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speed and location of some approaching vehicles will be such that they can stop safely at the stop line; others will have to continue at their speed or even accelerate into or through the intersection. The minimum length of the clearance interval (which may include an all-red interval after the yellow indication) should accommodate both situations and eliminate the possibility of a dilemma zone in which a driver can neither stop safely nor legally proceed into or through the intersection.

Gazis et al[36] analyzed this situation as follows. In order to come to a safe halt at the stop line:

$$x = t \cdot v + \frac{v^2}{2a} \tag{24.12}$$

where x = the distance required for stopping (in ft or m)

t = the perception-reaction time (in s)

v = approach speed (in ft/s or m/s)

a = deceleration rate (in ft/s^2 or m/s^2)

A driver at distance x from the intersection is in the most critical position. This driver can proceed *into* the intersection if the clearance time is at least:

$$\tau_{min} = \frac{x}{v} = t + \frac{v}{2a} \tag{24.13a}$$

or *through* the intersection if the clearance time is at least:

$$\tau_{min} = \frac{x + w + L}{v} = t + \frac{v}{2a} + \frac{w + L}{v} \tag{24.13b}$$

where τ_{min} = the minimum clearance interval (in s)

w = the width of the intersection (in ft or m)

L = the length of the vehicle (in ft or m)

In jurisdictions whose vehicle codes permit vehicles to enter the intersection throughout the yellow change interval and clear after the red indication has appeared, equation (24.13a) gives the minimum value for the clearance interval. However, for safety reasons, yellow intervals of less than 3 s are seldom used. Local conditions may require the use of longer intervals, up to the values obtained by equation (24.13b), especially where sight distances at the intersection are poor. Since excessively long yellow indications might encourage driver disrespect, a maximum of about 5 s is used; if a longer clearance period is required, an all-red phase can be inserted to follow the yellow period.

The clearance intervals computed by equation (24.13b) should usually be used in those jurisdictions whose laws require vehicle to have crossed the intersection before the red indication appears.

Yellow change and clearance intervals

At the termination of a green phase, motorists approaching a signalized intersection are advised by a yellow signal indication that the red interval is about to commence[35]. The

[34]"Traffic Control Signal Timing," *Manual on Uniform Traffic Control Devices for Canada*, Metric Ed., Apr. 1978.

[35]In Great Britain it is the practice to use the yellow clearance interval before the beginning of green as well as before the beginning of red. This is not permitted in the *Manual on Uniform Traffic Control Devices*.

[36]D. Gazis, R. Herman, and A. Maradudin, "The Problem of the Amber Signal Light Traffic Flow." *Oper. Res.* 8(1), 112–132, (1960).

TABLE 24–7
Minimum Theoretical Clearance Intervals* for Different Approach Speeds, Vehicle Lengths, and Cross Street Widths

Approach Speed mph	τ_{min} to Enter Intersection (24.13a)	τ_{min} to Clear Intersection for Combined Vehicle Length and Crossing Street Width ($w + L$) (24.13b)				
		60 ft	80 ft	100 ft	120 ft	140 ft
20	3.0†	4.5	5.2	5.9	6.6	7.2
30	3.2	4.6	5.0	5.5	5.9	6.4
40	3.9	5.0	5.3	5.6	6.0	6.3
50	4.7	5.5	5.8	6.0	6.3	6.6
60	5.4	6.1	6.3	6.5	6.8	7.0

*In seconds; assumed value of $t = 1$ s, of $a = 10$ ft/s^2.
†Minimum interval considered safe.

Note: 1 mph = 1.61 km/h; 1 ft = 0.305 m.

Figure 24.11. Examples of open networks.

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