Guidelines for Determining Traffic Signal Change and Clearance Intervals

By Douglas E. Noble, P.E., PTOE (F)

ITE has concluded a years-long effort to issue guidance on yellow change and red clearance intervals for signalized intersections. The final version of the Recommended Practice Guidelines for Determining Traffic Signal Change and Clearance Intervals (RP-040B) has been adopted by the ITE International Board of Direction and is now available.¹
Background

With the importance of this topic and the amount of study devoted to it, a consensus has been difficult to reach over the years on the most appropriate method of timing the yellow change and red clearance intervals at traffic signals. ITE published a proposed recommended practice in 1985 titled *Determining Vehicle Change Intervals* that was not ratified by the ITE International Board of Direction to become a recommended practice. Nine years later, ITE published an informational report titled *Determining Vehicle Signal Change and Clearance Intervals*. In 2001 ITE published another informational report, *A History of the Yellow and All-Red Intervals for Traffic Signals*, summarizing the development of practice up to that year.

In the interim, changes in technology, automated enforcement, the availability of new primary data, further research, as well as the public and professional concern that a defined standard of reference did not exist with regard to this topic, have led to the initiative to develop this report. Conversations between ITE leaders and the Federal Highway Administration identified specific guidance on engineering methods for traffic signal change and clearance intervals as a gap in engineering practice in the period. This took place immediately prior the October 2007 release of the request for proposals for the National Cooperative Highway Research Program (NCHRP) project that would become NCHRP Report 731: *Guidelines for Timing Yellow and All-Red Intervals at Signalized Intersections*. However, ITE’s development process for recommended practices follows a different development model than NCHRP projects, and includes peer review, a public comment period on the proposed recommended practice, and an appeals process.

ITE began the initial work drafting a recommended practice with launch of the NCHRP project in 2008. An initial draft of the report was completed prior to the release of NCHRP 731 in 2012. Subsequently, the recommend practice was completely revised by the volunteer technical committee, as well as a round of review panel comments leading to the release of the proposed recommended practice in February 2015. The technical committee, with ITE staff support, worked through addressing the public comments with detailed responses to each commenter and the review panel completed another evaluation on the resulting document. As result of this input and hundreds of individual comments from the technical committee, review panel, and public across multiple drafts, the recommended practice was reviewed and responses prepared. In September 2018, ITE issued a Notice of Intent to Adopt the recommended practice, which was appealed. The technical committee—again working with ITE staff—prepared responses to the appeals, the technical committee made changes where there was agreement, and ITE issued a second Notice of Intent Adopt, that was also appealed. This led to the convening of an Appeals Panel on August 28, 2019 and the ensuing guidance providing direction for concluding the technical revisions to the final version of *Guidelines for Determining Traffic Signal Change and Clearance Intervals Recommended Practice*.

Outreach and Survey

A survey of practice on the subject was coordinated between ITE and the NCHRP research project team, and ITE staff acted as a liaison to the research project. The survey sought to identify differences and similarities in methods and factors used in traffic signal change interval practices from a cross-section of national and international agencies. The results of the survey are shared in the state of the practice section of the recommended practice for each topic related to methods and values for determining yellow change and red clearance intervals.

During the development period, ITE hosted several roundtable discussions at its Annual Meetings and technical conferences where the needs of public agencies were clearly outlined. In addition, a number of individuals who would eventually become appellants presented their approaches at the ITE Annual Meetings in Anaheim, CA, USA and Hollywood, FL, USA.

Purpose and Intended Use

While municipal, county, and state jurisdictions have defined practices or procedures on the determination of change and clearance intervals at signalized intersections, historically there has been a lack of consensus best practices available in the United States and Canada. The guidelines are based not only upon existing information found during the initial research, but also on the collective experience of ITE staff, committee members, peer review panel, and others who participated in the development process.

ITE’s intent for the proposed recommended practice is to reflect a thoughtful balance between sound engineering theory and practical application. The recommendations presented in the report should yield reasonable times for the yellow change and red clearance intervals for traffic signals. These will allow the profession to balance those durations while enhancing intersection safety, maintaining reasonable traffic flow, and providing for movement of vehicles, bicycles, and pedestrians. The goal of the recommended practice is to create a consensus methodology for calculating and evaluating traffic signal change intervals that can be uniformly and consistently implemented by transportation agencies.

This report should not supersede engineering judgment. It is anticipated this document will be updated periodically to refine the procedures based on experiences of agencies using it and studies performed by the research community. Note that this report is specifically focused on the timing of traffic signal change intervals and does not discuss or intend to discuss pedestrian signal change intervals.

State of the Practice and Current Research

The report describes the sources of methods and values presented in the recommended practice to address the goal of the engineering profession to determine the appropriate duration of yellow change and red clearance intervals that provide for intersection safety while retaining a high level of operational efficiency. A broad cross-section of
topics affecting the timing of yellow change and red clearance intervals are addressed through discussion of the relevant literature, including the foundational work of DeGazis, Herman, and Maradudin, as well as research identified in the literature review, the current state of practice, comments received throughout during the drafting process, and the recommendations applied in the guidance. Those topics include:

- Calculation method
- Variance in vehicle codes
- Perception-reaction time
- Speed
- Deceleration
- Intersection width
- Vehicle length
- Grade
- Minimum and maximum intervals
- Rounding calculated intervals
- Use and calculation of red clearance interval
- Turning movements
- Other road users
- Special road conditions
- Implementation
- Safety
- Driver behavior

In addition, the report identifies topics recommended by ITE for additional study or new research that would be helpful to expand the body of knowledge on this topic (discussed in more detail in Jeff Lindley’s article on page 32).

**Recommended Methods of Determining Yellow Change and Red Clearance Intervals**

**Summary**

The report provides a description of the recommended methods to calculate traffic signal change and clearance intervals. The calculation methodology in the report is based on the extended kinematic equation and is shown in both U.S. and metric units. The report provides guidance for applying the methodology and for selecting input values for both through and turning movements at signalized intersections. Input values include perception-reaction time, approach speed, deceleration rate, approach grade, intersection width, vehicle length, and conflicting movement start-up delay. The report notes application techniques for wide intersections and bicycle traffic. The application of measures of effectiveness and recommendations for monitoring and evaluation close the report.

**What’s New**

The final recommended practice was updated in response to comments received on the proposed version of the document and the guidance provided by the panel convened to adjudicate appeals on the report. As a result there a number of new or revised elements in comparison to previous practice documents and previous versions of the proposed recommended practice as follows.

- The recommended calculation method uses an extended kinematic equation formula as the basis for calculation of change intervals, which is documented in the literature review (Jay Beeber (M) provides an explanation of Mats Järlström’s derivation of the extended kinematic equation on page 34). Text and formula references in the guidance emphasize that the calculation of the yellow interval is the minimum value.
- With the use of the extended kinematic equation, the discussion of application to left turning movements has been expanded to include intersection entry velocity and an allowance for the use of longer change intervals for these movements of up to maximum value of seven seconds. In addition, guidance is provided for several typical signal phasing methods.
- Since there is limited research on the complex nature of driver behavior, interactions, and theoretical formulation for right-turn maneuvers, some elements of these factors are not fully understood. Therefore, more information is necessary before making a definitive, separate recommendation for change and clearance intervals for right-turning vehicles.
- Inclusion of a simple grade factor in the extended kinematic equation formulation for non-zero grades.
- Supplemental discussion and guidance related to determining intersection width.
- Modification of the discussion on the use of conflicting movement start-up delay and removing the requirement for the use of non-zero value.
- Use of measured primary data is preferred wherever possible.
- An approach for estimating values of approach speeds is offered for when the primary 85th percentile speed data is unavailable.

**Additional Information and How to Purchase a Copy**

Additional information on the recommended practice, how to purchase, and other supporting material is available at: https://www.ite.org/technical-resources/topics/traffic-engineering/traffic-signal-change-and-clearance-intervals/. The publication may be purchased through the ITE Bookstore.

Members: $75.00 (electronic or print format)
Non-members: $150.00 (either format)
Emphasis on the use of engineering judgment is woven throughout the recommend practice.

The report provides the equations for calculation of the yellow change and red clearance intervals, rather than look up tables, to emphasize the need for the practitioner to have thorough understanding of the formulation.

The is a strong theme in the recommended practice for documentation of decision-making regarding the choice of yellow change and red clearance intervals.

This report is not intended to cover specific enforcement actions to address red light running, but does acknowledge that the range of values for variables used in calculating change intervals and the range of driver behavior they represent makes zero tolerance enforcement inappropriate.

References

Douglas E. Noble, P.E., PTOE (F) is senior director, management and operations with ITE, where he is responsible for integrating transportation system management and operations into various ITE products, programs, and professional development, with a particular emphasis on traffic signals. He holds a bachelor of science in civil engineering from Purdue University and master of science in engineering from the University of Texas. Doug serves as a council member for the Town of Vienna, VA, USA.