Traffic Signal Warrants—Their Use and Misuse

KENNETH SHACKMAN
Transportation Engineer
Ohio-Kentucky-Indiana Regional Planning Authority
Cincinnati, Ohio

INTRODUCTION

In the area of traffic control devices the traffic signal is one of the most flexible, sophisticated, and expensive of all such devices. If used properly it can reduce the number of certain types of accidents, provide orderly flow through an intersection, and decrease overall travel time along a street. However, if employed improperly one can expect increased congestion, high accident rates, driver irritation, and general disrespect of the implementing organization, i.e., the local or state traffic engineering agency. It is for these reasons that warrants were created.

RAMIFICATIONS OF A TRAFFIC SIGNAL INSTALLATION

Prior to discussing the warrants for the installation of a traffic signal, it might be of value to briefly state some of the consequences of the installation. These consequences should be carefully considered during the analysis to determine whether or not a traffic signal is justified.

1. Traffic Accidents

Although a traffic signal may reduce the number and severity of certain types of accidents, there are other types where the number may remain constant or be augmented.

The types of accidents that may be reduced are the following:

a. Accidents involving right angle collisions.

b. Accidents involving pedestrians crossing the path of straight-moving vehicles.

c. Accidents involving two vehicles approaching each other from opposite directions, one of which desires to turn left. The reduction of this type of accident will occur only if a separate left turn phase is provided.

The types of accidents that will remain constant are the following:

a. Accidents involving two vehicles travelling in the same or opposite directions and one crosses the path of the other.

b. Accidents involving pedestrians and turning vehicles moving during the same traffic signal phase.

The type of accident that will probably be augmented is the rear-end collision.

2. Delay

In nearly all instances the installation of a traffic signal will reduce the delay of the cross traffic over the period of a day. This is desirable; however, one must not ignore the increase in delay to the major street. It is possible to adversely increase the overall delay at an intersection by installing a traffic signal. This is particularly true in cases where multiple phases are provided.

3. System Harmony

As part of the traffic signal investigation, the location of the traffic signal and its consequent ramifications must be considered. Possible items of consideration may be:

a. The effect of the new installation on the existing or possible progressive system.

b. The inducement of undesirable turning movements, and

c. The reduction of existing left turn storage at adjacent traffic signals.

TRAFFIC SIGNAL WARRANTS

As part of the total traffic signal investigation, one should determine which, if any, warrants for installation are satisfied. These warrants are contained in both the *Manual on Uniform Traffic Control Devices for Streets and Highways* and the state version of this manual. The satisfaction of these warrants should not be considered the sole criterion for determining whether or not to install a traffic signal; however, at least one of them should be completely satisfied before an installation is approved. As noted earlier in this paper, there are numerous consequences that must be taken into account before a final decision is made.

In this section the warrants contained in the *Manual on Uniform Traffic Control Devices for Streets and Highways* (1971) will be reviewed. In addition, at least one difference contained in the Indiana manual will be discussed.

In order to review the warrants the following basic information is required:

1. A traffic count (machine or manual).
2. The number of approach lanes for both the major and minor streets.
3. The posted speed limit for the major street. In some cases the 85th percentile speed for the major street may be needed as well.

It is normally beneficial to first obtain a 48-hour machine traffic count, particularly if the volumes are anticipated to be below the requirements. In this way the investigator can review the warrants without expending large amounts of money and staff time. Furthermore, the investigator gets insight into the ADT and the hourly distribution of traffic on each approach.

If the pedestrian movement is expected to be heavy or if at least one warrant is satisfied using the machine traffic count, than a manual traffic count should be made. The duration of the manual traffic count should be at least 12 hrs. This traffic count can be used to ascertain satisfaction of the warrant requirements, to determine whether or not the existing approaches are adequate (capacity calculations), and to develop timing and phasing.

It is usually beneficial to prepare a table of highest eight-hour volumes. These eight hours need not be consecutive. Table 1, which is a part of a form used by the Traffic Engineering Division, Department of Transportation-City of Indianapolis (I-DOT), is an example.

In addition to establishing what the motoring public believes is a reasonable speed, the 85th percentile speed may be needed to determine whether or not the warrant requirements may be reduced 30 percent.

In order to simplify the procedure for determining the number of warrants satisfied, a form can be prepared. This form should contain the warrants and to what degree satisfied, but remain uncomplicated in order that it might be completed by a technician. Such a form was prepared by the Traffic Engineering Division of I-DOT and is used in the explanation of some of the warrants. (In the I-DOT form the requirements are divided into Groups I and II. Group II requirements should be employed only when the 85th percentile speed of the major-street traffic exceeds 40 mph or when the intersection lies within the built-up area of an isolated community having a population of less than 10,000. Further explanation of this point will be provided in another section.)

TABLE 1 THE HIGHEST EIGHT-HOUR VOLUMES (VEHICLES OR PEDESTRIANS PER HOUR)

TIME (use same hours for both streets)								
MAJOR STREET VOLUMES (total of both approaches)								
MINOR STREET VOLUME (one direction of the higher-volume minor-street approach)*								
PEDESTRIAN VOLUME (highest-volume crosswalk crossing the major street)								

* During the eight hours the direction of higher volume may be on one approach during some hours and on the opposite approach during others.

Warrant No. 1: Minimum Vehicular Volume

This warrant is usually satisfied at the intersection of two thoroughfares and is one of the more commonly satisfied warrants. See Table 2 for the requirements of the warrant.

Warrant No. 2: Interruption of Continuous Traffic

The basis for this warrant is the reduction of unreasonable delay and hazard to cross-street traffic. However, this does not mean that every local or collector street warrants a traffic signal at its intersection with a thoroughfare. See Table 2.

In Indiana this warrant has been expanded to make provision for "industrial plants, shopping centers, and other locations where surges of traffic occur for relatively short durations."

According to the *Indiana Manual on Uniform Traffic Control Devices for Streets and Highways* a traffic signal is justified if the following warrant is satisfied:

1. Vehicular volume on the major thoroughfare past an establishment of the type mentioned above exceeds 800 vehicles per hour at the approximate time of major movements of traffic to and from the establishment, and the traffic from the estab-

lishment roadway during the same period of time meets one of the following warrants:

a. A minimum of 300 vehicles per hour, or
b. A minimum of 200 pedestrians crossing per hour, or
c. A minimum of 200 vehicles and 100 pedestrians crossing per hour.

2. Left turns into or from the establishment roadway exceed 30 percent of the 800 vehicles per hour past the establishment.
3. The signal installation will not seriously disrupt the progressive traffic flow.

The warrant is satisfied when for each of any two hours of an average day the traffic volumes given above exist on the respective roadways.

This special provision is beneficial because it recognizes that there are times when special consideration is needed. Furthermore, in numerous instances a traffic signal is less detrimental to the street traffic than a hired police officer manually directing traffic.

Warrant No. 3: Minimum Pedestrian Volume

See Table 3 for the requirements.

A traffic signal justified by this warrant should be equipped with the following devices:

1. Pedestiran push buttons
2. Pedestrian indications
3. The traffic signal should be traffic actuated if it is located at an intersection.

In addition, if the traffic signal is installed at a mid-block location than the closest adjacent crosswalk should be more than 150 feet away.

Warrant No. 4: School Crossing

The new School Crossing Warrant is based on the frequency of gaps, size of gaps, and number of school children crossing the traffic flow. However, the manual gives only loose guidelines concerning these variables. Briefly, the warrant states that a traffic signal is warranted at an established school crossing if "the number af adequate gaps in the traffic stream during the period when children are using the crossing is less than the number of minutes in the same period."

This warrant is different than the School Crossing Warrant that was contained in the previous manual. In the old manual the warrant

TABLE 2

Warrant No. 1: Minimum Vehicular Volume			Requirements						
Description	Number of Lanes for Moving Traffic on Each Approach on Major St.	on Minor St.	Minimum Hourly Volume	Group I How many hrs. of the 8 Have Vols. ⩾ These Mins.?	Compliance Yes: if ⩾ 8 No: if < 8	Minimum Hourly Volume	Group II How many hrs. of the 8 Have Vols. ⩾ These Mins.?	Compliance Yes: if ⩾ 6 No: if < 6
	(Choose row that describes intersection)							
Numbers 1 *and* 2 must be satisfied.								
1. Volume requirement on major street.	1	1	500	.....	.....	350	.....	.....
	⩾ 2	1	600	.....	.....	420	.....	.....
	⩾ 2	⩾ 2	600	.....	.....	420	.....	.....
	1	⩾ 2	500	.....	.....	350	.....	.....
2. Volume requirement on minor street.	1	1	150	.....	.....	105	.....	.....
	⩾ 2	1	150	.....	.....	105	.....	.....
	⩾ 2	⩾ 2	200	.....	.....	140	.....	.....
	1	⩾ 2	200	.....	.....	140	.....	.....

Warrant No. 2: Interruption of Continuous Traffic

Numbers 1 *and* 2 must be satisfied.								
1. Volume requirement on major street.	1	1	750	.....	.....	525	.....	.....
	$\geqslant$ 2	1	900	.....	.....	630	.....	.....
	$\geqslant$ 2	$\geqslant$ 2	900	.....	.....	630	.....	.....
	1	$\geqslant$ 2	750	.....	.....	525	.....	.....
2. Volume requirement on minor street.	1	1	75	.....	.....	53	.....	.....
	$\geqslant$ 2	1	75	.....	.....	53	.....	.....
	$\geqslant$ 2	$\geqslant$ 2	100	.....	.....	70	.....	.....
	1	$\geqslant$ 2	100	.....	.....	70	.....	.....

TABLE 3

Warrant No. 3: Minimum Pedestrian Warrant	Requirements					
		Group I			Group II	
Description Numbers 1 *and* 2 must be satisfied.	Minimum Hourly Volume	How many hrs. of the 8 Have Vols. $\geqslant$ These Mins.?	Compliance Yes: if $\geqslant$ 8 No: if $<$ 8	Minimum Hourly Volume	How many hrs. of the 8 Have Vols. $\geqslant$ These Mins.?	Compliance Yes: if $\geqslant$ 6 No: if $<$ 6
Part A.						
1. Major Street Volume.	600	.....	.....	420	.....	.....
If a median 4 feet or greater is present.	1,000	.....	.....	700	.....	.....
2. Pedestrian Volume.	150	.....	.....	105	.....	.....

was a part of the Pedestrian Warrant and was based on volumes (vehicles and school children).

Warrant No. 5: Progressive Movement

This warrant is satisfied if the proposed traffic signal can become an effective part of a progressive system by providing speed control and platooning with adjacent traffic signals. Two important points concerning the warrant are:

1. The use of this warrant should not be considered if the spacing between adjacent signals after installation would be less than 1,000 feet.
2. The speed that the progressive system is based upon should be reasonable.

Warrant No. 6: Accident Experience

As noted earlier, the installation of a traffic signal is no panacea for an accident problem at an intersection. It can be expected to reduce the number of only certain types of accidents.

The requirements of this warrant are contained in Table 4. It must be emphasized that the satisfaction of the warrant is based on four criteria. A common misuse of this warrant is to eliminate some of the criteria, particularly the enforcement and the volume criteria. In some instances the accident problem might be due to the disrespect of the existing controls.

Warrant No. 7: Systems Warrant

This is a totally new warrant and was created to organize a city's or part of a city's traffic signals into a functional system.

> The Systems Warrant is applicable when the common intersection of two or more major routes has a total existing, or immediately projected, entering volume of at least 800 vehicles during the peak hour of a typical weekday, or each of any five hours of a Saturday or Sunday.

A major route as used in the above warrant has one or more of the following characteristics:

a. It is part of the street or highway system that serves as the principal network for a through traffic flow.
b. It connects areas of principal traffic generation.
c. It includes rural and suburban highways outside of, entering or traversing a city.

d. It has surface street freeway or expressway ramp terminals.
e. It appears as a major route on an official plan such as a major street plan in an urban area traffic and transportation study.

This warrant is somewhat deceptive. A cursory review of the warrant implies that the requirements are easily satisfied; however, a more detailed examination indicates that is not so.

Warrant No. 8: Combination of Warrants

The requirement of this warrant is that two or more of Warrants Nos. 1, 2, and 3 be at least 80 percent satisfied. In the previous manual this requirement did not specify which warrants could be reduced by 20 percent.

The manual further states that traffic signals be installed using this warrant only in "exceptional cases" and only after other remedies "which cause less delay and inconvenience to traffic" have been tried.

SOME CONCLUDING REMARKS

Earlier in this paper it was noted that under specified conditions Group II Requirements (original requirements reduced by 30 percent) might be substituted. According to the manual, this reduction is provided in "recognition of differences in the nature and operational characteristics of traffic in urban and rural environments and smaller municipalities."

Recently, use of this reduction in large urban areas (on high type arterials) and suburban areas has been questioned. In both instances the speeds are usually high enough to satisfy the provision. Some engineers believe that the reduction should be graduated and possibly be dependent on a variable such as population. This would be analogous to intersection capacity calculations where the capacity increases with population.

Another solution to this problem is to use the provision, but use the growth pattern as an additional criterion if the reduced warrant is satisfied. There should be reasonable growth on both streets and it should appear that the regular warrants will be satisfied within the next year or two before approval is given (assuming the other criteria for approval have been satisfied).

In conclusion, it must be emphasized that the analysis of these warrants is only one part of the total investigation. However, before a traffic signal is approved at least one of the eight warrants should be satisfied.

TABLE 4

Warrant No. 6: Accident Experience

Numbers 1 through 4 must all be satisfied. Number 4 should be completed even if there are less than five accidents for use in Warrant No. 6.

1. Adequate trial of less restrictive remedies with satisfactory observance and enforcement has failed to reduce the accident frequency.
2. Five or more accidents involving personal injuries or property damage over $100 in a 12-month period and of a type susceptible of correction by a traffic signal installation, i.e. right angle and excessive speeding.

YEAR	TOTAL NUMBER OF ACCIDENTS	RIGHT ANGLE	SPEEDING
19——	——— PI ——————— PD —	———————	———————
19——	——— PI ——————— PD —	———————	———————
19——	——— PI ——————— PD —	———————	———————

3. The signal will not seriously disrupt progressive traffic flow.
4. One of the following three warrants, whose requirements have have reduced 80%, must be met.

	Number of Lanes for Moving Traffic on Each Approach on Major St.	on Minor St.	Minimum Hourly Volume	How many hrs. of the 8 Have Vols. ⩾ These Mins.?	Compliance Yes: if ⩾ 7 No: if < 7	Minimum Hourly Volume	How many hrs. of the 8 Have Vols. ⩾ These Mins.?	Compliance No: if ⩾ 5 Yes: if < 5
Warrant #1	(Choose row that describes intersection)							
Major Street Volume	1	1	400	.....	.....	280	.....	.....
	⩾ 2	1	480	.....	.....	336	.....	.....
	⩾ 2	⩾ 2	480	.....	.....	336	.....	.....
	1	⩾ 2	400	.....	.....	280	.....	.....

Minor Street Volume	1	1	120	.....	.....	84	.....	.....
	⩾ 2	1	120	.....	.....	84	.....	.....
	⩾ 2	⩾ 2	160	.....	.....	112	.....	.....
	1	⩾ 2	160	.....	.....	112	.....	.....
Warrant #2								
Major Street Volume	1	1	600	.....	.....	420	.....	.....
	⩾ 2	1	720	.....	.....	505	.....	.....
	⩾ 2	⩾ 2	720	.....	.....	505	.....	.....
	1	⩾ 2	600	.....	.....	420	.....	.....
Minor Street Volume	1	1	60	.....	.....	43	.....	.....
	⩾ 2	1	60	.....	.....	43	.....	.....
	⩾ 2	⩾ 2	80	.....	.....	56	.....	.....
	1	⩾ 2	80	.....	.....	56	.....	.....
Warrant #3 Part A (See Description on page 165.)								
Major Street Volume	.....	.....	480	.....	.....	336	.....	.....
	.....	.....	800	.....	.....	560	.....	.....
Pedestrian Volume	.....	.....	120	.....	.....	84	.....	.....

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