



Highway Traffic and Safety Analyses

Lecture 11: Traffic Signals Design and Timing

**Purdue University
School of Civil Engineering
West Lafayette**

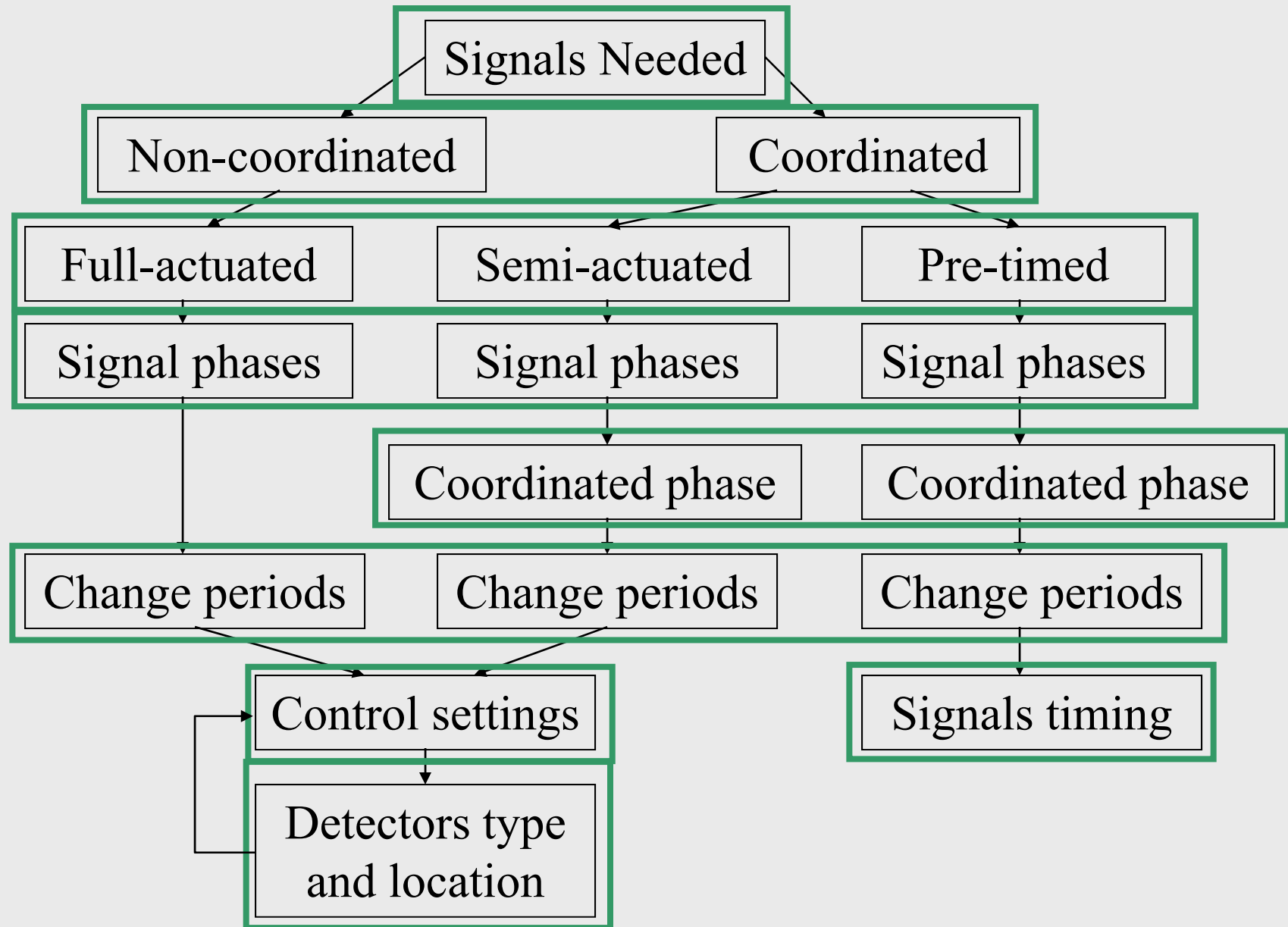
Management of Traffic Signals

- Major Decisions
 - Need for new signals
 - Signals design and setting
 - Field evaluation
 - Signals improvement
 - Removal of signals

Traffic Signals Studies

Decision	Study
New signal?	Traffic signal warrants study
Design and setting	Traffic signals design and optimization
Field evaluation	Delay and queuing studies
Signals improvement	Individual intersections and corridor studies
Remove signals?	Alternative control studies

Signals Design and Settings



Signals Coordinated or Isolated?

Actuated or Pre-timed?

- Coordination when 0.5 mile or less between signals
- Isolated signals when 1 mile or more to the closest signals
- Cost-effectiveness of coordination should be studied
- Pre-timed and semi-actuated signals in coordination
- Full-actuated at isolated intersections

Signal Phases - Left Turns Treatment

Two-lane left turn considered when 300 vehicles per hour or more.

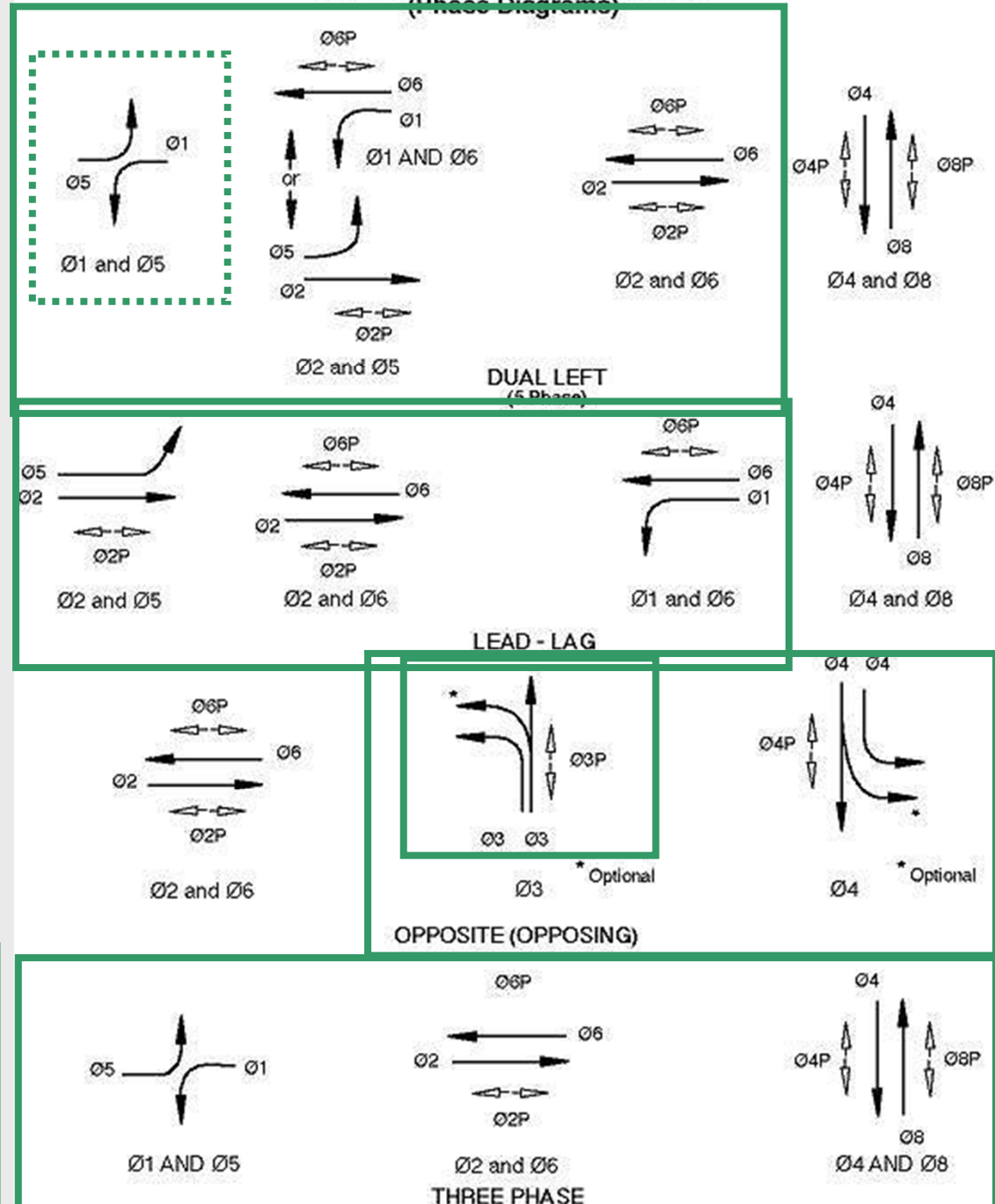
Dual Left – most efficient traffic actuated-operation. Various phases and combinations of phases appear only on demand.

Lead-Lag (With Overlap)- pre-timed or traffic-actuated. In coordination when the traffic in the opposing directions arrives at different times during a cycle.

Opposite/Opposing (Split Phase) – used when the left turns are equal or stronger than the through traffic.

Three Phase Operation - the simplest and the least expensive, pre-timed or traffic-actuated. Inefficient when strong traffic disproportion between the opposing approaches.

Figure 9-11
LEFT-TURN PHASING METHODS
(Phase Diagrams)



Signal Phases

Figure 9-17
TYPICAL SIGNAL LAYOUT
(Two Phase Operation)

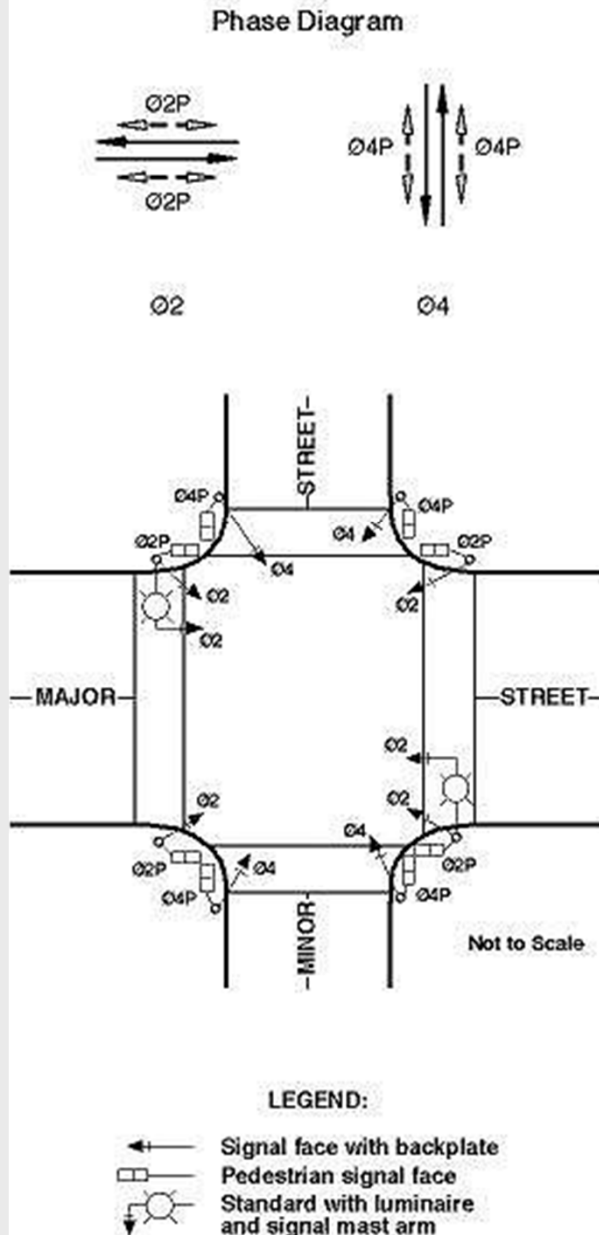
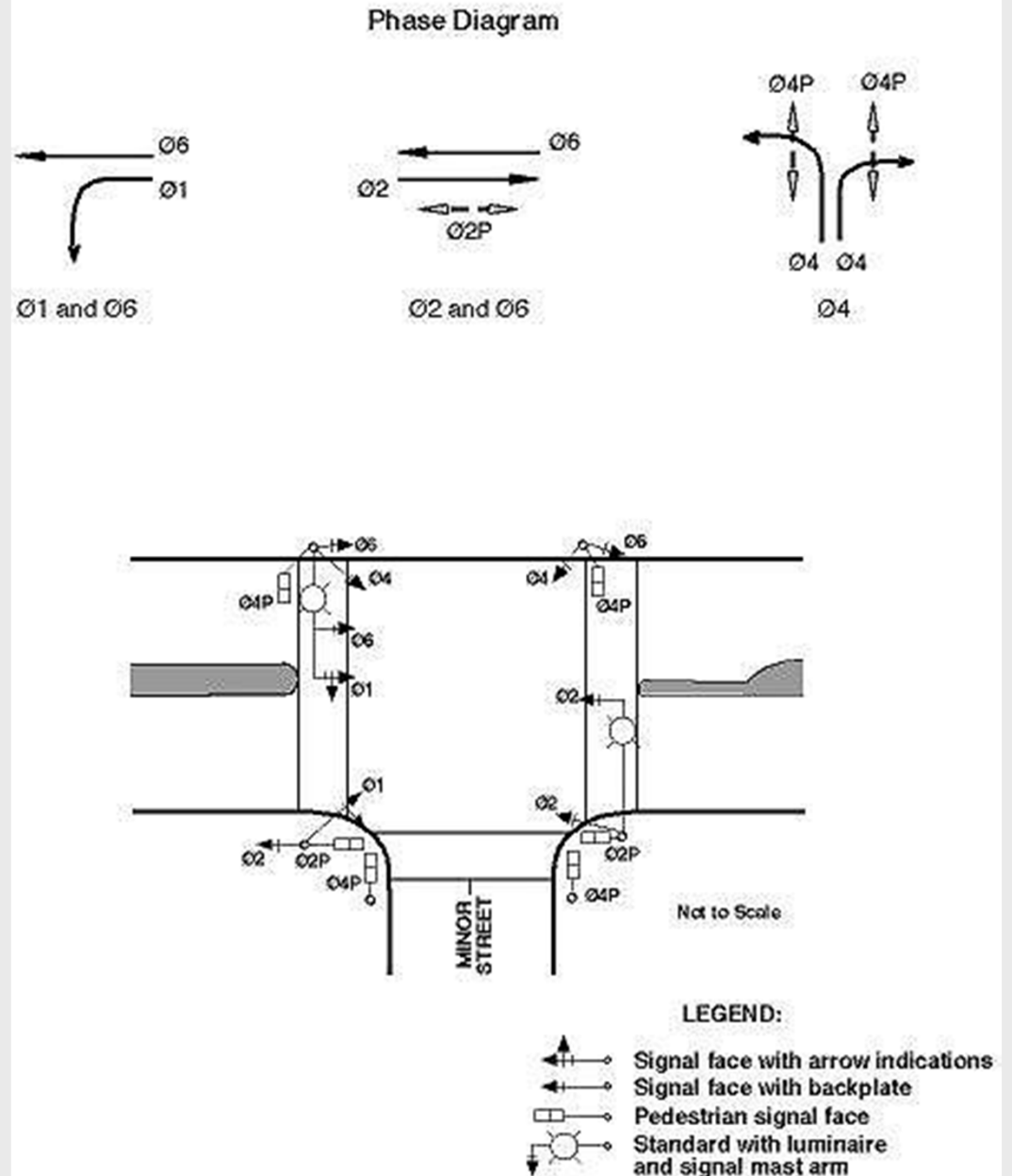
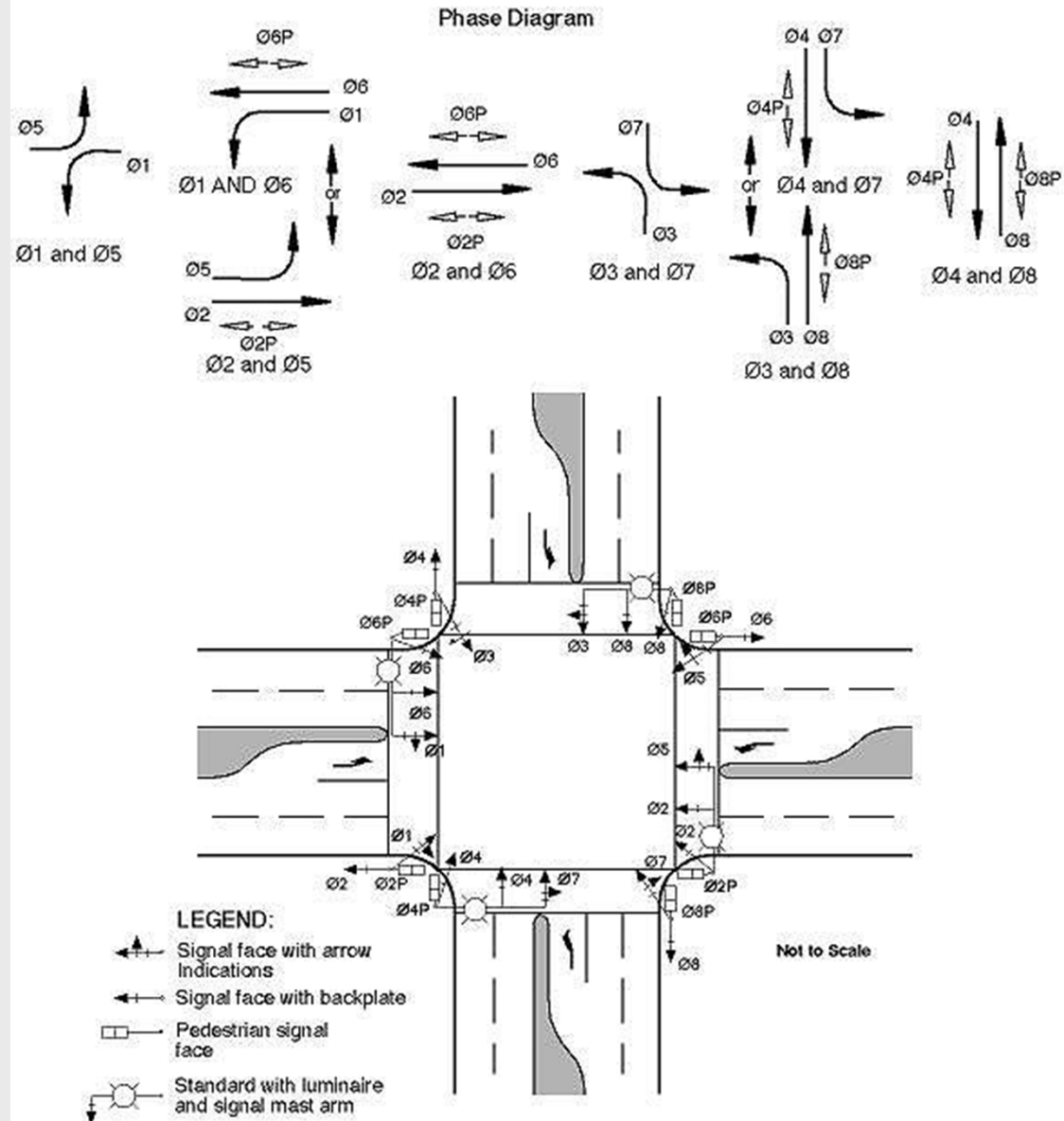


Figure 9-18
TYPICAL SIGNAL LAYOUT
(Three Phase Operation)



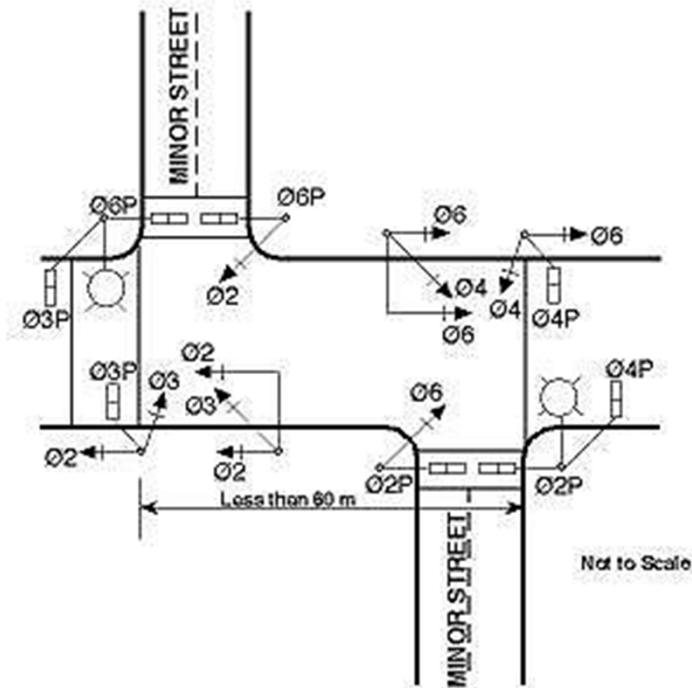
Signal Phases

Figure 9-21
TYPICAL SIGNAL LAYOUT
(Eight Phase "Quad Left" Operatin)

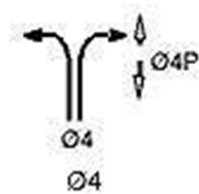
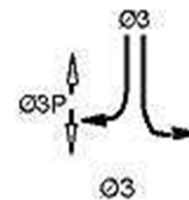
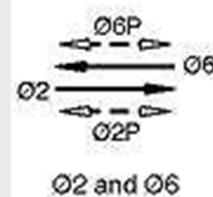


Signal Phases

Figure 9-13
TYPICAL SIGNAL LAYOUT AT OFFSET INTERSECTIONS
(Signalized and Marked as a Single Intersection)



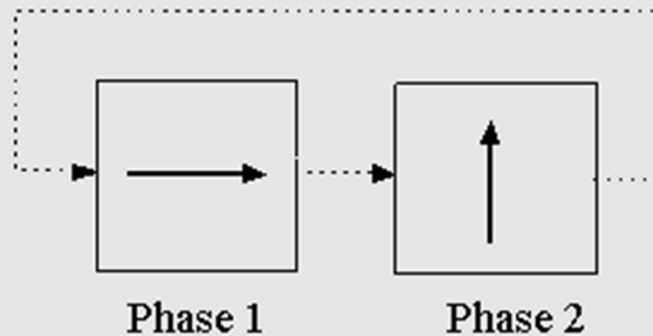
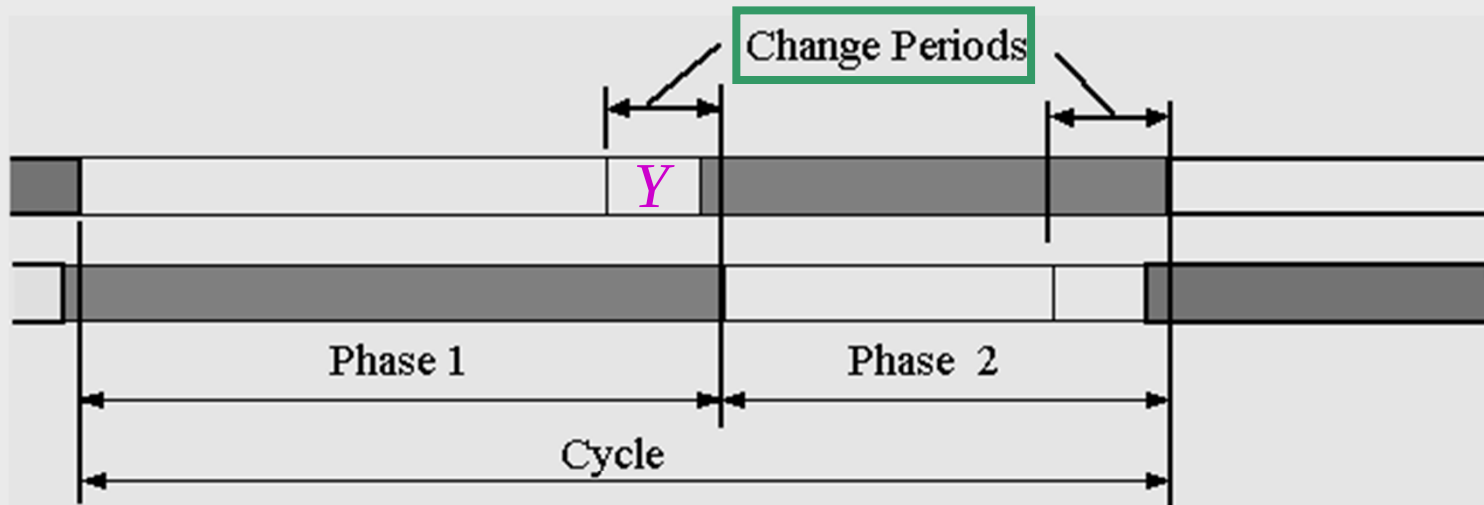
Phase Diagram



NOTE: Safety Lighting Design shall satisfy the requirements of Section 9-10.3.

Change Periods

$$CP = Y + AR$$

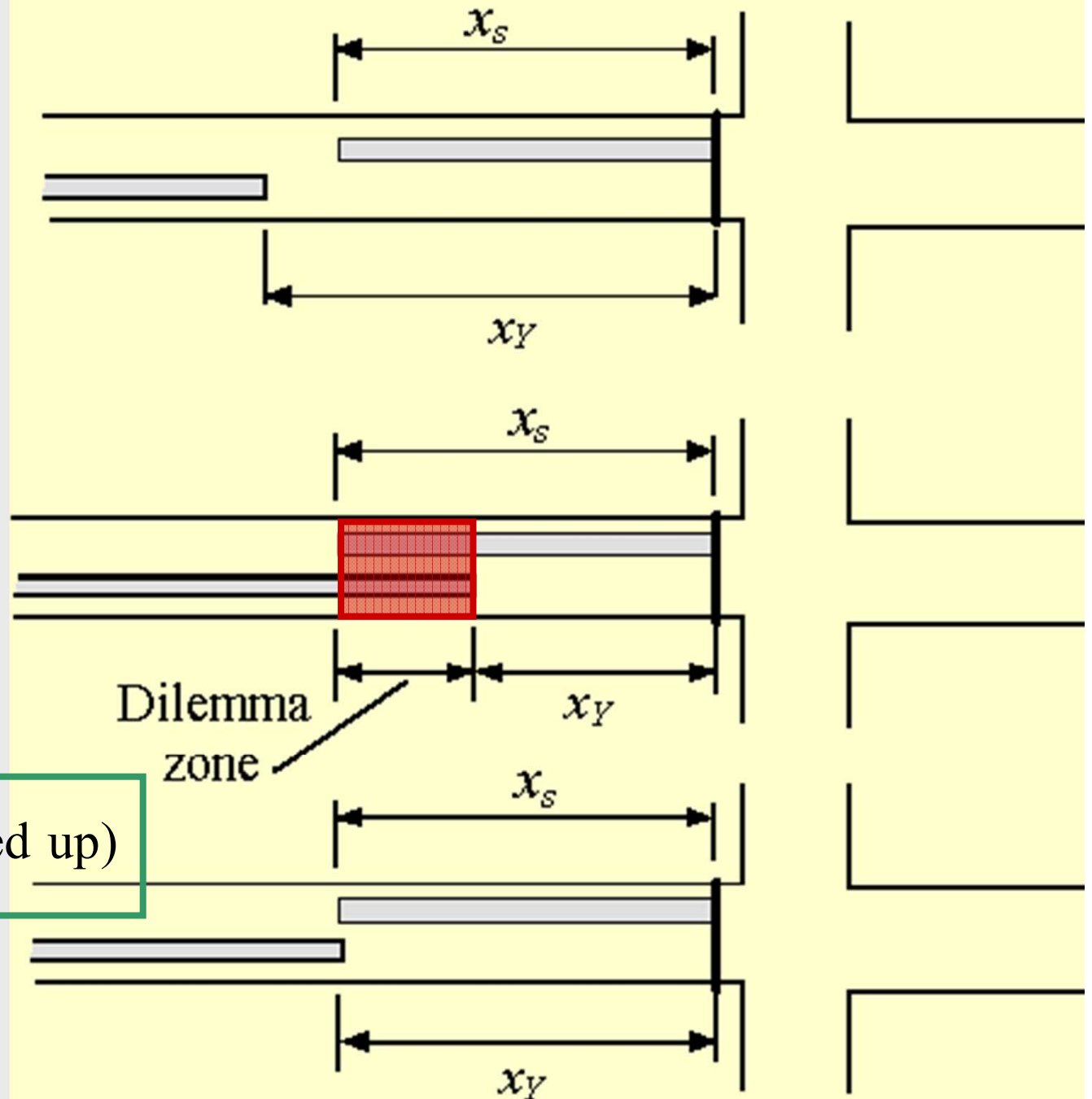


Change Periods - Yellow

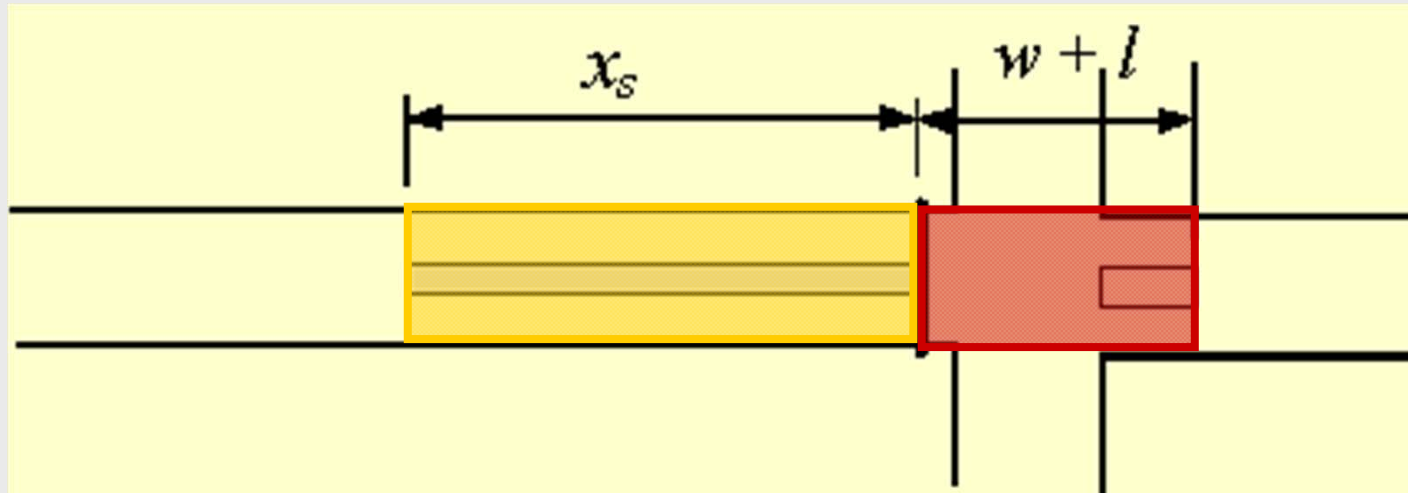
$$x_S = V \cdot t_r + \frac{V^2}{2a}$$

$$x_Y = V \cdot Y$$

$$Y \geq t_r + \frac{V}{2a} \text{ (rounded up)}$$



Change Periods – All Red



$$AR = \frac{w + l}{V} \text{ (rounded up)}$$

Pre-timed Signals Timing

- Cycle
- Green split
- Offsets (coordination)

Settings for Actuated Signals

Minimum green times

Maximum green times

Gap interval

Unit (vehicle) extension

Force offs

Offsets

Cycle length

Time-of-day settings

Signal Detectors

Vehicle Detectors

1. **Inductive loop detectors** detect standing vehicles as well as moving ones. The detection area is roughly that enclosed by the loop.
2. **Video detectors** have similar capabilities as the inductive loop detectors. They require video cameras installed at the intersection.

The longitudinal location (setback) of detectors relative to the stop line depends on the speed of traffic and the type of detector operation desired.

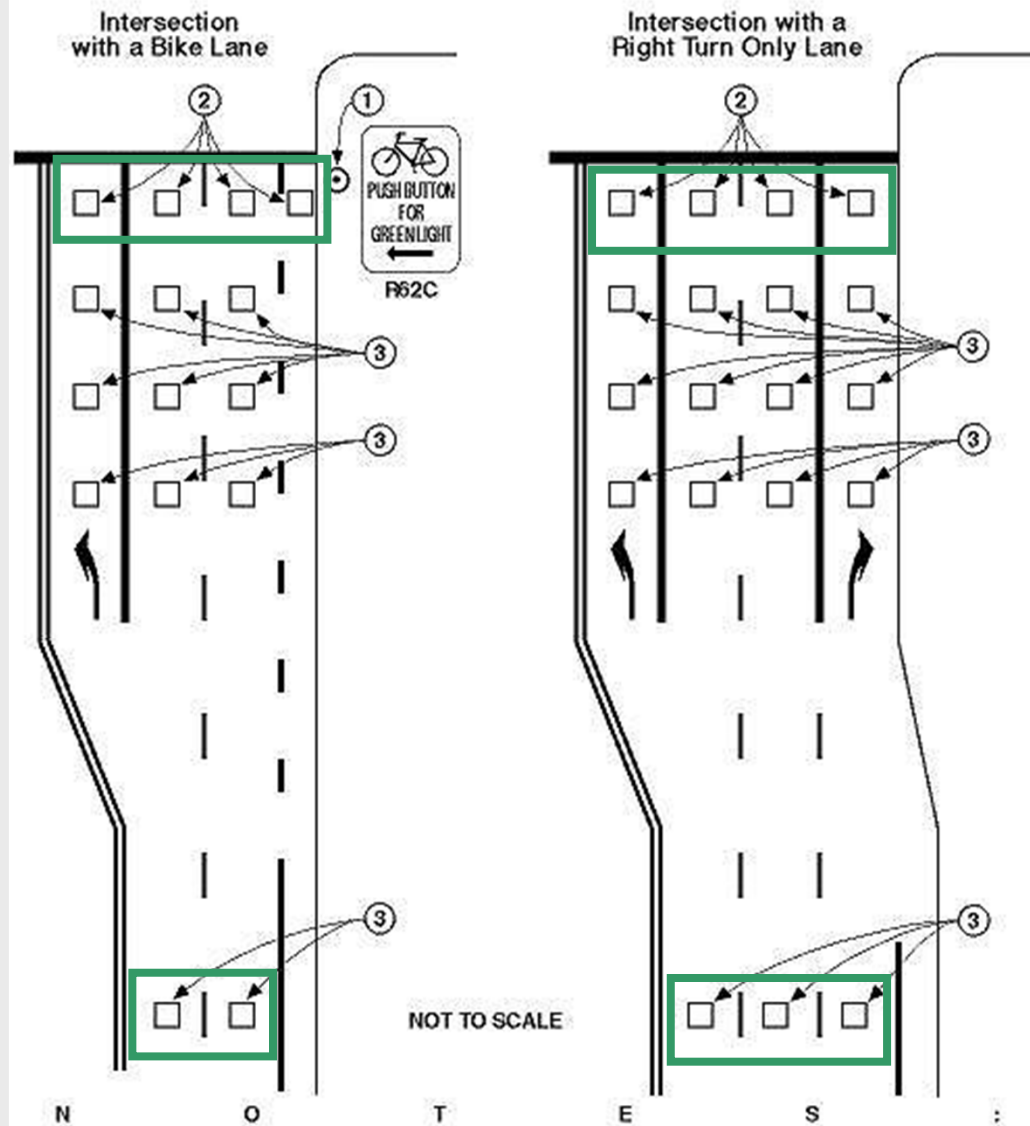
Bicycle Detectors

Bicycle detectors may be required at traffic-actuated signal installations. Type D loop configuration is effective for detecting bicycles and small motorcycles and shall be installed at the bicycle loop detector locations.

Signal Detectors

see *Northwestern-Stadium*

Figure 9-12
BICYCLE DETECTION SYSTEMS



- 1 . Bicycle Push Button and Sign (R62C) or a Type D Loop Detector may be used to activate a traffic signal. A push button should be located so it is convenient to use by bicyclists.
- 2 . Typical Type D Loop Detector locations.
- 3 . Typical Loop Detector locations. See Section 9-03.24.
- 4 . See Standard Plan A24C for Bicycle Loop Detector pavement marking details.

Signal Detectors

Table 9-1
SUGGESTED DETECTOR SETBACKS FROM LIMITLINE

Deceleration Rate $d = 3.6 \text{ m per second}^2$

Reaction Time $r = 1.00 \text{ second.}$

Deceleration Distance $= \frac{1}{2} dt^2 \text{ or } \frac{1}{2} Vt \text{ or } \frac{V^2}{2d}$

Deceleration Time $= \frac{V}{d}$

Detector Setback = Deceleration Distance + Reaction Distance

$$= \frac{V^2}{2d} + Vr$$

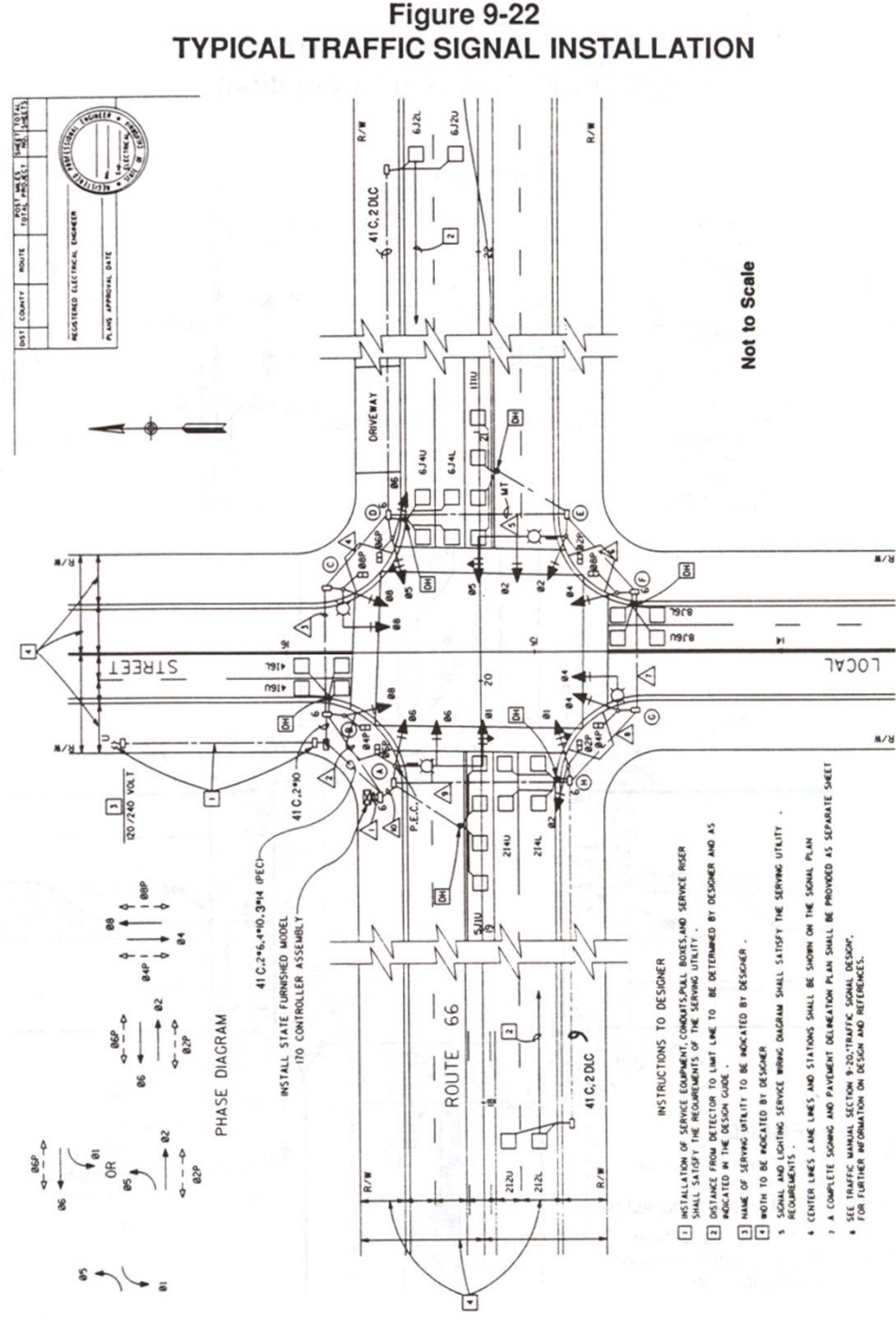
V = Speed (meter per second)

d = Deceleration Rate (meter per second²)

t = Deceleration Time (seconds)

SPEED	SPEED	DEC. TIME	DEC. DIST.	TOTAL TIME	TOTAL DIST.	USE
km/h	m/s	Seconds	Meters	Seconds	Meters	Meters
40	11.11	3.70	20.53	4.70	31.63	30.00
50	13.89	4.63	32.15	5.63	46.10	45.00
60	16.67	5.56	46.37	6.56	63.18	60.00
70	19.46	6.46	62.59	7.46	82.12	80.00
80	22.22	7.40	82.15	8.40	104.34	105.00
90	25.00	8.33	104.08	9.33	129.16	130.00
100	27.78	9.36	128.62	10.36	156.60	155.00
110	30.56	10.19	155.61	11.19	186.16	185.00

Typical Installation



NOTE: This plan accurate for electrical work only.

Sources about Traffic Signals

Traffic Signals Design and Timing, based on CALTRANS manual

http://web.ics.purdue.edu/~tarko/Ce597T/Lectures/manual_on_signals.doc

Minnesota DOT site with useful course materials on signals design (on-line)

<http://www.dot.state.mn.us/trafficeng/signaldesign/index.html>

Minnesota DOT Traffic Engineering Manual, Chapter 9, Traffic Signals

<http://www.dot.state.mn.us/trafficeng/otepubl/tem/>

Glossary of Controller Terms, Econolite Application Note 1000

http://web.ics.purdue.edu/~tarko/Ce597T/Lectures/Econolite_controller_glossary.pdf

Minimum Green for Pedestrians

