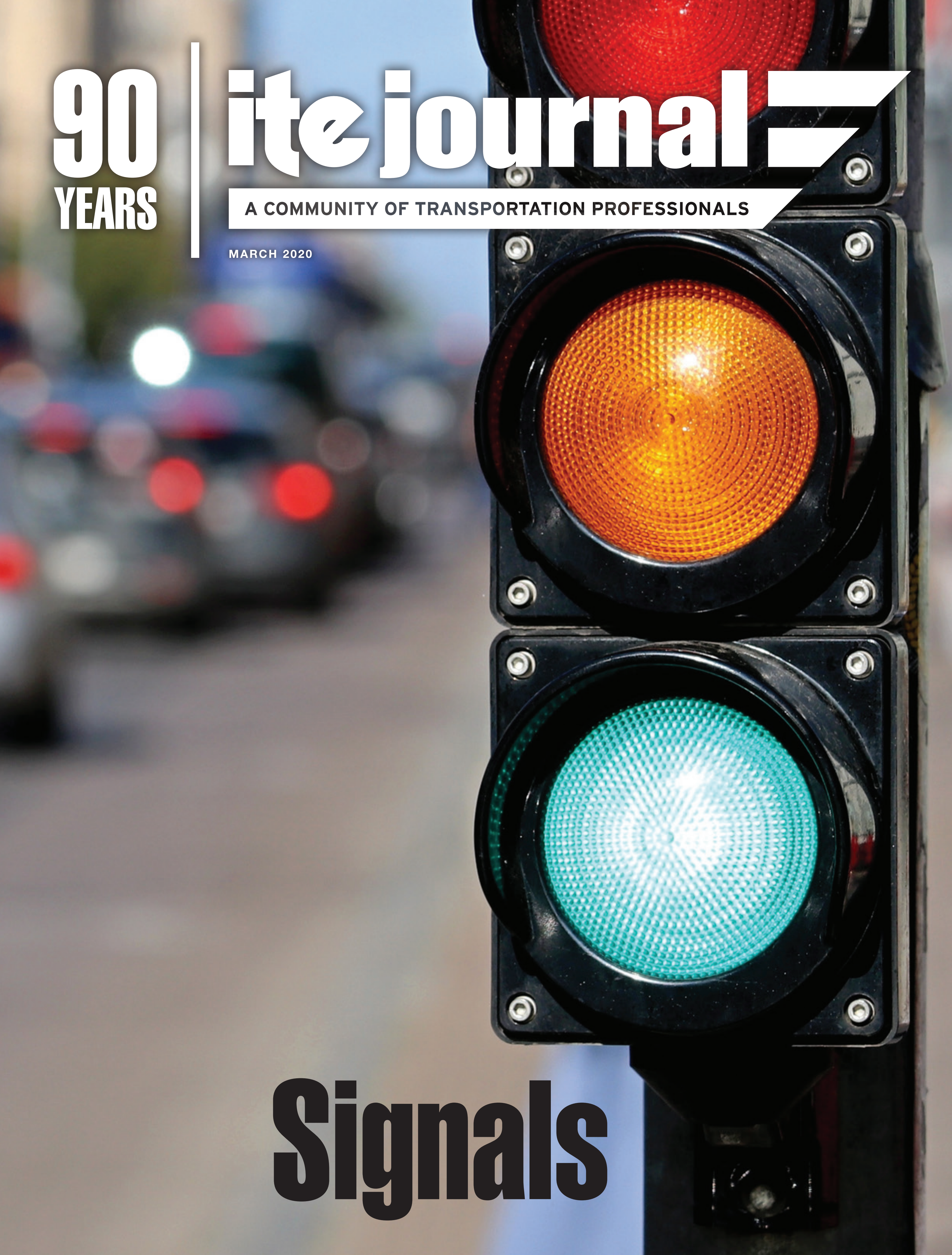

90 YEARS

ite journal

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MARCH 2020

Signals

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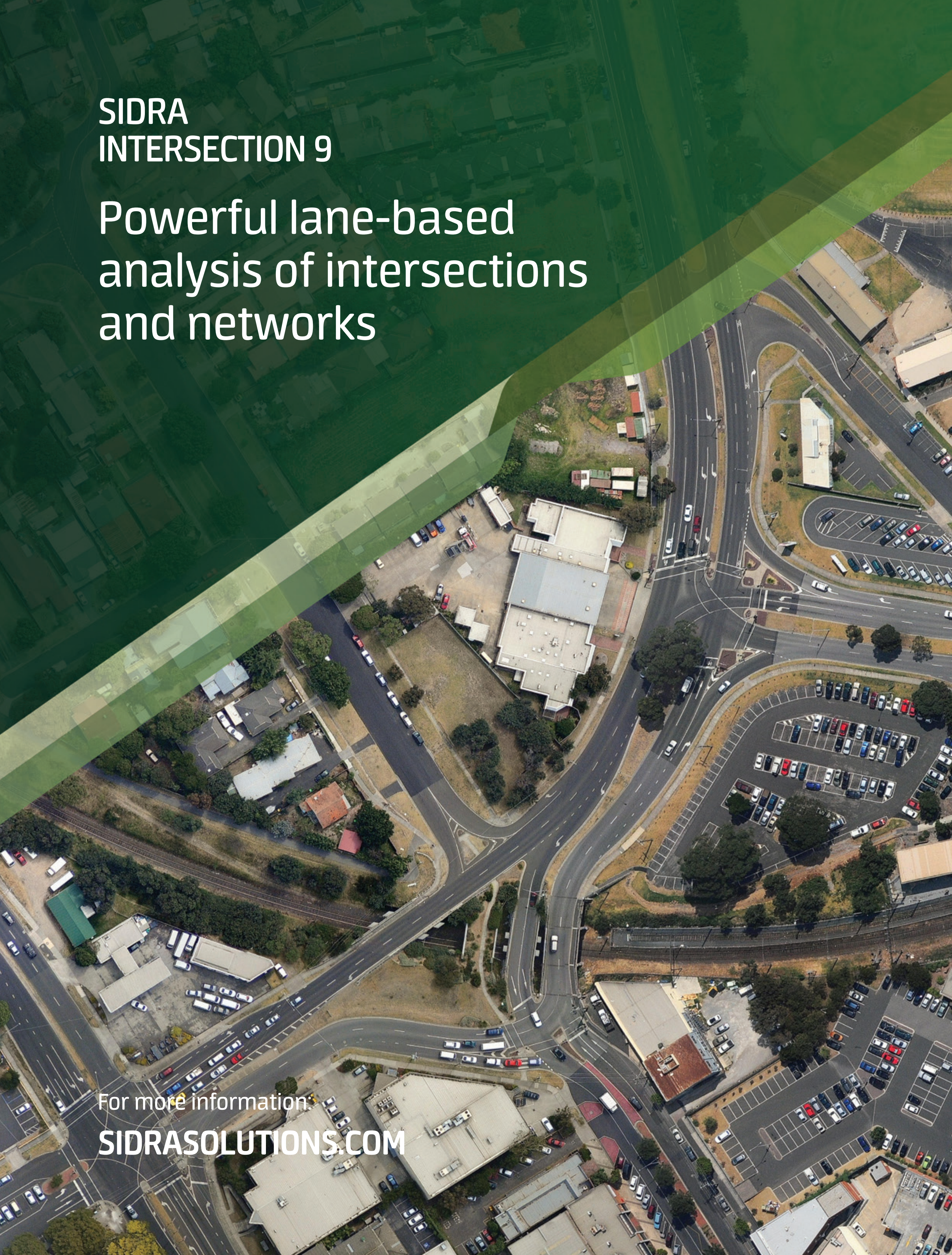

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Signals Are Us

RANSFORD S. MCCOURT, P.E., PTOE (F)
ITE International President

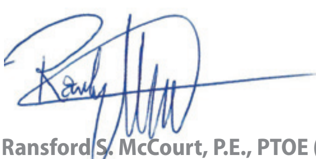
Upon graduating from the University of California–Berkeley, I had no idea the significant role traffic signals would play in my career. While I received more than my share of *Highway Capacity Manual* training from Dolf May, I didn't know jobs revolved around traffic signals. Moreover, I wanted to pursue transit-related planning and design and wanted little to do with signals. I quickly learned that knowledge of signals provided a gateway to transit projects. I had the great fortune to be mentored by pioneers in transit priority (**Hans Korve, P.E. (F)**, **Paul Olson, P.E. (F)**, Warren Tighe, Peter Coffey) and rapidly found my fear of signals was unwarranted. I became curious about how they could play an important role in safety, mobility, and transportation solutions for communities.

Traffic signals are a highly visible and familiar aspect of people's daily lives that they may not know much about. I coached youth sports for 10 years, and all the parents wanted to know was how I was going to turn the signals green for them. When I would speak to high schoolers about a career in transportation and asked about the height of a traffic signal, they would put their hands a few feet apart. When enlightened that they were actually taller than many of them (with backplates), they became incredulous.

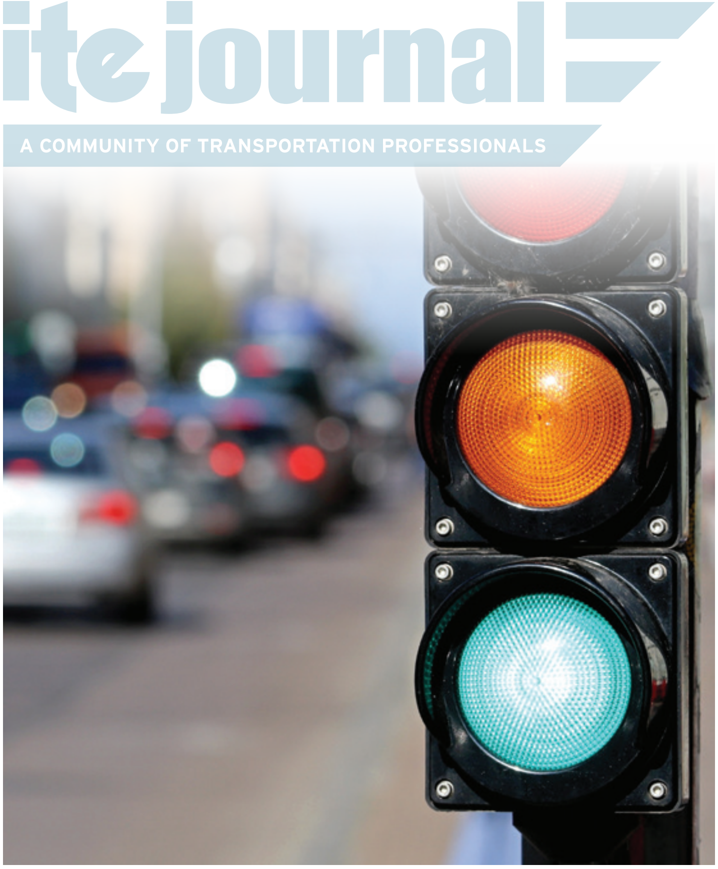
Now when a person tells me they work on traffic signals, I ask, "What aspect? Planning, analysis, design, systems, technology/equipment, construction, operations, maintenance, timing, or priority?" I have benefitted from having experiences in all these areas and discussions with passionate and knowledgeable people. There are many lions in our industry who have advanced traffic signals. **Mark Taylor, P.E., PTOE (M)**, **Darcy Bullock, P.E. (M)**, **Eddie Curtis (M)**, **Susan Langdon, P.E., PTOE (F), Pam O'Brien, P.E., PTOE (M)**, John Thai, **Wayne Kittelson, P.E. (M)**, Larry Head, **Randy Johnson, P.E., PTOE, ACTAR (M)**, **John Fisher, P.E., PTOE (R)**, **Ronnie Bell, P.E. (F)**, **Michael Kyte, P.E. (M)**—the list goes on. I would encourage you at a future ITE meeting to seek out these people to find out what they're curious about regarding signals. You'll be amazed at the developing trends and how they likely relate to what you're doing.

From micro-simulation to advanced controllers to clearance times, ITE members are constantly in pursuit of emerging practice using traffic signals to solve the mobility needs of our communities. From big data to connected vehicle technology, how we plan, design, and operate signals is changing. Our members are incorporating sustainability practices in design, addressing climate change effects on pole designs, making communities more accessible, improving community design with art on controller cabinets, and applying state-of-the-art technology detection practices and data to improve safety. And I'm just getting started.

In this issue, we highlight the next step in a long journey to define yellow clearance intervals. This change involves a diverse set of opinions and science. I know many of you won't be as passionate about clearance time as others, but we're all passionate about reducing fatalities. About one-quarter of all traffic deaths occur at intersections in the United States. There's ground to improve, and people are looking to us. Traffic signals are us.



Ransford S. McCourt, P.E., PTOE (F)
ITE International President



SHUTTERSTOCK/SEROV ALEKSEI

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How Hard Can That Be?

Let's imagine that, at a neighborhood party, I tell one of my friends that ITE had been working on a recommended practice on clearance intervals. Once I got past explaining to him or her, "This means determining how long the yellow (and sometimes all red) light stays on at a signal," I am pretty confident the reaction I would get is, "How hard can that be?"

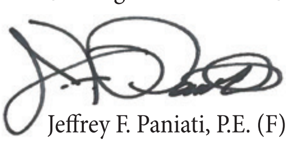
Assuming that they didn't immediately walk away to find a more interesting conversation, I might ask—Should the signal be timed for your 18-year-old son or 85-year-old mother? Should we assume the driver is paying attention, or distracted in some way? Will the driver be going below, at, or above the speed limit when they have to make a decision to stop or go? Will the vehicle be going straight through the intersection or turning? Like many things in life, something that seems very simple on the surface gets very complex once you start digging in.

This issue of *ITE Journal* features the release of the ITE Recommended Practice *Guidelines for Determining Traffic Signal Change and Clearance Intervals.* This recommended practice is more than 10 years in the making. Over the last three years we have published the recommended practice twice for member comment, held an appeals hearing, and made a number of adjustments and changes. Articles by **Doug Noble, P.E., PTOE (F)** and **Jeff Lindley, P.E. (F)** highlight key considerations and areas where we still need more research to fully understand driver behavior at traffic signals. Also included is an article by **Jay Beeber (M)**, one of the appellants, explaining why he advocated for a more precise formulation of the theory underpinning clearance interval computations.

In the final recommended practice we have tried to strike a balance between theory and real world considerations. We adopted the extended kinematic equation as the most appropriate representation of the physics involved, but we also recognize that transportation engineers must consider many factors in determining the appropriate clearance interval at a particular location. We have strongly encouraged the use of data in making these decisions, particularly in situations like protected left turns at higher speed intersections where the speed of entering and exiting vehicles and the size and design of the intersection significantly impact the time needed.

As we work to help all users—drivers, bicycles, pedestrians—get to their destinations in a timely manner, we have to keep safety at the forefront. Another consideration with clearance intervals is their relationship to automated enforcement. Given the complexity involved in setting appropriate clearance intervals, this recommended practice makes a very clear statement with regard to how aggressive jurisdictions should be in enforcing red light violations. In conjunction with this recommended practice, the ITE International Board of Direction proposed a new ITE Policy on Automated Enforcement. ITE strongly supports automated enforcement, not with a goal of raising revenue, but for the purposes of enhancing safety.

So there you have it. A simple question with a not so simple answer. We hope that this recommended practice furthers the understanding of appropriate clearance intervals and incentivizes additional research on the subject. As always you can reach me at jpaniati@ite.org or on Twitter: @JeffPaniatiITE.



Jeffrey F. Paniati, P.E. (F)
Executive Director and Chief Executive Officer

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PEOPLE IN THE PROFESSION

Industry Update

Sam Schwartz is proud to announce **Michael A. Shamma, P.E.** as president and **Meera Joshi** as principal and New York general manager. **Samuel I. Schwartz, P.E. (F)** will continue to serve as CEO. Mr. Shamma previously served as senior vice president and northeast area manager. He was previously northeast transportation business line leader for another national firm, spearheading DOT and tollway business strategy. Mr. Shamma also served as chief engineer of the New York State Department of Transportation and chief engineer of the New York State Thruway Authority and Canal Corporation.

A global transportation leader with wide-ranging experience navigating technological and regulatory change, Ms. Joshi is uniquely poised to help clients navigate a rapidly transforming mobility landscape. Ms. Joshi served as Chair and CEO of the New York City Taxi and Limousine Commission from 2014-2019 and, most recently, a visiting scholar at New York University's Rudin Center and an advisor to Remix.

Obituaries

ITE recently learned of the passing of the following member. We recognize his contributions to ITE and the profession, and we send condolences to his family.

John Foster, P.E. (F) of Wellington, New Zealand passed away on December 8, 2019. He was a Life Member of ITE. **itej**

New Members

ITE welcomes the following new members who recently joined our community of transportation professionals.

Canadian
Mo Askarian, P.Eng.
Danae Balogua
Greg Borisko
Aaron Dixon, MCP
Christine Edward
Anthony Ferrise
Mike Field, MIES
Mark Fisher
Stephen Gagne, E.I.T.
Jared Hebbs
Samer Inchasi, P.Eng., PMP
Evan Kanak, E.I.T.
Sarah Keene, E.I.T.
Mickaila Komonosky, E.I.T.
Jiu Tang Liu
Peter Locs
Jim Lowrie
William May
Michael Nguyen
Amy N. Parker
Tobi Pettet
James G. Rose
Andrew Sedor CIP, APPI
Erin Skimson
Crystal Trang, E.I.T.
Parker Wade Trimp, E.I.T.
Ryan Yuha

Florida Puerto Rico
Cristobal Afanador
Lucia Andrew
Jeff Bishop
Neil Byrne, P.E.
Sneha Chityala
Stefan Escanes
Mukunda Gopalakrishna, P.E., PTOE
James Hannigan, P.E.
Tate Reed

Global
Cassandra Min

Great Lakes
Brian Blayney
Jill Bosserd
Aashish Chaudhary
Wyatt Allen Huber
Samuel Jablonowski
Eric Lentz
Mark McCulloch
Sai Sravya Polavarapu
Erica Toussant

Mid-Colonial
Samuel Asare-Adjebeng
Lydia Conrad
Joseph Gurinko
Benjamin Guthrie
Seifu Hailu, P.E.
Jon Ryder
John E. Snedeker
William Weismantel

Midwestern
Rashmi Brewer
Joshua D. Clark
Erin Jordan
David M. Kratz
Michael J. Kronzer, P.E.
Jeremy Lee, E.I.
Shauna R. McIntire, E.I.T.
Sarah Okerlund
Nicholas C. Olson, P.E.
Miao Pan
Ashley Roup, P.E.
Kimberly R. Zlimen, P.E.

Mountain
Omar Aboulaban
Carlos Alfredo Botello
Clayton Brown
Lonnie Brown
Isaac Chavez
David Cox
George Eveleth
William Gil
M.J. Maynard
Libby Nordeen
Yelena Onnen, AICP
Lucien Paet, P.E.
David D. Quintana, P.E.
Chris Schwarz
Kim Vongries
Jenny Wolfschlag

Northeastern
S. M. Aftatul Aman
Samantha Arnold
Desiree Ascrate
Stephanie Bogue
Nicholas Campbell
Christopher J. Lew
Karnvir Mashiana
Nikhil Ramachandran

Southern
Jason Allinder
Nicholas S. Barnard, E.I.T.
Ems Baskins
Anthony H. Bouie
Jacob Austin Carson
Zachary Thomas Domingue
Randy Edwards
Patrick Fitzsimmons
Ligia C. Florim, P.E.
Michael Francis, P.E.
Ana Catalina R. Fraundorf
Samuel Hebb
Aaron Heustess, RSP1
Adika Iqbal
Ravina N. Jain
Zhu Qing
Drew Raessler

Texas
Kati Alcantara, E.I.T.
Nick Belair
Adam Ellis
Nelson Esike, E.I.T.
Michael Gaertner
Steve Gitkin
Adam McCreary
Paul Terranova, P.E.
Sadi Thapa
Eric Virag, P.E.

Western
Mary H. Ames, P.E.
Keith P. Blair, P.E.
Jun Caoayan Western
Megan Carter, P.E., T.E.
Angie Chan
Howard Puni Chee
Daniel Chuong
Spencer Cook
Reg Cullen
Chanh Dang, E.I.T.
Mitra Fakhry
Francisco Ureno Fernandez
Eric Fox
Marissa E. Garcia
Jessica Grant
David Anthony Holt
Jose Hurtado
Ferdinand Jaro
Dre Kalili
Jesse Khatkur
Marionne Philline Lapitan
Michael Michael
Grant Mizuno
Michael Motoki
Sargon Oraham
Travis Ota
Christopher Ovitt
Patrick Preusser
Marcela Rodriguez, P.E.
Thurein Shwe
Sihua Song
Kevin Howard Stankiewicz
Shawn Strasser, P.E.
Jerry Meng Tan
Christian Thompson
Joseph Tran
Trisha Tunilla
Ana Verschoor
Blair Wayte
Justin Wong
Roman Yakimchuk
Adrian Ziemer

Letters in parentheses after individuals' names indicate ITE membership status: S - Student Member; IA - Institute; M - Member; F - Fellow; R - Retired Member; and H - Honorary Member. Information reported here is based on news releases and other sources. If you have news of yourself or the profession that you would like considered for publication, please send it to Holly Stowell, hstowell@ite.org.

ITE NEWS

ITE Diversity Scholars: Application Deadline March 15

The ITE Diversity Scholars Program is accepting applications for 2020. This program is open to any U.S. high school student of African-American; Native American, Alaskan, Hawaiian, or Hispanic/Latino heritage with an interest in a career in transportation and seeking to study transportation engineering, planning, or in a related-field at a school with an established ITE Student Chapter. The goal of this program is to increase underrepresented populations' participation in the transportation profession by supporting increased diversity at the undergraduate level.

For eligibility criteria, award information, and further details, visit https://www.ite.org/membership/diversity-scholars-program/. The deadline to apply is March 15, 2020.

Help ITE Celebrate 90 Years by Giving $90

In honor of ITE's 90th anniversary year, please consider donating $90 to support the ITE Legacy Fund. The Legacy Fund helps support our Diversity Scholars, the student-led Student Leadership Summits, *LeadershipITE* scholarships, the STEM competition, and the Matson and Hammond Mentoring Program. Throughout our 90th anniversary year, members will have several opportunities to contribute to the $90 for 90 campaign. Visit bit.ly/ITE90for90Campaign to give. To see who has already donated, go to bit.ly/90for90contributors. Make a difference by adding your name to the list today!

Sign Up Today for the Matson and Hammond Mentoring Program

"My favorite part of being a mentor is watching the transformations take place as a result of personal and professional growth. However, I want to stress that the growth takes place for both the mentees and the mentors! This growth is a result of the participants learning new information, new skills, and being exposed to a diversity of ideas."

Jennifer Toth
Maricopa County
Department of Transportation
& ITE Public Agency Council Chair

"On the surface, being a mentor is a way of giving back. But it's also a powerful way to help someone work from their personal strengths and to find a new confidence. It becomes a rewarding experience for both and often leads to a long term relationship. For me, I'm always reminded to keep stretching as I listen and reflect on how I've used my own strengths to land opportunities."

Jen Malzer
City of Calgary
& Canadian District Director

Learn from the Experience of Others & Share Your Experience with Others

Get involved: https://community.ite.org/mentoring/how-to-get-started
(ITE membership log-in required)

Community Corner

Community Corner highlights the efforts of ITE members to not only encourage transportation education among our youth but to improve the daily lives of people in their community beyond transportation through acts of service.

CASITE Keep Austin Beautiful Adopt-A-Street Program

The Capital Area Section of ITE (CASITE) adopted 45th Street between Burnet Road and Guadalupe Street in Austin, TX, USA about three years ago. CASITE has been hosting street cleanup events with the University of Texas (UT) ITE Student Chapter as a fun event that helps the community and environment. They have the events once every four months and pick up trash for about two hours along the roadway. The Section hosts a social hour for CASITE members and UT ITE student members after the cleanup. It has been a great success encouraging members of both the local Section and Student Chapter to participate. It has also been a kid-friendly event, as seen in the photos! **itej**

We want to hear from you!

Have you, your Section, or Chapter taken on a community project or provided assistance to a non-profit organization? Large or small, we want to hear about it! Please send photos (300 dpi or higher) along with a write-up (no more than 200 words) to Pam Goodell, pgoodell@ite.org for inclusion in a future issue of Community Corner.

ITE Talks Transportation Podcast

New from the Thought Leadership Series

Leadership with Leslie Richards, SEPTA General Manager

Leslie Richards, general manager of the Southeastern Pennsylvania Transportation Authority (SEPTA), joins the *ITE Talks Transportation* podcast for a conversation on leadership, the inextricable link between community and transportation, and managing a multimodal transportation system. Richards, who recently wrapped up her tenure as secretary of the Pennsylvania Department of Transportation, is the first transportation planner to lead SEPTA. She discusses the opportunities and challenges faced by the agency, which provides 300 million trips per year.

All episodes available at www.ite.org/learninghub/podcast.asp | Subscribe for free via iTunes at http://apple.co/2hOUz8t

WHERE IN THE WORLD?

Can you guess the location of the "Where in the World?" photo in this issue? The answer is on page 50. Feel free to send in your own photos to hstowell@ite.org. Good luck! **itej**

2020 ELECTION BALLOT IS NOW OPEN!

For International President

Alyssa A. Reynolds Rodriguez, P.E., PTOE (F)
Assistant Director, Public Works
City of Henderson Nevada
Henderson, NV, USA

VOTE

Deadline to vote is March 13 at 12:00 p.m. ET. For more information, https://www.ite.org/about-ite/2020-candidates-for-international-board/

ite A Community of Transportation Professionals

For International Vice President

Jason A. Crawford, P.E. (F)
Division Head
Texas A&M Transportation Institute
Arlington, TX, USA

Beverly Thompson Kuhn, Ph.D., P.E., PMP (F)
Division Head | Senior Research Engineer
Texas A&M Transportation Institute
College Station, TX, USA

2020 EVENTS

MID-COLONIAL DISTRICT ANNUAL CONFERENCE
April 19–21 | Baltimore, MD, USA

MOVITE SPRING MEETING
May 6–8 | Tulsa, OK, USA

NORTHEASTERN DISTRICT ANNUAL MEETING
May 13–15 | Wading River, NY, USA

60TH ANNIVERSARY INTERMOUNTAIN SECTION MEETING
May 14–16 | Jackson, WY, USA

CITE/QUAD JOINT 2020 ANNUAL CONFERENCE
May 24–27 | Vancouver, British Columbia, Canada

JOINT MIDWESTERN AND GREAT LAKES DISTRICTS ANNUAL MEETING
June 3–5 | Chicago, IL, USA

FLORIDA SECTION SUMMER MEETING
June 24–26 | Ft. Lauderdale Beach, FL, USA

2020 JOINT WESTERN & MOUNTAIN DISTRICTS ANNUAL MEETING
June 29–July 1 | Honolulu, HI, USA

JOINT ITE INTERNATIONAL AND SOUTHERN DISTRICT ANNUAL MEETING AND EXHIBITION
August 9–12 | New Orleans, LA, USA

TRANSPO 2020/FLORIDA PUERTO RICO DISTRICT ANNUAL MEETING
October 11–14 | Bonita Springs, FL, USA

MET SECTION ANNUAL MEETING
November 12, 2020 | Astoria, NY, USA


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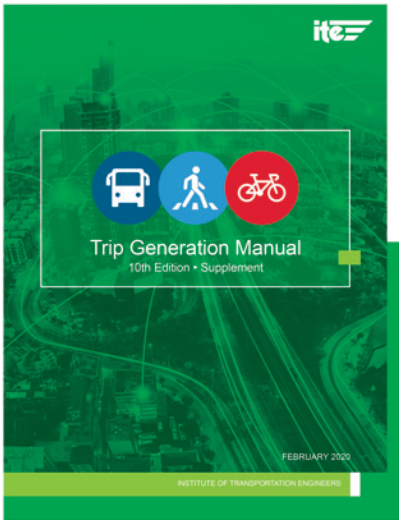
ITE Trip Generation Manual, 10th Edition Supplement



Questions and Comments

For questions or comments regarding *Trip Generation Manual*, 10th Edition and its supplement, contact:
Lisa Fontana Tierney
lfontana@ite.org
+1 202-785-0060

ITE released the *Trip Generation Manual,* 10th Edition Supplement in February 2020. The supplement represents the next step in ITE's continued commitment to improve the tools needed by its members and the general transportation community to understand trip-making in our communities.

The supplement adds **walk**, **transit**, and **bicycle** trip generation data for 53 land uses. The numbers of trips by mode are presented in the standard data plot format by time period and site setting. Modal trip generation is also presented in table form as a percentage of total person trips by land use.

The supplement adds **truck** trip generation data for 50 land uses. The numbers of truck trips are presented in the standard data plot format by time period and site setting. Truck trip generation is also presented in table form as a percentage of total vehicle trip generation by land use. The supplement also includes time-of-day distributions for truck trips by land use.

The supplement adds a new land use (Affordable Housing [223]) and substantially expands data for two land uses (High-Cube Fulfillment Center Warehouse [155] and High-Cube Parcel Hub Warehouse [156]).

The ITETripGen app has been updated to reflect changes initiated with the supplement. To make it easier for the analyst to distinguish between plots for different trip types, images depicting the individual trip types (i.e., walk, transit, bicycle, truck) are included as watermarks on each data plot. The watermark has been added even for current ITETripGen users who choose to not upgrade with the supplement.

Modal Trip Generation

The supplement provides data plots that the analyst can use to directly estimate modal trip generation as a function of an independent variable. Data plots are provided for 53 land uses, including the key residential, office, and retail uses.

Sample modal trip generation rates are presented in the table below for two land uses for which multimodal trips should be expected in an urban setting: Multifamily Housing (Mid-Rise) and General Office Building. The data in the table are for the peak hour of adjacent street traffic and for sites in a Dense Multi-Use Urban setting. Trips are recorded for walk, transit, and bicycle trips. The modal rates in a General Urban/Suburban setting are lower; in a Center City Core setting, the rates are higher.

Sample Modal Trip Generation Rates per Unit Value for Independent Variable

Land Use Code	221	710
Land Use Name	Multifamily Housing (Mid-Rise)	General Office Building
Independent Variable	Occupied Dwelling Units	1000 Sq. Ft. GFA
Time Period	PM Peak Hour of Adjacent Street Traffic	AM Peak Hour of Adjacent Street Traffic
Setting/Location	Dense Multi-Use Urban	Dense Multi-Use Urban
Trip Type		
Walk+Transit+Bicycle	0.22	0.33
Walk	0.13	0.16
Transit	0.09	0.15
Bicycle	0.01	0.02

The supplement also provides a table from which the analyst can calculate modal trips from a total person trip generation estimate for a development site. As an example, for Multifamily Housing (Mid-Rise) in a Dense Multi-Use Urban setting during the PM Peak Hour of Adjacent Street Traffic, the number of trips that are either walk, transit, or bicycle are, on average, 42 percent of the total person trips generated by the site. The observed values range between 21 and 65 percent. The calculated standard deviation for the values is 14 percent.

Truck Trip Generation

The supplement provides data plots that the analyst can use to directly estimate truck trip generation as a function of an independent variable. For the purposes of the supplement, a truck trip is defined as the movement of a commercial cargo transport vehicle (typically either a medium-duty or heavy-duty truck) that transports cargo across a site cordon line. Data plots are provided for 50 land uses, including the key industrial, retail, and services uses.

The supplement also provides a table from which the analyst can calculate truck trips from a total vehicle trip generation estimate for a development site. A sample set of weekday truck trip percentages for industrial uses is presented in the table below. The supplement also provides truck trip time-of-day distributions for 41 land uses. **itej**

Purchasing Information

For pricing and purchasing information for the supplement, visit http://bit.ly/TripGenSupplement.

Sample of Truck Trip Data Presented as a Percent of Total Vehicle Trips

Time Period	Weekday		
	Truck Trips as % of Total Vehicle Trips		
	Weighted Average	Range	Standard Deviation
110 General Light Industrial	8%	0 – 29%	8%
130 Industrial Park	15%	10 – 16%	3%
140 Manufacturing	10%	0 – 35%	10%
150 Warehousing	27%	0 – 65%	21%
154 High-Cube Transload and Short-Term Storage Warehouse	16%	3 – 52%	11%
157 High-Cube Cold Storage Warehouse	35%	32 – 39%	3%

Preemption of Traffic Signals Near Railroad Crossings

Shutterstock/GJones Creative

Notice of Intent to Consider for Final Adoption as an ITE Recommended Practice

The final version of *Preemption of Traffic Signals Near Railroad Crossings* (RP-025D) is moving for final adoption by the ITE International Board of Direction. ITE made the recommended practice available on March 5, 2020 for review and will submit the recommended practice for adoption as of April 30, 2020 if no appeals are received. In response to the comments received on the proposed version of the document, the report has been revised to:

- Modify the approach for passive crossing evaluation;
- Expand discussion of simultaneous versus advance preemption operation;
- Clarify aspects of upstream versus downstream pre-signal location, and the use of pre-signals and overhead flashing-light signals;
- Expand discussion of advance pedestrian preemption;
- Supplement discussion on the maximum preemption timer;
- Modify text regarding motion-sensing detection circuits;
- Clarify interconnection types relative to current standards;
- Modify definitions of certain terms and their use in the report, including terms such as right-of-way; right-of-way transfer time; and constant warning time to be consistent with other relevant recently adopted practice;
- Emphasize the role of the railroad signal engineer on the diagnostic team; and
- Include updated figures as well as other technical and editorial revisions to improve readability and clarity.

Purpose and Intended Use

Where a signalized intersection exists in close proximity to a railroad crossing—and either queues from the intersection impact the crossing, or queues from the crossing impact the intersection—the railroad signal control equipment and the highway traffic signal control equipment should be interconnected. The normal operation of the traffic signals controlling the intersection should be preempted to operate in a special control mode when trains are approaching. While public agencies have practices or procedures on the preemption of traffic signals near railroad grade crossings, there have been significant advances in engineering and technology since the last edition in 2006. The goal of the recommended practice is to reflect the current state-of-the-practice and to provide the user with a broad overview of key considerations. The report is written primarily for engineers working for public agencies, railroads, and public transit agencies engaged in signal design and operational timing. ITE's intent for the recommended practice is to reflect a balance between sound engineering theory and practical application.

The Recommended Practice

The report includes new information on the design and operation of traffic signal preemption that has been developed since the previous edition was published, including:

- The concept and the function of diagnostic teams.
- Explanation of the critical factor for determining the need for preemption is not the distance to the crossing, but the likelihood that a traffic queue will extend onto the tracks, regardless of distance. Additional methods for estimating queue lengths are provided.

Availability

The recommended practice *Preemption of Traffic Signals Near Railroad Crossings* (RP-025D) is now available. A version of the full report will be available for review by request by sending an email to PTSRRXings-RP@ite.org.

- New definitions have been added as well as new drawings illustrating the definitions of the Clear Storage Distance and the Minimum Track Clearance Distance.
- Illustrated explanation of the procedure for preempting traffic signals of diagonal crossings at intersections.
- Illustrated discussion of the use of pavement markings to warn drivers of the area of a railroad crossing to not block.
- Discussion of Americans with Disabilities Act (ADA) considerations.
- Additional discussion on the need for special traffic control when there is construction in the vicinity of a railroad crossing, consistent with the requirements of the *Manual on Uniform Traffic Control Devices*.
- Detailed information regarding the use of pre-signals and queue-cutter signals as well as hybrid systems for long distances between the traffic signal and the railroad crossing.
- Expansion of the section on the design of preemption interconnection circuits.
- Supplemental information regarding the timing of traffic signal preemption to accommodate pedestrians.
- New information regarding the need for preemption of flashing beacons or hybrid beacons at pedestrian crossings.
- References to preemption timing worksheets from two roadway jurisdictions as methodological examples.

The development of the recommended practice was coordinated with the *Highway-Rail Crossing Handbook*, 3rd Edition, so that the information will be consistent in both documents. **itej**

How to File an Appeal

If you wish to appeal ITE's adoption of the recommended practice, submit a written appeal to ITE Headquarters, Attn: Douglas E. Noble, 1627 Eye Street, NW, Suite 600, Washington, DC 20006 USA, by the close of business on April 15, 2020. The written appeal shall state the nature of the objection(s) including any adverse effects, the step(s) of the ITE procedures or the section(s) of the recommended practice that are at issue and the specific remedial action(s) that would satisfy the appellant's concerns. Any previous efforts to resolve the objection(s) and the outcome of each shall also be noted.

Sustainable Traffic Signal Development Informational Report

ITE announces the release of the *Sustainable Traffic Signal Development* Informational Report. The report explores past, present, and future practices in the development of traffic signal installations and their sustainability. The Sustainable Traffic Signal Development Committee prepared the informational report as a joint effort under the guidance of the Sustainability Standing Committee, the Transportation Planning Council, and the Public Agency Council.

Answering the question "What is a sustainable traffic signal development?" the report defines the term as follows: A sustainable traffic signal development is one that is planned for, designed, and constructed so that—when operational—it serves all users, operators, and other stakeholders in a safe, efficient, accessible, equitable, and informative way, without compromising the needs of future generations.

The report reviews warrants and policies that lead to the installation, modification, or removal of signals as well as design and construction methods from a sustainability perspective. The report identifies cases where the profession is under utilizing the capabilities of the signal equipment and electrical systems, and could enhance other public services, lessen impacts on the environment, and improve safety through better utilization of the traffic signal and lighting infrastructure and brings several questions to light, such as:

- Do controller cabinets need to be so large?
- Are communications conduits shared with other public service providers to the extent they should be?
- Is the best use of excess capacity of electrical circuits being made?
- Are designers and operators maximizing the potential of modern controllers?

The report discusses emerging technologies being used and planned for use in traffic signals by looking ahead to the next half-century and exploring how advanced driver assistance systems, an aging population, wearable technologies, vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communications, and other factors will likely affect traffic signal development, modification or removal. In closing, the report encourages planners, designers, builders and operators of traffic signals to look at traffic signal installations more holistically than just a traffic control device. **itej**

How to Purchase a Copy

The publication is available for purchase through the ITE Bookstore:
Member – electronic copy: $50.00
Non-member – electronic copy: $100.00

Shutterstock/TierneyMJ

Keeping it Moving

The ITE Traffic Engineering Council (TENC) is the largest ITE Technical Council, and we cover a wide range of topics. Our goal is to keep our members current in this rapidly changing transportation environment. We recently organized into a series of subcommittees: Innovation/Developing Trends; Urban Mobility; SimCAP Standing Committee, ITS Operations/Data Analytics, Global (Traffic Engineering Outside North America), Traffic Signal Design and Operations, and Traffic Control Devices Design. We also have two Standing Committees under our umbrella, each of which has their own administrative structure: Roundabouts Standing Committee and Joint Rail Grade Crossing Standing Committee. Last year, the Traffic Engineering Council sponsored seven webinars and finalized a white paper on wrong-way driving, in addition to other ongoing activities. This year, we are committed to sponsor and develop at least 10 webinars. Our on-going activities are as follows:

Traffic Engineering Handbook Webinar Series – A recent survey concluded that the ITE *Traffic Engineering Handbook* was the second most valuable ITE product, after the ITE *Trip Generation Manual*. Last year, TENC launched an effort to prepare webinars for each chapter of this manual. In 2018, three webinars on chapters were presented. In 2019, four webinars on chapters were held, and at least one more is planned for December. There are a total of 15 chapters available for webinar development. The Professional Development Committee is considering developing a Learn as You Go online training program for the Traffic Engineering Handbook in the future, with the chapter by chapter webinars used as a starting point.

Right Turn on Red Informational Report – In 2019, the TENC launched a committee to develop a new Right Turn on Red Informational Report (IR). The project proposal form was submitted and approved in May 2019. At their meeting in August, the Board approved the TENC's request to rescind the existing recommended practice. In late September/early October 2019, a survey was conducted which was focused on assessing the current state of practice for the prohibition of turns on red. The results of the survey will be used to develop a new IR. The goal is to submit a draft IR to ITE for review in mid-2020.

Route Guidance Data – In late 2018, the TENC launched a project based on an emerging issue, Route Guidance Data, which addresses the impact of route guidance on our roadway network, including unintended consequences on local neighborhoods.

Wrong Way Driving – In 2018, the TENC launched a project regarding best practices to prevent wrong-way driving. A white paper was prepared and completed in 2019. A webinar was held in 2019. Future efforts may consist of an *ITE Journal* article and an Annual Meeting session.

SimCAP Reboot – For 2020, we are gathering a new group of individuals for SimCAP, and they are charged with providing guidance for traffic analysis and simulation. One of their initial efforts will be a white paper on best practices for analyzing roundabouts.

Hot Topics Webinars – The Traffic Engineering Council will be developing webinars based on webinar member requests. These include Signal Timing Practices for Municipalities, Adaptive Traffic Systems, Warrants for Warning Signs/Usage/Sign Clutter, Traffic Analysis and Simulation, and Traffic Management around Schools.

If you are interested in participating in these or any other topics, please contact us. We are actively trying to find micro-volunteering opportunities, with well-defined scopes and durations. A perfect example of this is putting on a webinar. **itej**

Contact

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Gordon Meth
gmeth@optonline.net

Vice Chairs
Christa Greene
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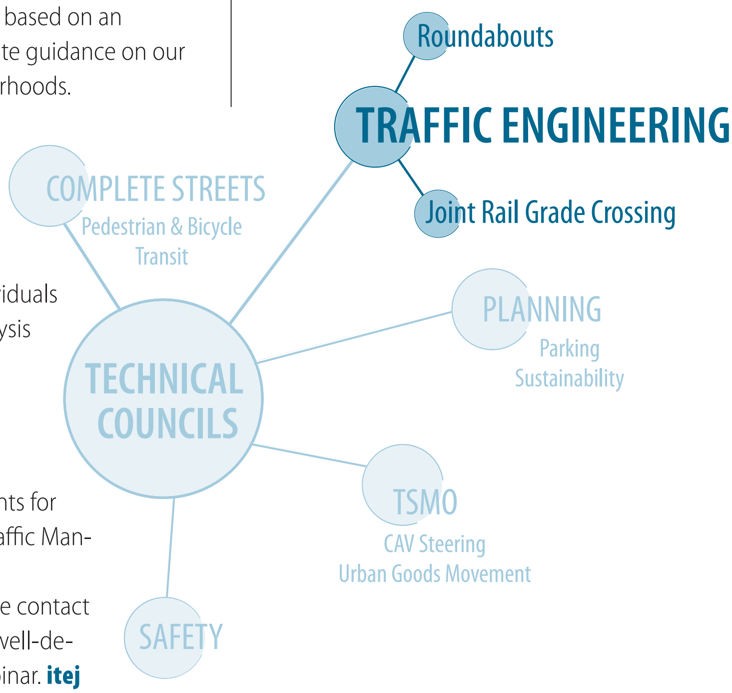


Signal Savvy

Steve Gault, P.E., PTOE (M)
Pennsylvania Department of Transportation (PennDOT)
Chief, TSMO Arterials and Planning Section

Previous Experience

Traffic Project Manager, Michael Baker International

Township Administrator/Engineer, Mount Joy Township

Project Manager, Traffic Planning and Design, Inc.

ITE Leadership Positions

Membership Chair, Mid-Atlantic Section– January 2017–Present

Technical Committee, Mid-Colonial District Annual Meeting – 2019, 2020

Vendor and Sponsors Coordinator, Mid Colonial District Annual Meeting – 2018

Mid-Atlantic Section Annual Meeting Chair – 2010

Steve Gault, P.E., PTOE (M) knows better than most just how intricate the work of traffic signals can be. He talks to *ITE Journal* about traffic signalization technologies, the evolution of data collection and its impact on the field, and how ITE has helped shape his career so far.

***ITE JOURNAL*: At PennDOT, your responsibilities include helping to implement the latest technologies for traffic signals. With so many technologies available, what are some of your strategies for researching and acquiring new products?**

GAULT: Before new traffic signal technology is approved for sale in Pennsylvania, we review the manufacturer's literature, gather insight from sales representatives and other states, and look to deploy a demonstration unit to test the products under real-world conditions.

Building a strong network with traffic signal equipment vendors and suppliers is critical, whether it's through exhibit booths or more personalized demonstrations of their products. We also leverage these relationships to help the manufacturers know our needs as they consider new products for development. It's important to get out of the office and see equipment actually operating in the field. Whether it's with a contractor or agency maintenance staff, engineers benefit from seeing how different types of equipment work, knowing what their limitations are, and determining first-hand what locations are good candidates for specific types of technology. One size doesn't fit all.

***ITEJ*: How have you seen the technology around traffic signals evolve over the past couple of decades that you have been in the industry? What are you most excited by?**

GAULT: I'm most excited about the ability to use technology to automate data collection and analysis, particularly with Automated Traffic Signal Performance Measures (ATSPM). This is allowing signal engineers to focus more time on solving problems rather than hoping to find the problem with expensive and limited traffic counts.

My search for better data to understand and improve traffic signal operations began when I was sitting at hundreds of intersections manually counting turning movements early in my career. This led to experimenting with data from closed loop systems, but this often had similar limitations of binned data. Thanks to the research and leadership of Purdue University, Indiana DOT, and Utah DOT, we now have timestamped event-log data. Instead of spending countless hours trying to model what happened in the past to predict what might happen in the future, we know exactly what happened and why it happened. The power of this data is just starting to be unlocked, and the future potential to improve signal operations is boundless.

Steve at the installation of the first flashing yellow arrow in Pennsylvania.

***ITEJ*: You also help provide guidance to other entities in the maintenance and operation of ITS and traffic signal systems. Do any stories come to mind when you were able to help such entities solve a major issue with traffic flow/calming through signal improvement?**

GAULT: My favorite examples are when we can leverage equipment already at a traffic signal to more efficiently serve traffic. A decade ago, I was helping a local municipality which was paying significant police overtime to manually control several signals to manage traffic leaving a minor league hockey arena. After trying to collect data through a dial-up modem and closed loop system (which crashed and sent signals to flash), I resorted to videotaping what the police were doing. It turned out they were providing relatively consistent timing, so we just needed to program the signal controller to detect the increasing traffic volume and provide similar timing as the police were doing. The dynamic max feature of the controllers was used, and cleared out the arena parking lot more quickly and without manual control.

More recently, we had a similar situation with a signalized ramp terminal leading to an NCAA Division I football stadium, with police manually controlling the signal for a few hours before game time. With the new technology, we were able to develop a better timing plan from high-resolution data using ATSPM, watched the results with a CCTV camera, and didn't need to travel to the intersection.

***ITEJ*: As a traffic signal engineer, how does being an ITE member enhance your career, and perhaps help you connect with other professionals in the industry you may not otherwise be as integrated with?**

GAULT: Since I first got involved with the local events committee of the Mid-Atlantic Section, ITE has been instrumental in my career. I've made many friends through ITE events through the years, especially at the local level, and it extends far beyond just professional networking. My career growth wouldn't have happened without connections made through ITE. Being involved in local committees and organizing events is a great way for industry peers to learn who you are. In my current position, I frequently give presentations to the transportation community. This type of public speaking is much easier and more relaxed by knowing the audience, many of whom I have met over the years through ITE. **itej**

Karen Jehanian, P.E. (F), KMJ Consulting, Inc.

Steve speaking at the 2018 ITE Mid-Atlantic Section Annual Meeting.

Mid-Colonial District Administrator

Susan L. Best, P.E. (R)
ITE Retired Fellow Member

Education

Master's in Civil Engineering, California State University, Los Angeles
Bachelors in Civil Engineering, University of Delaware

Professional Affiliations

National Society of Professional Engineers (1996-Present)
Society of Women Engineers (1975-Present)
American Society of Civil Engineers, (1976-1984, 1989-Present)
American Society of Highway Engineers, Senior Member, 1986-2018

Awards

Service Recognition Award, ITE Mid-Colonial District – 2019
Hall of Fame, Society of Women Engineers, Philadelphia Section – 2010
Transportation Engineer of the Year, American Society of Civil Engineers, Philadelphia Section – 2005
Donald McNeil Award, ITE Mid-Atlantic Section – 1997

In celebration of its 90th anniversary, ITE is recognizing each of its District Administrators throughout the year in a series of profiles in *ITE Journal*. Each month, this column will also feature historical facts and figures on the various Districts, including important dates and people throughout their history to present day.

Should you broach the subject of her impressive resume, ITE Mid-Colonial District Administrator **Susan L. Best, P.E. (R)**, has a modest reaction. "Part of it is, I just can't say no," she tells *ITE Journal* with a laugh. "It's just always been something that I do—I just like to get involved with things."

Now in her eleventh year as District Administrator, Susan recently received a service award from the Mid-Colonial District marking her decade-long tenure in the role. Growing up with a father who was actively involved in his profession, Susan remembers vacations based around wherever the American Society of Agricultural Engineers conventions were held. Witnessing his service to that organization, including his term as president in 1979, partly inspired her to be involved with ITE and a variety of other professional organizations.

A Fellow of ITE since 1996, Susan has served in numerous leadership positions in the organization, including Mid-Colonial District Director for the International Board of Direction (IBOD). When the idea of having a District Administrator came up during her IBOD term, Susan applied her meticulous attention to detail, surveying other Districts within ITE that had the position. "I actually did a survey of the other Districts and looked at what they had online. I emailed all of the Directors and said, 'How do you define your District Administrators, what roles do they have?'. . .and they sent me whatever documents they had that outlined the role," she says.

After working with the District board to prepare a job description for the position, it wasn't long until Susan was approached with the suggestion that she take on the job. "Even as I was writing the description, I wasn't writing it for me—but I knew I was interested in doing it," she notes.

Having served as executive director of the Engineers' Club of Philadelphia from 2010-2014, among various other leadership roles, Susan brings a wealth of experience to the role of District Administrator. She says her main responsibility as District Administrator is "to provide continuity," which is needed as the elected leadership changes term-to-term. "I'm a resource, particularly with the new revisions of bylaws and charters, as I've had a lot of experience over the years with that kind of work," Susan notes. She also maintains the District's operations manual, and helped the District achieved and maintain its 501(c)(3) status.

With a career spanning more than four decades, Susan has enjoyed learning new technologies as they emerge, and puts her computer aptitude to use as District Administrator. She says having the ability to collaborate via technology has transformed the entire profession, recalling a time when ITE technical committees conducted business via mail. "It was just harder," she says. "Today the technology—conference calls, emails, and sharing online—has helped a lot. Being involved is certainly something I would encourage people to do more."

The Mid-Colonial District is unique in that it only consists of two Sections—the Mid-Atlantic Section and the Washington, DC Section. The elected board consists of the secretary/treasurer, vice president, and president, as well as International Director and past president, and an elected representative from

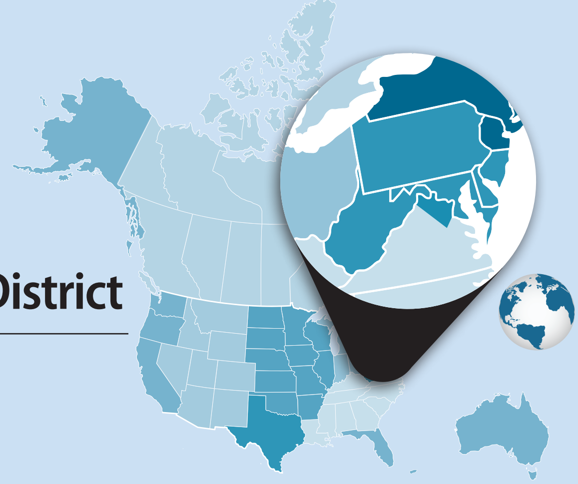
Susan has enjoyed traveling with her husband since retiring in 2014. This 2018 trip to Alaska marked visiting their 50th state.

each Section. Traditionally that representative is the immediate past-president from the Section, though it is not a requirement. Frequently, Section representatives will end up running for the secretary/treasurer role, which eventually moves up to vice president and then president.

Starting in 2007, the Mid-Colonial District began holding leadership meetings in January for the District and Section leadership. "We'll have a dinner Thursday night, anybody who can get there comes, and then Friday morning we have a District board meeting with both Section boards in attendance," Susan explains. "Then in the afternoon, each Section has a breakout so they can have their first board meeting of the year."

She says that these face-to-face gatherings are instrumental in helping District members operate more cohesively. "That's helped us feel more like a District," she says. "We used to have a board meeting during TRB, and one at our annual meeting, and that was pretty much it. We didn't do a lot in between. That leadership meeting, along with our almost monthly conference calls, has helped a lot."

Susan adds that this type of collaboration is a key theme she has observed among transportation professionals. "One of the neat things I like in traffic engineering is that we share our experiences so easily, even if we're competitors in a local area." She recalls that years ago, competing firms would share traffic count boards with one another. Nowadays, she says they share things like Sim Traffic coding tips and tricks. "Rather than considering it a trade secret, we saw how it would benefit the industry if we're not making mistakes, if we're properly coding unusual circumstances…and that is really wonderful." **itej**



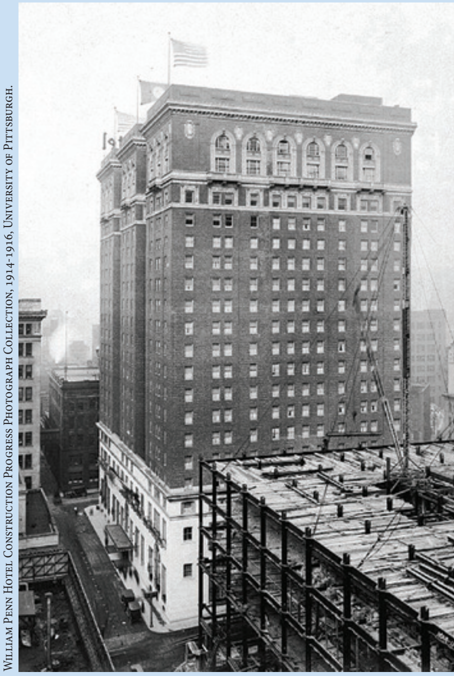
Getting to Know ITE's Mid-Colonial District

Sections

Washington, DC Section of ITE (WDCSITE)
Mid-Atlantic Section of ITE (MASITE)

U.S. States Covered

Pennsylvania
Maryland
Delaware
Washington, DC
West Virginia
Northern Virginia
Southern New Jersey



WILLIAM PENN HOTEL CONSTRUCTION PROGRESS PHOTOGRAPH COLLECTION, 1914-1916. UNIVERSITY OF PITTSBURGH.

The William Penn Hotel was the site of the founding of ITE in 1930 during a meeting of the National Safety Council.

Members

Approximately 1,200 members

Student Chapters: 11

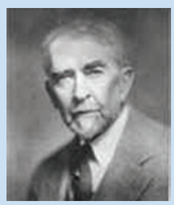
District Leadership

President – **Gerard Baxter, P.E., PTOE (M)**
Vice President – **Nicole Kline-Elsier, P.E., PTOE (M)**
Secretary/Treasurer – **Jeff Bergsten, P.E. (M)**
Immediate Past President – **Kate Russo, P.E., PTOE (M)**
MASITE Representative – **Al Federico, P.E., PTOE (M)**
WDCSITE Representative – **Vivek Hariharan, P.E., PTOE (M)**
International Director – **Jeff Riegner, AICP, PTOE (F)**

Did You Know?

- The Mid-Colonial District has two Sections and no Chapters because the District's geographic area is relatively small. You can drive from east to west or north to south of the District in just four hours.
- With the exception of five years in Arlington, VA, USA from 1973-1978, ITE has been headquartered in Washington, DC, USA since 1956.

Historical Perspective



Arthur N. Johnson

- The Mid-Colonial District and specifically the Mid-Atlantic Section is the birthplace of ITE, which was formed from discussions in October 1930 at the National Safety Council's Annual Convention in Pittsburgh, PA, USA at the William Penn Hotel. The historic hotel was the site of ITE's Annual Meeting and Exhibit in 1980 as part of its 50th anniversary celebration. To celebrate the 100 year anniversary, ITE's Annual Meeting will be held in Pittsburgh in 2030.
- Arthur N. Johnson of College Park, MD, USA was a founding member of the Institute of Traffic Engineers. In 1936, he was named ITE's third Honorary Member.
- ITE's first official Annual Meeting was held in what is now the Mid-Colonial District. "The 1945 Annual Meeting held in September in Philadelphia was the first annual meeting the Institute held by itself," according to ITE historical documents. "Prior to that time, it had piggybacked its efforts onto those of the annual meetings of the National Safety Council."
- ITE had Sections before Districts were formed. Wasington, DC was one of the original Sections in addition to New York and Michigan.

Looking Back: Transportation through the Decades

In celebration of ITE's 90th anniversary, throughout 2020 *ITE Journal* will feature a monthly snapshot of the transportation industry by decade, beginning with the turn of the 20th century through present day. These are the technologies, events, and key players that transformed transportation to bring us where we are today.

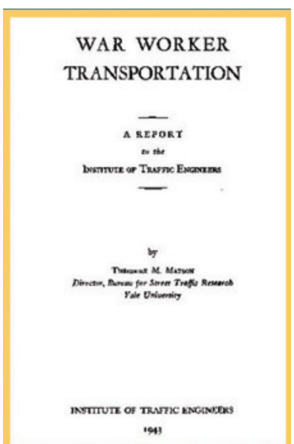
1940s

Everett Historical/Shutterstock

Speed limits in Washington, DC, USA were lowered from 40 to 35 miles per hour to conserve gas during World War II, 1942.

World War II – 1939-1945

The United States joined World War II in late 1941, putting critical transportation materials like gasoline and rubber in short supply. With a ban on automobile manufacturing from 1942-1945, automakers became part of the war mobilization effort, making airplane engines, tanks, trucks, munitions, and other war materials.



WAR WORKER
TRANSPORTATION

A REPORT
to the
Institute of Traffic Engineers

by
Theodore M. Matson
Director, Bureau for Street Traffic Research
Yale University

INSTITUTE OF TRAFFIC ENGINEERS
1943

The National Interregional Highway Committee – April 14, 1941

The National Interregional Highway Committee was appointed by U.S. President Franklin D. Roosevelt on April 14, 1941 to investigate the need for a limited system of national interstate highways.[1]

Early ITE Publication: *War Worker Transportation* – 1943

This 1943 report was prepared for the Institute of Traffic Engineers by ITE pioneer **Theodore M. Matson,** Director, Bureau for Street Traffic Research, Yale University.

Traffic Signs and Signals

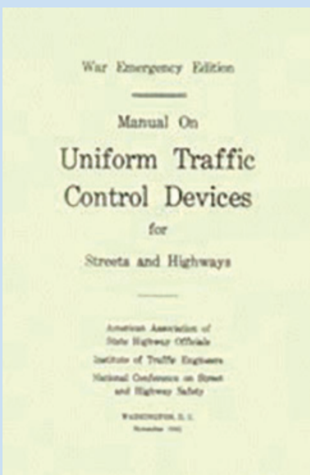
As traffic signs and signals became part of everyday life for drivers and pedestrians, they were seen as a type of public gathering place, and began to feature advertisements, government signage, and even newspaper stands.

Library of Congress

Sign on traffic stop-light in Hartford, CT, USA indicating housing shortage, 1941.

Library of Congress

Newsboy's stand and traffic signal light, 1942, Los Angeles, CA, USA.



The War Emergency Edition: Manual on Uniform Traffic Control Devices for Streets and Highways – November 1942

Because of the war's many restraints on highway travel and traffic control in the United States, the Joint Committee on Uniform Traffic Control Devices reconvened in May 1942 to consider revisions to the original *MUTCD*. The committee agreed to a manual with emergency standards for traffic control devices adapted to existing and foreseeable wartime conditions.[4]

ITE Presidents – 1940s

Hawley S. Simpson
1939-1941

D. Grant Mickle
1941-1943

Harold F. Hammond
1943-1945

Thomas J. Seburn
1945-1947

Robert A. Mitchell
1947-1949

Federal Aid Highway Act – January 1, 1944

The Federal-Aid Highway Act of 1944 approved the 40,000-mile (64,000-kilometer) National System of Interstate Highways, establishing a federal-aid secondary system of principal secondary and feeder roads.

Everett Historical/Shutterstock

Traffic on the West Side Highway, New York City, NY, USA.

Post-World War II: Urban Expansion

According to ITE's *Pioneers of Transportation*: the end of the war led to the "suburban explosion" of the nation, with returning servicemen starting new families. "The need for new housing created whole new cities. Shopping centers and new business sprung up to serve the needs of the automobile-oriented suburban population."[3] **itej**

Everett Historical/Shutterstock

Aerial view of suburban housing developments sprawling from Los Angeles, CA, USA.

1) The history of transportation in the United States was compiled with assistance from the U.S. Department of Transportation's History of Transportation webpage, https://www.transportation.gov/50/timeline. 2) Snyder, Jess. "No new cars, but that didn't stop U.S. automakers, dealers during WWII," Auto News, October 31, 2011. https://www.autonews.com/article/20111031/CHEVY100/310319970/no-new-cars-but-that-didn-t-stop-u-s-automakers-dealers-during-wwii. (Accessed February 3, 2020) 3) Robinson, Carlton C.; Goodman, Leon; Brahms, Thomas W.; Pline, James C.; Dondaville, Laurence A.; Pisarski, Alan E. *Pioneers of Transportation,* February 1, 2011, Institute of Transportation Engineers. [Accessed February 3, 2020] https://www.ite.org/pub/?id=5AFE0861-FEF3-C067-77A8-22F9A311AF16. 4) Information on the history of the MUTCD was gathered from *ITE Journal* articles written by H. Gene Hawkins, Ph.D., P.E. (F) between 1991-1994. He maintains a website on the history of the MUTCD. For more information visit https://ceprofs.civil.tamu.edu/ghawkins/MUTCD-History.htm.

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]

Shutterstock/RomanYa

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.[2] Nine years later, ITE published an informational report titled *Determining Vehicle Signal Change and Clearance Intervals*.[3] 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.[4]

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*.[5] However, ITE's development process for recommended practices follows a different development model than NCRHP 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.[6] 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

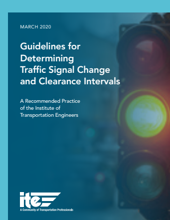
The report provides a description of the recommended methods to calculate traffic signal change and clearance intervals. The calculation methodology in the report is based on the extended kinematic equation and is shown in both U.S. and metric units. The report provides guidance for applying the methodology 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. **itej**

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Traffic Signal Change and Clearance Intervals: Research Still Needed!

By Jeff A. Lindley, P.E. (F)

Yellow change and red clearance intervals have been a topic of research for at least the last 60 years. It would be easy to assume that we now know all we need to know about the subject and that the remaining challenge is merely to put what we know into practice. But there is still much about driver behavior at intersections during traffic signal changes that we don't know with certainty or completely understand. During the development of the ITE *Guidelines for Determining Traffic Signal Change and Clearance Intervals* Recommended Practice, current knowledge, research, and practice in this area was documented, but the following 11 areas of interest were identified where additional study or new research is needed to expand the body of knowledge. Research in these areas would be useful in further refining the concepts and procedures in the ITE Recommended Practice.

- **Safety benefits of yellow change and red clearance intervals.** Additional study of driver compliance rates with and their sensitivity to signal timings set for yellow change and red clearance intervals across different vehicle types would be helpful. This work should incorporate left-, through- and right-turn movements as well as the impact on instances of red-light running. Additionally, the analysis should employ an approach that can quantify safety benefits related to fatality and injury reduction. Supporting analysis incorporating non-motorized modes of pedestrian and bicycle movement would be beneficial as well.
- **Impact on driver behavior and safety of yellow change intervals greater than 5 seconds.** It is widely thought that longer change intervals can lead to unsafe behavior once drivers are aware of and familiar with them. However, this understanding is very anecdotal in nature and available literature is not definitive on this issue. Continued research in this area would be improve the body of knowledge.
- **Perception-reaction time and deceleration for alerted drivers for turning movements**. Additional data and analysis, for both right- and left-turning vehicles, of the effect of a planned choice of movement by an alerted driver on perception-reaction time and deceleration rate. Similarly, whether information from countdown pedestrian signal indications affect perception-reaction time and deceleration rate. The effect of different age groups, vehicle types, and approach speeds on these two parameters would need to be incorporated. The recent availability of high-resolution driver behavior data sets would add value to this type of research.
- **Approach and passage speed variations associated with different left-turn lane characteristics.** Left-turn lanes have a variety of geometric and operational characteristics potentially affecting their approach and passage speeds that would benefit from additional research, including (for example): speed limits less than 30 miles per hour (mph) (50 kilometers per hour [km/hr]), turn-lane length, number of lanes, signal phasing, and movements where U-turns are allowed in addition to left turns on single- or multi-lane approaches. This research should also examine the significance of these potential effects and whether they could be practically applied to change and clearance interval calculations.
- **Approach and passage speed variations for different right-turn lane characteristics.** Right-turn lanes have a variety of geometric and operational characteristics potentially affecting the approach and passage speeds that would benefit from additional research, including: driver behaviors, speed limits less than 30 mph (50 km/hr), turn-lane length, number of lanes, signal phasing, driveway access, and conflicting bicycles and pedestrians. While characteristics of right-turns are analogous to left turns, how they affect application of the calculations may be different. This research should also examine the significance of these potential effects and whether they could be practically applied to change and clearance interval calculations.
- **Passage speed variation on the path through an intersection from left or right-turns.** The approach to estimating the passage speed for a turning path through an intersection in the ITE Recommended Practice is based on the 85th percentile intersection entry speed. Additional empirical analysis of field data in comparison to theoretical values for small radii and the curvature of complex paths, along with guidance for application, would enhance understanding of these relationships.
- **Data collection methods for approach speeds of through movements compared to posted speed limits.** With the expansion of automated traffic signal performance measures programs, the ability to collect and archive intersection detection data, including vehicle speeds, is rapidly increasing. Supporting research would examine processes to use data from detector infrastructure to provide an expanded data set

of approach speeds by lane, roadway classification, speed limit, under- and over-saturated traffic conditions, and area type.

- **Approach speeds on "non-posted" roadways and on roadway with speed limits of 35 mph (56 km/hr) or less.** There is need for development of supporting information to determine approach speeds for driveways, alleyways, short approaches, entrances to new developments, and other "non-posted" roadways. The proposed research should determine values and guidance for practical application for these types for roadways. Research should also examine the significance of these potential effects and measures of effectiveness associated with approach speeds and intersection entry under yellow or red signal indications.
- **Easy-to-implement method to determine the length of travel path through intersections for turning movements and complex intersection geometries.** Vehicles making turning movements or moving through complex intersection geometries typically do not follow circular paths. Research should also examine the significance of these potential effects and whether they could be practically applied to change and clearance interval calculations.
- **Effect of weather conditions.** Many jurisdictions implement special timing plans for inclement weather situations. An additional study opportunity could examine the significance of these potential effects and whether they could be practically applied to change and clearance interval calculations or assumptions.
- **Detectors**. Additional study would be useful on the effect of detector configuration in determining approach speeds in such cases as multi-detector designs for high-speed approaches, advance end-of-green warning, or dynamic red clearance extension.

If you are an educator or student in a university looking for a good research topic or a research sponsor seeking useful research to fund, the list above offers a wide range of ideas that would be valuable to both the transportation profession and the safety of the traveling public. **itej**

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An Explanation of Mats Järlström's Extended Kinematic Equation

By Jay Beeber (M)

Since the yellow indication was first added to traffic signals in 1920, the proper interval duration has been robustly debated.[1] Seemingly, the timing of the yellow indication appears straightforward. However, determining the illumination interval is quite intricate since it is part of a complex system of physical and human-made laws, technology, and human behavior that all must operate compatibly.

In 1960, Denos Gazis, Robert Herman, and Alexei A. Maradudin (GHM) provided a scientific solution to the yellow change interval question in their paper, "The Problem of the Amber Signal Light in Traffic Flow."[2] GHM presented a kinematic solution to a binary STOP or GO dilemma when a driver is faced with the onset of a yellow signal indication. The problem GHM solved and eliminated was an area in the roadway known as the "dilemma zone", where a driver-vehicle complex could neither STOP safely and comfortably nor GO without the need to violate the red or accelerate unsafely into the intersection.

GHM's solution to regulate a yellow change interval first appeared in the 1965 ITE *Traffic Engineering Handbook*, and it has become known as the kinematic equation.[3] However, GHM's solution is limited to vehicles traveling through level intersections at constant velocity, which does not include vehicle deceleration to execute safe turning maneuvers. This article presents a brief review covering GHM's original solution and Mats Järlström's extended kinematic equation which allows for vehicle deceleration and turning maneuvers.[4]

GHM's Solution

The foundation of GHM's solution is a minimum safe and comfortable DISTANCE to STOP, defined as the "critical distance" (x_C), which is composed of an allocated perception-reaction distance (x_{PR}) plus a minimum braking distance (x_{Br}). It is expressed mathematically as:

$$x_C = x_{PR} + x_{Br} = v_0 \bullet t_{PR} + \frac{v_0^2}{2a_{max}} \quad (1)$$

Where:

x_C= Critical distance - the minimum safe and comfortable stopping distance, (feet [ft.] or meters [m])

v_0= Maximum uniform (constant) initial/approach velocity, (foot per second [ft./s] or meter per second [m/s])

t_{PR}= Maximum allocated driver-vehicle perception-reaction time, (s)

a_{max}= Maximum uniform (constant) safe and comfortable deceleration, (ft./s^2 or m/s^2)

GHM's GO solution is the minimum TIME needed for a vehicle to travel across the critical distance (x_C) and is thus the minimum yellow change interval (Y_{min}) required to eliminate the dilemma zone. The solution is calculated by dividing the critical distance by the vehicle's maximum constant velocity across that distance. For driver-vehicles that maintain their initial velocity (v_0) across the critical distance, this is expressed mathematically as:

$$Y_{min} = \frac{x_c}{v_0} = \frac{v_0 t_{PR}}{v_0} + \frac{\frac{v_0^2}{2a_{max}}}{v_0} \quad (2)$$

Which reduces to the well-known kinematic equation:

$$Y_{min} = t_{PR} + \frac{v_0}{2a_{max}} \quad (3)$$

Since restrictive yellow laws (drivers must not enter the intersection on yellow) prevailed in their jurisdiction, GHM's original yellow time solution also included the minimum clearance interval (t_{Cl}) to allow a vehicle with length (L) to travel straight through and exit an intersection with a width (w), expressed as:

$$t_{Cl} = \frac{w + L}{v_0} \quad (4)$$

Internationally, "permissive" yellow change laws (driver-vehicles may enter the intersection during the entire yellow interval) are most common and the clearance interval function is often handled by employing a separate "all-red" interval.

Figure 1 illustrates the above concepts for both restrictive (Y_R) and permissive (Y_p) yellow timing policies.

This article promotes the most common permissive yellow change interval timing policy, but practitioners should note that where restrictive yellow laws prevail, the yellow interval must also handle the clearing function.

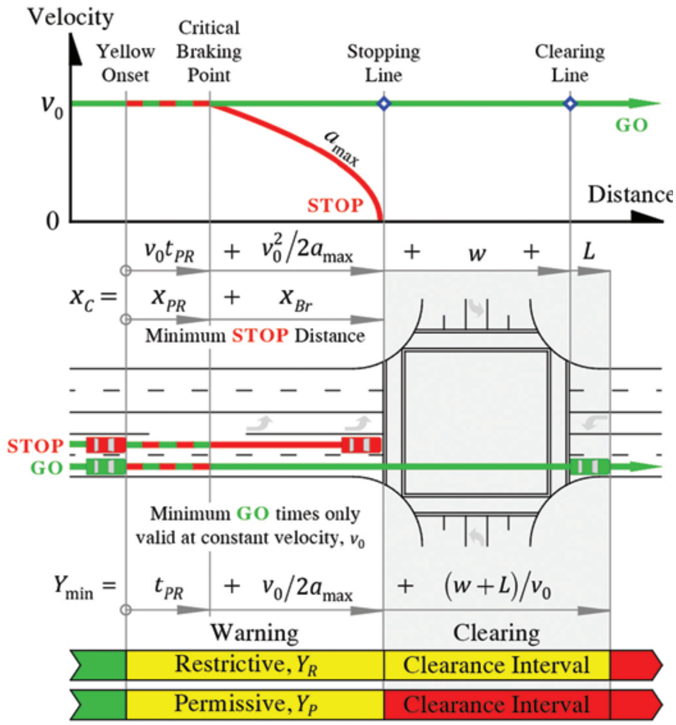

Figure 1. GHM's minimum STOP and GO equations plotted and referenced to a signalized intersection.

Limitations of GHM's Kinematic Equation

An essential concept to be recognized is that GHM's Kinematic Equation can only be derived if both the initial velocity (v_0) which is used to calculate the minimum stopping distance and the vehicle's velocity while traversing the minimum stopping distance are the same. Where a vehicle must slow down for any reason, such as to negotiate a turn, the initial velocity (v_0) and the vehicle's velocity while traversing the critical distance are NOT the same and GHM's Kinematic Equation cannot be used. This point has been reiterated in correspondence by Dr. Alexei A. Maradudin, the sole surviving author of the original GHM paper:[5]

"This formula which we derived, cannot be applied to turning lanes or to any situation where the driver must decelerate within the critical distance. The formula can only be applied to vehicles which start at the maximum allowable speed measured at the critical stopping distance and which proceed at a constant speed into the intersection."

Järlström has devised a new protocol to extend the kinematic equation for situations where a vehicle must slow down within the minimum stopping distance based on GHM's logic.

GHM's Logic Extended to Turning Movements

A central axiom of traffic signal timing is that, at the onset of the yellow indication, a "reasonable" driver farther from the intersection than their minimum stopping distance (critical distance) has sufficient distance to stop comfortably and should do so. Likewise, a "reasonable" driver closer to the intersection than their critical distance proceeds into the intersection when presented with a yellow indication. Figure 2 illustrates this concept.

The logic behind the methodology for determining the duration of the yellow change interval is that the interval should provide a reasonable driver who is too close to the intersection to stop safely and comfortably (i.e., closer than the critical distance) with adequate time to traverse the minimum stopping distance and legally enter the intersection before the signal turns red.

A reasonable driver is defined as one who is not violating the law (i.e., acting legally), and whose chosen actions are rational, prudent, and feasible. Safety and equity requires that the motion of any roadway user who exhibits reasonable behavior must be accommodated within the signal timing protocol, even if their chosen actions are not the "average" or most common to be encountered upon the roadway.

In conformance with the standard for through lane movements, the calculation of the minimum yellow change interval for turning movements must also provide a reasonable driver adequate time to traverse the minimum stopping distance and legally enter the intersection before the onset of the red indication. This calculation must allow for the extra time necessary for a vehicle to traverse

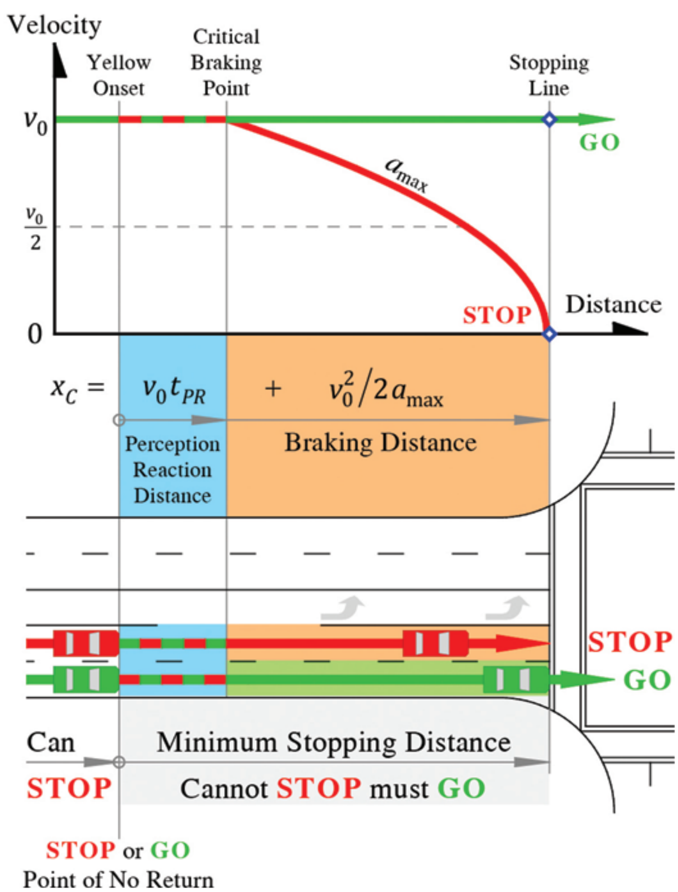

Figure 2. Illustration of the STOP or GO scenario encountered when approaching a signalized intersection.

the stopping distance while decelerating from the initial approach velocity (v_0) to the intersection entry velocity (v_E) to safely and comfortably negotiate a turning maneuver.

In contrast to the condition where a driver approaches a signalized intersection in a through lane, scenarios where a driver approaches a signalized intersection in a turning lane are significantly more complicated. Although there is a range of possibilities as to where a driver might begin to decelerate on approach to the intersection, the extended solution presented in this article is based on a model of driver-vehicle motion which encompasses the "worst-case scenario" or "boundary condition" for a decelerating vehicle. A full explanation of this concept and examination of other models of driver-vehicle motion is presented in "Yellow Change Intervals for Turning Movements Using Basic Kinematic Principles," available on the ITE website at www.ite.org/technical-resources/topics/traffic-engineering/traffic-signal-change-and-clearance-intervals.

Järlström's Extended Kinematic Equation

For the extended solution, conceive that the driver begins their deceleration at the Critical Braking Point, decelerating at their maximum safe and comfortable deceleration (a_{max}) to their target entry velocity (v_E) and then traverses the remainder of the braking distance at this velocity into the intersection.

Under this "boundary condition" model for a decelerating vehicle, the minimum stopping distance (x_C) is divided into three distinct areas of vehicle movement: 1) the Perception-Reaction zone (x_{PR}), 2) a Deceleration Zone (x_{Dec}) where the driver decelerates to their target entry velocity (v_E) beginning at the Critical Braking Point, and 3) a Non-Deceleration "Go Zone" (x_{Go}) starting at the end of the Deceleration Zone where the driver continues at their target entry speed to the limit line and into the intersection. Figure 3 illustrates these concepts.

The minimum time to traverse the minimum stopping distance is, therefore, the combination of 1) the time to traverse the perception-reaction distance (t_{PR}), plus 2) the time to traverse the Deceleration Zone (t_{Dec}), plus 3) the time to traverse the Go Zone (t_{Go}). This combination is the minimum yellow change interval (Y_{min}) necessary to eliminate the dilemma zone for this model of driver-vehicle motion, expressed as:

$$Y_{min} = t_{PR} + t_{Dec} + t_{Go} \qquad (5)$$

The time to traverse the Deceleration Zone is given by:

$$t_{Dec} = \frac{(v_0 - v_E)}{a_{max}} \qquad (6)$$

The time to traverse the Go Zone (t_{Go}) is determined as follows: First, calculate the length of the Go Zone (x_{Go}) by subtracting the length of the Deceleration Zone (x_{Dec}) from the full braking distance (x_{Br}).

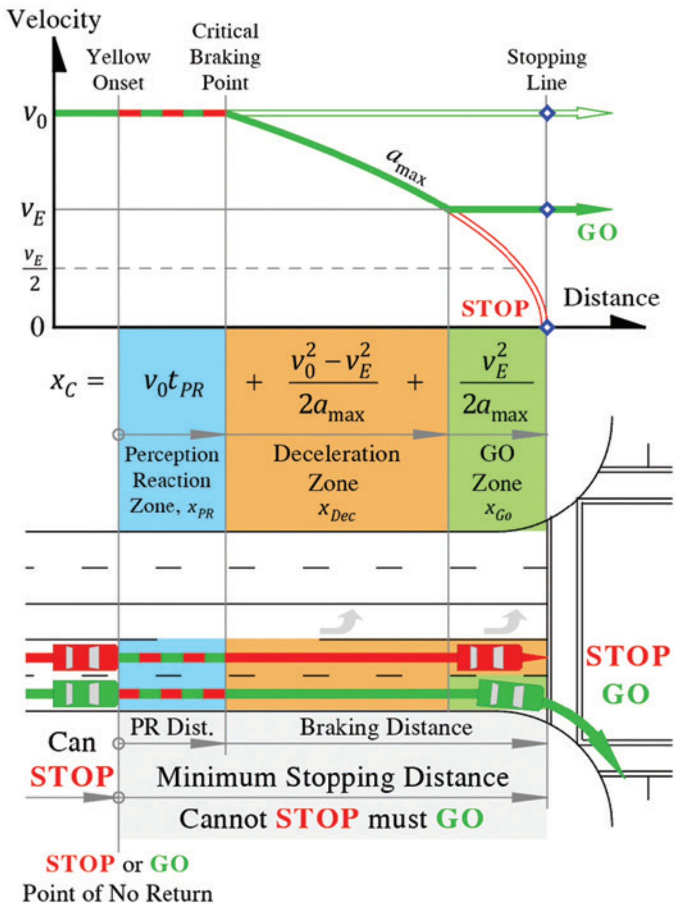

Figure 3. Zones of driver-vehicle motion while decelerating to negotiate a turn.

Since the length of the Deceleration Zone (x_{Dec}) equals the vehicle's time to traverse the Deceleration Zone (t_{Dec}) multiplied by the vehicle's average velocity (v_{av}):

$$x_{Dec} = v_{av} t_{Dec} = \frac{(v_0 + v_E)}{2} \bullet \frac{(v_0 - v_E)}{a_{max}} = \frac{v_0^2 - v_E^2}{2a_{max}} \tag{7}$$

And, from the last term of Equation 1, the braking distance is:

$$x_{Br} = \frac{v_0^2}{2a_{max}} \tag{8}$$

The length of the Go Zone is:

$$x_{Go} = x_{Br} - x_{Dec} = \frac{v_0^2}{2a_{max}} - \frac{v_0^2 - v_E^2}{2a_{max}} = \frac{v_E^2}{2a_{max}} \tag{9}$$

The time to traverse the Go Zone (t_{go}) equals the length of the Go Zone (x_{go}) divided by the vehicle's velocity across this distance (the driver's target entry velocity (v_E)):

$$t_{Go} = \frac{x_{Go}}{v_E} = \frac{\frac{v_E^2}{2a_{max}}}{v_E} = \frac{v_E}{2a_{max}} \tag{10}$$

Therefore, the minimum time to traverse the minimum stopping distance (by definition, the minimum yellow change interval, Y_{min}) for a vehicle that decelerates within the critical distance to negotiate a turn is given by:

$$Y_{min} = t_{PR} + \frac{(v_0 - v_E)}{a_{max}} + \frac{v_E}{2a_{max}} \tag{11}$$

Algebraic simplification of the Järlström's extended kinematic model shown in Equation 11 yields:

$$Y_{min} = t_{PR} + \frac{v_0 - \frac{1}{2} v_E}{a_{max}} \tag{12}$$

Where ($v_0 \geq v_E > 0$):
Y_{min} = Minimum yellow change interval (s)
v_0 = Maximum uniform initial/approach velocity, (ft./s or m/s)
v_E = Maximum intersection entry velocity, (ft./s or m/s)
t_{PR} = Maximum allocated driver-vehicle perception-reaction time, (s)
a_{max} = Maximum uniform safe and comfortable deceleration, (ft./s^2 or m/s^2)

Figure 4 illustrates the extended kinematic model compared to GHM's STOP or GO solutions across the critical distance (x_C) referenced to time.

The validity of Järlström's Extended Kinematic Equation is established in the following manner:

When $v_E = v_0$ (constant velocity), the protocol yields the ITE Kinematic Equation applicable for through movements (Equation 3).

When $v_E = 0$ (zero end velocity), the protocol yields the equation to calculate the minimum time to come to a complete stop:

$$t_{Stop} = t_{PR} + \frac{v_0}{a_{max}} \tag{13}$$

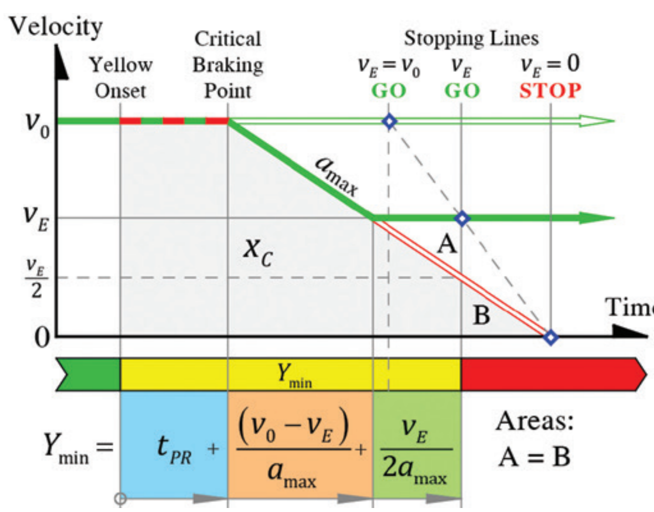

Figure 4. Time model including vehicle deceleration traversing the minimum stopping distance.

Note that stopping vehicles will reach the limit line after the signal has changed to red and, for these vehicles, the length of the yellow interval is irrelevant.

Additional Considerations

1. The methodology for determining the length of the yellow change interval described by both the classic and extended kinematic equations incorporates the following presumptions:
   a) The vehicle travels in free-flow conditions (unimpeded movement, no queue, etc.).
   b) The yellow indication illuminates at the moment the vehicle arrives at the critical distance.
   c) When the yellow illuminates, the vehicle's initial approach velocity (v_0) is the actual or estimated 85th percentile speed or the posted limit, whichever is higher.
2. The extended kinematic equation presented here yields the minimum yellow interval for a level intersection approach. As with the kinematic equation for through movements, grade adjustments should be made for vehicles approaching on a downgrade.
3. The assumed intersection entry velocity should be determined using engineering judgment. Generally, drivers entering an intersection to conduct a left turn, do so at approximately 20 miles per hour (mph) (32 kilometers per hour [km/hr]) depending on the intersection radius. Right-turning drivers generally negotiate the turn at approximately 12 mph (19 km/hr). An entry speed can also be estimated based on the *curve design speed* published by ITE.[6] For a full explanation of this calculation, see "Yellow Change Intervals for Turning Movements Using Basic Kinematic Principles," available at www.ite.org/technical-resources/topics/traffic-engineering/traffic-signal-change-and-clearance-intervals.
4. Calculating tolerance is standard engineering practice and should be employed in calculations of the minimum yellow change interval. Perception-reaction time, deceleration, approach velocity, and entry velocity are not constants. A reasonable range of values for each of these parameters is applicable for every driver-vehicle complex approaching a signalized intersection. Driver-vehicles whose metrics fall within a reasonable range but do not strictly match the parameters typically chosen by the traffic engineer should be accommodated.

   For example, research shows that the 85th percentile PRT is closer to 1.5 seconds (sec.) rather than the traditionally accepted PRT of 1.0 sec.[7] Likewise, some drivers, as well as larger vehicles, cannot safely and comfortably decelerate at 10 ft./s^2 (3.05 m/s^2) and employ a deceleration of 8.0 ft./s^2 (2.44 m/s^2) or less.[8] Therefore, engineering tolerances should be employed within signal timing protocols to accommodate all reasonable driver-vehicle combinations, especially where the rate of red-light violations is higher than acceptable.
5. The benefit of the extended kinematic equation is to provide a sufficient yellow change interval for all driver-vehicle movements to eliminate the dilemma zone and reduce red-light violations. Practitioners should be aware that red-light violations may increase in turning lanes if the available green time is reduced to accommodate longer yellow intervals. This is especially true where the green interval is insufficient to clear the queue. Rather than reducing the green interval, practitioners may consider increasing the cycle length instead.
6. Practitioners may have concerns about yellow intervals that are "excessive," resulting in drivers stopped at the signal still viewing a yellow indication. However, yellow intervals calculated using the extended solution do not exceed the minimum time required for a vehicle to come to a safe and comfortable STOP (Equation 13). Therefore the circumstance of a stopped driver facing a stale yellow light should typically not occur. **itej**

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Traffic Signal Benchmarking AND State of the Practice Report

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

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The design, operation, and maintenance of traffic signals directly influence how safely and efficiently the needs of pedestrians, bicycles, and vehicles are served as they traverse the estimated 328,000 signalized intersections in the United States. State and local agencies have collectively invested an estimated $122.4 billion USD in the planning, design and construction of signalized intersections. The estimated ongoing annual operating and maintenance expenditure is about $1.23 billion USD, with an annual additional capital program investment of $763 million USD. The responsibility for traffic signals begins at the state level and is frequently delegated to local agencies by state departments of transportation, resulting in more than 3,000 jurisdictions involved in some level of traffic signal management and operation.

The *2019 Traffic Signal Benchmarking and State of the Practice Report* is part of the continuing effort to raise awareness of the importance of and need for investment in the management and operations of traffic signal programs.[1] This effort—combined with research, training, technical assistance and outreach provided by the Federal Highway Administration's (FHWA) Arterial Management Program—is part of an evolving effort to improve, apply, and assess how the incorporation of programmatic, objectives and performance-based management approaches can enhance the ability of organizations to deliver on safety, mobility, and reliability goals.

This article will present the results of the capability and maturity component of the 2019 *Traffic Signal Benchmarking and State of the Practice Report* Card. We will also discuss how the approach for developing the report evolved from and is distinctly different from its predecessors. Finally, we will share the latest information on successful approaches to traffic signal program management drawn from observations of leading organizations and insights gathered from our interaction with them.

Systems and Technology	C+
Infrastructure	B-
Business Processes	
Design	C+
Operations	C+
Maintenance	C+
Management	C
Workforce	C+
Management and Administration / Leadership	
Culture	C+
Organization	C+
Collaboration	C+
Performance	C
OVERALL GRADE	C+

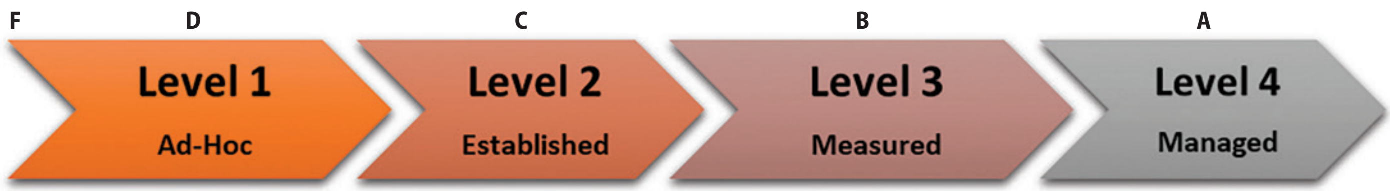
Figure 1. 2019 National Traffic Signal Report Card.

2019 National Traffic Signal Report Card

The *2019 Traffic Signal Benchmarking and State of the Practice Report* has two components. The first component is the scorecard, which applies the FWHA Traffic Signal Systems Capability Maturity Framework to evaluate how effectively organizations support sustained attainment of their most important objectives. The FHWA Traffic Signal Systems Capability Maturity Framework, consistent with the AASHTO guidance, identifies six dimensions of capability. The six dimensions of capability were projected on to a Traffic Signal Program Model developed by FWHA, which breaks a traffic signal program into four program areas (Systems and Technology, Workforce, Business Processes and Management, and Administration) with a central focus on supporting objectives. To be consistent with the typical division of labor within traffic signal programs, the program area and capability maturity dimension of business processes were sub-divided into the areas of design, operation, and maintenance. To distinguish between the hard infrastructure such as poles, mast arms, and signal indications from system components such as traffic signal controllers, communications, and detection devices; the AASHTO dimension of systems and technology was divided into Infrastructure and Systems and Technology. The scores provided for each of the dimensions is an aggregate of 144 responses to the *Self Assessment,* distributed in May 2018 to collect capability maturity and benchmarking data. The collective state and local agencies that completed the 2018 *Self Assessment* are responsible for the management of approximately 24 percent of the estimated 327,860 signals in the United States.

By combining the capability maturity assessment technique with the traffic signal program model, the presence of gaps in capability can be assessed as an indicator of risk. Gaps in organizational capability represent the risks to consistent and sustained attainment of objectives within any of the four program areas to the attainment of program goals and objectives. Four broad levels of maturity and capability are defined (Figure 2) as:

- **Level 1: Ad Hoc** – Activities and relationships largely ad hoc, informal, and champion-driven, substantially outside the mainstream of other DOT activities.
- **Level 2: Established** – Basic strategy applications understood; key processes support requirements identified and key technology



FHWA

Figure 2. Levels of Organizational Capability-Maturity.

and core capacities under development, but limited internal accountability and uneven alignment with external partners.

- **Level 3: Measured** – Standardized strategy applications implemented in priority contexts and managed for performance; technical and business processes developed, documented, and integrated into DOT; partnerships aligned.
- **Level 4: Managed** – Full, sustainable core DOT program priority, established on the basis of continuous improvement with top level management status and formal partnerships.

The grades from F to A are distributed among the levels to provide a connection to prior traffic signal report card efforts. Previous traffic signal report cards, completed in 2005, 2007, and 2012, assigned incrementally increasing national scores of D-, D and D+, respectively.[2,3,4] These prior assessments focused primarily on evaluating individual agency practices, relative to best practice(s). The outcome of the prior process was a national traffic signal management and operations score based on an aggregate response to all self assessment questions. The *2018 Traffic Signal Benchmarking Self Assessment* approached creating a grade from a capability maturity basis; **the equivalent 2019 National Traffic Signal Report Card score has improved to a national grade of C+**.

This is a meaningful improvement. It demonstrates that agencies are using established processes to support management and operations of traffic signals to meet their own stated goals and objectives rather than relying on ad hoc methods. The letter grade represents a snapshot of national traffic signal program capability and maturity, and represents the risk to these programs of not consistently meeting their core operations and maintenance objectives.

Benchmarking

The *2019 Traffic Signal Benchmarking and State of the Practice Report* is more than a scorecard of organizational capability. The second part of the report is benchmarking which covers demographic information about infrastructure, systems, and organizations. Data from the U.S. Department of Transportation Joint Program Office 2019 deployment tracking survey were combined with data collected from the 2018 traffic signal self-assessment to highlight trends and provide a national benchmark in the areas of traffic signal infrastructure, organizational characteristics, and systems and technology.[5]

Benchmarking traffic signal infrastructure, current practices, and technology implementation is an essential tool to informing the investment decisions of policymakers, department managers, and transportation professionals, both now and into the future. The *2019 Traffic Signal Benchmarking and State of the Practice Report* explores the current state of these topics for agencies across the United States. Benchmarking describes the current complexity, extent, and processes that support traffic signal assets, and is integral to informing investment decisions. This report captures how these agencies are organized, as well as workforce trends, technology implementation, and business processes involved in the planning, design, operation, and maintenance of traffic signals. The analysis methods examine if agencies are articulating goals and objectives, and how they support their attainment by structuring and organizing the areas of the program to manage risks.

At the beginning of this effort, the project team held a structured interview process with a dozen selected representatives of the target audiences from local, regional, and state agencies known for their leadership in traffic signal program management. The structure and focus of the resulting report is an outcome of information collected and feedback from the interviews.

An Approach to Improve Traffic Signal Programs

More than 3,000 agencies are involved in traffic signal management and operations. The systems managed by these organizations are diverse, ranging in size from as few as two traffic signals to more than 10,000. The contexts surrounding these signals are equally

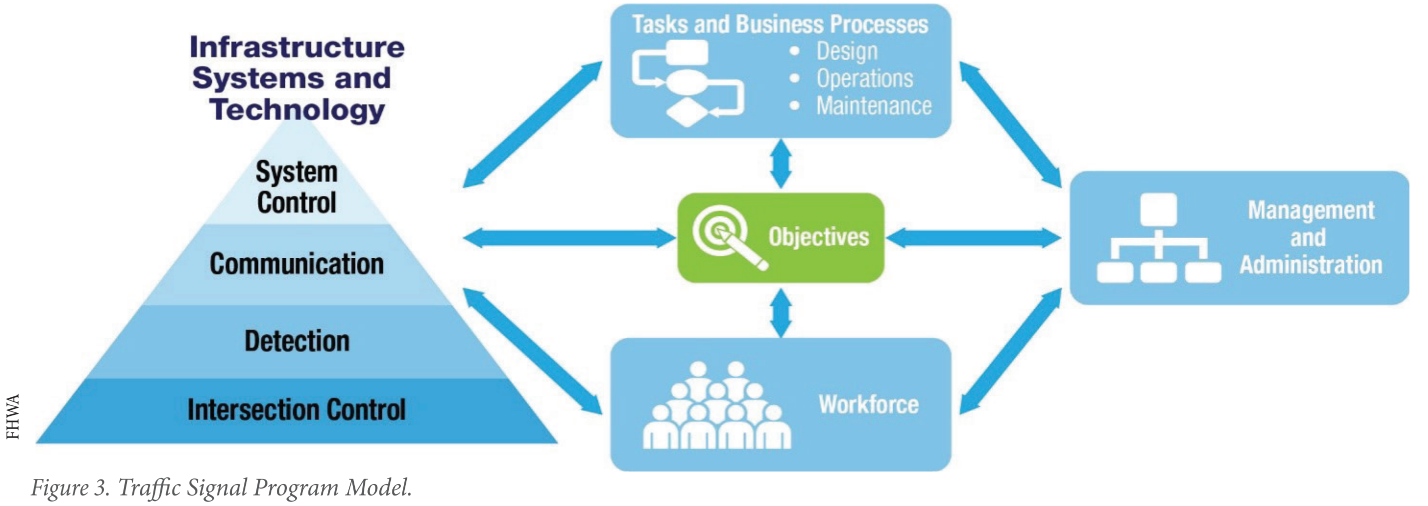


Figure 3. Traffic Signal Program Model.

diverse, covering areas from rural to urban; vehicle traffic conditions that range from light to congested; and users including pedestrians, bicycles, transit, freight, and rail. The agencies involved vary in terms of their understanding and knowledge of their own capabilities and organizational maturity. As a consequence, the practical method to improve traffic signal programs is to develop strategies that can be implemented on an incremental basis from different starting points. By following a structured process, agencies can identify their current and desired levels of capability within program area.

To meet the purpose and intent of improving organizational capability to manage transportation on the nation's roadways, a programmatic approach to traffic signal management and operations ensures that transportation goals such as safety, mobility, reliability, and state-of-good-repair are attained within the organization's capability and resource constraints. The maturity of each area of the program can be assessed to determine the level of risks to sustained attainment of the programs objectives. The recommended approach is to organize as an agency service delivery for traffic signal systems around the Traffic Signal Program Model, as shown in Figure 3.

The model simplifies and illustrates the relationships between the four core areas of a traffic signal program:

- Infrastructure, Systems, and Technology, shown as hierarchal triangle on the left
- Workforce, shown as rectangle at the bottom
- Tasks and Business Processes, shown as a rectangle at the top
- Management and Administration, shown as a rectangle on the right

Traffic signal program objectives, shown at the center of the model, are the output of a process that continually evaluates context to extract attainable objectives from goals (shown in detail in Figure 4).

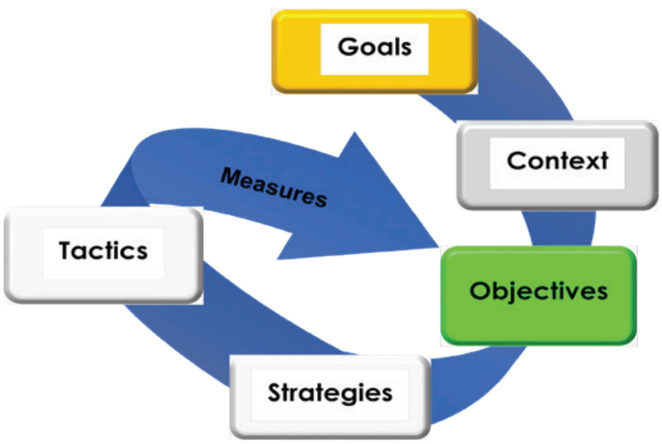


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Figure 4. Traffic Signal Program Model Goals, Context, Objectives, Strategies, and Tactics.

Goals are the high-level, broad expressions of the desired outcomes experienced by stakeholders. Context is the dynamic physical, operational, and organizational influence that determines the priority of the goals and leads to a selection of attainable objectives. The process of evaluating context is ongoing, and the program should be able to attain all identified objectives. Objectives are what the program must do to make progress towards one or more goals. Within each area of the program areas are the activities (strategies) and the methods (tactics) that must be applied to attain objectives. The reliability of the program to consistently deliver activities and methods that attain objectives is assessed through evaluation of the program process using the *Self Assessment*.

The infrastructure, systems, and technology shown in Figure 2 are an outcome of the program; the arrows shown between each area of the program and objectives illustrate the close relationship between all program areas. The application of the *Self Assessment* provides an evaluation of how reliably the programs processes will sustain attainment of the objectives. The *Self Assessment* is a tool used in the traffic signal program plan to identify gaps in capability to support the development of an action plan for program improvement. A successful program effectively balances the activities of the four program areas to ensure objectives are persistently attained.

Making Your Case – Actions to Take Now

A well-crafted Traffic Signal Management Plan (TSMP) provides a mechanism for all program stakeholders to clearly articulate the relationship between the activities of the traffic signal program and the goals of the transportation agency and larger transportation system management and operations (TSMO) context. Relating the activities of the program to agency and TSMO goals with the support of objectives and performance measures is fundamental to gaining the support of stakeholders for the program and critical to successfully competing for resources. A TSMP does the work of demonstrating the connection between traffic signal operations and maintenance activities and organizational and TSMO goals, such as safety, mobility, reliability, resilience, and efficiency. The TSMP development process is show in Figure 5.

The following are recommended steps for agencies in defining key objectives around a TSMP:

- Identify and champion a committee to discuss the need for and approach to developing the TSMP.
- Agencies can jump-start traffic signal program planning by routinely completing the *Traffic Signal Benchmarking and Self Assessment Survey* and include meaningful measures that are directly connected to the programs objectives.
- Kick-off a development process for the TSMP.
- Create an action plan developed as an outcome of completing the *Self Assessment* and subsequent TSMP development process to provide a number of steps an organization might consider implementing to address risks related to a particular dimension and level of capability.

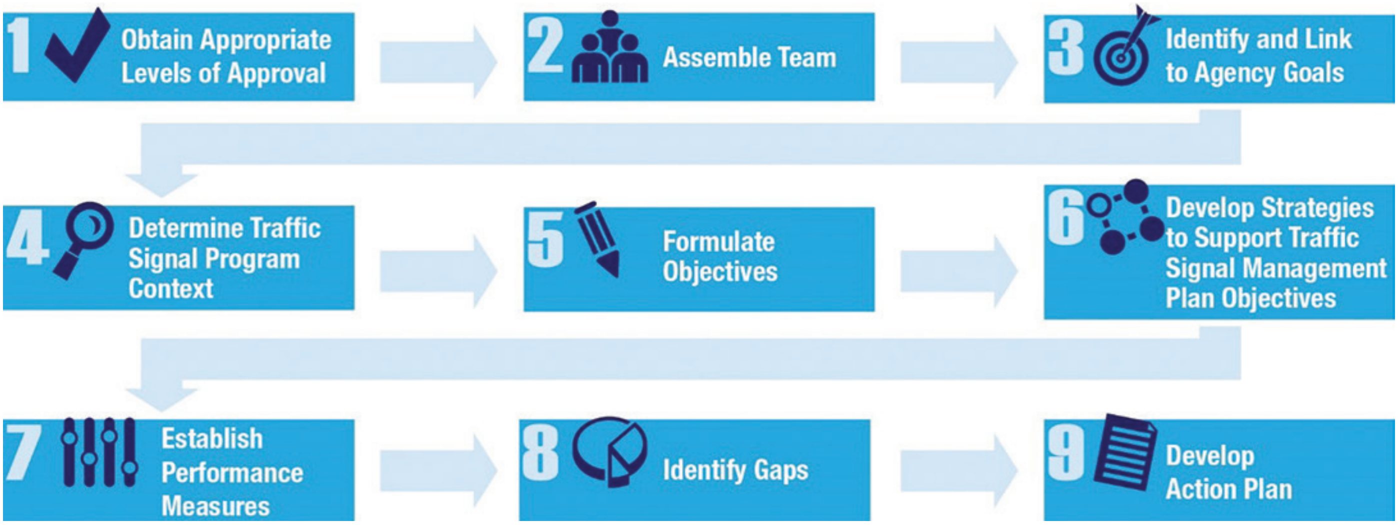

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Figure 5: Traffic Signal Management Plan Development Process.

- Develop an outreach strategy for policymakers and the public for the traffic signal program management plan.

FHWA has partnered with ITE and the National Operations Center of Excellence. Training and documents are available to support development of Traffic Signal Management Plans, implement technology such as Automated Traffic Signal Performance Measures (ATSPM), and to improve signal timing. Resources can be found by visiting the FHWA Arterial Management website at https://ops.fhwa.dot.gov/arterial_mgmt/, and those interested can become involved with councils and committees hosted by ITE, AASHTO, and the Transportation Research Board (TRB). There are ongoing and innovative programs available through peer networks, research, professional capacity building, and resources available from FHWA and professional organizations. There are many opportunities for transportation professionals to move their agencies forward to the next level of organizational capability. **itej**

Acknowledgements

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CASE STUDY

Automated Traffic Signal Performance Measures: **A Program Approach**

By Justin R. Effinger, P.E. (M)

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Lake County, situated in the northeastern most corner of Illinois, USA, has a current population of more than 700,000—a population growth of 36 percent since 1990. The Illinois Department of Transportation (IDOT) found that there was an increase of approximately 875,000 daily vehicle miles (1.4 million kilometers [km]) of travel in Lake County (six percent growth) from 2010 to 2017, and this growth is expected to continue. Traffic congestion impacts the quality of citizens' daily lives—time spent frustrated in traffic backups means less time with one's family. The Lake County Division of Transportation (LCDOT) has been using Synchro traffic analysis software to evaluate intersection operations and performance. Table 1 summarizes the levels-of-service (LOS) for each of the county-involved, signalized intersections and roundabouts currently modeled in the Synchro model. LCDOT recognizes that effectively addressing congestion issues is not simply adding new lanes to our highway system, but making the roads work better.

Automated Traffic Signal Performance Measures (ATSPMs) became more popular in the United States through the Every Day Counts – 4 Innovations.[1] ATSPMs consist of logging high-resolution data from modern traffic signal controllers utilizing the "Indiana Traffic Signal Hi Resolution Data Logger Enumerations" for data analysis

LOS	Number of Signalized Intersections		Number of Roundabouts		Number of All-Way Stop Controlled Intersections	
	AM	PM	AM	PM	AM	PM
A	100 (32%)	67 (21%)	2 (40%)	1 (20%)	6 (40%)	2 (13%)
B	72 (23%)	71 (23%)	3 (60%)	2 (40%)	7 (47%)	5 (33%)
C	87 (28%)	79 (25%)	0	2 (40%)	1 (7%)	4 (27%)
D	30 (10%)	57 (18%)	0	0	0	2 (13%)
E	9 (3%)	22 (7%)	0	0	1 (7%)	1 (7%)
F	15 (5%)	17 (5%)	0	0	0	1 (7%)
Totals	313		5		15	

Table 1. Intersection Level of Service (From Synchro) 2018. Note: Level-of-Service for signalized intersections is defined in the 2010 Highway Capacity Manual.

and to proactively identify and correct any deficiencies if they exist.[2] LCDOT created an ATSPM program to address the following:

1. Improving traffic signal operations;
2. Quicker response time to citizen concerns;
3. Evaluation of adaptive signal control;
4. Transportation Management Center (TMC) Operations;
5. Planning selection process of improvement (modernization/expansion) projects.

Automated Traffic Signal Performance Measures (ATSPM) Program

The established Lake County Passage program made a larger scale ATSPM implementation possible. Traffic signal and other roadway data are collected and returned to the Transportation Management Center (TMC) through the field communications network, including a fiber optic network consisting of more than 300 (483 km) miles of fiber cable, licensed wireless radio communication, and cellular connections. The expansive communication network connects more than 600 of the approximately 750 state, county, and locally owned traffic signals in Lake County.

The ATSPM program started with utilizing the available open-sourced ATSPM software developed by the Utah Department of Transportation that provided a framework for public agencies to implement the research that went into ATSPMs.[3] For testing purposes, a "retired" server that previously held the central traffic signal system software was utilized, the open-sourced ATSPM software was implemented, and the code was modified in-house to be applicable to LCDOT.

Once the value of the program was proven (see "Results and Success of the Program"), a wider implementation and upgrade to the open-sourced ATSPM software version 4.2 was funded along with controller firmware upgrades of 116 traffic signals to be ATSPM ready. To date, 250 traffic signals currently collect ATSPM data, including the addition of 47 more traffic signals at the end of 2019 due to a project to update traffic signal controller technology.

To obtain more accurate benefits of the technology, LCDOT created a new lane-by-lane detection approach. The new detection scheme also utilized speed detection for higher accuracy vehicle counts and a lower rate of detection being stuck on. Figure 1 shows the old detection approach and Figure 2 shows the new detection approach, which also includes special count detectors for intersection movement counts. Figures 3 and 4 show the potential difference in the number of vehicles being detected approaching the traffic signal (symbolized by the black dots).

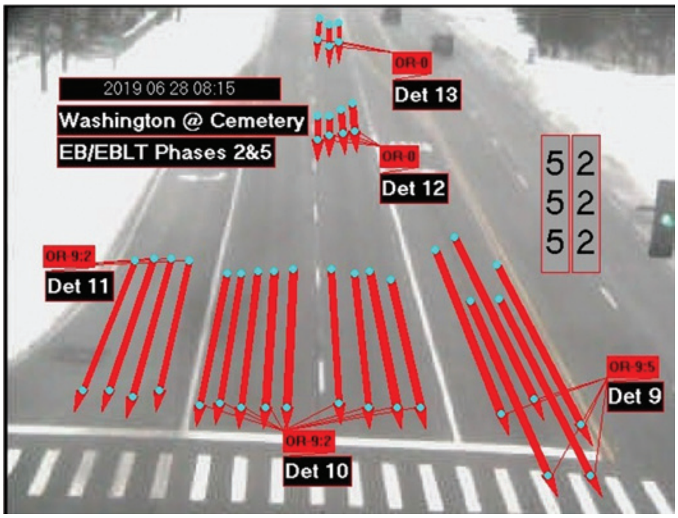

Figure. 1. Old detection approach (Autoscope video detection). The intersection is Washington Street and Cemetery Road in Gurnee, IL, USA.

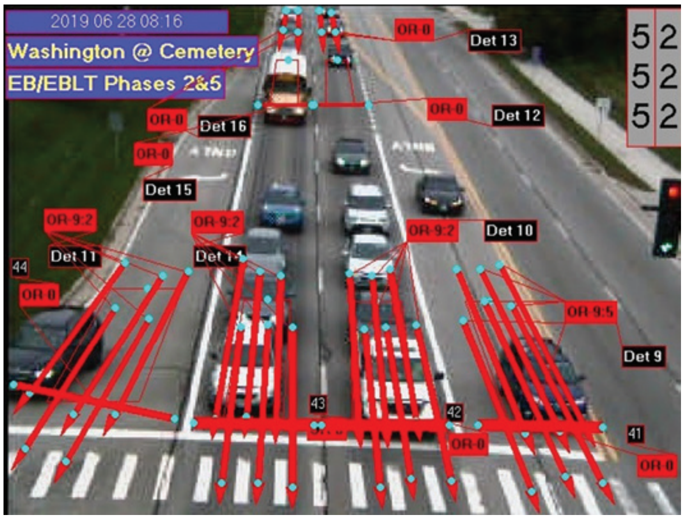

Figure 2. New detection approach (Autoscope video detection). The intersection is Washington Street and Cemetery Road in Gurnee, IL, USA.

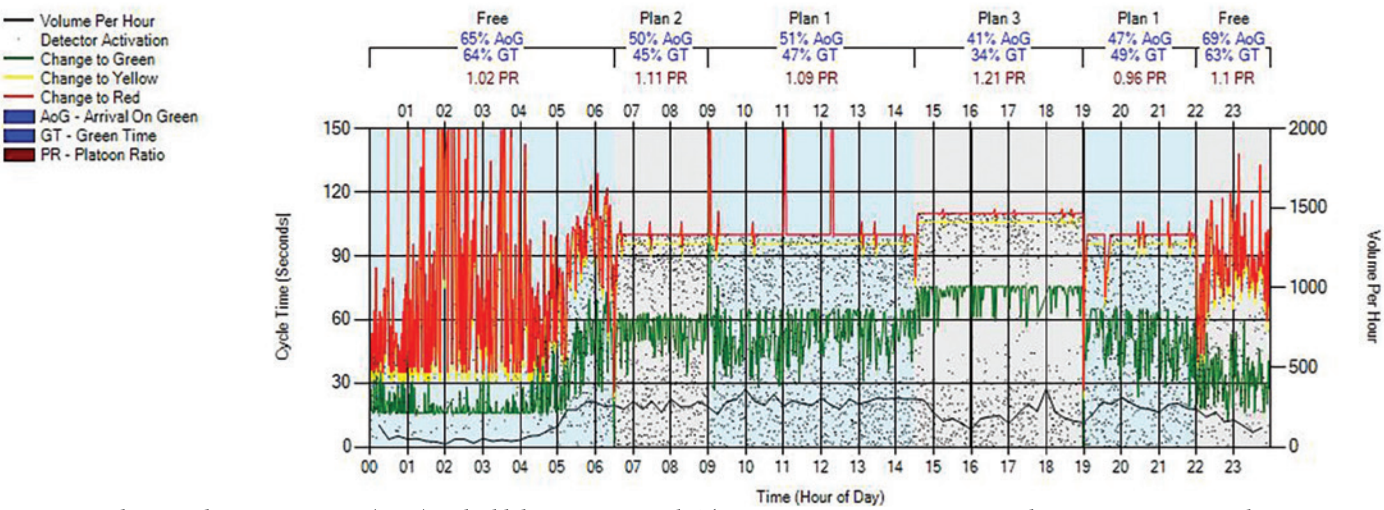

Figure 3. Purdue Coordination Diagram (PCD) with old detection approach. The intersection is Lewis Avenue and Sunset Avenue in Waukegan, IL, USA.

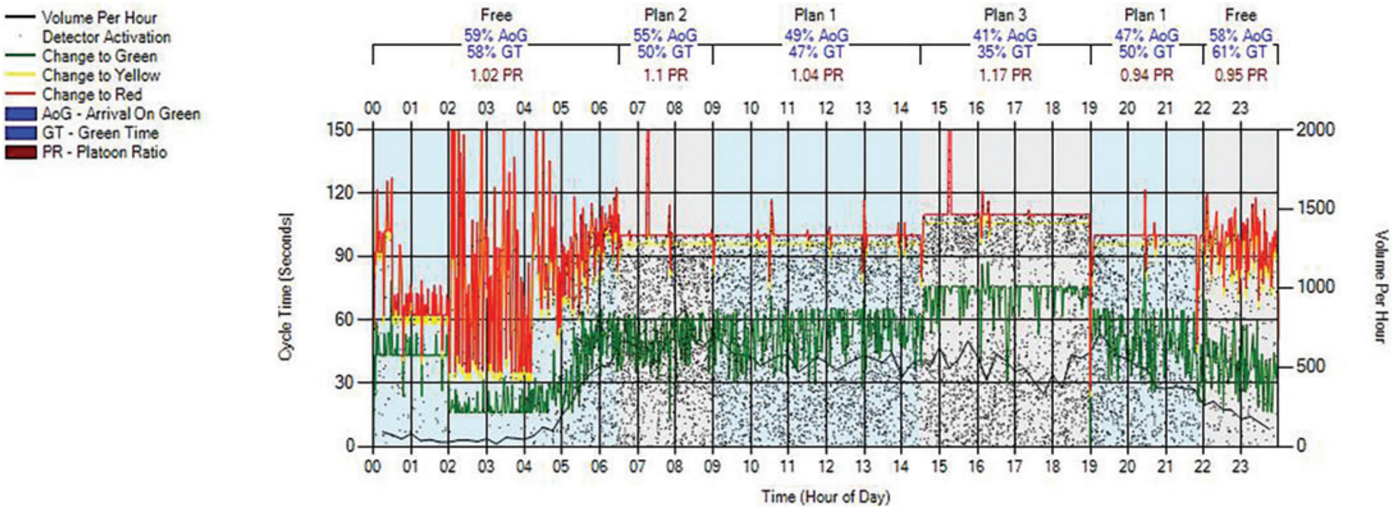

Figure 4. Purdue Coordination Diagram (PCD) with new detection approach. The intersection is Lewis Avenue and Sunset Avenue in Waukegan, IL, USA.

Use of the Technology and Cost of the Program

The ATSPM program was deployed in three phases. Each phase of the program makes optimal use of existing infrastructure by tying together communications elements owned by multiple agencies. Phase 1 was deployed and became operational in November 2017. The deployment included implementation of the initial open-sourced ATSPM software (4.0.1) and traffic signal controller software upgrades. As the ATSPM software was implemented in house, the total cost for phase 1 was approximately $42,000 USD for the traffic signal controller software upgrades for better utilization of the high-resolution traffic signal data.

Phase 2 was completed in June 2019 and includes an upgrade to the newest open-sourced ATSPM software, version 4.2, and implementation of a watchdog feature which will create an alarm to LCDOT personnel if detectors at traffic signals are not operating correctly. Due to the staffing needs and complexity of updating a software without an executable, the project was consulted out to a company with traffic engineering and computer coding expertise. The total cost for Phase 2 was approximately $52,000 USD.

Phase 3, completed in September 2019, included a request for proposal (RFP) with system requirements from a systems engineering analysis for a cloud-based solution with enhancements for more tangible benefits. The budget for the five-year cloud-based solution selected is $482,700 USD, which includes data storage, initial implementation, two, two-day training courses, importing existing signal configuration data, and six months of high-resolution data. The items of most importance to Lake County included a solution that incorporates multiple different signal controller vendors and the following advanced ATSPM features:

1. The ATSPM should be capable of providing offset recommendations for signal groups via the Purdue link pivot and report the comparisons of logged data when requested by the user:
   a. Day to day
   b. Hour to hour
   c. Hour of day to hour of day
   d. Hour of week to hour of week
   e. Day of week to day of week
   f. Day of year to day of year
2. The ATSPM should be capable of providing cycle and split recommendations for signal groups and report the comparisons of logged data when requested by the user:
   a. Day to day
   b. Hour to hour
   c. Hour of day to hour of day
   d. Hour of week to hour of week
   e. Day of week to day of week
   f. Day of year to day of year
3. The ATSPM should be capable of analyzing past event logs and provide alerts to the user when signal timing anomalies are occurring. (This requirement may be fulfilled by sending the alerts to a designated list of recipients by a designated means, or by using an external maintenance management system.)
4. The ATSPM should be capable of a dashboard that has the overall health of the traffic signals with ability to generate recommendations on how to improve signals or signal groups.
5. The ATSPM should be capable of integrating travel times to integrate different reporting features and generate new reporting features, including, but not limited to, countywide heat maps.
6. The ATSPM should be capable of future integration of connected vehicle technology, including, but not limited to, vehicle trajectory to improve traffic signal timings.
7. The ATSPM should be capable of analyzing a user specified before and after analysis of a signal group to generate a report with the following performance benefits:

a. Change in delay
b. Change in fuel consumed
c. Annual change in CO2
d. Annual benefit
e. Change in travel time
f. Change in average speed

Finally, the RFP included collaboration language for expansion of the ATSPM solution to all the collar counties of the Chicago metropolitan area, in which the other jurisdictions can add their traffic signals at the bulk rate and customized to a per month charging basis with no long-term commitment. LCDOT incorporated comments on the RFP from Kane County, DuPage County, City of Naperville, Federal Highway Administration (FHWA), and the Chicago Metropolitan Agency for Planning.

Results and Success of the Program

Through coordination and cooperation at many levels from IDOT to local municipalities, the Lake County ATSPM Program has enabled many industry-leading and cost-effective solutions. This project provided the following benefits:

Improved Traffic Signal Operation

LCDOT typically consults out Signal Coordination and Timing (SCAT) studies, in which:

1. Turning movement counts are collected;
2. A Synchro traffic signal analysis is conducted;
3. Traffic signal cycle lengths, splits, and offsets are optimized;
4. A before and after travel time study is conducted; and
5. A benefit to cost analysis is done.

ATSPMs have allowed LCDOT to better review performance of these optimized signal systems. Reports such as Arrival on Green (AoG) have shown a flaw in the SCAT process in which arrival on green was not optimized as well as it could have been. Most signal systems are analyzed using a start-to-end methodology that does not properly factor internal traffic that does not go the entire system. A good example is the PM Peak traffic impacts from Discover Financial, which is a Fortune 500 Company with their headquarters in Riverwoods, IL, USA. At the traffic signal at Saunders Rd. and Discover Way, there is a large amount of vehicles exiting the Discover Financial headquarters, disrupting Saunders Rd. Figure 5 shows the low AoG for a downstream traffic signal at Deerfield Rd. and Saunders Rd., along with the Purdue Link Pivot results (Figure 6) to improve the offset along the route to balance the company exiting traffic with peak northbound Saunders Rd. traffic.

The result is an overall delay reduction for the entire route. Utilizing ATSPM will be an LCDOT requirement through a special provision update for SCAT studies to calibrate the signal system based on at least three weeks of typical traffic conditions.

Quicker Response Time to Citizen Concerns

TMC operators can use ATSPMs to review traffic progression inconsistencies like Emergency Vehicle Preemption (EVP), pedestrian movements that aren't able to fit into a coordinated split time, and handling traffic signal operations during incidents to improve traffic temporarily due to lane reductions or roadway closures. ATSPMs give TMC operators quick access to data for phone calls and email submissions, which gives an opportunity to educate citizens on how traffic signals operate and the information that goes into making decisions on how a specific traffic signal operates.

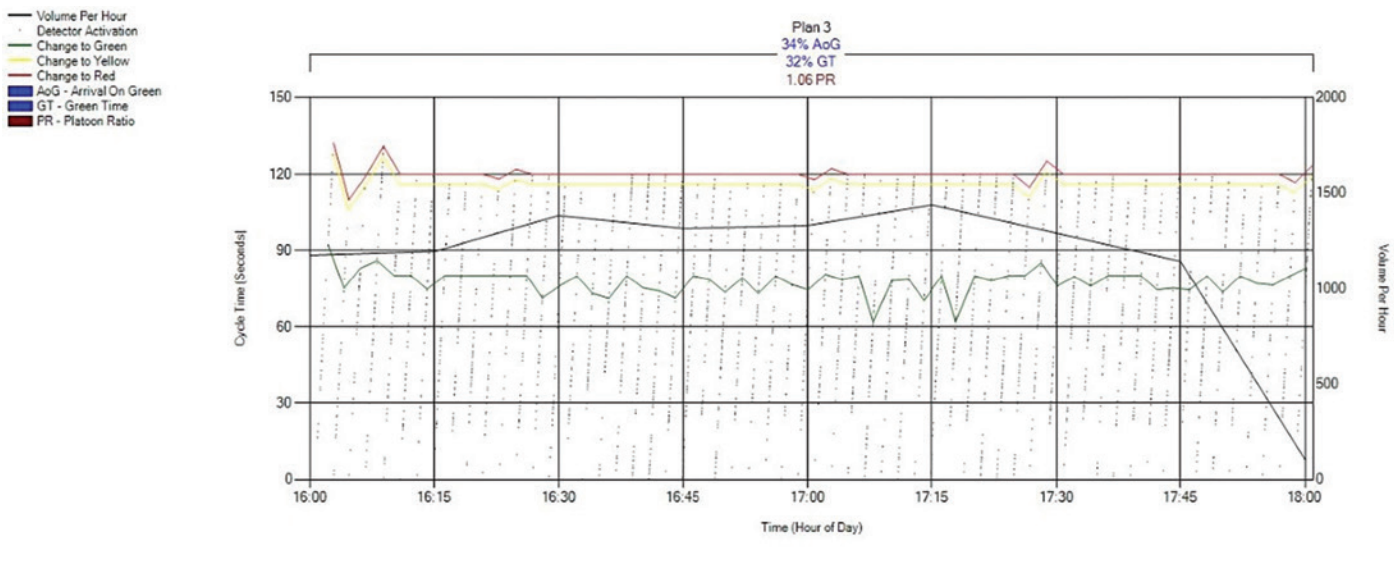

Figure 5. Purdue Coordination Diagram (PCD) with 37 percent AoG. The intersection is Saunders Road and Riverwoods Road in Riverwoods, IL, USA.

ATSPMs are critical in helping with citizen concerns as they relate to traffic signals not operating in a more efficient manner. Typically, addressing a traffic signal problem, making changes, and calibrating the change can take days or weeks. With ATSPM, LCDOT can make more complicated changes in three to five hours and more simple changes in less than one hour, decreasing the need to spend time on other calibration techniques, like simulation. For example, a call came in from the public regarding the operation of the traffic signal at Illinois Route 176 and Hawley St, which is part of an adaptive signal system. The motorist stated that the traffic signal was cycling too fast, causing backups on Illinois Route 176. Utilizing the Split Monitor Report in the ATSPM, shorter than expected green times for Illinois Route 176 were found. In looking at the adaptive program, a gap between the coordinated tunnels (green bands) was observed allowing enough time to double serve Hawley St. The backups along Illinois Route 176 were confirmed with closed circuit television (CCTV) cameras in the TMC. The solution was to close the gap to prevent the traffic signal from double serving Hawley St., but only when Illinois Route 176 was busiest. After implementation, the ATSPM showed longer green times for Illinois Route 176 and the CCTV cameras confirmed the backups were gone. With ATSPM, the problem was identified, and a solution was implemented in less than 30 minutes. ATSPM has helped with new innovative traffic signal timing innovations, as it provides a mechanism for studying the change in a much more efficient manner.

Adaptive Traffic Signal Operation

The LCDOT ATSPM program is being used for continued evaluation of adaptive traffic signal operation. Most agencies will select an adaptive traffic signal program and expect that it will not need to be changed, or minimally changed in the future. LCDOT sees the need for ATSPM in consistently evaluating adaptive routes in the most efficient way possible based on changing goals and objectives. An approach was created to utilize ATSPM on routes even when the adaptive technology intercepts vehicle detection calls. Through this approach, LCDOT has been able to calibrate and fine-tune its adaptive routes based on citizen concerns and conduct

Link	Approaches		Upstream AOG			Downstream AOG			Total Link AOG			Delta	AOG Chart
	Upstream	Downstream	Existing	Predicted	Change	Existing	Predicted	Change	Existing	Predicted	Change		
1	LC338 Northbound	LC460 Southbound	993	974		1138	1247		2131	2221		10	PCD Options
	LC338 - Saunders Rd Discover Way	LC460 - Saunders Rd Baxter Pkwy	67%	66%		73%	80%		70%	73%			
2	LC460 Northbound	LC459 Southbound	1661	1661		832	844		2493	2505		2	PCD Options
	LC460 - Saunders Rd Baxter Pkwy	LC459 - Saunders Rd Parkway North	76%	76%		84%	85%		79%	79%			
3	LC459 Northbound	LC454 Southbound	2174	2199		153	156		2327	2355		3	PCD Options
	LC459 - Saunders Rd Parkway North	LC454 - Deerfield Rd Saunders Rd/Riverwoods Rd	86%	87%		26%	26%		74%	75%			
Corridor Summary			4828	4834		2123	2247		6951	7081			
			78 %	78 %		68 %	72 %		74 %	76 %			

Figure 6. Purdue Link Pivot showing coordination offset recommendations for optimal AoG. The route is Saunders Road from Deerfield road to Discover Way in Riverwoods, IL, USA.

proactive countermeasures years after the initial installation of the adaptive system. LCDOT has also developed ways to incorporate ATSPM into the systems engineering process for the selection of new adaptive signal control technologies.

Foundation for Connected Vehicles

LCDOT is currently mapping out a plan for connected vehicles in Lake County. The vision is that Signal Phasing and Timing (SPaT) data can be broadcast to the vehicles, and in return, there is an opportunity to get GPS data, which could move towards a paradigm shift that could use ATSPM as a foundation for artificial intelligence to make traffic signals more automated and as efficient as possible from a central system standpoint. In addition to using cellular data and utilizing existing infrastructure, Lake County is entering no cost data sharing partnerships with third parties and universities to develop new and innovative techniques to improve traffic in Lake County using data from ATSPMs.

LCDOT Planning Process

LCDOT is guided by the goals and strategies outlined in the current Lake County Strategic Plan. The highway improvement program is a balance of the following priorities:

- System Preservation Projects: Keeping county highway pavements, bridges, bikeways, signals and other related items in good conditions.
- System Modernization Projects: Reducing delay and increasing safety by accommodating short-term traffic growth and the needs of non-motorists.
- System Expansion Projects: Providing highway capacity to meet long-term traffic needs and provide for economic development.

One tool used to program these projects is a project scoring matrix, which includes project specific information such as crash rates, intersection level of service (from simulation), non-motorized components, regional significance, and project readiness. The information is entered into a matrix, scored, and ranked against each other. Other factors such as project cost and schedule are factored in, but the matrix makes the process more data-driven.

The process is dynamic and updated regularly as other tools and data become available. Instead of using simulated level of service, LCDOT is going to use level of service generated from its ATSPM software, and plan on using other features inside of ATSPM like travel times, CO_2 waste, annualized cost caused by vehicle delay, vehicle queue length, and more as they become available.

Conclusion

With the cost of new construction continuing to increase and traffic demand on the rise throughout the county, the Lake County Division of Transportation implemented an Automated Traffic Signal Performance Measures program. The success of the program hinged on a three-stage process of learning with the open sourced ATSPM software and finishing with a systems engineering analysis that resulted in an RFP for a cloud-based solution.

The cloud-based solution allows LCDOT to conduct the SCAT studies in-house without adding more staff, thus paying for the new system, and saving $17,300 USD over the five-year period. It also gives LCDOT the ability to do the SCAT studies more frequently. This means instead of doing two to four studies per year, the agency can potentially do most, if not all, county-coordinated systems each year. From a regional perspective, agencies inside the MPO's jurisdiction have an approximate cost savings of $140,000 USD per year by adding to the cloud-based system when compared to purchasing the cloud-based system on their own.

Lake County continues to enhance ATSPMs as funding opportunities arise and is involved in national collaboration efforts under way to increase the knowledge and implementation of ATSPMs on a government level. **itej**

Acknowledgement

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Answer to "Where in the World" on page 12: Going-to-the Sun Road in Glacier National Park, Montana, USA. Photo courtesy Alan Woodmansey, P.E., PMP (M).