

Traffic Analysis fundamentals

This document outlines some of the basic concepts and terminology to provide a fundamental understanding of the technical traffic analysis.

TERMINOLOGY:

Performance Measure – A quantitative or qualitative characteristic describing the quality of service provided by a transportation facility.

Average Daily Traffic (ADT) Volume – Average 24-hour traffic volume in both directions.

A.M. Peak Hour Traffic Volume – One-hour peak volume of traffic during the morning.

P.M. Peak Hour Traffic Volume – One-hour peak volume of traffic during the afternoon or evening.

Queue – A line of stopped vehicles (typically waiting at an intersection).

Signal Warrant – a threshold traffic condition or other factor used to determine whether installing a traffic signal is justified at a particular intersection.

OPERATIONAL PERFORMANCE MEASURES

A number of performance measures are used to gauge the overall quality of the travel experience through an intersection or roadway segment as it is perceived by the traveler.

Level of Service

Level of service (LOS) has been the most commonly used performance measure. LOS uses an “A” to “F” ranking based on the average control delay experienced by motorists. LOS “A” conditions have very low vehicle delay times (10 seconds or less), while LOS “F” conditions have high delay times (over 80 seconds per vehicle at a signalized intersection) that are considered unacceptable to most drivers.

Volume-To-Capacity Ratio

Volume-to-capacity ratio (V/C) compares the volume of traffic to the theoretical capacity of the facility to accommodate traffic. A V/C ratio of 1.0 indicates an intersection is operating at capacity. A V/C ratio over 1.0 indicates the intersection’s capacity is exceeded.

Washington County Standards

Washington County standards allows a maximum V/C ratio of 0.99 and LOS “E” during the peak hour for the project study area.

TRAFFIC SIGNAL WARRANTS

Before installing a traffic signal, an engineering study of traffic conditions, pedestrian characteristics, and physical characteristics of the location should be performed to determine whether installation is justified. A Federal Highway Administration publication provides direction on these studies and identifies eight potential traffic signal warrants that can be investigated:

- Warrant 1 – Eight-Hour Vehicular Volume
- Warrant 2 – Four-Hour Vehicular Volume
- Warrant 3 – Peak Hour
- Warrant 4 – Pedestrian Volume
- Warrant 5 – School Crossing
- Warrant 6 – Coordinated Signal System
- Warrant 7 – Crash Experience
- Warrant 8 – Roadway Network

Washington County generally requires that Warrants 1 and/or 2 are met if traffic volumes are to be used as the basis of the justification. More detailed information on these signal warrants is provided in the appendix.

Appendix

DESCRIPTION OF LEVEL-OF-SERVICE METHODS AND CRITERIA

Level of service (LOS) is a concept developed to quantify the degree of comfort (including such elements as travel time, number of stops, total amount of stopped delay, and impediments caused by other vehicles) afforded to drivers as they travel through an intersection or roadway segment. Six grades are used to denote the various level of service from "A" to "F".

Signalized Intersections

At signalized intersections, level of service is defined by a single performance measure: average control delay per vehicle. Control delay is defined to include initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay. Table D1 provides a qualitative description of each LOS category as it applies to signalized intersections, and Table D2 identifies the average control delay threshold point used as the boundary for each LOS category. LOS thresholds for the specific reviewing jurisdiction(s) are described in the body of the report.

Table D1
Level of Service Definitions (Signalized Intersections)

Level of Service	Average Delay per Vehicle
A	Very low average control delay, less than 10 seconds per vehicle. This occurs when progression is extremely favorable, and most vehicles arrive during the green phase. Most vehicles do not stop at all. Short cycle lengths may also contribute to low delay.
B	Average control delay is greater than 10 seconds per vehicle and less than or equal to 20 seconds per vehicle. This generally occurs with good progression and/or short cycle lengths. More vehicles stop than for a level of service A, causing higher levels of average delay.
C	Average control delay is greater than 20 seconds per vehicle and less than or equal to 35 seconds per vehicle. These higher delays may result from fair progression and/or longer cycle lengths. Individual cycle failures may begin to appear at this level. The number of vehicles stopping is significant at this level, although many still pass through the intersection without stopping.
D	Average control delay is greater than 35 seconds per vehicle and less than or equal to 55 seconds per vehicle. The influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle length, or high volume/capacity ratios. Many vehicles stop, and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.
E	Average control delay is greater than 55 seconds per vehicle and less than or equal to 80 seconds per vehicle. This is usually considered to be the limit of acceptable delay. These high delay values generally (but not always) indicate poor progression, long cycle lengths, and high volume/capacity ratios. Individual cycle failures are frequent occurrences.
F	Average control delay is in excess of 80 seconds per vehicle. This is considered to be unacceptable to most drivers. This condition often occurs with oversaturation. It may also occur at high volume/capacity ratios below 1.0 with many individual cycle failures. Poor progression and long cycle lengths may also contribute to such high delay values, even when the volume/capacity ratio is significantly below 1.0.

**Table D2
Level of Service Criteria for Signalized Intersections**

Level of Service	Average Control Delay per Vehicle (Seconds)
A	≤10
B	>10 and ≤20
C	>20 and ≤35
D	>35 and ≤55
E	>55 and ≤80
F	>80

UNSIGNALIZED INTERSECTIONS

Unsignalized intersections include two-way stop-controlled (TWSC) and all-way stop-controlled (AWSC) intersections. The 2000 Highway Capacity Manual provides models for estimating average control delay at both TWSC and AWSC intersections. Table D3 provides a qualitative description of each LOS category as it applies to unsignalized intersections, and Table D4 identifies the average control delay threshold point used as the boundary for each LOS category. LOS thresholds for the specific reviewing jurisdiction(s) are described in the body of the report.

**Table D3
Level of Service Criteria for Unsignalized Intersections**

Level of Service	Average Delay per Vehicle to Minor Street
A	<ul style="list-style-type: none"> Nearly all drivers find freedom of operation with very little time spent waiting for an acceptable gap. Very seldom is there more than one vehicle in queue.
B	<ul style="list-style-type: none"> Some drivers begin to consider the average control delay an inconvenience, but acceptable gaps are still very easy to find. Occasionally there is more than one vehicle in queue.
C	<ul style="list-style-type: none"> Average control delay becomes noticeable to most drivers, even though acceptable gaps are found on a regular basis. It is not uncommon for an arriving driver to find a standing queue of at least one additional vehicle.
D	<ul style="list-style-type: none"> Average control delay is long enough to be an irritation to most drivers. Average control delay is long because acceptable gaps are hard to find, because there is a standing queue of vehicles already waiting when the driver arrives, or both.
E	<ul style="list-style-type: none"> Drivers find the length of the average control delay approaching intolerable levels. Average control delay is long because acceptable gaps are hard to find, because there is a standing queue of vehicles already waiting when the driver arrives, or both. There may or may not be substantial excess capacity remaining at the intersection when this condition is encountered.
F	<ul style="list-style-type: none"> Most drivers encountering this condition consider the length of the average control delay to be too long. Average control delay is long because acceptable gaps are hard to find, because there is a standing queue of vehicles already waiting when the driver arrives, or both. There may or may not be substantial excess capacity remaining at the intersection when this condition is encountered.

Table D4
Level of Service Criteria for Unsignalized Intersections

Level of Service	Average Control Delay per Vehicle (Seconds)
A	≤ 10
B	> 10 and ≤ 15
C	> 15 and ≤ 25
D	> 25 and ≤ 35
E	> 35 and ≤ 50
F	> 50

It should be noted that the level of service criteria for unsignalized intersections are somewhat different than the criteria used for signalized intersections. The primary reason for this difference is that drivers expect different levels of performance from different kinds of transportation facilities. The expectation is that a signalized intersection is designed to carry higher traffic volumes than an unsignalized intersection. Additionally, there are a number of driver behavior considerations that combine to make delays at signalized intersections less onerous than at unsignalized intersections. For example, drivers at signalized intersections are able to relax during the red interval, while drivers on the minor street approaches to TWSC intersections must remain attentive to the task of identifying acceptable gaps and vehicle conflicts. Also, there is often much more variability in the amount of delay experienced by individual drivers at unsignalized intersections than signalized intersections. For these reasons, the control delay threshold for any given level of service has been set to be less for an unsignalized intersection than for a signalized intersection. **While overall intersection level of service is calculated for AWSC intersections, level of service is only calculated for the minor approaches and the major street left turn movements at TWSC intersections.** No delay is assumed to the major street through movements. For TWSC intersections, the overall intersection level of service remains undefined: level-of-service is only calculated for each minor street lane.

In the performance evaluation of unsignalized intersections, it is important to consider other measures of effectiveness (MOE's) in addition to delay, such as volume-to-capacity ratios for individual movements, average queue lengths, and 95th-percentile queue lengths. By focusing on a single MOE for the worst movement only, such as delay for the minor-street left turn, users may make inappropriate traffic control decisions.

SIGNAL WARRANT ANALYSIS

Before installing a traffic signal, an engineering study of traffic conditions, pedestrian characteristics, and physical characteristics of the location should be performed to determine whether installation is justified. The 2003 *Manual on Uniform Traffic Control Devices* (MUTCD) provides direction on these studies and identifies eight potential traffic signal warrants that can be investigated.

According to the MUTCD¹, “the investigation of the need for a traffic control signal shall include an analysis of the applicable factors contained in the following traffic signal warrants and other factors related to existing operation and safety at the study location:

- Warrant 1 – Eight-Hour Vehicular Volume
- Warrant 2 – Four-Hour Vehicular Volume
- Warrant 3 – Peak Hour
- Warrant 4 – Pedestrian Volume
- Warrant 5 – School Crossing
- Warrant 6 – Coordinated Signal System
- Warrant 7 – Crash Experience
- Warrant 8 – Roadway Network

The manual notes that “the satisfaction of a traffic signal warrant or warrants shall not in itself require the installation of a traffic control signal” and provides the following guidance:

- “A traffic control signal should not be installed unless one or more of the factors from the eight warrants are met.” Washington County generally requires that Warrants 1 and/or 2 are met if traffic volumes are to be used as the basis of the justification.
- “A traffic control signal should not be installed unless an engineering study indicates that installing a traffic control signal will improve the overall safety and/or operation of the intersection.” Because crash rates are often higher at signalized intersections than at unsignalized intersections, both operations and safety must be considered.
- “A traffic control signal should not be installed if it will seriously disrupt progressive traffic flow.” Maintaining traffic progression on arterial roadways is especially important in managing overall system delay and congestion. Disrupting progression can impact vehicles on the broader roadway system.
- “The study should consider the effects of the right-turn vehicles from the minor-street approaches. Engineering judgment should be used to determine what, if any, portion of the right-turn traffic is subtracted from the minor-street traffic count when evaluating the count against the above signal warrants.” Because right-turn movements from the minor street generally experience much lower delays than vehicles making left-turn or through movements, they are sometimes discounted from the calculations if a separate right-turn lane exists or the right-turns are not impacted delays for the other movements.

¹ *Manual on Uniform Traffic Control Devices*, Federal Highway Administration, Washington, D.C., 2003, Section 4C, p. 4C-1