Guidelines for Determining Traffic Signal Change and Clearance Intervals Recommended Practice FAQs

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Who developed the Recommended Practice?
The Recommended Practice was developed by a volunteer committee consisting of subject matter experts (SMEs), supported by a separate SME review panel and ITE staff. These individuals are listed in the front of the Recommended Practice document.

When did the update process start? How long did the process take? Why did it take so long?
The process started in 2007 and was completed in late 2019. The long duration was due to several contributing factors and occurrences, which included the completion of a related National Cooperative Highway Research Program report, the receipt of comments that required multiple review cycles to resolve, volunteer and ITE staff availability, and the overall complexity of the topic.

Does this new document replace an existing Recommended Practice?
No. Although several ITE technical publications contain guidance on this subject, ITE has not, up to now, had an adopted set of recommended practices on traffic signal change and clearance intervals.

What significant changes to current practices are contained in this new document?
While this is not an exhaustive list, the major changes to recommended practice are:

- Use of the extended kinematic equation rather than the traditional kinematic equation as the basis for calculating yellow change intervals.
- An increase in the recommended maximum change interval to seven seconds for left turning movements.
- No separate recommendation for right turning movements is included.
- Use of measured primary speed data is preferred whenever possible, however an approach for estimating approach speeds is offered if this data is not available.
- The Recommended Practice does not cover enforcement actions to address red light running, but cautions that zero tolerance enforcement is inappropriate due to the wide variety of factors and assumptions that are involved in calculating and implementing yellow change intervals.

What is the difference between a change interval and a clearance interval?
The change interval is the time provided to a driver after seeing a yellow indication to decide 1) to proceed through the intersection with sufficient time to enter, or 2) to come to a stop at the intersection. The clearance interval is the time provided for the vehicle to clear the intersection before a conflicting green indication is displayed. In the vast majority of U.S. States and Canadian provinces and territories, the change interval is provided by the yellow time and the clearance interval is provided through “all red” time. The ITE Recommended Practice is written from this perspective. In states with more restrictive laws (which require all vehicles come to a stop before entering the intersection once a yellow indication is displayed) both the change and clearance intervals are provided through the yellow indication.
How are differing driver characteristics and capabilities (old, young, aggressive, conservative) considered in these recommendations?

Drivers can exhibit a wide range of possible behaviors that affect calculation of traffic signal change and clearance intervals, from aggressive to conservative, faster to slower driving speeds, faster to slower perception and reaction times, etc. The recommended practices are based on the behavior of “reasonable” drivers (the vast majority), but not necessarily the behavior of all drivers.

What is the primary difference between the kinematic equation and the extended kinematic equation?

The primary difference is that the extended kinematic equation includes an additional term to account for the slowing that occurs as a turning vehicle approaches an intersection.

How will use of the extended kinematic equation affect change intervals calculated for turning movements?

This will vary by location, but in general change intervals (yellow times) calculated using the extended kinematic equation will generally be slightly longer than change intervals calculated using the traditional kinematic equation at lower approach speeds and more significantly at higher approach speeds. For example, for a 30 mph approach speed, with all other standard assumptions, the traditional kinematic equation will calculate a change interval of 3.2 seconds while the extended kinematic equation will calculate 3.9 seconds, a difference of 0.7 seconds. For a 50 mph approach speed, the traditional kinematic equation calculates a change interval of 4.7 seconds while the extended kinematic equation calculates 6.9 seconds.

If left turn vehicles are slowing to turn, why is the yellow time longer? This seems counterintuitive.

Picture a roadway with a one lane approach accommodating both through and turning movements. There is a critical distance from the intersection where a driver is equally likely to stop or proceed if a yellow indication is displayed. The driver traveling through the intersection that decides to proceed will maintain speed, and the yellow time calculated using the extended kinematic equation is the same as that calculated using the traditional kinematic equation. The driver that is turning left and decides to proceed will need to decelerate to comfortably make the turn. Doing so will lengthen the amount of time needed to enter the intersection before the red indication is displayed. The extended kinematic equation provides this additional yellow time. At low approach speeds the difference in the yellow time needed by through and turning vehicles is small, however, at higher speed approaches it can be more significant.

How will use of the extended kinematic equation affect change intervals calculated for through movements?

For through movements, there would likely be no change to previously calculated values. The extended kinematic equation reduces to the traditional form of the kinematic equation when the intersection entry speed is set equal to the intersection approach speed (i.e. no slowing for through vehicles approaching the intersection).

What are the practical considerations in determining the appropriate change and clearance interval?

Determining appropriate change and clearance intervals is a process of trying to account for a range of possible driver behavior, mix of traffic (cars, trucks, etc.) and other users, traffic movements (through or turning), intersection geometry, and other factors. The goal is to provide change and clearance intervals that focus on safety for all users, but also do so in a practical manner.
Why is there no specific recommendation for right turn movements?
There is limited research on the complex nature of driver behaviors, interactions, and theoretical formulations for right turn maneuvers and some elements of these factors are not completely understood. As a result, ITE did not feel comfortable in offering separate recommendations for right turning movements. In our judgement the recommended calculation procedures for through and left turning movements will safely accommodate right turning vehicles. However, additional research has been recommended by ITE on the topic of right turn movements.

There is a 7 second maximum time recommended for the change interval for turning movements, even if the formula calculates a higher number? Why?
Transportation professionals have long been concerned that change intervals that are long in duration increase the likelihood that more familiar drivers will decide to continue through the intersection, potentially creating conflicts with unfamiliar drivers and other system users. The Manual on Uniform Traffic Control Devices (MUTCD) contains a longstanding guidance statement that yellow time should not exceed 6 seconds. Recommending a 7 second maximum yellow time for turning movements is an acknowledgement that turning vehicles which do not stop when a yellow indication is displayed may need a longer time to enter the intersection, but there is a practical limit to how much additional time should be provided in order to avoid the worst of the potential adverse effects of longer yellow times. Using the default assumptions the 7 second maximum accommodates use cases up to 50 mph encompassing the vast majority of intersections.

Is the maximum change interval for through movements also 7 seconds? Is there a minimum recommendation for the change interval? How about for the clearance interval?
No. For through movements, the recommended maximum change interval is 6 seconds and the recommended minimum change interval for both through and turning movements is 3 seconds. This is consistent with the MUTCD guidance statement for 3 to 6 second change intervals. For all red clearance intervals, both the ITE Recommended Practice and the MUTCD recommend a maximum of 6 seconds, if used. There is no recommended minimum time for an all-red clearance interval, if used.

How do you adjust for upgrade or downgrade slopes on approaches at an intersection?
A simple factor has been added to the extended kinematic equation to reflect upgrade or downgrade slopes on approaches at an intersection. This factor will add a small amount of time to the change interval for downgrades and subtract a small amount of time for upgrades.

What is the 85th percentile speed? How is it calculated?
The 85th percentile speed in a free flowing traffic stream with a typical distribution of driver behavior is the speed value that 15% of drivers exceed and 85% of drivers travel at or below. This speed is widely considered to be the speed that captures all “reasonable” drivers. It should be determined periodically for all approaches to an intersection. 85th percentile speed is calculated by collecting speed data for vehicles over a period of time, arraying the data by value, and determining the speed breakpoint that divides the fastest 15% of vehicles from the 85% of slower vehicles.

Where and how should approach speed and intersection entry speed be measured?
Approach speed is the 85th percentile approach speed as determined under free-flow conditions, if known or as determined by a speed study. The 85th percentile approach speed should be measured on the intersection approach, upstream of the area of influence of the intersection operations.
Intersection entry speed should be measured at the point where the approaching vehicle crosses the stop line (if none, the nearest side of the crosswalk, if none the extension of the curb line or edge of roadway of the near side of the cross street). The speed used is suggested to be the 85th percentile of intersection entry speed data collected. Speeds may be measured using traditional data collection methods such as radar, lidar, video, or paired road tubes. Alternatively, certain types of traffic signal detectors measure passage speed mid-block and/or near the intersection threshold and can yield a reasonable approximation of the approach speeds depending specific location.

I understand that the extended kinematic equation has been used to calculate change and clearance intervals in few, if any, real-world locations. Why is ITE recommending use of a method that has so little implementation experience?

ITE believes that the extended kinematic equation has a sound theoretical basis for use in calculating change and clearance intervals for through and left turn movements (in fact, for through movements, the extended kinematic equation reduces to the more familiar traditional kinematic equation). We believe its use will result in slightly longer but more appropriate change intervals for left turning movements, which should enhance safety. ITE will seek to monitor real world experience with the extended kinematic equation to capture user experience, including any concerns or unintended consequences.

I understand that at least some of the Recommended Practice was developed through a survey. Who took the survey and how many people responded?

The survey, which was designed to identify differences and similarities in methods and factors used in current traffic signal change interval practices by public agencies, was distributed to about 2,000 transportation professionals employed by public agencies in 2009. A copy of the survey is included in the Recommended Practice. About 270 responses to the survey were received.

What other information / evidence was considered in developing the Recommended Practice?

In addition to the survey, the development of the Recommended Practice relied on an extensive review of existing literature, expertise and experience from involved subject matter experts, input from transportation professionals gathered at ITE meetings, through webinars and other outreach activities, and comments received through several review and appeals cycles as the Recommended Practice was being developed.

What were the opportunities for input and comment on this Recommended Practice before it was finalized?

A draft of the proposed Recommended Practice was published for comment in February 2015 and extensive comments were received and largely resolved. Notices of Intent to Adopt the Recommended Practice were published and the draft report was available for comment in September 2018 and May 2019. Appeal of several specific items were received each time and resolved, the last eight items through an Appeals Panel meeting held in August 2019.

I understand that some of the recommendations resulted from an appeals process. How does that process work? What issues were appealed? How did input from the appeals process influence the final content of the Recommended Practice?

The final step in the adoption of an ITE Recommended Practice is the opportunity for individuals or agencies to appeal the content of specific provisions. In this case, 5 appellants appealed 8 specific
issues, which were reviewed by a 3 person panel of uninvolved subject matter experts who heard verbal arguments from the appellants and a representative of the Technical Committee. The appeals panel decided four issues in favor of the appellants and four in favor of the Technical Committee. On the most significant issue where the appeals panel found in favor of the appellants, ITE was directed to reconsider the inclusion of the extended kinematic equation for tuning movement change interval calculations.

I keep hearing the term “dilemma zone” used when this topic is discussed – what is that?
In general, the “dilemma zone” refers to a portion of the intersection approach where a driver can neither comfortably stop nor continue through the intersection before the end of the yellow change interval, and thus is faced with a “dilemma.” The goal of a well-timed yellow change interval is to eliminate the dilemma zone by allowing sufficient time for a driver deciding to continue through the intersection to enter the intersection before the signal turns red or stop safely. It should be noted that yellow change intervals established based on the procedures of the Recommended Practice eliminate the dilemma zone, but there will always be an indecision zone because different drivers respond differently to the same set of circumstances.

Are use of recommended practices mandatory?
No. ITE recommended practices are voluntary standards that may be adopted, in whole or in part, or not used at the discretion of segments of the transportation profession to which they are directed (public agencies which own and operate traffic signals in this case).

How many places follow ITE’s current technical guidance on change and clearance intervals (use of traditional kinematic equation)?
This is difficult to know for certain, but in the 2009 survey, about 40% of respondents indicated that they used the kinematic equation for calculating yellow change intervals.

Do agencies that adopt the recommended practices need to retime all of their traffic signals? If so, how long will that take? If not, what do they need to do?
Agencies that choose to adopt the recommended practices may need to recalculate change and clearance intervals for at least some of their traffic signals or some movements at their traffic signals. Decisions regarding implementation of any resulting changes and the time period taken to implement them rest with each agency.

How do the recommended practices relate to red light camera enforcement? What does the recommended practice say about photo enforcement?
The Recommended Practice does not cover enforcement actions, either through traditional or automated means – it is intended to support the development of safe and appropriate change and clearance intervals. However, the Recommended Practice does include a note cautioning against enforcement of red light violations with zero tolerance due to the wide range of factors and assumptions regarding driver behavior that are used in the calculation of yellow change intervals.

Does ITE have a policy on red light camera enforcement?
ITE has no current adopted policy on automated enforcement. However, a new policy has been proposed as part of a current review of ITE policies. The comment period on this policy recently closed and final adoption of this and other ITE policies will occur at the April 2020 meeting of the ITE International Board of Direction. The proposed policy strongly supports automated enforcement for
purposes of improving safety, but not for a goal of raising revenue.

If a vehicle enters the intersection before the signal turns red, but is still in the intersection when it turns red, is that legal?
This is legal in the vast majority of U.S. States and Canadian provinces and territories. The remainder of jurisdictions require a vehicle to come to a stop before entering the intersection once a yellow indication is displayed.
Traffic Signals 101

- It is estimated that there are about 328,000 traffic signals in the United States (using an accepted rule of thumb of one signal per 1,000 population).
- Responsibility for the management and operation of roadways (and traffic signals) is shared between State Departments of Transportation and local governments and varies from State to State. There are more than 2,000 separate agencies responsible for traffic signal management and operation throughout the United States, with a significant percentage of these responsible for fewer than 50 traffic signals. Across the U.S., approximately 20% of signals are managed by state agencies and the remaining 80% by municipal or county agencies.
- The basic operation of a traffic signal involves allocating the available time to each leg of the intersection, for each movement (through or turning) and each indication of the signal (red, yellow, green). This is done through settings in a traffic signal controller.
- The cycle length is the total amount of time it takes a traffic signal to serve each leg of the intersection, all movements and all phases. Cycle lengths typically range from 60 sec. at a simple intersection to as much as 180 sec. at a more complex one.
- The yellow change interval coincides with the amount of time given to allow vehicles to either travel the distance to brake to a stop or proceed through the intersection before the signal turns red. In addition, some jurisdictions use a short “all red” clearance interval providing additional time for vehicles entering an intersection on yellow to clear the intersection.
- Traffic signal controller settings may be changed remotely through a central system or locally at each intersection depending on the type of system being used by the jurisdiction managing the signals.
- The frequency of update of traffic signal timing varies from jurisdiction to jurisdiction. General practice is to review the settings every 3 years and update as necessary. In practice, updates occur more or less frequently depending on the degree to which travel patterns are changing and the available staff and financial resources of the jurisdiction.