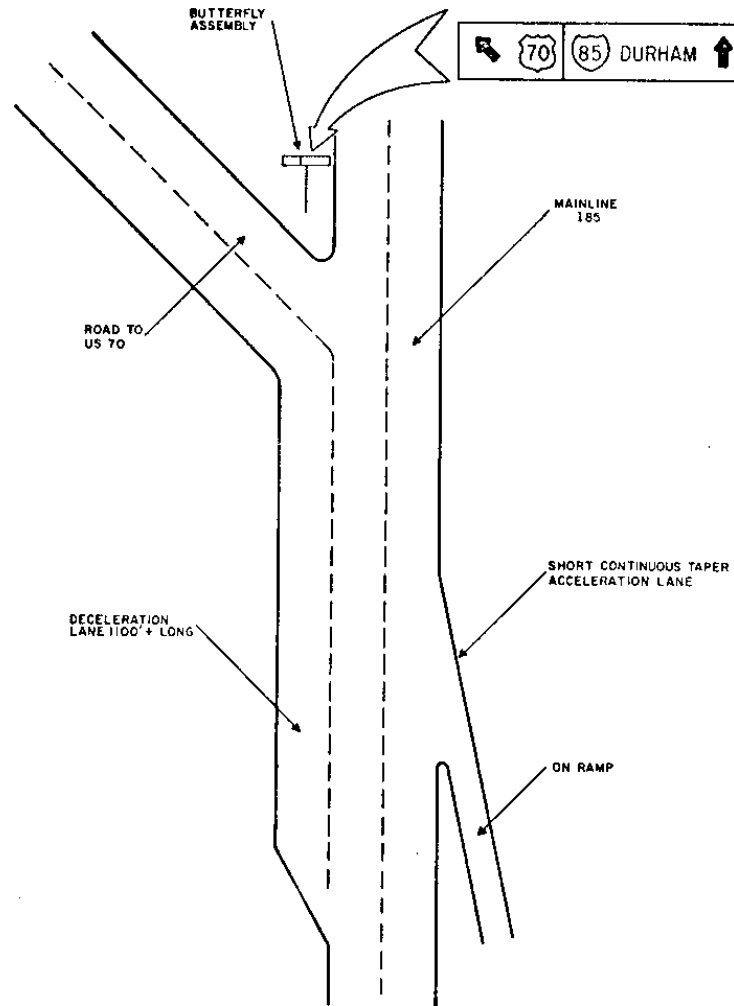
Information System Deficiencies

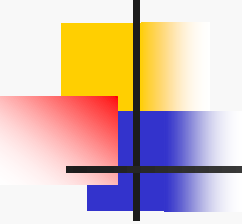
(continued)

- 
- Information display is not in optimum location
 - **Poor legibility of a sign under low-beam illumination**
 - **Lack of signing at or prior to a deceleration lane for an off-ramp, especially route change**
 - Physical, climatological or lighting factors
 - **Sign blocked by bridge abutment**
 - **Glare, headlights of other vehicles, rising or setting sun**

Example Deficiency

EXAMPLE OF INFORMATION SYSTEM DEFICIENCY —INFORMATION DISPLAY NOT IN OPTIMUM LOCATION—





Information Handling

Successful performance by the driver is dependent upon his ability to:

- **Detect a hazard**
- **Recognize it as such**
- **Decide on an appropriate speed and path**
- **Act on the speed and path decisions**

Exhibit E-2

Site Diagram Showing Existing Information and Information Handling Zones

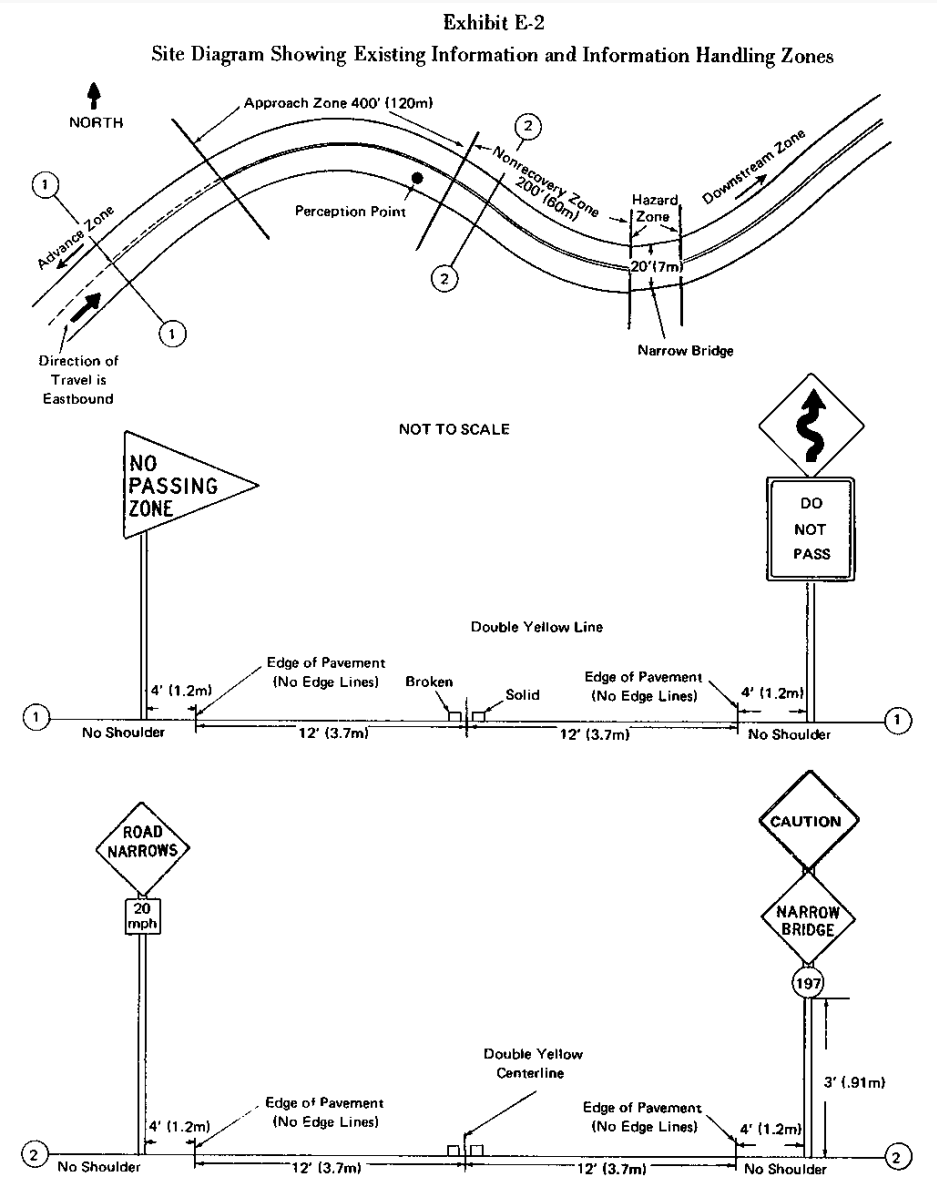
The diagram illustrates the information handling zones for a narrow bridge. It includes a plan view of the road and a cross-section view of the bridge.

Plan View:

- Direction of Travel:** Eastbound.
- Advance Zone:** Indicated by a dashed line and arrow.
- Approach Zone:** 400' (120m).
- Perception Point:** Indicated by a dot.
- Nonrecovery Zone:** 200' (60m).
- Hazard Zone:** 20' (7m).
- Downstream Zone:** Indicated by an arrow.
- Narrow Bridge:** Indicated by a vertical line.
- NOT TO SCALE:** Text label.

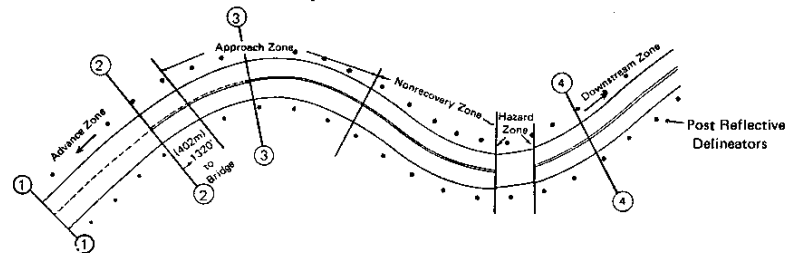
Cross Section View:

- Left Side:**
 - NO PASSING ZONE:** Sign.
 - Edge of Pavement (No Edge Lines):** 4' (1.2m).
 - Double Yellow Line:** 12' (3.7m).
 - Broken:** Indicated by a dashed line.
 - Solid:** Indicated by a solid line.
 - Edge of Pavement (No Edge Lines):** 4' (1.2m).
 - No Shoulder:** Indicated by a dashed line.
 - ROAD NARROWS:** Sign.
 - 20 mph:** Speed limit sign.
- Right Side:**
 - DO NOT PASS:** Sign.
 - Edge of Pavement (No Edge Lines):** 4' (1.2m).
 - Double Yellow Line:** 12' (3.7m).
 - Edge of Pavement (No Edge Lines):** 4' (1.2m).
 - No Shoulder:** Indicated by a dashed line.
 - CAUTION:** Sign.
 - NARROW BRIDGE:** Sign.
 - 197:** Mileage marker.
 - 3' (.91m):** Distance from the edge of the pavement to the centerline.



Sample Positive Guidance Plan

Exhibit E-3
Sample Positive Guidance Plan



NOT TO SCALE

