

PROFESSIONAL TRAFFIC OPERATIONS ENGINEER CERTIFICATION PROGRAM REFRESHER COURSE

Developed for the Institute of
Transportation Engineers



1

Housekeeping

- Be prepared to respond to polls.
- All participant phone lines are muted to avoid distractions during presentations.
- Questions can be asked via the Question Pod. Only the instructor and moderator will see the questions submitted.
- Questions & Answer session at the end of the presentation or at specific time during the presentation.
- Citrix /Go-To-Webinar Customer Service: 1-800-263-6317. Select Go-to-Webinar (#2) Technical Support for login assistance or help during the Webinar.



2

2

Earning PDH/CEU

Successful completion of this Web seminar includes:

- Verification of attendance
- Completion of course evaluation
- Verification of learning objectives (online quiz)

At the conclusion of the course you will receive an email with directions to the online quiz. An additional fee may apply.



3

Meet Your Instructor

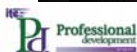


Robert K. Seyfried, PE, PTOE

President

R.K. Seyfried and Associates, Inc.

r-seyfried@northwestern.edu



4

PTOE REFRESHER COURSE

Module 5 Traffic Control Devices



5

Learning Objectives

- 1) Understand principles of driver information processing as they apply to design and location of traffic control devices.
- 2) Recall five basic requirements for all traffic control devices.
- 3) Recall terminology and definitions
- 4) Understand the application of standard sign shapes, colors, and legends.
- 5) Distinguish between types and applications of modes of traffic signal control.
- 6) Understand basic principles of traffic signal phasing and timing.
- 7) Calculate appropriate timing of traffic signal phase change intervals and pedestrian intervals.
- 8) Understand concepts of signal system timing.
- 9) Apply appropriate traffic control measures for highway work zones.
- 10) Calculate appropriate taper lengths for work zone lane closures

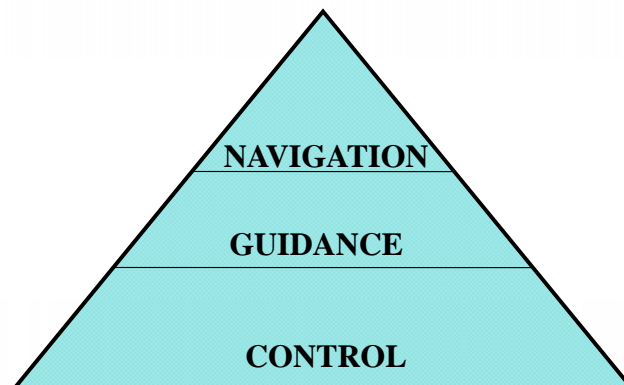


6

Presentation Overview

- Driver Information Needs
- Manual on Uniform Traffic Control Devices
- Signs and Pavement Markings
- Traffic Control Signals
- Highway-Railroad Grade Crossings
- Traffic Control for Highway Work Zones

Three Levels Of Driver Information



Reasons For Driver Error:

INFORMATION OVERLOAD



Reasons For Driver Error:

DEFECTIVE INFORMATION DISPLAY



Reasons For Driver Error:

MISSING INFORMATION



Reasons For Driver Error:

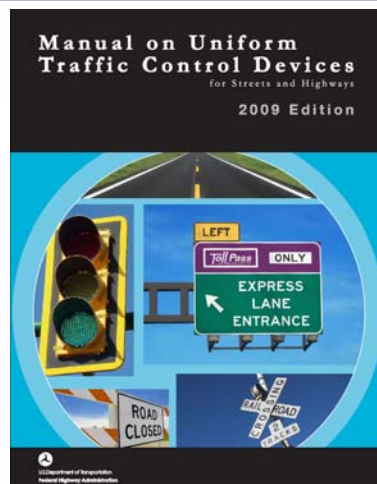
DEFICIENT TRAFFIC CONTROL DEVICE



Human Factors

- Timing
- Primacy
- Expectancy
- Redundancy

Manual on Uniform Traffic Control Devices



Promotes
Uniformity in
Design and
Application

Five Basic Requirements

For All Traffic Control Devices

- Fulfill a Need
- Command Attention of Road Users
- Convey a Clear, Simple Meaning
- Command the Respect of Road Users
- Give Adequate Time For Proper Response

MUTCD Definitions

- Shall-Mandatory Condition (Standard)
- Should-Advisory Condition (Guidance)
- May-Permissive Condition (Option)

Engineering Judgment/ Engineering Study


- Evaluation of available information, and application of appropriate principles, standards, guidance and practice
- Exercised by an engineer or person working under the supervision of an engineer
- Engineering judgment: documentation not required
- Engineering study: documentation required

Signs






- Regulatory Signs
 - Inform User of Regulation
- Warning Signs
 - Inform Users of Hazards
- Guide Signs
 - Navigation Information
- Motorist Information Signs
 - Provide Additional Information


Regulatory Signs




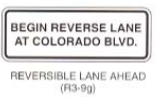

- Right-of-Way Series
- Speed Series
- Movement Series
- Parking Series



19





Common Regulatory Signs












MANDATORY MOVEMENTS IN LANES AT AN INTERSECTION


20

Warning Signs

- Alignment Series
- Intersection Series
- Traffic Control Series
- Cross Section Series
- Advance Crossing and Crossing Series
- Surface Conditions


21

Common Warning Signs

					
<small>HARPEN CURVE AHEAD (W1-11)</small>	<small>VERY SHARP (270 DEGREE) CURVE AHEAD (W1-15)</small>	<small>SHARP CURVE TO RIGHT (W1-6)</small>	<small>INTERSECTION WITH CURVE AHEAD (W1-10)</small>	<small>CROSS ROAD AHEAD (W2-1)</small>	<small>T INTERSECTION AHEAD (W2-5)</small>
					
<small>ENTERING ROADWAY "MERGE (RIGHT)" (W4-14)</small>	<small>ENTERING ROADWAY "ADDED LANE (RIGHT)" (W4-20)</small>	<small>MERGING TRAFFIC (FROM RIGHT) AHEAD (W4-1)</small>	<small>ADDED LANE (FROM LEFT) (W4-3)</small>	<small>HILL (W7-1)</small>	<small>HILL WITH GRADE (W7-10)</small>
					
<small>DEER CROSSING (W11-3)</small>	<small>CATTLE CROSSING (W11-4)</small>	<small>FARM MACHINERY CROSSING (W11-5)</small>	<small>SNOWMOBILE CROSSING (W11-6)</small>	<small>FIRE STATION (W11-8)</small>	<small>YIELD AHEAD (W3-26)</small>


22


Warning Signs

- Locate Far Enough in Advance of Hazard so Drivers can Take Appropriate Action
- PRT times of 2.5 to 14.5 seconds
 - (Table 2C-4, MUTCD)

Common Guide Signs



Common Motorist Information Signs



↑ Overlook Park
Visitor Center

← Rogers Locomotive

City Hall →

ADOPT A HIGHWAY


SPONSORED BY
FREDS
SIGN SHOP

H


REST AREA
1 MILE

TOURIST ACTIVITIES

← 1	STEWARD'S JET BOATS
← 3	DICK & HARRY'S TROUT FARM




TRAVEL
INFO
CALL 511


25

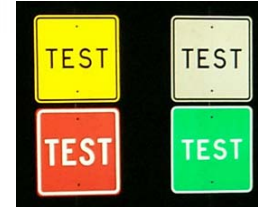
Signs Must Be Retroreflective or Illuminated

- Retroreflection Returns Light Directly Back to Light Source
- Minimum Maintained Retroreflectivity Guidelines Added to MUTCD (December 2007)
- Letter sizes based on ratio of 30 feet of legibility for each 1 inch of letter height


26

Assessment Methods

- Visual nighttime inspection
 - Calibration signs (view prior to inspection)
 - Consistent parameters (2000 or later SUV or pickup, inspector ≥ 60 years old)
 - Comparison panels (attach to sign face)



Assessment Methods

- Retroreflectivity measurement
 - Portable retroreflectometer



Management Methods

- Expected sign life
 - Use agency experience or manufacturer's warrantee
- Blanket replacement
 - All signs in area or corridor replaced at specified intervals
- Control signs
 - Periodically monitor small sample of signs



Pavement Markings

- Indicate Regulations
- Supplement Other Devices
- Guide Road Users
- Warn Road Users

Minimum maintained retroreflectivity criteria to be added to the MUTCD

Traffic Control Signals

When Properly Designed and Located:

- Provide Orderly Flow of Traffic
- Reduce Frequency of Some Crashes
- Increase Capacity
- Provides Gap for Minor Movements



31

Traffic Control Signals

When Improperly Designed or Located:

- Increase Delay and Fuel Consumption
- Increase Certain Types of Crashes
- Increase Frustration
- Induce Road Users to Use Less Appropriate Routes



32

MUTCD Signal Warrants

Eight-Hour Vehicle Volume
Four-Hour Vehicle Volume
Peak Hour
Pedestrian Volume
School Crossing
Coordinated Signal System
Crash Experience
Roadway Network
Intersection Near a Grade Crossing



33

Traffic Signal Operation

- Pretimed Control
 - Consistent Cycle and Interval Lengths
 - Lower Installation and Maintenance Costs
 - Simpler Operation
- Traffic Actuated Control
 - Responds to Changing Traffic Flows
 - Greater Efficiency
 - Minimizes Delay
 - Minimizes Some Crashes

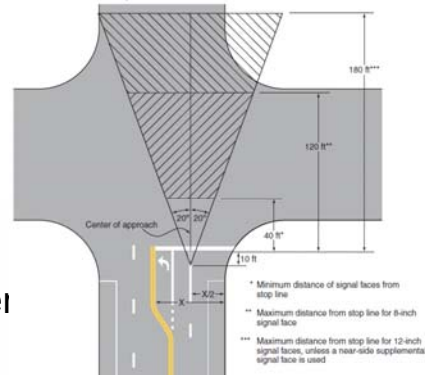


34

Signal Visibility

Minimum of 2 Signal Heads;
At Least One Signal Head:

- > 40' from stop line
- < 180' from stop line
- Within 20° angle left and right of centerline of approach
- Between 15-19' to bottom of housing above pavement



Principles of Signal Phasing

- Number of Phases Depends on Geometric Design, Volume, and Pedestrians
- Phase to Minimize Potential Hazards
- As Number of Phases Increases, Total Delay Increases
- Use the Minimum Number of Phases to Accommodate Traffic

Principles Of Signal Timing

- Relatively Short Cycles Reduce Delay
- Green Intervals Should Be Proportional to Traffic Demand
- Timing Must Accommodate Pedestrians
- Phase Change Intervals Must Ensure that Vehicles can either Stop or Clear the Intersection
- Must Be Field-Checked



37

Phase Change Interval

$$CP = t + \frac{V}{2a + 64.4g} + \frac{W + L}{V} \quad (U.S. \text{ units})$$

$$CP = t + \frac{V}{2a + 19.6g} + \frac{W + L}{V} \quad (\text{metric})$$

CP = Change period (sec)

t = Perception-reaction time (usually 1.0 sec)

V = Approach speed (ft/sec or m/sec)

a = Deceleration rate (usually 10 ft/sec² or 3 m/sec²)

g = Grade of approach (decimal)

W = Width of cross street (ft or m)

L = Length of vehicle (usually 20 ft or 6 m)



38

Timing for Pedestrians

- Pedestrian Start-off Time
- Pedestrian Clearance Time
- Buffer Time

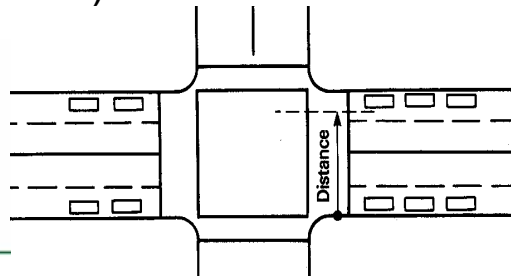
Pedestrian Start-off Time

- Permits all pedestrians who have accumulated to start crossing
- Pedestrian Walk interval
(WALKING PERSON symbol)
- Should be minimum of 7 seconds
- May be longer if pedestrian traffic is heavy
- May be reduced to 4 seconds if necessary



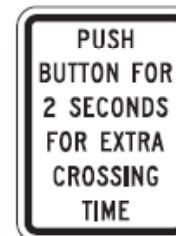
Pedestrian Clearance Time

- Time needed to cross the street = D/S
- D desirably is full curb-to-curb distance
- D may be measured to far side of traveled way (or median wide enough to store pedestrians)



Pedestrian Clearance Time

- Walking speed, S , should be 3.5 feet per second for typical adult pedestrians
- Consider lower walking speed if significant volume of people in wheelchairs or who walk slowly
- Consider lower walking speed if crossing is congested
- Speed of 4 fps may be used if extended pushbutton push or passive detection provides longer crossing times if needed



Pedestrian Clearance Time

- Pedestrian Clearance Time is the sum of:
 - Pedestrian Change Interval (flashing UPRAISED HAND signal indication)
 - Buffer Interval (steady UPRAISED HAND signal indication)
- MUTCD requires Buffer Interval of at least 3 seconds before any conflicting vehicle traffic is released

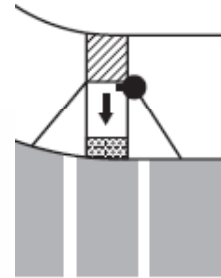


Pedestrian Clearance Time

- Buffer Interval shall not begin later than the start of vehicle Red Clearance Interval (if used)
- Buffer Interval may overlap part or all of Yellow Change Interval

Secondary Check for Ped. Crossing Time

- Combined Walk, Pedestrian Change, and Buffer Intervals should permit slowly moving pedestrian to cross:
 - At speed of 3.0 feet per second
 - Starting at pedestrian pushbutton or 6 feet from curb if no pushbutton



Coordinated Signals

- Reduced Travel Time and Delay
- Reduced Stops, Fuel Consumption, Air Pollutant Emissions, and Vehicle Costs
- Reduction of Stopping Crashes
- Built-In Speed Control

Coordinated Signals

FACTORS TO CONSIDER

- Signal Spacing
- Directional Movement
- Signal Phasing
- Arrival Patterns
- Traffic Fluctuation
- Incompatible Signal Cycle Requirements



47

Coordinated Signals

System Cycle Length

Set at even multiple of average travel
time between signals

$$C = X \times \frac{D}{V}$$

Where C = System cycle length (sec)

X = An integer (e.g., 1, 2, 4, etc.)

D = Average spacing between signals (ft or m)

V = Progression speed (ft/sec or m/sec)



48

Highway/Railroad Grade Crossings

FACTORS THAT CONTRIBUTE TO “DRIVER ERROR”

- Difficult to Judge Speed and Distance of Train
- Visibility Obstructions
- Train in Crossing Difficult to See at Night
- Active Devices May Lose Credibility
- Multiple Trains In Crossing
- Excessive Delays Breed Impatience
- Perception of Low Probability of Conflict



49

Highway/Railroad Grade Crossings

IMPROVEMENTS TO CONSIDER

- Upgraded Traffic Control Devices
- Changes in Horizontal or Vertical Alignment
- Improvements in Sight Distance
- Crossing Surface Improvements
- Crossing Illumination
- Grade Separation
- Closing the Crossing



50

Highway/Railroad Control Devices

- Passive Devices
 - Railroad Crossing Sign (“Crossbuck”)
 - Advance Warning Sign
 - STOP or YIELD Sign
 - Pavement Markings
- Active Devices
 - Flashing Light Signals
 - Gates
 - “Four-Quadrant” Gate Installation



51

Signal Preemption

- Transfer to Special Mode of Operation so Railroad and Highway Traffic Control Systems do Not Conflict
- Provide When Traffic Queues Across Tracks
- Provide Adequate Warning Time



52

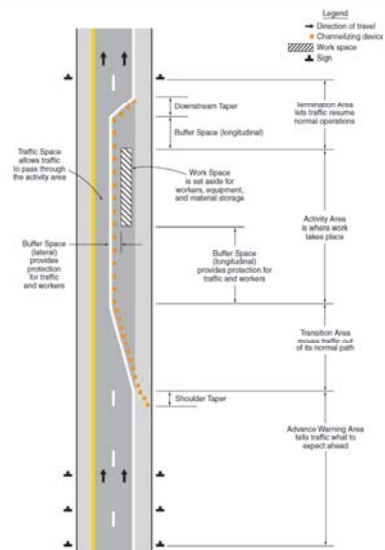
Highway Work Zones

POTENTIAL PROBLEMS:

- Insufficient Advance Warning
- Inadequate Guidance
- Unprotected Hazards
- Conflicts Created by Work Activities
- Poor Housekeeping
- Distractions
- Confusion
- Congestion

Traffic Control Zones

- Advance Warning Area
- Transition Area
- Activity Area
 - Work Space
 - Traffic Space
 - Buffer Space
- Termination Area



Work Zone Duration

- Long Term Stationary: > 3 days
- Intermediate Term Stationary: 1-3 days or nighttime work lasting > 1 hour
- Short Term Stationary: daylight work, 1-12 hours
- Short Duration: < 1 hour
- Mobile: intermittent or continuous movement



55

Traffic Control In Work Zones

- Signs
- Changeable Message Sign
- Arrow Display
- Channelizing Devices
- Pavement Markings
- Lighting Devices
- Flaggers
- Portable Barriers



56

Tapers

$$L = WS^2/60$$

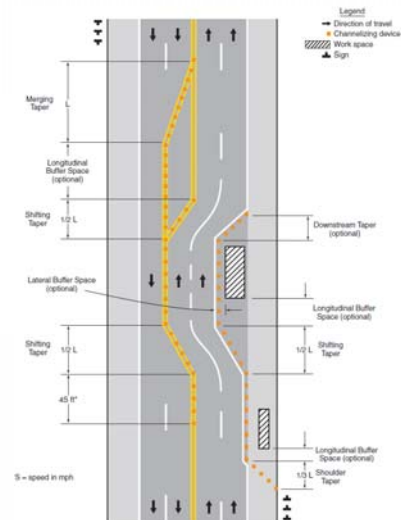
for $S = 40$ mph or less

$$L = WS$$

for $S = 45$ mph or more

Merging Taper = L

Shifting Taper = $1/2 L$



57

Sample Study Question

The prevailing speed of traffic on an approach to a signalized intersection is 45 mph. The width of the cross street is 65 ft. Using the “ITE procedure”, what is the minimum length of the phase change interval for this approach?



58

Sample Study Question

The length of the phase change interval is calculated as:

$$CP = t + \frac{V}{2a} + \frac{W + L}{V} \quad (U.S. \text{ units})$$

Where t = reaction time = 1.0 sec

V = speed = 45 mph x 1.47 = 66 ft/sec

a = acceleration rate = 10 ft/sec/sec

W = width of cross street = 65 ft

L = length of vehicle = 20 ft

$$CP = 1.0 + \frac{66}{2 \times 10} + \frac{65 + 20}{66} = 5.6 \text{ sec}$$

Sample Study Question

On a freeway with posted speed limit of 65 mph, the 12 ft wide left hand lane is to be closed for a construction project. How long of a taper should be used for this lane closure?

Sample Study Question

For high-speed conditions (>40 mph), lane closure taper length is:

$$L = W \times S$$

Where W = width of lane = 12 ft

S = design speed = 65 mph

$$L = 12 \times 65 = 780 \text{ ft}$$

For closing two lanes (question 82), the MUTCD indicates that the first lane be closed with taper L , then a distance of $2L$ is provided before the second lane is closed with taper L . Therefore the total distance for a two-lane closure is $L+2L+L = 3120$ ft



61

Sample Study Question-Audience Participation

There is a sharp curve on a rural collector highway with an 50 mph speed limit. The comfortable speed on the curve is determined to be 35 mph. What is the **MOST** appropriate sign display for this condition?

- One or more chevron signs
- A Turn sign with advisory speed plaque
- A 35 mph speed limit sign
- A Curve sign with advisory speed plaque



62

Sample Study Question

Five signalized intersections are spaced at 1400 ft intervals along a two-way arterial street. What would be the **BEST** cycle length for a coordinated signal system if the desired progression speed is 35 mph?

- a. 70 sec.
- b. 85 sec.
- c. 100 sec.
- d. 110 sec.



63

Sample Study Question

The best cycle length for the system is an even multiple of the travel time between intersections.

Travel time = $D/V = 1400/(35 \times 1.47) = 27$ sec

Good cycle lengths would be 27 sec., 54 sec., 108 sec., 162 sec., etc.

Of the choices available, 110 sec. is the best cycle length



64

Questions



Before You Go

- **Submit your sign-in sheet**
- **Distribute the post-webinar assessment/evaluation email to your site attendees for them to follow instructions to get course credit.**

Thank You

Please provide your feedback. A link to an online Web seminar evaluation and quiz will follow in an e-mail to Web seminar registrants. Please distribute this email to participants at your site. The assessment and evaluation will close in one week.

Questions/Comments
Professional Development Department
ITE

1627 I Street, NW, Ste 600
Washington, DC 20006
202-785-0060; pdinfo@ite.org

