CHAPTER 3

Data Collection and Warrants

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3.0 DATA COLLECTION AND WARRANTS

3.1 COMMITMENT

When an agency decides to install a signal, they make a long-term investment of resources at a specific point on the transportation network. Signals require consistent care throughout their life. For example, agencies must respond to emergency repairs such as power outages; adjust timing due to changing traffic patterns; replace outdated equipment as the state of technology changes; and monitor safety performance for all users.

3.2 WHERE DO YOU START? IMPORTANCE OF AN ENGINEERING ANALYSIS AND STUDY

When evaluating changes to intersection traffic control, engineers can refer to a wide range of research and best practices. Some examples are the ITE Traffic Engineer's Handbook, State DOT MUTCD manuals, and the Minnesota DOT Intersection Control Evaluation (ICE).[43] Engineers should keep in mind that signalizing an intersection has broad implications for the transportation network, both positive and potentially negative. For example:

- Signalizing an intersection can eliminate barriers to pedestrians created by arterials bisecting adjacent neighborhoods.
- Signals can attract drivers away from unintended by-pass routes that were previously used to avoid busy unsignalized intersections.
- Signals can reduce, but not eliminate, right angle crashes.
- Signals can significantly increase rear end crashes.

3.3 INTERSECTION DATA COLLECTION NEEDED

Studying an intersection requires a basic set of information. This list of information is not an exclusive list (e.g., in some cases detecting a horse in an Amish community is needed). However, the vast majority of intersections will require most of the items on this list:

- Number and turning movement of vehicles.
- Physical roadway attributes (e.g., number of lanes, approach grade).
- Vehicles' classification, especially specialty vehicles (e.g., school buses).
- Number of pedestrians.
- Number of bicyclists.
- Speed study of each approach.
- Knowledge of the region, such as surrounding development (e.g., large specific traffic generators).
- Location of transit stops and facilities.
- Most importantly, field observations of peak hours.

3.4 INTERSECTION COUNTS

Easily the most important piece of information that is needed to study an intersection is traffic count data. Reviewing the count is a starting point to understanding how traffic ebbs and flows throughout the day. An intersection count should cover 12 hours of a typical day and should be conducted in 15-minute intervals. Counts typically occur manually or with automated count stations (see Exhibit 3-1). From the count, the engineer can easily start to see what movements are critical to the overall operation of the intersection.

3.4.1 What is a Typical Day?

Knowledge of the area may alter what is considered a "typical" day. A large recreational area or shopping area may require a weekend count. Recent advances in counting technology, such as automated intersection counting stations, make it easier to evaluate weekdays, weekends, holidays, and special events, and to perform counts longer than a standard, manual 12-hour count.

Exhibit 3-1. Automated intersection count station.

Source: Traffic Technology Today
http://www.traffictechnologytoday.com/news.php?NewsID=39788

3.4.2 Procedures for Future Intersections

Some agencies have enacted procedures to estimate traffic volumes for future intersections. Traffic impact studies commonly require estimated traffic volumes, typically completed using the guidelines found in the ITE Trip Generation Manual.[42] The practitioner should be able to generate the number of trips resulting from the proposed development. These trips are distributed over the street network to determine future traffic patterns. An engineer must be comfortable that actual traffic volume will be sufficient to require a traffic signal. Some planning agencies use traffic planning software to estimate future traffic patterns on the network. The MUTCD recommends evaluating the intersection after a year to be sure the initial assumptions were correct.

3.4.3 Vehicle Classification

Practitioners must also consider the expected types of vehicles when designing a signalized intersection. Intersection counts should capture this information. Examples of various vehicle combinations that should be counted or noted are:

- Tractor-trailer units in either single or combination trailers.
- City transit and tour buses.
- School buses.
- Large recreational vehicles in single or combination units.
- Emergency vehicles (e.g., ladder trucks).

Practitioners should note any vehicles larger than a WB-50 truck and their frequency of occurrence. These vehicles' large turning radius, long start up time, and safety impacts can affect intersection design. In some cases, larger vehicles can be calculated into Passenger Car Equivalents (PCEs) to account for their additional impacts on the system.

In addition, practitioners may adjust type and location of detection, timing parameter settings, and target lengths of turn lanes and auxiliary lanes to accommodate the queue needs of these larger vehicles.

3.4.4 Pedestrians

Pedestrians are the most vulnerable class of roadway users. Counting pedestrians is the first step to ensuring their needs are incorporated into the signal design and operations. This information is necessary to help practitioners develop signal timing and design pedestrian cross walks and refuge islands. Practitioners should also consider the environment in which an intersection is located. An area lacking in sidewalks may still have pedestrians to be accommodated at an intersection. This information can be collected during the intersection counts and should include the size of pedestrian groups, their frequency, and their walking speed.

Exhibit 3-2. Pedestrians crossing at a signal

Source: PBIC Image Library Alpena, Michigan, Dan Burden, 2006.

http://www.pedbikeimages.org/pubdetail.cfm?picid=1019

3.4.5 Bicyclists

Practitioners can also capture bicyclists' information during intersection counts. Bicyclists using crosswalks should be included in the pedestrian count.

Exhibit 3-3. Pennsylvania Ave., Washington, DC
Source: Google

3.4.6 Speed Study of Each Approach

ITE recommended practices for calculating clearance intervals requires assessing approach speeds. ITE recommends using the 85th and 15th percentile speeds for this purpose. Practitioners should also perform a "spot speed" survey for each approach. These surveys can be done manually using radar or automatically using counting technology. This information is also used to determine dilemma zone concerns.[44]

3.4.7 Knowledge of the Region

Warrant analysis covers the basic reasons for installing a signal; however, a signal should also support the overall function of a regional transportation network. Signalized intersections offer the most benefits when installed at major street junctions. Signals should almost always enhance through movements of any major street while balancing access to minor streets and pedestrians. Practitioners should be aware that many mid-size cities and counties have identified key intersections in their long range transportation plan. These planning documents are often a small part of a larger planning effort that combines both transportation engineering and a vision for the community's future. Signals can also support completing connections between large industrial sites, mixed use developments, schools, and emergency services.

Exhibit 3-4. Pennsylvania Ave., Washington, DC

Source: Matthew Myers, 2011

3.5 TRAFFIC SIGNAL WARRANTS

Practitioners perform engineering studies of planned signalized intersections to predict their immediate and future impacts. The basis of every engineering study concerning signals is the set of warrants found in the MUTCD. The warrants are part of the basic principles in the MUTCD that govern the design and use of traffic control devices. In addition, Code of Federal Regulations (CFR) 655.603 adopts the MUTCD as the National standard for all traffic control devices installed on any street, highway, bikeway, or private road open to public travel (see definition in Section 1A.13). When a State or Federal agency manual or supplement is required, that manual or supplement shall be in substantial conformance with the National MUTCD.

3.5.1 What Do the Warrants Constitute?

The warrants represent the basic areas an engineer's analysis should cover: intersections where users have difficulty maneuvering through the intersection due to high mainline volumes; drivers trying to cross streets with inadequate gaps; and pedestrians trying to cross large expanses of pavement.

3.5.2 Volume Warrants

Warrant 1: Eight-Hour Vehicular Volume

Warrant 1, the Eight-Hour Vehicular Volume Warrant, is one of the most widely used and familiar warrants. It is a count of the number of entering vehicles at an intersection in an 8-hour period. The practitioner will review the operations of a "typical" day at the intersection. Overall, satisfying this warrant indicates that a signal can be a reasonable investment towards improving the overall efficiency and safety of the intersection.

The engineer will find two conditions under this warrant. The warrant is satisfied when one of the conditions is met. Condition A indicates that the total number of entering vehicles from every approach causes undue delay, and condition B is satisfied when an imbalance occurs between the major and minor route, causing undue delay to motorists entering from minor roads.

This warrant should cause the practitioner to ask "What is the typical day or week for this intersection?" For example, high-use recreational areas, such as a lake or shopping mall, are different than a city arterial serving large subdivisions.

Right-turning Vehicles. One question often asked by practitioners is, "How should we count right turning vehicle traffic?" Many times this movement is unimpeded and does not contribute to the approach delay or other operational deficiencies of the intersection. The engineer, through their judgment, may subtract the volume of right-turning vehicles from the warrant analysis, especially those turning from the side street. Practitioners should consult the policies of the local governing agency responsible for the intersection for possible details concerning right-turning vehicles.

Left-turning Vehicles – Major Approach**.** In some cases, major approach left turns may queue past the available storage and reduce the capacity of the approach. In this situation the engineer should consider using a heavy left turn off of the major approach to satisfy the minor approach volume. This is an example in which engineering judgment is necessary throughout a warrant analysis to determine if signalizing an intersection will improve the overall operations and safety of the intersection.

Warrant 2: Four-Hour Volume and Warrant 3: Peak Hour Volume

Both of these warrants address unusually high, short duration side street traffic volumes. Practitioners should take care when using these warrants. Many types of businesses generate these volumes at any given time. In most cases, this would not constitute justification for installing a signal. In fact, some agencies place additional emphasis on making sure these warrants are used sparingly compared to Warrant 1.

3.5.3 Specialty Conditions

Warrant 4: Pedestrian Volume

This warrant is similar in application to the previous warrants. The data necessary are major street traffic volume and pedestrian volume, and the warrant is satisfied either for four hours or a single peak hour.

Many regions of the United States have recently placed a higher emphasis on non-motorized travel. However, many arterials were built to standards that created barriers to non-motorized users. Many cities now create networks focused on non-motorized travel. Signalizing intersections for pedestrians supports these networks. Agencies and practitioners implement treatments to improve the pedestrian safety, such as enhanced crosswalks using medians and signing. Agencies may also implement other available alternatives to traditional traffic signals, such as Pedestrian Hybrid Beacons (also known as High Intensity Activated Crosswalks (HAWKs). Additional information on the Pedestrian Hybrid Beacon is available on the FHWA Office of Safety website at:
http://safety.fhwa.dot.gov/provencountermeasures/fhwa_sa_12_012.htm.

As more communities focus their efforts on non-motorized travel, facilities more widely support bicyclists and pedestrians. Bicyclists should be counted as either vehicles or pedestrians depending on how they enter the intersection. In a community with high bicycle use, practitioners will likely encounter both at an intersection.

Warrant 5: School Crossing

This warrant is similar to Warrant 4, but deals specifically with school age pedestrians. Installing a signal can eliminate the barrier created by a busy and wide intersection that pedestrians find difficult to cross safely. Practitioners are asked to measure the frequency of adequately sized gaps in traffic flow that permit the average group of school age children cross the major street. The warrant is met if no gaps occur.

The engineer should be aware of any policies or procedures the agency has in place for school crossings, such as requiring an adult crossing guard to supervise the crosswalk. Also, these signals may “rest” in green for the majority of the day, which can cause issues for drivers who do not expect them to change. Adding advance signing helps increase drivers’ awareness when the signal is active during selected hours of the day. Pedestrian hybrid signals, mentioned previously, are an alternative to traditional signals. The city of Tucson, Arizona has been successful with these types of treatments.

Warrant 6: Coordinated Signal System

Practitioners may need to use a signal to platoon traffic flow down a major road, improving the overall effectiveness of a signalized corridor. The MUTCD warns that this warrant should not be used if the intersection spacing is less than 1,000 ft. Warrant 6 is not widely used

For signal coordination purposes, the spacing between signals should range from ¼ to ½ mile. Signal spacing less than 1,000 ft is difficult to coordinate.

Warrant 7: Crash Experience

Practitioners must analyze the intersection’s crash history as part of the engineering study. Many practitioners focus on the threshold listed in this warrant. Signals can provide some safety benefits under the right situations, but other crash types at the intersection can increase dramatically, especially rear end crashes. Often right angle crashes will decrease, but these crash types will not be completely eliminated.

Information related to assessing the impact of a traffic signal can be found in the following resources:

- Highway Safety Manual
- States Strategic Highway Safety Plans
- Crash Modification Factors (CMF) Clearinghouse website

These resources can help practitioners develop a focused, data-driven approach to reducing the severity of roadway crashes; screening the roadway network for intersections to review; quantifying safety impacts associated with modifying existing signalized intersections; and/or establishing the installation of a new signal.

Warrant 8: Roadway Network

An efficient and safe network of transportation options requires significant effort by metropolitan planning organizations, regional planning commissions, cities, counties, and State DOTs. Increased travel demand due to regional growth necessitates change. Traffic control at arterial and other major roadway intersections requires maintaining adequate levels of user service. These organizations may have conducted preliminary studies to determine which intersections should be signalized intersections or roundabouts. Practitioners who are evaluating future traffic impacts due to signals should seek out this information from these organizations.

Warrant 9: Intersection near a Grade Crossing

Practitioners must ensure that drivers and other road users are able to clear railroad tracks to prevent any conflicts from approaching trains. The figures used in this warrant offer the practitioner guidance and information on factors related to buses, tractor-trailers, and frequency of trains per day. Figure 4C-9 from the MUTCD is one of the figures related to this warrant. This warrant addresses any intersection within 140 feet of a railroad track.

Figure 4C-9. Warrant 9, Intersection Near a Grade Crossing (One Approach Lane at the Track Crossing)

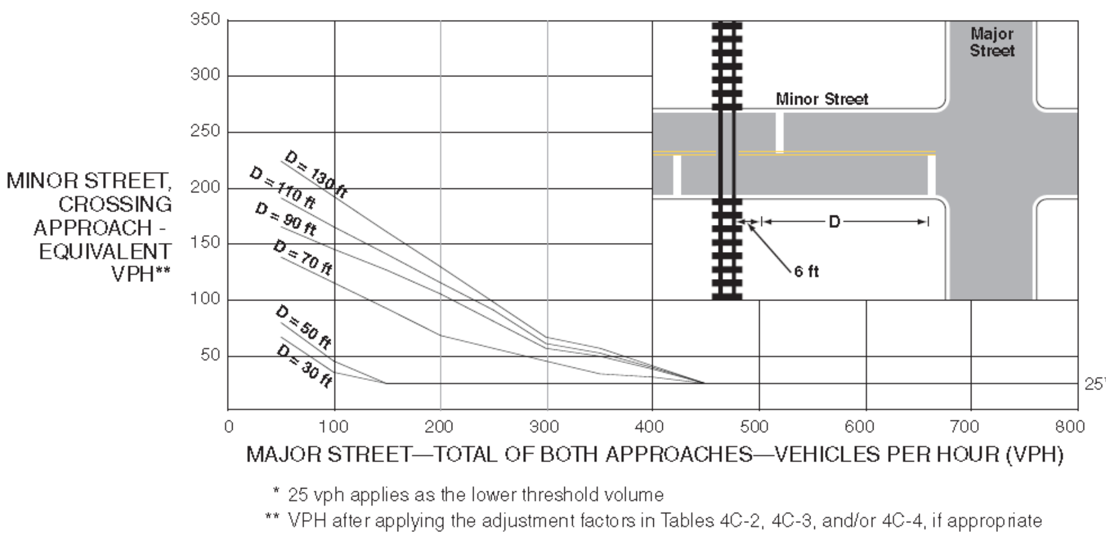

Exhibit 3-5. Warrant 9: Intersection near a Grade Crossing.

Source: MUTCD, 2009

Preemption control shall be provided at any signal near railroad tracks installed under this warrant, and any other signalized intersection that regularly queues traffic onto a set of tracks.

3.6 WHEN IS NOT SIGNALIZING AN INTERSECTION THE RIGHT DECISION?

This is one of the perplexing questions a practitioner and the general public may ask. The MUTCD acknowledges the importance of engineering judgment. The warrants represent best practice, but a signal can dramatically change traffic patterns. Signalized intersections should complement a transportation network, even if it is only an isolated signal. Corridors with closely or oddly spaced signals are difficult to time effectively and can cause a premature decline of the network.