

4. Planning and Justification

4.1 General

Purpose

This section discusses the planning and justification for a traffic signal installation. Traffic signals are not the only alternative available to provide right-of-way control. There are a range of other choices that exist, such as stop signs, yield signs or roundabouts, and traffic signals should be selected with due consideration of the appropriateness of other traffic control devices. A comprehensive study of the traffic conditions and the physical characteristics of the site should be undertaken to determine whether the installation of a traffic control signal would benefit the intersection operation.

Traffic signals have advantages, but they can also have disadvantages that users should be aware of. Traffic signals can provide an efficient movement of traffic, using displays to judiciously distribute time and alternate the right-of-way. They can also be beneficial in the reduction of certain types of collisions. However, if a signal is poorly timed it can be inefficient in serving traffic. Users should also be aware that the installation of a traffic signal does not guarantee the elimination of all collisions, and some types of collisions may increase following the installation of traffic signals.

Background/Context

The decision to install a traffic signal should be based on sound engineering judgment. This section provides guidance on a number of justification procedures that should be used to assist in determining the need for traffic signals. The

fulfillment of a traffic signal justification or justifications does not in itself require the installation of a traffic signal. Justifications must be used in combination with traffic engineering experience, professional judgment and economic analysis. The satisfaction of the signal installation justifications is only one criterion for determining the suitability of traffic signals for any location.

Even if a location being evaluated meets a justification, a traffic signal should not be installed if it will result in operational problems that create a potential for collisions and/or significantly increase delays to all users. Appendix A of this section provides guidance for a procedure that can be used to assess the potential for impact on collisions as a result of signalization. Other potential problems should also be assessed, including the extension of vehicle queues through upstream intersections, or impacts on existing signal progression. These broader network considerations must be taken into account and necessitate the application of engineering judgement over and above strict reliance on justification criteria alone.

This section identifies seven distinct types of justifications for traffic signal installation. Other considerations may also be encountered that support justification for a signal installation. For example, if visibility at a location is inadequate for the safe and efficient operation of the intersection in its unsignalized form, and geometric or operational improvements cannot resolve the situation, experience and professional judgement may support signal installation. Other relevant issues may be considered by the experienced analyst, such as the disproportionate benefits that can be provided when public transit use is taken into account.

4.2 Information Requirements

Basic Input Data

A number of basic input data and location attributes are required for the analysis of signal justification. Table 9 outlines and describes the basic input data

required for the volume, collision and pedestrian components of the signal justification. Not all information items need be collected, only those relevant to the likely justification to be applied (e.g., there is no need to gather pedestrian data at a high-volume intersection for which Justifications 1 through 4 will govern).

Table 9 – Traffic Control Signal Justification: Data Input Requirements

Justification 1 – Minimum 8 Hour Vehicle Volume Justification 2 – Delay to Cross Traffic Justification 3 – Combination Warrant Justification 4 – Minimum 4 Hour Volume		
Information Required	Description	Notes/Comments
Intersection Configuration	Number of approaches.	Three or four leg intersection.
	Number of lanes on each approach.	Divided into left, through, right and channelized right turn lanes.
Traffic Volumes	Number of vehicles entering the intersection during the eight highest hours of an average day categorized by left, through and right.	Vehicles should be categorized into passenger cars, trucks/buses and bicycles.
Pedestrian Volumes	Number of pedestrians crossing each leg of the intersection during each of the eight highest hours of an average day.	Eight hour pedestrian volume should coincide with the eight highest traffic volume hours.
Roadway Speed	Design, actual operating or posted speed on the main roadway during the signal justification analysis period.	For future roadways, the design speed on the main roadway should be used. For existing facilities, the operating or posted speed should be applied. If either figure exceeds 70 km/h, the intersection is assumed to function under free flow conditions.
Area Population	Approximate population of built-up or urban area.	Quantitative measure to assist in determining if the intersection is operating under free flow (rural) or restricted flow (urban) conditions.

Justification 5 – Collision Warrant		
Information Required	Description	Notes/Comments
Intersection Configuration	Number of approaches.	Three or four leg intersection.
Traffic Volumes	Traffic volume. Entering AADT volumes for major and minor streets.	At least three years of historical AADT volumes should be provided, corresponding to collision data years.
	Expected volume after signalization.	If known, expected traffic volume following the installation of the signal.
Collision Data	Most recent three or more year history of reported collisions.	Collision history should be as current as possible. A shorter time period may be used if major changes to the intersection have taken place.
	Initial Impact type detail.	Collision data must be sufficiently detailed to allow the determination of initial impact type, such that the collision can be categorized as susceptible to reduction (“Reducible”) or not-susceptible to reduction (“Non-reducible”) following signalization. Reducible collisions include: Angle and Turning Movement. Non-Reducible collisions include: Rear End, Approaching, Sideswipe, Single Motor Vehicle and Other.

Justification 6 – Pedestrian Warrant		
Information Required	Description	Notes/Comments
Roadway Configuration	Number of lanes on the main road.	Divided into left, through, right and channelized right turn lanes.
	Presence of median island.	Width of median, if any, on main street.
Traffic Volumes	Total number of vehicles in both directions during the eight highest hours of an average day.	Vehicles should be categorized into passenger cars, trucks/buses and bicycles.
Pedestrian Volumes	Number of pedestrians crossing main roadway during the same eight highest hours of an average day.	Total pedestrian volume categorized as “assisted” (children under the age of 12, seniors or mobility challenged) or “unassisted” and segregated by zones.
Pedestrian Delay	Delay time experienced by each pedestrian for the same eight highest hours of an average day.	Eight hour monitoring of delay is desirable; however, delay counts for brief periods can be factored up to create eight hour totals. A minimum of two one-hour peak periods should be surveyed.
Pedestrian Crossing Opportunities	Percentage of pedestrians from each zone to apply to the justification calculation.	A qualitative assessment of the percentage of pedestrians crossing in each zone that would choose to use the proposed crossing control.

Provided below is additional guidance relating to the collection and application of the above data input requirements.

Flow Conditions

The justification for traffic signals has been developed for two types of flow conditions. This division is necessary to reflect the different operating characteristics that exist under each condition. Engineering judgment should be used in determining which of the following conditions best describes the study location under its existing operating conditions or at a predetermined future analysis scenario:

- Restricted Flow Conditions represent roads with operating or posted speeds less than 70 km/h and are normally encountered in urban areas where side friction on the roadway such as parking and numerous entrances reduces the operating speed of the road.
- Free Flow Conditions represent roads with operating or posted speeds equal to or greater than 70 km/h and are normally encountered in rural areas or on controlled access roads in urban areas. Also, since the driving characteristics in small urban communities can be different from those in larger urban areas, free flow conditions are used for isolated communities with a population less than 10,000 and located outside the community influence of a large urban center, even if the operating speed is less than 70 km/h.

Intersection / Roadway Configuration

Main Street Approach Characteristics

The minimum justification values in Justifications 1 and 2 for the volume on the main road are given for a two-lane, two-way roadway as well as a multi-lane roadway with four or more through lanes. Vehicle

volume justification values for multi-lane roadways having four or more through lanes on the main road are 25% higher. Two-lane, two-way roadways with exclusive left-turn lanes are generally not classified as multi-lane roadways; however, engineering judgement should be used to determine if the inclusion of left and right auxiliary turn lanes in the main street approach configuration is appropriate. If vehicles encounter conflicts or delays in turning from a right turn lane it could be included. The main street approach should be considered a multi-lane approach if approximately half of the traffic on the approach turns left and the auxiliary lane is of sufficient length to accommodate all left-turn vehicles.

Median Islands

For the application of Justifications 1 through 4 (traffic volume-based warrants), an intersection with a wide median, even a wide median greater than 9 m, should be considered as one intersection. For the application of Justification 6, each direction on a divided roadway with a raised median island of at least 1.2 m may be considered individually in the justification process.

Roadway Type

Vehicle volume justifications for multi-lane roadways having four or more through lanes on the main road should be 25% higher. Two-lane, two-way roadways with exclusive left-turn lanes are not classified as multi-lane roadways.

Traffic Volume Data

Main Road

The main road should be taken as the road carrying the greatest hourly vehicular traffic volume over the period of study. The “main road”, however, may not always carry the greater volume during each of the hours studied; refinement of the definition to incorporate analysis on an hour-by-hour basis is possible. Where the intersecting volumes are approximately equal, the road having the least restrictive form of existing control is generally selected as the main road.

Determination of an Average Day

The traffic and pedestrian volumes used in the analysis should be representative of those likely to be experienced on an average day, which reflects the operating conditions that the signal is intended to address. When signal justifications are met on days other than weekdays, signals may be justified on the basis of recurring congestion but their design and operation should reflect the variations in their use. Example of these conditions may include roadways in:

- Retail oriented areas that are congested on Saturdays and Sundays, rather than during weekdays
- Recreational areas that experience peak traffic conditions only during summer weekends
- Employment areas where major shift changes or other operational attributes result in peak travel generation during periods outside typical morning and afternoon weekday peak travel demands
- Special event areas such as stadiums, arenas, exhibition grounds, theme parks and community centres, which have reoccurring congestion on a relatively frequent basis

In each of the above cases, the signal should be operated so as not to cause undue delay during the majority of the days during which the demand is reduced.

The hours counted should reflect the eight highest hours of the day. Traffic volumes normally vary hourly, daily, monthly, seasonally and annually. If available counts are for the periods other than the one(s) of interest, they may be factored appropriately with reference to local or provincial experience. Guidance relating to these temporal variations and appropriate adjustment factors is provided in the Traffic Characteristics section of the Geometric Design Standards for Ontario Highways (MTO 1999)²⁸. Alternative references include Section 4 of

the Institute of Transportation Engineers Traffic Engineering Handbook²⁹ and Chapter 8 of the Highway Capacity Manual 2000⁸.

Vehicle Counts

Only vehicles entering the intersection should be considered, whether they turn right, go straight through or turn left. If the right turns are channelized and are effectively segregated from the through traffic by means of a physical island, right-turning vehicles are not considered to enter the intersection and therefore should not be included in any justification calculations.

Bicycles

For the purposes of traffic signal justification analysis, bicycles must be treated as vehicles when on the road and included in vehicle volume counts as such; bicycles should be treated as pedestrians at the intersection of roads and park paths where cyclists dismount to cross the road.

Heavy Vehicle Movements

At locations in heavy industrial, manufacturing, agricultural or natural resource extraction areas, heavy vehicle travel may be predominant on one or more of the side street approaches. In these cases, engineering judgement and visual observations of delay, roadway grades and conflict potential will be required to determine if a heavy vehicle adjustment factor should be applied to reflect the site specific operational characteristics. Heavy vehicle adjustment factors ranging from 1.5 to 3.5 passenger car unit equivalents (PCUs) have been applied in many operational analysis methodologies. The Canadian Capacity Guide for Signalized Intersections (ITE, 1995)¹ provides some guidance with respect to the application of passenger car unit equivalents.

Pedestrian Volume Data

For the purpose of Justification 6: Pedestrian Volume and Delay, an adjusted pedestrian volume is applied to reflect a factored volume based on “equivalent adults” and the following definitions:

- Unassisted – Adults and adolescents at or above the age of 12 are considered “unassisted” pedestrians.
- Assisted – Children under the age of 12, senior citizens, disabled pedestrians and other pedestrians requiring special consideration or assistance are considered “assisted” pedestrians. In cases where an adult is accompanying a pedestrian included in the “assisted” category, both individuals should be counted as “assisted” pedestrians to reflect their higher vulnerability. It should be recognized that the exact age of the pedestrian is not critical, but the observer will need to use their judgement to place each pedestrian into one of the two categories.

The factored pedestrian volume is calculated as follows:

$$\text{Adjusted volume} = \text{Unassisted Pedestrian Volume} + 2 \times \text{Assisted Pedestrian Volume}$$

Collision Data

Reportable Collision: Collisions involving personal injury or property damage that appear to be serious enough to be reported to police.

Supplementary Input Data

The following data may provide a more precise understanding of the operation of the intersection and assist the analyst in applying additional engineering judgement to the results of the signal

justification analysis. Such information may be obtained during the time periods for which the relevant Justification applies:

- Vehicle Delay – Vehicle-seconds delay determined separately for each approach.
- Gaps – The number, length, and distribution of gaps in vehicular traffic on the main road when side road traffic experiences significant delays.
- Site Conditions – A condition diagram showing the intersection geometrics, lane arrangements, channelization, pavement markings, pedestrian paths, sight distance restrictions and distance to nearest traffic signals. To supplement the above basic data, the condition diagram may also include approach grades, bus stops and routing, on-street parking conditions, driveways, street lighting, utility poles and fixtures and adjacent land use/plans.

4.3 Principles of Justification

General

The initiative to consider installing a traffic signal at an existing intersection or mid-block location will generally arise from complaints or analysis regarding delay, congestion, safety, or pedestrian crossing problems. The resultant investigation of the need begins with the collection of traffic, pedestrian, collision and geometric data (as described in Section 4.2). Then, an assessment of whether or not a signal is technically justified is made, using the following criteria:

Justification 1 – Minimum Vehicle Volumes (Section 4.4)

Justification 2 – Delay to Cross Traffic (Section 4.5)

Justification 3 – Combination Warrant (Section 4.6)

Justification 4 – Minimum Four-Hour Vehicle Volume (Section 4.7)

Justification 5 – Collision Experience (Section 4.8)

Justification 6 – Pedestrian Volume (Section 4.9)

Justification 7 – Projected Volumes (Section 4.10)

For a traffic signal installation to be technically justified, at least one of the above justifications must be fulfilled. Unless one or more of the signal justifications are met, the installation of signals would not normally proceed as it would likely result in an increase in overall intersection delay and/or have a negative impact on intersection safety.

4.4 Justification 1 – Minimum Vehicle Volume

Purpose

The Minimum Vehicular Volume Justification is intended for applications where the principal reason to consider the installation of a traffic signal is the cumulative delay produced by a large volume of intersecting traffic at an unsignalized intersection.

Justification 1A reflects the lowest total traffic on all approaches and Justification 1B reflects the lowest volume on the minor road for which the average delay is similar for both signalized and unsignalized conditions. Therefore, this justification is intended to address the minimum volume conditions in which signalization can be used to minimize total average vehicle delay at the intersection.

As volumes increase over the threshold criteria, delay to traffic on the minor road will increase such that the overall delay for the intersection is greater than if minor delays are distributed between both roadways.

Standard

The need for a traffic signal must be considered if both Justification 1A and Justification 1B are 100% fulfilled.

If Justifications 1A and 1B do not surpass 100% but are at least 80% fulfilled, the lesser fulfilled of the Justifications 1A or 1B can be used in the assessment of Justification 3, the Combination Justification.

In applying Justification 1 (Minimum Vehicle Volume) for “T” intersections, the justification values for the minor street are increased by 50%. This reflects the reduction in traffic volumes given the elimination of one of the approaches.

Use Table 10 or Justification 1: Minimum Vehicle Volume. Restricted Flow is applicable to Urban Conditions, while Free Flow is applicable to Rural conditions (see Section 4.3.2 for definitions).

Guidelines

Justification 1 compares total intersection volume with total minor road volume. The hours selected should represent the eight highest hours of the 24-hour traffic volume and they do not have to be consecutive hours. Each one of the highest eight hours of the entering volumes are compared to the justification value and the justification should be met for each of the eight hours. “Section Percent” is calculated in Table 10 for reference purposes, and may indicate how close an intersection is to achieving full justification. “Total Across” is calculated by adding all 8-hour compliance percentages. The Compliance % figures used in Table 10 must not exceed 100%.