Network Signal Coordination

CIVL 4162/6162
Learning Objectives

- Define progression of signalized intersections
- Quantify offset, bandwidth, bandwidth capacity
- Compute progression of one-way streets, two-way streets, and networks
- Estimate progression by different types
Network Level Coordination

Offset $t_1$

Offset $t_2$

Offset $t_3$

Offset $t_4$ is fully determined by Offsets 1–3.
Optimization for Two or More Arterials

• When optimizing using Synchro’s ‘Network Cycle Length’, many times it gives ‘Mixed Cycle Length’ (and not multiple of minimum cycle length)

• When you use mixed cycle length, the progression can not be achieved.

• In such situation, you have to analyze the arterials independently.
Optimization for Two or More Arterials

• When the arterials are separately (independently) analyzed, progression on both arterials can be achieved.

• However, the offset for both the arterials shall be adjusted such that both the arterials get the desired progression.

• Usually, offset of one of the arterial’s is fixed (due to jurisdictional boundary, or other reason) and the offset for the other arterial is adjusted accordingly.
Here, both 14 Mile Road and Farmington Road are two arterials and both require progression.

Source: WSU CIVIL 7670
The timing plan for 14 Mile Road is as shown below.

Cycle Length = 80 sec: Offset for 14 Mile Road (East-West) = 29 sec

The timing plan (splits, phasing patterns and cycle length) for Cross Arterials (Farmington Road) shall also be the same, except OFFSET for Cross Arterial (Farmington Road).

The offset for Farmington Road in this example = 29 sec + 49 sec = 78 sec

Source: WSU CIVIL 7670
Arterials – A Practical Example - 2

Source: WSU CIVIL 7670
Arterials – A Practical Example - 2

The timing plan for 13 Mile Road is as shown below.

The timing plan (splits, phasing patterns and cycle length) for Cross Arterials (Farmington Road) shall also be the same, except OFFSET for Cross Arterial (Farmington Road).

The offset for Farmington Road in this example = 76 sec + (31 sec + 10 sec) – (80 sec) = 37 sec

Source: WSU CIVIL 7670
Single Left Turn Lane
Overflow and Blockage

Overflow

Blockage

Through Vehicle

Left-Turn Vehicle
## Available Methods

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Rule of Thumb Method

\[ L = K \left( \frac{V}{N_C} \right) S \quad \text{for signalized intersection} \]

and

\[ L = K \left( \frac{V}{(3600/I)} \right) S \quad \text{for unsignalized intersection} \]

where:

- \( L \) = storage length (ft)
- \( V \) = left-turn flow rate during the peak hour (vph)
- \( K \) = a constant to reflect random arrival of vehicles (usually 2)
- \( N_C \) = number of cycles per hour (for signalized intersection)
- \( I \) = average vehicle waiting interval in seconds (for unsignalized intersection)
- \( S \) = average queue storage length per vehicle (average distance, front bumper-to-bumper of a car in queue)
Queuing Based Method: Signalized

\[ n = \frac{\log P_n - \log (1-\lambda/\mu)}{\log (\lambda/\mu)} \]  \hspace{1cm} (16)

where:

- \( n \) = number of vehicles in the queue
- \( P_n \) = probability of \( n \) vehicles in the queue
- \( \lambda \) = arrival rate, equivalent passenger cars per second (pcps)
- \( \mu \) = service rate, equivalent passenger cars per second (pcps)

and, \( \lambda \) and \( \mu \) can be estimated by following Equations:

\[ \lambda = 1.1 \times \frac{V}{3600} \]  \hspace{1cm} (17)
\[ \mu = S \times \frac{(G/C)}{3600} \]  \hspace{1cm} (18)

where:

- “1.1” = adjustment factor for the equivalence of left-turn vehicles with a separate phase
- \( V \) = left-turn volume, equivalent passenger cars per hour (pcph)
- \( S \) = lane saturation flow, equivalent passenger cars per hour of green (pcphg)
- \( G/C \) = ratio of green time to cycle length (cycle split) for the turning-lane phase
Regression Based Method-Unsignalized

- Since queuing is not prevalent

\[ Q = f_2(D, G) \]

and

\[ G = f_1(V) \]  \hspace{1cm} (6)

where:

- \( Q \) = maximum left-turn lane length, in vehicles
- \( D \) = left-turn volume, in vehicles per interval
- \( G \) = total acceptable gap times in opposing traffic in a specific interval, sec
- \( V \) = opposing traffic volume, in vehicle per interval

The functions \( f_1 \) and \( f_2 \) were derived by regression analysis and the general forms of these two equations were given in Equation (7).

\[ G = f_1(V) = \alpha^g V^{g^0} \]
Final Exam and Class Project

- Based on input from all
  - Final exam: 10%
  - Class project: 25%
- Final Exam: December 7\textsuperscript{th}, 2:20-3:20pm
  - Bring A-4 size one page written formula
- Class Project Presentation: 3:30pm-5:00pm
  - 25 minutes presentation and 5 minutes Q&A
- Project reports are due at the beginning of class
Final Exam Content

• 10 questions in one hour
• Uninterrupted Facilities
  - LOS and Weaving
• Interrupted Facilities
  - Signal control, warrants,
  - Signal timing design (pretimed, and actuated)
  - Progression (single intersection, and network)
  - Before and After Studies
Example of a Question

- Determine if the following intersection can be safely operated under basic rules of the road.