

Left Turn Signal Assessment Warrant Guidelines

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Introduction

This document provides the information, warrant criteria and guidelines for designing and operating left turn operations at signalized intersections. Left turn operation is a critical component for promoting safer and more efficient traffic signal operations. A proper design of left turn operations results in minimizing traffic delay, improving traffic flow, as well as in reducing collision rates. Traffic engineers face the following critical decisions in designing left turn signal operation:

1. Whether a left turn signal is required
2. If a left turn signal is required
 - a. What type of left turn signals should be used that will provide the safest and most efficient operations:
 - Permissive Only
 - Protected-Permissive
 - Protected-Prohibited
 - b. The sequence of left turn signal phases should be used that will maximize traffic flow:
 - Lead-Lead
 - Lead-Lag
 - Lag-Lag

The warrant criteria and guidelines presented in this document will outline the methodology and recommendation in designing and managing left turn operations but will not be used to determine the phasing sequence of left turn signal. Recommendations for left turn signal sequences should be made in a separate engineering study that considers, but is not limited to the following:

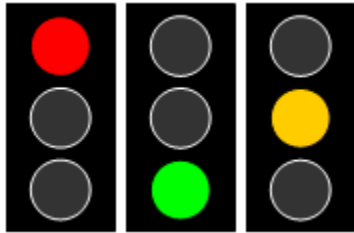
- Geometric constraints (interlock issue);
- Sight distance restrictions;
- Unique intersection geometry;
- Heavy left turn volumes; and
- Signal coordination

Type of Left Turn Signals

Different types of left turn signals have been deployed by Strathcona County and the typical operations of left turn signals are described and summarized as below:

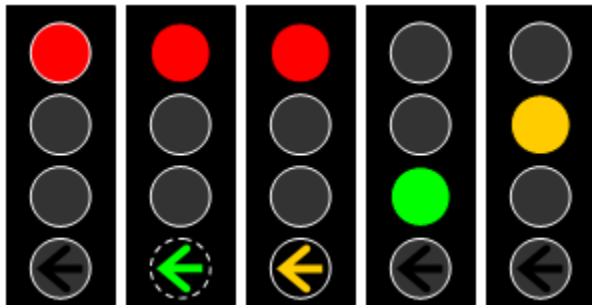
Permissive Left Turn:

Left turning vehicles are permitted to turn during the green ball display for through traffic and can complete the turn when adequate gaps occur in the opposing through traffic. The left turning vehicles must yield to the opposing through traffic and pedestrians who has the right of way to cross the roadway.



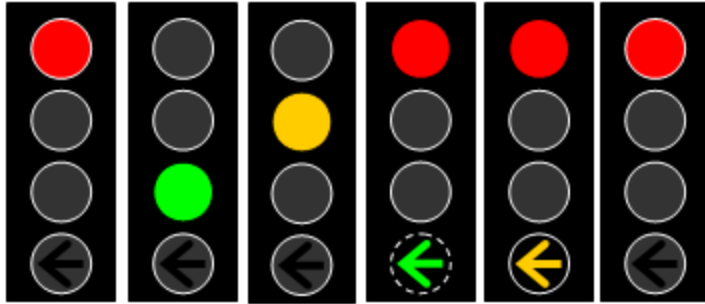
Protected-Permissive (Leading) Left Turn:

Left turning vehicles are given a protected phase to turn during the display of a flashing green arrow, and are also permitted to turn during the green ball display for through traffic and can complete the turn when adequate gaps occur in the opposing through traffic. A four-section with left turn arrow and circular signal indications, is used.



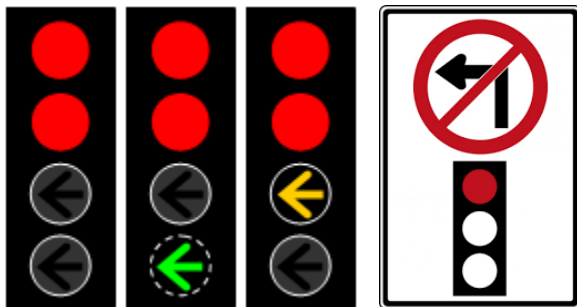
Permissive-Protected (Lagging) Left Turn:

Left turning vehicles are first permitted to turn during the green ball display for through traffic and can complete the turn when adequate gaps occur in the opposing through traffic and then are protected to turn left during the display of a flashing green arrow. A four-section signal head, with left turn arrow and circular signal indications, is used. This type of left turn signal must only be used for a T-intersection or a 4-leg intersection with opposite left turn movement banned to prevent yellow entrapment. The left turn phase must be end with a red interval and therefore, the last left turn vehicle waiting inside the intersection must clear prior to the start of the next signal phase.



Protected-Prohibited Left Turn:

This phasing provides left turning vehicles with their own separate left turn flashing arrow signal indications and no conflicting traffic and pedestrian movements are allowed during the operation of this exclusive phase. The left turn traffic is prohibited to proceed after the protected phase. A static sign “No Left Turn on Red” is always installed for this type of signal operation to remind left turn traffic that they are not allowed to turn during the red phase. The left turn phase must be end with a red interval and therefore, the last left turn vehicle waiting inside the intersection must clear prior to the start of the next signal phase.



Left Turn Signal Warrant Guidelines

An effective design of a left turn movement should be supported by an engineering study and left turn signals should be installed if they meet the warrant criteria suggested in these guidelines. These guidelines should be used to determine if a protected-permissive or protected-prohibited left turn is warranted at a signalized intersection. If neither type of protected left turn signals is warranted, a permissive phase should be used. An effort should be made to identify the most efficient left turn phasing that will safely accommodate all road users.

Protected-Permissive Left Turn

To determine if a protected-permissive left turn signal is warranted, a field study will be conducted for the left turning movement. This study will normally be conducted for a time period of 30 signal cycles. However, we may do a survey with a minimum of 20 signal cycles for a much lighter left turning and/or low traffic delay conditions. A signal cycle is defined as the combination of solid green, amber, and red signals in the direction of the left turning movement that is being analyzed. If a green arrow signal is pre-existing for the movement being analyzed it should be included along with the solid green, amber, and red signal combination used to define as a cycle. The study is usually conducted during the morning and afternoon peak hours where the left-turn volumes usually reach the highest level. However, the County will conduct the study at any time if the need

to review the left turn signal is justified. All traffic data will be collected in a format of EPCU (Equivalent Per Car Unit) and the vehicular EPCU conversion rates are shown in **Appendix A**. A work sample of the left turn signal assessment worksheet is also included in **Appendix B**.

The County will consider implementing a **protected-permissive** left turn signal if any **five (5)** of the following criteria are met based on a 30-signal cycle study period:

No.	Warrant Type	Implication
1	Traffic Volume	Warrant: Total left turn volume exceeds 100 vehicles The total left turn volumes within the study period is over 100 vehicles
2	Traffic Volume	Warrant: Average left turn volume per cycle is 3 or more The average left turn volume of each cycle is at least 3 vehicles.
3	Traffic Delay	Warrant: More than 25% of the average left turn volume is not able to turn during the first cycle The left turn traffic is heavy that some of left turning traffic is not able to clear during the first cycle.
4	Traffic Delay	Warrant: Less than 50% of the average left turn volume is able to turn during the solid green portion of the cycle The opposing through traffic is heavy and most of the left turning traffic is not able to make the turn during the permissive green phase
5	Traffic Delay	Warrant: The number of average vehicles queued at the start of the cycle is 2 or more The left turn bay has at least two vehicles waiting in the turning bay at the beginning of the green phase. They could be the late arrival traffic or delayed left turning traffic from the last signal cycle
6	Driver Aggressiveness	Warrant: More than 2 average vehicles per cycle turn on intergreen intervals More left turning drivers show aggressiveness during the amber and all-red intervals at the end of the permissive phase
7	Geometry	Warrant: An exclusive left turn lane exists for the turning movement The consideration of a left turn signal will be desired if there is an exclusive left turn lane because the capacity of a left turn signal is limited for a shared lane.
8	Overspill	Warrant: The left turn queue of vehicles exceeds the length of the turning lane during more than 20% of the cycles The queue length of left turning vehicles frequently extends beyond the given bay length at any time during the study period.

No.	Warrant Type	Implication
9	Transit	Warrant: More than 3-transit vehicles turn left during the study This warrant includes any in-service and “out of service” transit related vehicles that make a turn during the study period. This warrant does not include any school and commercial buses.
10	Safety	Warrant: More than 2 average LTXP crashes occur per year over the last 3 years This warrant considers an average of two or more left turn across path crashes occurs per year over a period of last 3 years. The total number of crashes covers all crashes occurs on a 24 hours a day and 7 days a week basis.

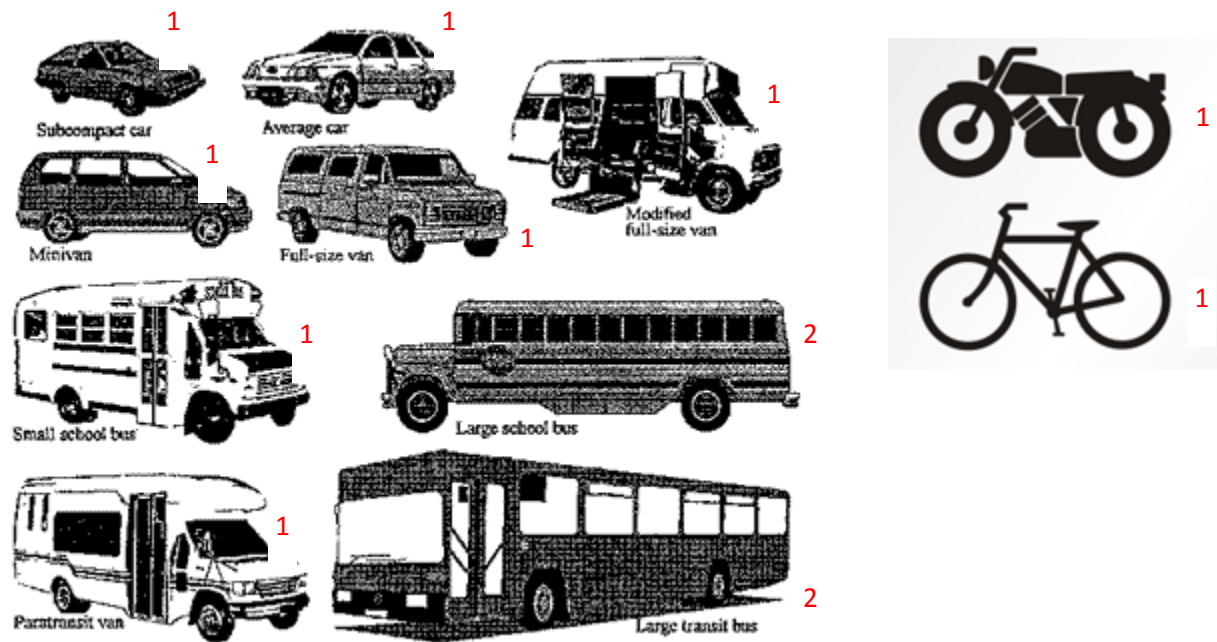
Protected-Prohibited Left Turn Signals:

An engineering review should be conducted to determine if a protected-prohibited left turn signal is warranted. The County will consider implementing a **protected-prohibited** left turn signal if any **one (1)** of the following criteria is met

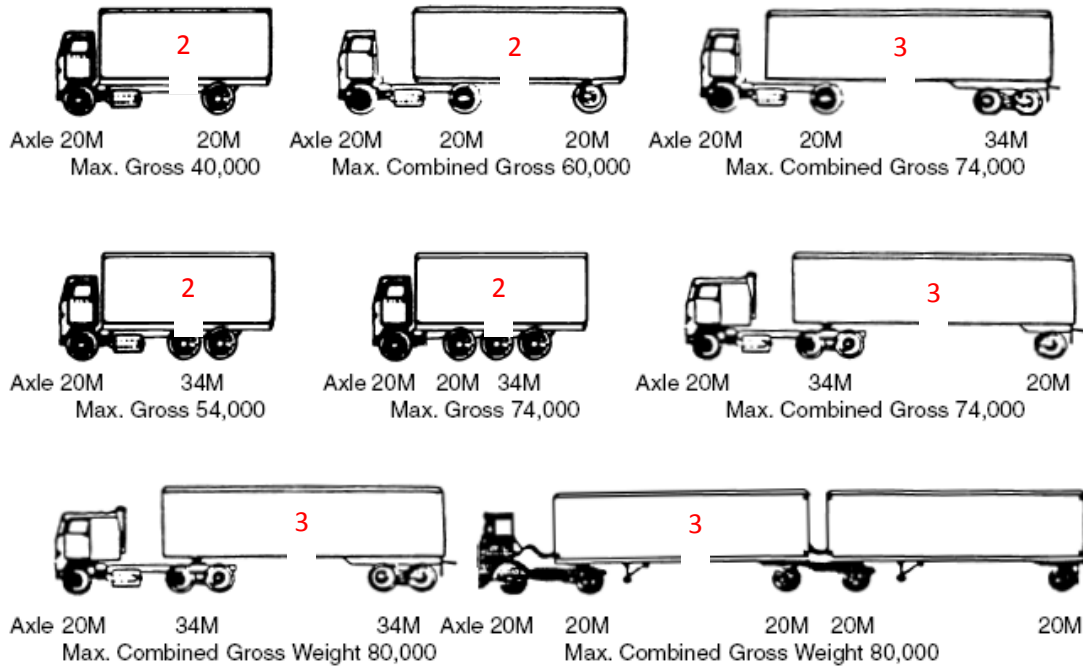
No.	Warrant Type	Implication
1	Geometry	Warrant: 4 or more opposing through lanes with either a posted or 85th percentile speed greater than 70 km/hr. Left turning traffic cross a road section that has high number of lanes and speed limit.
2	Geometry	Warrant: Inadequate sight distance for making safe permissive left turns Left turning traffic is not able to perceive other conflicting traffic movement(s) due to geometric constraints. Left turning drivers has insufficient sight distance to decide when to turn left, across the lane(s) used by opposing through traffic
3	Geometry	Warrant: More than one exclusive left turn lane for the left turning movement The configuration of multiple left turn lanes creates a sightline issue. The left turning vehicles on the outer lane blocks the view of the left turning vehicles on the inside lane for seeing the oncoming through traffic.
4	Safety	Warrant: 5 or more LTXP collisions within the last year or 8 or more LTXP collisions occurring within the last 2 years.

		This warrant considers an average of five or more left turn across path crashes occurs per year and eight or more collisions occurring in within the last 2 years. The total number of crashes covers all crashes occurs on a 24 hours a day and 7 days a week basis.
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Appendix A EPCU (Equivalent Passenger Car Unit) Conversion Rates



MAXIMUM WEIGHT LIMITATIONS (20M = 20,000 Pounds, 34M = 34,000 Pounds)



The maximum weight of 20,000 pounds can rarely be placed on the front axle so maximum gross weights shown above would frequently be excessive. Bridge laws will also limit weight according to axle spacing.

Appendix B Left Turn Signal Assessment Worksheet

LEFT TURN PHASE CHECKS													
Location: Lakeland Drive and Cloverbar Road							Date: Wednesday May 20, 2015						
Direction: Westbound Left							Time: 4:45 pm - 5:30 pm						
Staff: Chelsea Maier							Weather: Sunny, 20°C, clear skies						
Cycle #	Queue @ SOG	Discharge during				Queue @ EOG	Cycle Waits					# of Vehicle Overflow	# of ETS Buses
		Gr Arrow	Solid Gr	Amber	Red		1 cycle # of Veh	2 cycles # of Veh	3 cycles # of Veh	4 cycles # of Veh	5 cycles # of Veh		
1	4		3	1	1	5	0	0	0	0	0	0	0
2	6		4	2	1	6	0	0	0	0	0	0	0
3	6		8	2	1	1	0	0	0	0	0	0	0
4	4		6	0	0	2	0	0	0	0	0	0	0
5	5		6	2	0	0	0	0	0	0	0	0	0
6	7		8	0	0	0	0	0	0	0	0	0	0
7	8		8	1	0	0	0	0	0	0	0	0	0
8	5		2	1	2	0	0	0	0	0	0	0	0
9	7		0	2	2	4	3	0	0	0	0	0	0
10	7		7	2	0	1	0	0	0	0	0	0	0
11	7		7	1	2	4	0	0	0	0	0	0	0
12	7		1	1	0	10	5	0	0	0	0	0	0
13	10		5	1	0	4	4	0	0	0	0	0	0
14	5		3	1	1	0	0	0	0	0	0	0	0
15	3		0	2	1	1	0	0	0	0	0	0	0
16	4		4	0	0	0	0	0	0	0	0	0	0
17	5		5	0	0	3	0	0	0	0	0	0	0
18	5		2	1	0	5	2	0	0	0	0	0	0
19	7		8	0	0	0	0	0	0	0	0	0	0
20	1		2	0	0	0	0	0	0	0	0	0	0
21	3		4	1	1	0	0	0	0	0	0	0	0
22	6		6	0	0	0	0	0	0	0	0	0	0
23	2		3	0	0	0	0	0	0	0	0	0	0
24	2		6	0	0	0	0	0	0	0	0	0	0
25	2		4	0	0	0	0	0	0	0	0	0	0
26	3		4	0	0	0	0	0	0	0	0	0	0
27	1		1	0	0	0	0	0	0	0	0	0	0
28	2		1	0	2	0	0	0	0	0	0	0	0
29	2		4	0	0	0	0	0	0	0	0	0	0
30	4		4	0	0	0	0	0	0	0	0	0	0
	sum	sum	sum	sum	sum	sum	sum					sum	sum
	140	0	126	21	14	46	14					0	0
Number of cycles (≥20)		30											
LTXP collisions (3yrs)		0											
Signal Cycle Length		100											
CHECK SUMMARY													
Minimum 2.5 veh/cycle during the peaks						YES	Vehicles / cycle:						5.4
Queue of 2 or more veh/cycle at SOG						YES	Average queue:						4.67
More than 25% of left turn vehicles have delays ≥ one cycle						NO	% vehicles with delay ≥ 1 cycle:						8.7%
							% cycles with delay ≥ 1 cycle:						13.3%
Fewer than 50% of left turns on green						NO	% left turns on green:						78%
More than Ave. of 2 veh/cycle on intergreen						NO	Intergreen vehicles / cycle:						1.17
Queues extend past bay (> 20% of cycles)						NO	% of cycles with overflow:						0.0%
More than 3 in-service transit vehicles per hour						NO	Number of ETS buses per hour:						0
Average LTXP collisions >2/yr over 3 years						NO	3 year collision rate:						0.00
Exclusive left turn lane exists						YES							
Warrants left turn:		NO. Does not meet criteria											
Field notes:													
Note: Consider left turn phase only if 5 or more of these conditions are met (Left turn phase still not recommended if Int. delay increases 20%+, and degree of saturation of any through phase exceeds 0.85)													