Change and Clearance Intervals

A brief history

- Initial research and needs
- Original publications
- The kinematic equation
- The stopping probability method
- Inconsistent implementation
- Automated enforcement

NCHRP 731 Guidelines for Timing Yellow and All-Red Intervals at Signalized Intersection

- The perception reaction time was confirmed to be 1.0 s.
- The deceleration rate was confirmed to be 10 ft/s².
- The 85th percentile approach speed for through vehicles is closely approximated by adding 7 mph to the posted speed limit. However, if field data are not available, this estimation is acceptable.
- The 85th percentile approach left-turn speed is closely approximated by subtracting 5 mph from the posted speed limit. This estimation should be used to calculate the yellow change interval. For red clearance interval calculations, the left-turn speed should be considered as 20 mph, regardless of the posted speed limit.

\[ Y = \frac{0.47v^2 + 64.4g}{a} \]

Where:
- \( Y \) = Yellow Change Interval (sec)
- \( t \) = perception reaction time (sec) – recommend 1 second
- \( v \) = 85th percentile approach speed (MPH) *
- \( a \) = deceleration rate (ft/sec²) – use 10 ft/sec²
- \( g \) = grade (ft/ft) – positive for uphill grade, negative for downhill grade, round up to nearest grade

* In lieu of field measured speed data, the speed limit plus 7 mph should be used as a rule of thumb. For left-turning movements, 85th percentile speeds should be used for the approach (less than 20 mph; greater than 20 mph). If field data are available, the yellow change interval should be used to calculate the yellow change interval duration.

NCHRP 731 Guidelines for Timing Yellow and All-Red Intervals at Signalized Intersection

\[ R = \frac{W + L}{1.47V - 1} \]

Where:
- \( R \) = Red clearance interval (sec)
- \( W \) = Intersection width measured from the back edge of the approaching movement stop line to the far side of the intersection as defined by the extension of the curb line or outside edge of the farthest travel lane (ft)
- \( L \) = Length of vehicle (ft) (recommended using 20 ft)
- \( V \) = 85th percentile approach speed
ITE Proposed Recommended Practice
DRAFT Guidelines for Determining Traffic Signal Change and Clearance Intervals

\[ Y = \frac{1.47v}{a + 64.4g} \]

- \( Y \) = yellow change interval (sec);
- \( t \) = perception reaction time (sec);
- \( V \) = 85th percentile approach speed (mph);
- \( a \) = deceleration rate (ft/sec^2);
- \( g \) = grade of approach (percent)/100, downhill is negative.

Old Kinematic

\[ Y = \frac{1.47v}{2a + 64.4g} \]

NCHRP 731

\[ Y = \frac{1.47v}{2a + 64.4g} \]

Proposed ITE

\[ Y = \frac{1.47v}{2a + 64.4g} \]

Recommended ITE

\[ Y \geq t + \frac{1.47(V_{0d} - V_{1d})}{a + 64.4g} + \frac{1.47V_{1d}}{2a + 64.4g} \]

Revised ITE

\[ Y \geq t + \frac{1.47(V_{0d} - V_{1d})}{a + 32.2g} + \frac{1.47V_{1d}}{2a + 64.4g} \]
The Extended Kinematic Equation
Guidelines for Determining Traffic Signal Change and Clearance Intervals

- New element to the formula that was not balloted or peer-reviewed.
- Derived from characteristics of single driver.
- Maximum yellow time increased to 7 seconds.
- New speed modification element of intersection entry.
- Results in substantially increased calculated yellow times.
- Conflicts with MUTCD.
Moving Forward

FHWA Sponsored Pooled Fund Research

- Coalition of agencies supporting effort
- Broad spectrum of topics to be researched
- Red light running enforcement
- Permissive yellow vs. restrictive yellow laws
- Leveraging technology to broaden understanding of human factors (e.g., dilemma zone)
- Context

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- Eddie Curtis, PE, FHWA Office of Operations
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Letter from AASHTO

Committee on Traffic Engineering

- "CTE’s primary concern is the inclusion of the extended kinematic equation in the published guidelines"  
- "CTE requests that ITE rescind the guidelines as published"  
- "Our Committee will be advising our state agency members to not adopt the guidelines and await completion of upcoming research through pooled fund studies sponsored by the Federal Highway Administration"

Connected Vehicles and Red Light Violation Warning

Advanced Warning of End of Green

Beyond Clearance Intervals

Operations of Arterials and Traffic Signals

- Signal timing is not a maintenance activity
- Connection to safety and mobility
- Engineering thought and design to support CAV