Transportation Systems Management & Operations (TSM&O) Traffic Signal Training Module B –Traffic Signal Warrants.

Welcome to the TSM&O Traffic Signal Training Module B – Traffic Signal Warrants.

In this module, we're going to go more in-depth on traffic signal warrants now that you're familiar with the term and more importantly, you know that the warranting procedures must be reviewed prior to installing a traffic signal. We'll briefly discuss each of the nine signal warrants and we'll perform a few exercises.

What is a warrant? According to the MUTCD, a warrant is a condition that must be met to justify installation of a traffic signal. As I mentioned, there are 9 warrants. These are outlined in section 4C.01 of the MUTCD.

It is important to understand that the satisfaction of a signal warrant, or multiple warrants, shall not in itself require the installation of a traffic signal. The satisfaction of a warrant merely permits an engineer to determine that a traffic signal should be installed. The final decision is made based upon the judgment of a traffic engineer.

So why do we have this warranting procedure? We discussed in the first module that traffic signals can actually increase crash frequencies, specifically rear-end type crashes. For this reason, we want to make absolutely sure that a traffic signal is the right solution to a demonstrated problem.

Warrants provide the justification we need to determine if a traffic signal is the right solution. Warrants prevent unnecessary traffic signals from being installed. It is difficult to have signals removed later when they are deemed unwarranted. However, in some cases, there might be other factors that influence this decision to install traffic signals. Lastly, the MUTCD process provides uniformity across the state for evaluating when and where traffic signals should be installed.

The Warrant Process includes the following:

1. Collect traffic data for 24-hour time period
2. Observe field conditions
3. Parse traffic data for analysis of traffic demand by time periods
4. Determine link traffic demands
5. Follow FDOT's Manual on Intersection Control Evaluation, or ICE
6. Perform traffic signal warrant analysis
7. Determine if warrant conditions are met

Now that you've received a request to install a traffic signal and you've decided to initiate a signal warrant analysis, what data do you need to conduct the study?

You need 24 consecutive hours of intersection approach volumes for all approaches to a particular intersection. These are most often gather with pneumatic tube count machines; however, video collection is becoming more common.

Using the 24 hours of count data, you will then select the 8 – 12 hours with the greatest volume of traffic approaching the intersection and conduct turning movement counts during those 8-12 hours. Be sure to include trucks separate in the Turning Movement Counts, or TMC, and always count bicyclists and pedestrians. While conducting the TMC, it is most efficient to also conduct the delay study during the AM, mid-day, and PM peak periods. The procedure for conducting the delay study is covered in Chapter 7 of the Manual on Uniform Traffic Studies (or MUTS).

The graph shows a 24-hour continuous count conducted using tubes and a pneumatic machine. The graph allows us to see the peaking characteristics to determine the hours in which to conduct to the turning movement counts.

When conducing a signal warrant analysis, it's very important that you perform a qualitative assessment in the field. The qualitative assessment will include at a minimum, the number of lanes on each approach, the presence or absence of exclusive right turn lanes on the minor street, the availability of gaps in major street traffic, intersection sight distance on the minor street approach, pedestrian and bicycle activity and the interaction between these modes and cars, and any conflicts either apparent or potential.

Other data that is critical to evaluating the feasibility of a signal includes turn lane storage lengths, distances to adjacent signals and median openings, and presence of existing traffic control devices. These considerations are valuable in understanding the operations of an intersection and allow us to look beyond just traffic volumes when evaluating signalization. Always refer to FDOT's MUTS to make sure you are following current procedures.

Recently, a requirement has been added to the FDOT Design Manual or FDM to perform Intersection Control Evaluation, or ICE, analysis on new construction and reconstruction projects and for all other types of projects that propose new signalization. The requirement permits changes such as signal phasing and signal replacement where the primary purpose is to upgrade deficient equipment and installations. You can find a link to the Manual on Intersection Control Evaluation on the resources page.

FDOT's screening process is based on the National Cooperative Highway Research Program and FHWA requirements. The ICE process quantitatively evaluates several intersection control scenarios, or alternatives, and ranks these alternatives based on their operational and safety performance. Implementing a "performance-based" procedure such as ICE creates a transparent and consistent approach to consider intersection alternatives based on metrics such as safety, operations, cost, and social, environmental, and economic impacts.

The ICE activities consist of three stages; however, determining the selected intersection control strategy may not require all three stages.

Stage 1: Screening – completed during a project's initial stage. FHWA's Capacity Analysis for Planning of Junctions (CAP-X) is an operational analysis tool to evaluate selected types of innovative intersection designs. FHWA's Safety Performance of Intersection Control Evaluations (SPICE) is a separate tool used for safety analysis.

Stage 2: Preliminary Control Strategy Assessment – completed following a project's initial stage when more detailed information is available. SPICE is used for a more detailed safety analysis than in Stage 1.

Stage 3: Detailed Control Strategy Assessment – completed prior to Preliminary Design/Phase I plans. Typically, Stage 3 analysis is included in the Project Development and Environment, or PD&E, studies.

At the completion of each stage, the appropriate FDOT ICE form is completed and submitted to the District Traffic Operations Engineer and District Design Engineer.

Completing the Stage 1 ICE form is required for all projects. Stage 2 and Stage 3 ICE forms are required if prior stages did not identify a single viable control strategy. You can access these forms on the resources page.

The next several slides describe the 9 warrants contained in the MUTCD. Warrants 1 and 2 are vehicle volume warrants that are used to warrant signals the majority of the time.

Warrant 1 is intended for when there is a large volume of intersecting traffic or when the traffic volume on the major street is so excessive that traffic on the minor street suffers delay. This warrant requires at least eight hours' worth of traffic volume data.

Warrant 2 is intended to be applied when the volume of intersecting traffic is the principal reason to consider installing a traffic control signal. This warrant requires at least four hours' worth of traffic volume data.

Warrant 3, Peak Hour Warrant is generally not used except for unique situations. The Peak Hour signal warrant is intended for use at a location where traffic conditions are such that for a minimum of one hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the major street. This warrant requires just one hour of data and is often used for land use or impact studies. The MUTCD limits the application of this warrant to only special traffic generators such as large employment centers.

Warrant 4, the Pedestrian Volume signal warrant is intended for application where the traffic volume on a major street is so heavy that pedestrians experience excessive delay in crossing the major street. Meeting the pedestrian warrant may indicate the need for HAWK or pedestrian hybrid beacon, rather than a full traffic signal. This is where your engineering judgment comes in to play.

Warrant 5, the school crossing warrant, is intended for application where the fact that school children cross the major street is the principal reason to consider installing a traffic control signal. For the purposes of this warrant, the word "school children" includes elementary through high school students.

Warrant 6, the coordinated signal system warrant, is met when the progressive movement in a coordinated signal system necessitates installing traffic control signals at intersections where they would not otherwise be needed in order to maintain proper platooning of vehicles. A good example of this would be when a study shows that side-street traffic entering the main street is creating slowdowns or stoppage of the main street platoon and signalization would help with the progression. Such a scenario could be caused by a large residential development, a large shopping center, or industrial developments that contribute a lot of trucks to the network.

Warrant 7 is the crash experience warrant. The Crash Experience signal warrant conditions are intended for application where the severity and frequency of crashes are the principal reasons to consider installing a traffic control signal. It's important to review each crash report when evaluating this warrant and use only the crashes that could have been correctible with a traffic signals. Types of collisions that are considered correctible are right angle crashes and left turn crashes, in some instances. Warranting criteria is 5 or more of these correctible crashes in a 12-month period.

In warrant 8, the roadway network warrant, installing a traffic control signal at some intersections might be justified to encourage concentration and organization of traffic flow on a Roadway Network. As you can tell, this warrant requires exercise of engineering judgment to determine if it is satisfied. An example of when Warrant 8 may be applicable is when anticipated volumes due to land development are projected to exceed thresholds for warrants 1, 2, or 3 or when a governmental agency is planning new corridors.

Lastly, warrant 9 is for intersections near rail road grade crossings. The Intersection Near a Grade Crossing signal warrant is intended for use at a location where none of the conditions described in the

other eight traffic signal warrants are met, but the proximity to the intersection of a grade crossing on an intersection approach controlled by a STOP or YIELD sign is the principal reason to consider installing a traffic control signal.

The MUTS provides procedures specific to Florida for conducting signal warrant analyses. The procedures are based on the 9 MUTCD warrants we previously discussed. In addition to the guidance contained in chapter 3 of the MUTS, Microsoft Excel based forms are provided to assist with data entry and evaluation. You can find a link to FDOT's Signal Warrant forms on the Resources page.

Third-party vendors also provide software to assist with signal warrant analysis. It is very important to understand that whatever tool you use to assist in evaluating signal warrants, you always need to understand the MUTCD guidance and apply engineering judgment, regardless of the software output.

The figure here introduces warrant 1 that is used in the exercises that follow. It shows a typical intersection with a major street and a minor street with two lanes in each direction on both the major and minor street. This info is used in the following slide along with the traffic volumes that must be present for the 8-hour time period.

Now we're going to walk through an example to evaluate Warrants 1 and 2. We'll start with Warrant 1A. First, let's look at the number of lanes on each approach. For the major street, we look at through lanes in each direction. For example, if we have a four-lane divided roadway, then we have two lanes on each approach. Therefore, we use the highlighted row showing 2 or more.

Next, we select the appropriate column. You'll notice the appropriate columns are determined using the superscripts a – d. In this example, we are using the 100% column. The total of both approaches on the major street needs to exceed 600 Vehicles Per Hours, or vph, for 8 total, non-overlapping hours within a 24-hour period for the warrant to be satisfied.

In addition, the higher-volume of the minor street approaches needs to exceed 200 vph for the same 8 hours that we used to evaluate the major street approach volume. If both the major street and minor street volumes exceed the thresholds, warrant 1a is satisfied.

This slide show us how to evaluate warrant 1b. It's very similar to how we evaluated warrant 1a. The only difference is that the volume thresholds are different. You'll use the same rows and columns and the same 8 hours that you used for warrant 1a. Notice the differences in the volume thresholds between warrant 1a and 1b. Warrant 1a has a much greater minor street threshold and warrant 1b has a much greater major street threshold. In the example, our major street threshold is 900 vph and our minor street warrant threshold is 100 vph.

Warrant 1b is the most frequent warrant to be satisfied, especially when the major street speed is 40 mph or greater. You see in the table that when the 70% reduction is applied with a single lane on the minor street approach, the threshold is reduced to just 53 vph.

Now that we've established the thresholds, let's look at the volumes. In this example, the east-west roadway is the major street. We sum the volumes for all approach lanes in both directions. We then sum the minor street approach volumes. According to the MUTCD, if there is an exclusive right turn lane and right turning vehicles are not observed to experience significant conflict or delay, they are typically subtracted from the minor street approach volumes. If there is a shared right turn movement, engineering judgement should be used to reduce the number of rights between 10-50%.

We previously discussed steps 1 and 2. Based on superscript B, step 3 can be considered after adequate trial of remedial measures have been tested. Remedial measures would pertain to the request that initiated the warrant study.

Here, we see the sum of the hourly volumes from the previous slide where we discussed removing the right turns and we see the warranting thresholds. Note that while the major street thresholds are exceeded for all 8 hours, the minor street thresholds are not exceeded for a single hour. Therefore, condition 1a is not satisfied. The next slide takes us through warrant 1b.

As mentioned earlier, this is the warrant that is most often satisfied. You see that for 7 hours, the warranting thresholds were exceeded. However, in this instance, the warrant is not satisfied because we need to exceed the thresholds for 8 hours. This is a case where we may apply engineering judgment based on other information we know about the intersection.

For example, from 10:00 – 11:00, we are 22 vehicles shy of meeting the minor street warrant. If you have good reason to believe that the warrant will be exceeded in the near term, you may want to proceed with planning for a traffic signal and do an abbreviated evaluation of just 1 or 2 hours at a later date. Or, you may look at historic traffic growth trends and see that the volumes will likely be exceeded in the near-term and Warrant 8 is then applied.

Here, we evaluate warrant 2, which is the 4-hour warrant. This location met 70% volume level criteria, and therefore all eight hours are above the threshold and the warrant is satisfied. Had it not met the 70% criteria, only two hours would have been met and the warrant would not have been satisfied. Do you remember when the 70% reduction is applied? When the major street speed limit meets or exceed 40 mph.

In this module, we covered traffic signal warrants, intersection design guide including Intersection Control Evaluation, MUTCD warrants, and reviewed examples of Warrants 1 and 2.

This concludes Module B –Traffic Signal Warrants. For more information on Traffic Signal Training please contact Raj Ponnaluri.