City of Phoenix

Agenda
City Council Policy Session

Meeting Location:
City Council Chambers
200 W. Jefferson St.
Phoenix, Arizona 85003

Tuesday, January 24, 2023 **2:30 PM** **phoenix.gov**

OPTIONS TO ACCESS THIS MEETING

Virtual Request to speak at a meeting:

- Register online *by visiting the City Council Meetings page on phoenix.gov* ***at least 2 hours prior to the start of this meeting****. Then, click on this link at the time of the meeting and join the Webex to speak:* https://phoenixcitycouncil.webex.com/phoenixcitycouncil/onstage/g.php?MTID=e1bddedbb35d196b446a1e6b3beb408e2

- Register via telephone at 602-262-6001 **at least 2 hours prior to the start of this meeting,** noting the item number. Then, use the Call-in phone number and Meeting ID listed below at the time of the meeting to call-in and speak.

In-Person Requests to speak at a meeting:

- Register in person at a kiosk located at the City Council Chambers, 200 W. Jefferson St., Phoenix, Arizona, 85003. Arrive **1 hour prior to the start of this meeting**. Depending on seating availability, residents will attend and speak from the Upper Chambers, Lower Chambers or City Hall location.

- Individuals should arrive early, 1 hour prior to the start of the meeting to submit an in-person request to speak before the item is called. After the item is called, requests to speak for that item will not be accepted.

At the time of the meeting:

- Watch the meeting live streamed on phoenix.gov or Phoenix Channel 11 on Cox Cable, or using the Webex link provided above.

- Call-in to listen to the meeting. Dial 602-666-0783 and Enter Meeting ID 2555 329 6201# (for English) or 2551 039 4761# (for Spanish). Press # again when prompted for attendee ID.

- Watch the meeting in-person from the Upper Chambers, Lower Chambers or City Hall depending on seating availability.

Para nuestros residentes de habla hispana:

- Para registrarse para hablar en español, llame al 602-262-6001 **al menos 2 horas antes del inicio de esta reunión** e indique el número del tema. El día de la reunión, llame al 602-666-0783 e ingrese el número de identificación de la reunión 2551 039 4761#. El intérprete le indicará cuando sea su turno de hablar.

- Para solamente escuchar la reunión en español, llame a este mismo número el día de la reunión (602-666-0783; ingrese el número de identificación de la reunión 2551 039 4761#). Se proporciona interpretación simultánea para nuestros residentes durante todas las reuniones.

- Para asistir a la reunión en persona, vaya a las Cámaras del Concejo Municipal de Phoenix ubicadas en 200 W. Jefferson Street, Phoenix, AZ 85003. Llegue 1 hora antes del comienzo de la reunión. Si desea hablar, regístrese electrónicamente en uno de los quioscos, antes de que comience el tema. Una vez que se comience a discutir el tema, no se aceptarán nuevas solicitudes para hablar. Dependiendo de cuantos asientos haya disponibles, usted podría ser sentado en la parte superior de las cámaras, en el piso de abajo de las cámaras, o en el edificio municipal.

CALL TO ORDER

COUNCIL INFORMATION AND FOLLOW-UP REQUESTS

This item is scheduled to give City Council members an opportunity to publicly request information or follow up on issues of interest to the community. If the information is available, staff will immediately provide it to the City Council member. No decisions will be made or action taken.

CONSENT ACTION

This item is scheduled to allow the City Council to act on the Mayor's recommendations on the Consent Agenda. There is no Consent Agenda for this meeting.

CALL FOR AN EXECUTIVE SESSION

A vote may be held to call an Executive Session for a future date.

REPORTS AND BUDGET UPDATES BY THE CITY MANAGER

This item is scheduled to allow the City Manager to provide brief informational reports on topics of interest to the City Council. The City Council may discuss these reports but no action will be taken.

DISCUSSION AND POSSIBLE ACTION (ITEM 1)

1 **Update on Yellow Light Timing Study** Page 5

This report provides an update on the Street Transportation Department's progress on a field study to investigate and evaluate the "before" and "after" impacts of a focused implementation of the new Institute of Transportation Engineers' guidelines on yellow change and red clearance intervals in comparison with Phoenix's current practices of setting yellow change and red clearance intervals at signalized intersections.

THIS ITEM IS FOR DISCUSSION AND POSSIBLE ACTION.

Responsible Department

This item is submitted by Deputy City Manager Mario Paniagua and the Street Transportation Department.

ADJOURN

City of Phoenix

Report

Agenda Date: 1/24/2023, **Item No.** 1

Update on Yellow Light Timing Study

This report provides an update on the Street Transportation Department's progress on a field study to investigate and evaluate the "before" and "after" impacts of a focused implementation of the new Institute of Transportation Engineers' guidelines on yellow change and red clearance intervals in comparison with Phoenix's current practices of setting yellow change and red clearance intervals at signalized intersections.

THIS ITEM IS FOR DISCUSSION AND POSSIBLE ACTION.

Summary

The Street Transportation Department (Streets) is conducting a field study in partnership with the University of Arizona to examine whether implementing Institute of Transportation Engineers' (ITE) 2020 guidelines on yellow change and red clearance intervals can enhance safety at signalized intersections. This report addresses relevant background information, including why it is important to study road users' compliance with traffic signal change intervals, the procedure for study site selection, data collection and analysis, baseline condition, and how the study design is being implemented.

Background

Red-light running (RLR) is one of the riskiest behaviors at signalized intersections. According to a report published by the American Automobile Association (AAA) Foundation for Traffic Safety, more than two people were killed every day due to noncompliance with red signal indications (AAA Foundation for Traffic Safety, 2020). According to a report published by the Insurance Institute for Highway Safety, RLR violations caused 928 fatalities in 2020 in the United States. In addition, an estimated 116,000 people suffered injuries in RLR collisions (IIHS, 2022). Similar to cities across the nation, RLR-related violations in the Phoenix metropolitan area have become one of the most severe causes of fatal crashes, with 113 fatalities and 9,320 injuries reported from 2014 to 2020.

The basic purpose for the yellow change interval is to inform the driver that the green phase has ended. The yellow change interval provides time for the driver to either stop before entering the intersection or to proceed and clear the intersection.

The basic purpose of the red clearance interval is to provide the driver who decides to enter the intersection during the yellow change interval adequate time to clear the intersection prior to a conflicting (or opposing) green phase beginning at the intersection. The red clearance interval is typically called the “all-red” time.

Streets' Current Signal Timing Practices

Streets has a standard operating procedure (SOP) for determining the duration of traffic signal intervals. The SOP utilizes the pre-2020 ITE kinematic equation and also states that any deviations from the SOP must be approved by the Streets’ Deputy Director over the Traffic Services Division. The current City of Phoenix equations for calculating the yellow change and red clearance intervals is included in **Attachment A**.

ITE 2020 Guidelines

The updated ITE guidelines for calculating traffic signal timing were released in March 2020. Since 1965, ITE has developed a variety of methods for calculating yellow change and red clearance intervals, all of which are based on the kinematic equation method.

According to ITE, the kinematic equation method is the most popular and widely accepted technique for determining yellow change intervals (Noble, 2020). In comparing the new ITE 2020 guidelines to the prior ones, there are three key modifications.

- Change in the speed at which a reasonable driver approaches an intersection. If a speed study is not completed and the 85th percentile speed is not available, the 85th percentile approach speed for through movements may be estimated and substituted by the value of “Posted Speed Limit +7.” For the left-turn movements, the “Posted Speed Limit” can be used as the 85th percentile approach speed.
- Change in the method for yellow change interval calculations for left-turn movements.
- Change in maximum yellow change interval for left-turn movements. ITE advises use of 7.0 seconds as the maximum yellow change interval for left-turn movements.

The current 2020 ITE-recommended equations for calculating the yellow change and red clearance intervals are included in **Attachment A**.

The challenges and difficulties associated with determining traffic signal timings have been extensively discussed among scholars and professionals in the field of traffic engineering. It has long been an area of study to determine the proper traffic signal

timings to ensure intersection safety while maintaining an acceptable level of travel efficiency. However, there is still no broad consensus on the most appropriate method for calculating yellow change and red clearance intervals.

ITE indicates they believe there has been sufficient theoretical work, research, and practice information to reach a consensus recommendation. However, ITE acknowledges that this is not true for all potential elements or aspects of the process and so they recommend areas for further research. It is important to note that many practitioners do not accept the ITE 2020 guidelines due to lack of specific field research. There are a number of studies underway such as the Federal Highway Administration's Pooled Fund Study: Traffic Signal Change and Clearance Interval to address this concern. As Streets has the same concerns, the City of Phoenix, with Council approval, is participating in this study, with the hopes it will provide relevant industry and peer guidance to the City of Phoenix.

In order to effectively reduce the total number of RLR-related crashes and maintain a safe journey for all road users, it is crucial to explore RLR behavior at local intersections, understand the impact of different signal timing parameters (e.g., yellow change and red clearance intervals) on RLR frequency, and ultimately develop appropriate countermeasures.

Signal Timing Field Study

Objectives

Streets' purpose in performing this field study is to examine the ITE 2020 guidelines for yellow change and red clearance intervals and identify the relationship between signal timing parameters and RLR violations. Initially, based on several criteria, including the frequency and severity of RLR-related crashes and infrastructure feasibility, twelve intersections were selected to be part of the study. Then, at each study intersection, smart sensor equipment was installed. Finally, to determine the relationship between signal timing parameters and RLR violations, an experimental design for before-and-after analysis is being conducted and implemented.

Study Site Selection, Smart Sensor Equipment, and Field Implementation

In order to evaluate and select the intersections for the study, the City of Phoenix's signalized intersections were ranked using the following criteria.

- RLR-related crash frequency and severity;
- List of 100 intersections ranked by crash risk (provided by Maricopa Association of Governments);
- Former RLR camera locations; and

- Infrastructure feasibility.

As part of this identification process, the Arizona Crash Information System (ACIS) was queried for five years of crash data (from 2016 to 2021) to identify prospective intersections. From that data, only crashes at four-way intersections resulting from disregarding traffic signals were utilized.

Intersections were then ranked based on the frequency and severity of the crashes. The list of 100 intersections and the intersections where RLR cameras had previously been installed were two additional datasets that were considered. The list of 100 intersections contains the top 100 intersections ranked by crash risk and intersection safety score provided by the Maricopa Association of Governments (MAG). The document "MAG Network Screening Methodology for Intersections" provides a detailed description of the Intersection Safety Score (MAG, 2010).

After ranking the intersections, the feasibility of smart sensor equipment installation was considered. Due to the infrastructure limitation, intersections that required new signal cabling or new conduits in one or two legs of the intersection were eliminated from further consideration. The twelve intersections selected as the final candidate locations for the study were the ones that had the highest rank that also did not require any upgrades for smart sensor equipment installation. Selection of the twelve intersection locations for the study was completed in June 2022.

Concurrently, Streets staff was working to procure and install the necessary smart sensor equipment (Miovision’s SmartView 360). The smart sensor equipment provides traffic-related data, signal timing information, and high-resolution event-based data. The data and performance measures provided by the equipment include RLR, simple delay, and approach volumes. Despite some equipment delivery delays, all smart sensor equipment was installed and activated in August 2022.

Data Collection and Analysis
Signal timing information, turning movement counts, as well as red light and yellow light running data are being collected from the smart sensor equipment at each study intersection. The signal timing data contains information about traffic signal cycle lengths, yellow change intervals, and green durations. The turning movement counts represent various approach movements (left-turn, through, and right-turn movements) that pass through each intersection over 15-minute intervals. For red light and yellow light running data, each vehicle that ran the red light or yellow light has its own timestamp, vehicle classification, and approach movement recorded. The data collected will also go through a quality control check process to identify and filter out outliers. As part of this process, information collected by the smart sensor equipment

is reviewed, analyzed and compared to ground-truth video recordings at the intersections.

Baseline Condition Data - Intersection Through Movements
At each of the twelve intersection study locations, baseline data was collected on weekdays between Sept. 1 and Nov. 21, 2022. Over this twelve-week period, a total of 144,795 RLR incidents were observed. Among the study sites, two intersections experienced the most RLR incidents at more than 300 per day, eight of the intersections experienced between 200 and 300 RLR incidents per day, while the remaining two intersections had less than 200 RLR incidents per day.

It was found that the majority of RLR violations (88.5 percent or 128,164 events), occurred during the red clearance interval, while the remaining (11.5 percent or 16,631 events) RLR violations occurred after the red clearance time elapsed when opposing green phase movement began. The figure in **Attachment B** shows the percentage of RLR incidents that passed through the intersection on a red light both during and after the red clearance time.

As noted earlier, Streets' current practices calculate yellow change intervals based on posted speed limits for the streets approaching an intersection. Therefore, streets with lower speed limits have a lower calculated yellow change interval than streets with higher speed limits. The baseline data showed that RLR frequency per 1,000 vehicles during the yellow change intervals at each intersection was higher for intersections with streets with lower approach speed limits and shorter yellow change intervals. In summary, the approaches with shorter yellow intervals have greater RLR frequencies per 1,000 vehicles than those with longer yellow intervals. However, it is worth noting that side streets and approaches coming out from neighborhoods are most often associated with lower speed limits and shorter yellow intervals.

Study Design to Implement and Analyze ITE 2020 Guidelines
The "before-and-after" aspects of this study is intended to statistically determine whether the ITE 2020 guidelines for yellow change and red clearance intervals can improve intersection safety by reducing the number of RLR violations. Moreover, the potential relationship between different signal timing parameters and the potential impact of signal timing parameters on RLR frequency will be identified. Finally, a statistical method will be developed to identify the appropriate amount of yellow change and red clearance intervals that will result in reduction in RLR frequency.

With respect to the twelve study intersections, for the through and left-turn movements, some intersections will be used as the control sites, and the yellow change and red clearance intervals for these control intersections will not be changed from their current

timing. The control sites are used to eliminate the effects of traffic volume and pattern variation during the holiday seasons in our statistical analysis.

The remaining intersections are then considered as treatment sites, and the yellow change intervals will be changed for all the treatment sites. The new ITE 2020 guidelines were used to calculate the yellow change intervals for through and left-turn movements for the experimental design at the treatment sites.

To make the study conclusions statistically sound, the study timeline includes twelve weeks to collect sufficient data, which will occur over six, two-week time periods as outlined below.

- Period 1: Nov. 21, 2022 - Dec. 5, 2022;
- Period 2: Dec. 5, 2022 - Dec. 19, 2022;
- Period 3: Dec. 19, 2022 - Jan. 2, 2023;
- Period 4: Jan. 2, 2023 - Jan. 16, 2023;
- Period 5: Jan. 16, 2023 - Jan. 30, 2023; and
- Period 6: Jan. 20, 2023 - Feb. 13, 2023.

Through Movements - Treatment Site Changes
In accordance with the ITE 2020 guidelines, due to the absence of approach speed at the intersections, for this study, the “speed limit +7” guidance was used in lieu of the through movement's 85th percentile of approach speed. Using the “speed limit +7” guidance results in an increase between 0.4 seconds and 0.6 seconds for the yellow change interval in comparison to the current yellow change interval for through movements.

For evaluation of through movements at the twelve study intersections, three of the intersections will be used as the control sites, and the yellow change and red clearance intervals for these three control intersections will not be changed from their current timing. The remaining nine intersections are considered treatment sites. The yellow change intervals for the through movements will be changed for all the treatment sites. To better understand driver behaviors and the influence of the yellow change interval over the short-term and long-term, the nine treatment intersections are divided into three equal groups for implementation methodology as outlined below.

- Incremental Intersections Group: For this group of three intersections, the increase in the yellow change interval is implemented at the selected treatment sites over five two-week time periods. Therefore, at each of the three incremental sites, the yellow change interval is increased by 0.1 - 0.2 seconds at the start of each two-

week time period, depending on how much the total calculated yellow change interval increased.

- Periodically Intersections Group: For this group of three intersections, the yellow change interval is adjusted at the beginning of each two-week time period. That is, the yellow change interval will alternate between the new calculated yellow change interval and the baseline (current) yellow change interval every two weeks to study the drivers' compliance behavior over a short period. During the first, third, and fifth two-week time periods, the new yellow change intervals will be implemented at sites for the entire two-week time period. During the second, fourth, and sixth two-week time periods, the yellow change interval is returned to the baseline (current) yellow change interval.
- Long-Term Intersections Group: For this group of three intersections, the focus is on studying the impact of increasing the yellow change interval on drivers' compliance behavior in the long-term. The new yellow change intervals are implemented at the beginning of the first two-week time period and will not be modified for the duration of the data collection timeframe. These sites are selected to study the long-term impact of ITE 2020 guidelines on driver behavior.

Left-Turn Movements - Treatment Site Changes

In accordance with the ITE 2020 guidelines, due to the absence of approach speed for left turns at the study intersection, the "speed limit +7" guidance was used in lieu of the left-turn movement's 85th percentile of approach speed. The estimated intersection entry speed for left-turn movements was 20 miles per hour, following the ITE 2020 guidelines, which results in an increase between 0.3 seconds and 3.2 seconds for the yellow change interval in comparison to the current yellow change interval for left turn movements. Since two of the selected intersections for study do not have protected left -turn phase movements, only ten intersections are being used for studying left-turn movements.

Of the ten study intersections for left-turn movements, two of the intersections will be used as the control sites, and the remaining eight intersections will be used as treatment sites. The significant increases in left-turn yellow change intervals calculated under ITE 2020 guidelines for some intersections represent a change in left-turn yellow change intervals that could raise safety concerns. Therefore, the eight treatment intersections are being implemented as either the Incremental Intersections Group or the Long-Term Intersections Group as outlined below; there are no intersections designated for a Periodically Intersections Group.

- Incremental Intersections Group: For this group of four intersections, the increase in the yellow change interval is implemented at the selected treatment sites over five

two-week time periods. Therefore, the yellow change interval is increased by 0.3 - 0.7 seconds at the start of each two-week time period, depending on how much the total calculated yellow change interval is increased.

- Long-Term Intersections Group: For this group of four intersections, the focus is on studying the impact of increasing the yellow change interval on drivers' compliance behavior in the long-term. The new yellow change intervals are implemented at the beginning of the first two-week time period and will not be modified for the duration of the data collection timeframe. These sites are selected to study the long-term impact ITE 2020 guidelines on driver behavior.

Red Clearance Intervals - Treatment Site Changes
The red clearance interval is intended to allow a reasonable driver who approaches the intersection before the yellow interval ends enough time to clear the intersection before conflicting traffic enters the intersection.

For evaluation of the ITE 2020 guidelines related to red clearance intervals, a study has been designed similar to the yellow change interval study. However, to avoid impacting the results of the yellow change interval study currently underway, the new red clearance intervals will be implemented near the end of the data collection effort for the yellow change interval study.

Next Steps
Following the initial baseline data collection efforts, the study's twelve-week phased implementation of the new yellow change intervals calculated using the ITE 2020 guidelines began on Nov. 21, 2022. Preliminary evaluation and results of implementation data collected in the first few two-week time periods were presented to the Transportation, Infrastructure and Planning Subcommittee at its Jan. 18, 2023 meeting.

All data collection will be completed in February 2023, and the final study findings will be presented to City Council later this Spring. Additionally, Phoenix will participate in a national pooled study.

Attachment C provides a list of references for this report.

Concurrence/Previous Council Action
This report was provided to the Transportation, Infrastructure and Planning Subcommittee on Jan. 18, 2023.

Responsible Department

This item is submitted by Deputy City Manager Mario Paniagua and the Street Transportation Department.

Attachment A

Current City of Phoenix equations for calculating the yellow change and red clearance intervals:

Yellow Change Calculation

$$Y \geq t + \frac{1.47V}{2a + 64.4g}$$

Where:
Y = minimum yellow change interval (in seconds) with a maximum of 5 seconds (if the calculation exceeds 5 seconds, any excess time from the calculation is added to the red clearance interval);
t = perception-reaction time (in seconds); the time needed for an approaching driver to "perceive" the yellow indication and to "react" by braking to a stop or deciding to pass through the intersection. Default value of 1.0 second.
V = intersection entry speed (mph); the approach speed limit is assumed.
a = deceleration (ft/second^2); the rate at which it is assumed a driver will slow down upon seeing the yellow signal. Default value of 10 ft/second^2.
g = grade of approach (downhill is negative grade)

Red Clearance Calculation

$$R = \left[\frac{W}{1.47V}\right]$$

Where:
R = red clearance interval (seconds);
V= intersection entry speed (mph); the approach speed limit is assumed.
W = distance to traverse the intersection (width), stop line to far side no-conflict point along the vehicle path (ft.);

Current 2020 ITE-recommended equations for calculating the yellow change and red clearance intervals:

Yellow Change Calculation

$$Y \geq t + \frac{1.47(V_{85} - V_E)}{a + 32.2g} + \frac{1.47V_E}{2a + 64.4g}$$

Where:
Y = minimum yellow change interval (in seconds);
t = perception-reaction time (in seconds); the time needed for an approaching driver to "perceive" the yellow indication and to "react" by braking to a stop or deciding to pass through the intersection. Default value of 1.0 second.
V_{85} = 85th percentile approach speed (mph); the speed at which a "reasonable" driver is assumed to approach the intersection.
V_E = intersection entry speed (mph); the speed at which a "reasonable" driver is assumed to cross the stop line of the intersection when they have been slowing down in preparation for making a left turn.
a = deceleration (ft/second^2); the rate at which it is assumed a driver will slow down upon seeing the yellow signal. Default value of 10 ft/second^2.
g = grade of approach (downhill is negative grade)

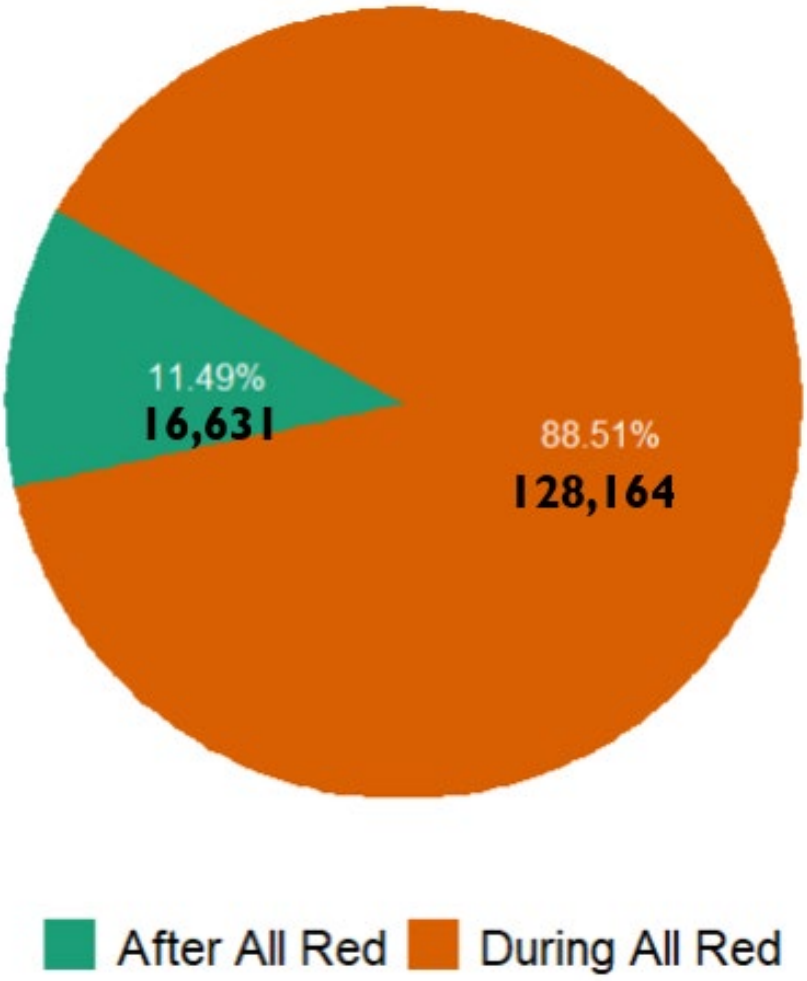
Red Clearance Calculation

$$R = \left[\frac{W + L}{1.47V_E}\right] - t_s$$

Where:
R = red clearance interval (seconds);
W = distance to traverse the intersection (width), stop line to far side no-conflict point along the vehicle path (ft.);
L = length of vehicle (ft.); 20 ft is often used as the representative length for vehicles entering the intersection.
t_s = conflicting vehicular movement start up delay (seconds); an optional parameter with an initial value set at 0.0 seconds, values may be used based on engineering judgment or as supported by an engineering study.

Attachment B

Percentage of red-light running incidents that passed through the intersection on a red light both during and after the red clearance time



Attachment C

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