Signalized Intersection Analysis and Level of Service

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Types of Traffic Signal Control

For Isolated Intersections (Free Mode):
- Fixed time
- Actuated

For Arterials, Corridors and Networks:
- Coordinated fixed-time
- Coordinated actuated

Optimal signal timing plan?
What do you exactly mean by that?

- Users' prospective ["I am stopping for too long compared to vehicles in the major street. That's not fair and not optimal"]
- System operators' prospective [minimize system wide delay, travel time, cost, and users' complains]
- Environmental advocates' prospective [minimize vehicle-related emissions]
- Politicians prospective ["whatever makes people (voters) happy is, for me, optimal"]

Semi-Actuated and Fully-Actuated Signals

Semi-Actuated Signals
- Green time allocated to major street except when there is a detector call on minor street
- Detectors on minor street ONLY
- Usually used in rural areas where side streets carry low volumes

 Fully-Actuated Signals
- Fully adjusts to traffic demand on ALL approaches
- Green time allocation based on detector actuation and minimum and maximum green time setting
- Detectors on all approaches
### Fully-Actuated Signals – Design Parameters

- **Minimum Green Time**
  Minimum green time allowed for the green phase

- **Gap/Passage Time**
  Maximum gap between vehicles arriving at the detector to retain a given green phase

- **Maximum Green Time**
  Maximum green time allowed for the green phase

- **Volume Density Settings**
  During peak period, it might be necessary to increase the maximum green time for the phase through volume/density setting

#### The Concept of Actuation

- **Design Volume**
  Maximum number of vehicles counted during the peak period

- **Typical 15-minute volumes in 2-hour peak period**
  Typical cycle-by-cycle volumes

- **Maximum Green**
  Phase Starts
  Detector Actuation
  Passage Time
  Yellow Interval
  Phase Terminates
  Detector Actuation on a Conflicting Phase

#### Operation of an Actuated Phase – Maximum Green Not Reached

- **Maximum Green**
  Phase Starts
  Detector Actuation
  Passage Time
  Total Green Time
  Extension Green
  Yellow Interval
  Phase Terminates
  Detector Actuation on a Conflicting Phase

#### Operation of an Actuated Phase-Maximum Green Reached
### Volume/Density Setting

- Time to Extend
- Maximum Extension
- Time Before Reduction
- Time to Reduce
- Seconds Per Actuation

### Operation of Dual-Ring Controllers

Each of the respective phase groups in the two rings must cross the barrier simultaneously to select and time phases in the phase group on the other side of the barrier.

### NEMA: Intersection Phases

### Actuated Signals - Detector Configuration

- Local signal controller communicates with all traffic detectors.
Actuated Signal Control Settings

- Eliminate dilemma zone
- Yellow Time (Yellow Change)
- All Red Time (Red Clearance)

\[ Y + R = T + \frac{V}{2A + 2G} + W + L \]

- \( Y \): length of the yellow interval; 
- \( R \): length of the all-red interval; 
- \( T \): driver perception/reaction time, recommended at 1.5 seconds; 
- \( V \): velocity of approaching vehicle; 
- \( A \): vehicle comfortable deceleration rate; 
- \( G \): grade of the signal approach in percent; 
- \( W \): width of intersection measured; 
- \( L \): length of vehicle clearance.

Pedestrian Times

Must be coordinated with vehicle signal phase (Minimum green values)

- 4 to 7 seconds recommended by MUTCD
- Don’t Walk Clearance

Must guarantee adequate crossing time for pedestrian safety (Average pedestrian walking speed is 3.5 to 4.0 feet/sec (elderly???))

Actuated Signal Control Settings – Max Green

- Maximum Green Time

Equation for through, right-turn, and protected left-turn traffic:

\[ G = 3.7 + 2.1N \]

Where \( N \) = Expected number of vehicles in the critical lane

Equation for unprotected left-turn, through, and right-turn traffic:

\[ G = 3.7 + 2.1N + 2.7L \]

Where \( N \) = Number of opposing through, and right-turn vehicles in the critical lane; \( L \) = number of left-turn vehicles in the critical lane.

Actuated Signal Control Settings

- Minimum Green Time

- Time for one vehicle to move into the intersection from the point of detection.

- Minimum green time setting should be at 4.0 to 5.0 seconds.

- Gap/Passage Time

Set according to loop spacing and travel speed of the road. The gap/passage time should not be less than 2.0 seconds.