Intersection Operation

CIVL 3161

Terminology

• Intersection – area shared by two or more roads
  - Grade separated
  - At grade

• Conflict points – determined by number of approaches, turning movements, type of traffic control

Types of Traffic Conflicts

- Diverging
- Merging
- Crossing

TRB Manual, Pg. 8
Vehicular Conflicts at a 4-way Intersection

16 Crossing
8 Diverge
8 Merge
32 Total

Goal in Design of Traffic Control Systems:
• Reduce the # of significant conflict points!
• What determines significance?
  - Type
  - Volume
  - Speed

TRB Manual, pp. 8-9
Terminology

- Cycle Length - time required for one complete sequence of signal indications (typical range 40-120 sec)

- Interval - Any one of several divisions of the cycle in which signal indication does not change.

- Phase - Part of cycle allocated to any traffic movement or combination of movements receiving right of way. The sum of the phase lengths (in seconds) is the cycle length.

Terminology

- Saturation Flow ($s$) - maximum flow rate that can pass through an intersection if the approach had constant green for one hour.

- Departure headway - Time spacing between vehicles entering the intersection.

- Saturation headway ($h_s$) - equilibrium headway (Greenshields)
Saturation flow rate is given by

\[ s = \frac{3600}{h} \]

Where:
- \( s \) = saturation flow rate in veh/h,
- \( h \) = saturation headway in s/veh, and
- 3600 = number of seconds per hour.

Saturation Flow Rate

- Saturation flow assumes constant vehicle demand is present when measuring the headway.
- Typical maximum saturation flow rate of 1900 passenger cars per hour per lane (pc/h/ln) is possible at signalized intersections, and is referred to as the base saturation flow rate.
- This corresponds to a saturation headway of about 1.9 seconds.
Lost Time
• Starts and stops mean a portion of the cycle length is not being completely utilized.

• This is called lost time (time which is not effectively serving any movement of traffic).

• Total lost time is a combination of start-up and clearance lost times.
  • Start-up lost times occur when a signal indication first turns from red to green, drivers in the queue do not instantly start moving at the saturation flow rate.

• Stopping a traffic movement also results in lost time – when the signal indication turns from green to yellow, the latter portion of time during the yellow interval is generally not utilized by traffic.

• Also, if there is an all-red interval, this time period is generally not utilized by traffic.

• These periods of time during the change and clearance intervals that are not effectively used by traffic is referred to as clearance lost time, $t_c$. 
Lost Time

Start-up and clearance lost times are summed to arrive at a total lost time for the phase, given as

\[ t_L = t_1 + t_2 \]  \hspace{1cm} (7.2)

Where:
- \( t_L \) = total lost time for a movement during a cycle in seconds,
- \( t_1 \) = start-up lost time in seconds, and
- \( t_2 \) = clearance lost time in seconds.

Effective Green

The effective green time is calculated as

\[ g = G + Y + AR - t_L \]  \hspace{1cm} (7.3)

Where:
- \( g \) = effective green time for a traffic movement in seconds,
- \( G \) = displayed green time for a traffic movement in seconds,
- \( Y \) = displayed yellow time for a traffic movement in seconds,
- \( AR \) = displayed all-red time in seconds, and
- \( t_L \) = total lost time for a movement during a cycle in seconds.
Capacity

Intersection approaches do not receive a constant green indication (as in the definition for saturation flow rate).

So capacity and is given by:

\[ c = \frac{s \cdot g}{C} \]  

(7.6)

Where:

- \( c \) = capacity (the maximum hourly volume that can pass through an intersection from a lane or group of lanes under prevailing roadway, traffic, and control conditions), in veh/h,
- \( s \) = saturation flow rate in veh/h, and
- \( g/C \) = ratio of effective green time to cycle length

Example

Given:

Intersection of two two-lane streets

- \( C = 60 \) sec
- 50-50 splits
- \( l = 4.5 \text{ sec/phase} \)
- \( h_s = 2.1 \text{ sec/veh} \)

Find:

Capacity of the northbound movement.