

VEB1072 Traffic Engineering



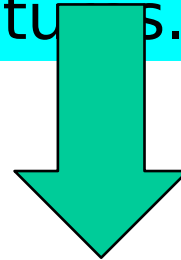
UNIVERSITI TEKNOLOGI PETRONAS

Lecture 5 : Junction Capacity



Junction Capacity Analysis

Able to analyse and propose improvement on the performance of transportation infrastructures. (CLO2)



Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. (PLO3)



Junction Capacity Analysis

LEARNING OUTCOMES

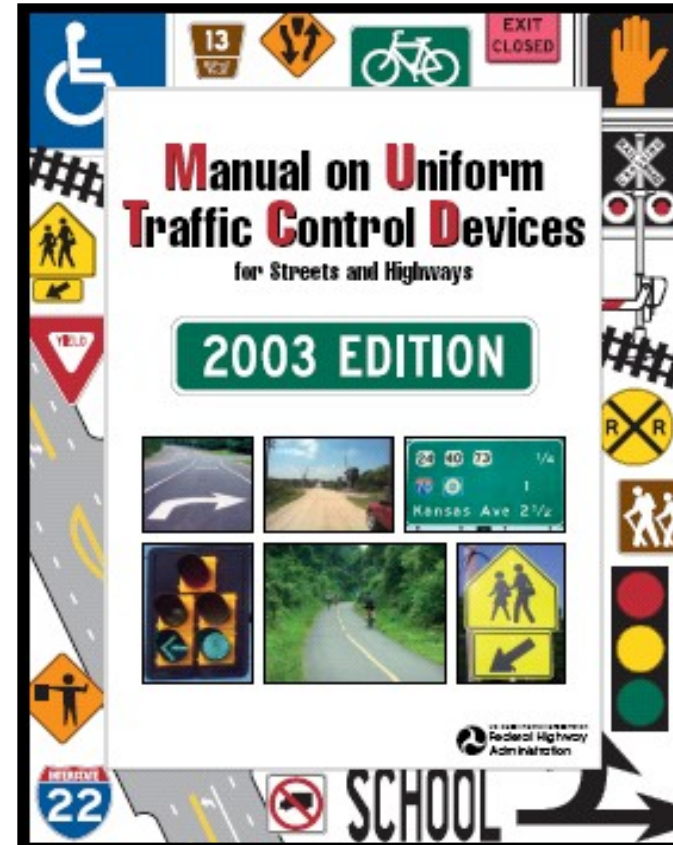
- Able to explain the purpose of traffic control. (C3)
- Able to suggest types of traffic control. (C5)
- Able to identify warrants for a traffic signal. (C3)
- Able to evaluate and determine the LOS of unsignalized T-junction and Four-Leg junction. (C6)



Manual of Uniform Traffic Control Devices (MUTCD)

Control may be achieved by using traffic signals, signs, markings, or markers that regulate, guide, warn, and/or channel traffic.

MUTCD provides guidelines for determining whether a particular control type is suitable for a given location; it also provides details on the size, color, shape, and legends, if necessary, and location for a particular control type.





Manual of Uniform Traffic Control Devices (MUTCD)

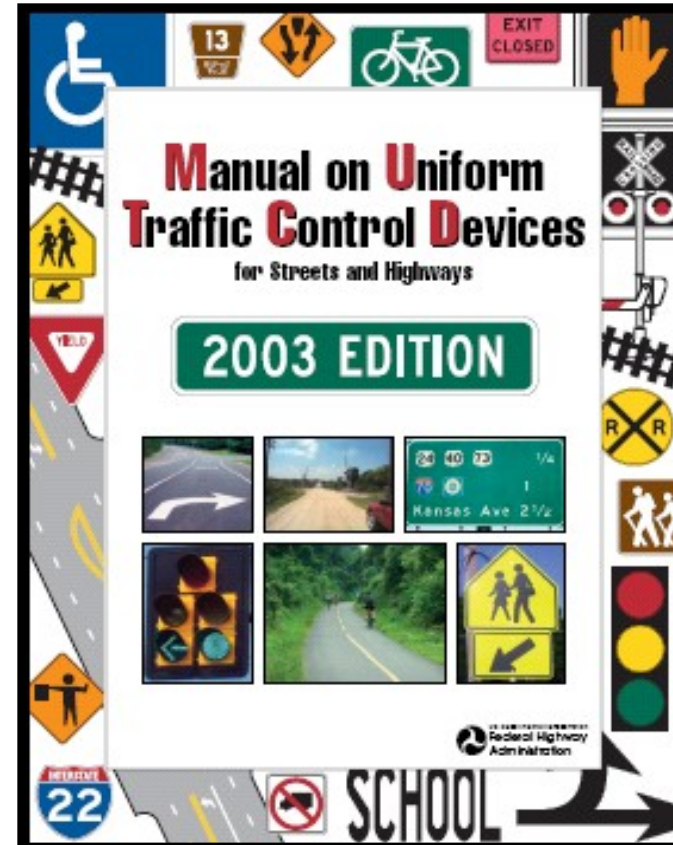
Requirements to make a traffic control device effective:

- ***Fulfill a need***
 - ***Place a proper one, place only the one needed***
- ***Command attention***
 - ***Make it stand out by color, shape, etc.***
- ***Convey a clear simple meaning***
 - ***Do not confuse the driver by wordy legends. Give only***
one
instruction by device
- ***Command the respect of road users***
 - ***When you place it you really mean it***



Manual of Uniform Traffic Control Devices (MUTCD)

- **Design**
- **Placement**
- **Operation (fulfilling requirements)**
- **Maintenance (legibility)**
- **Uniformity**



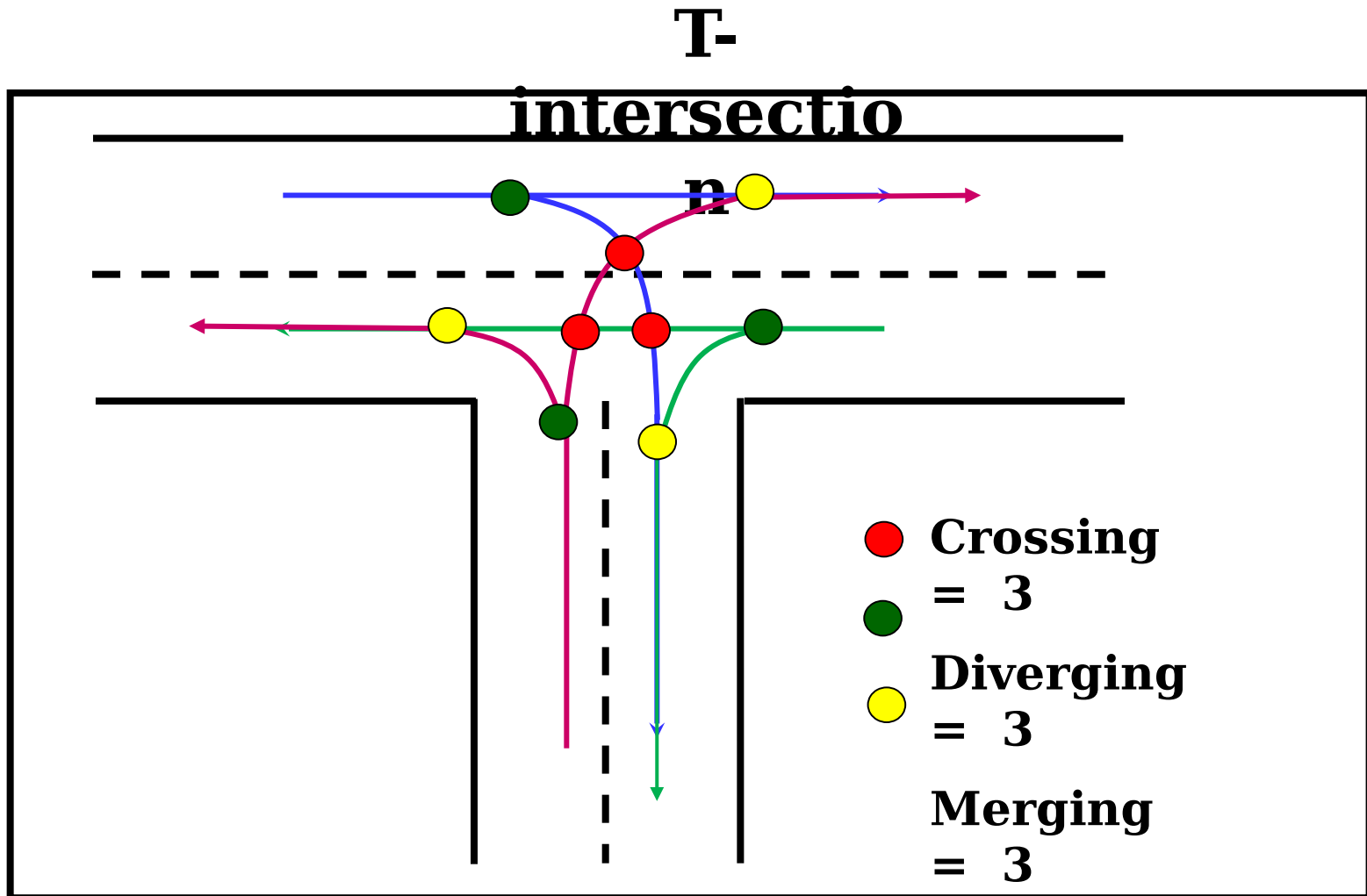


Local Guidelines...

- 1. Arahan Teknik (Jalan) 2A/85**
Manual on Traffic Control Devices : Standard Traffic Signs
- 2. Arahan Teknik (Jalan) 2B/85**
Manual on Traffic Control Devices : Traffic Sign Applications
- 3. Arahan Teknik (Jalan) 2C/85**
Manual on Traffic Control Devices : Temporary Sign and Work Zones
- 4. Arahan Teknik (Jalan) 2D/85**
Manual on Traffic Control Devices : Road Marking and Delineation
- 5. Arahan Teknik (Jalan) 2E/87**
Manual on Traffic Control Devices : Guide Signs Design and Applications



Conflicts Points at Unsignalized Intersections

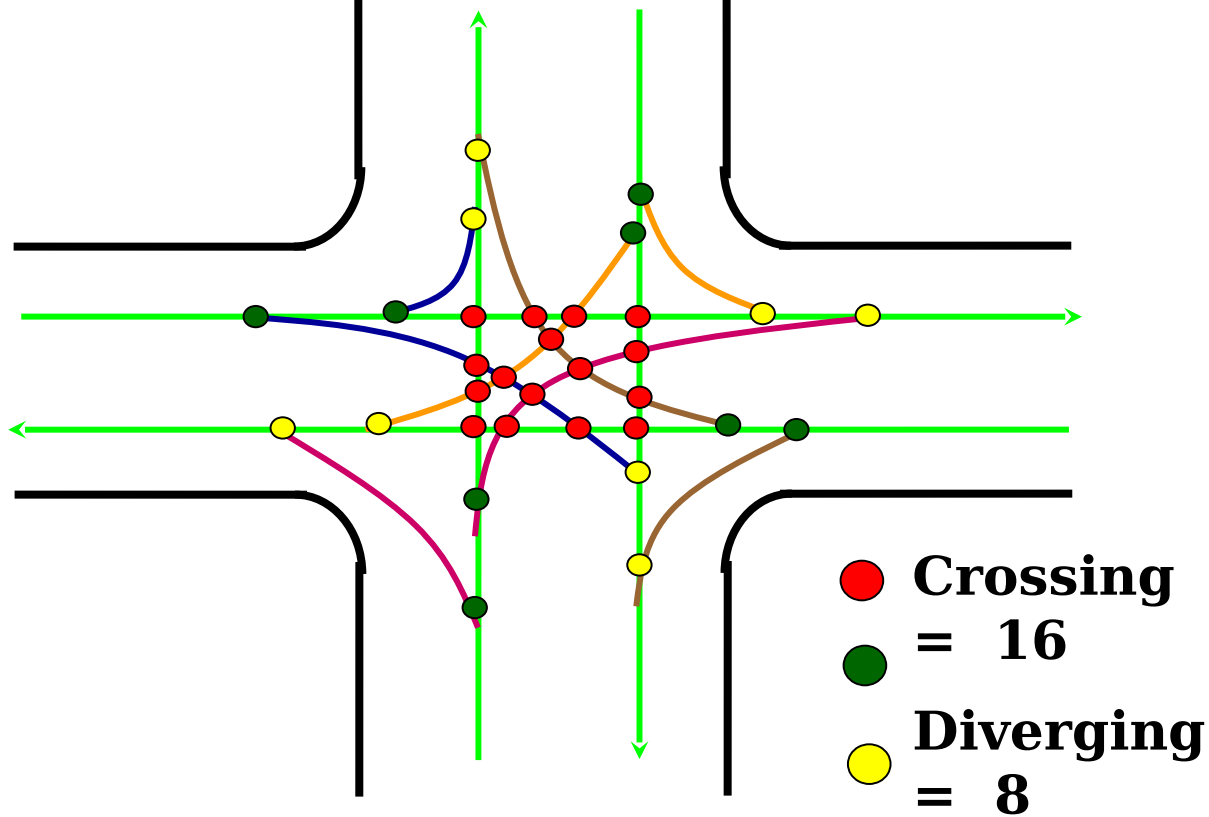




Conflicts Points at Unsignalized Intersections

4-leg

intersection



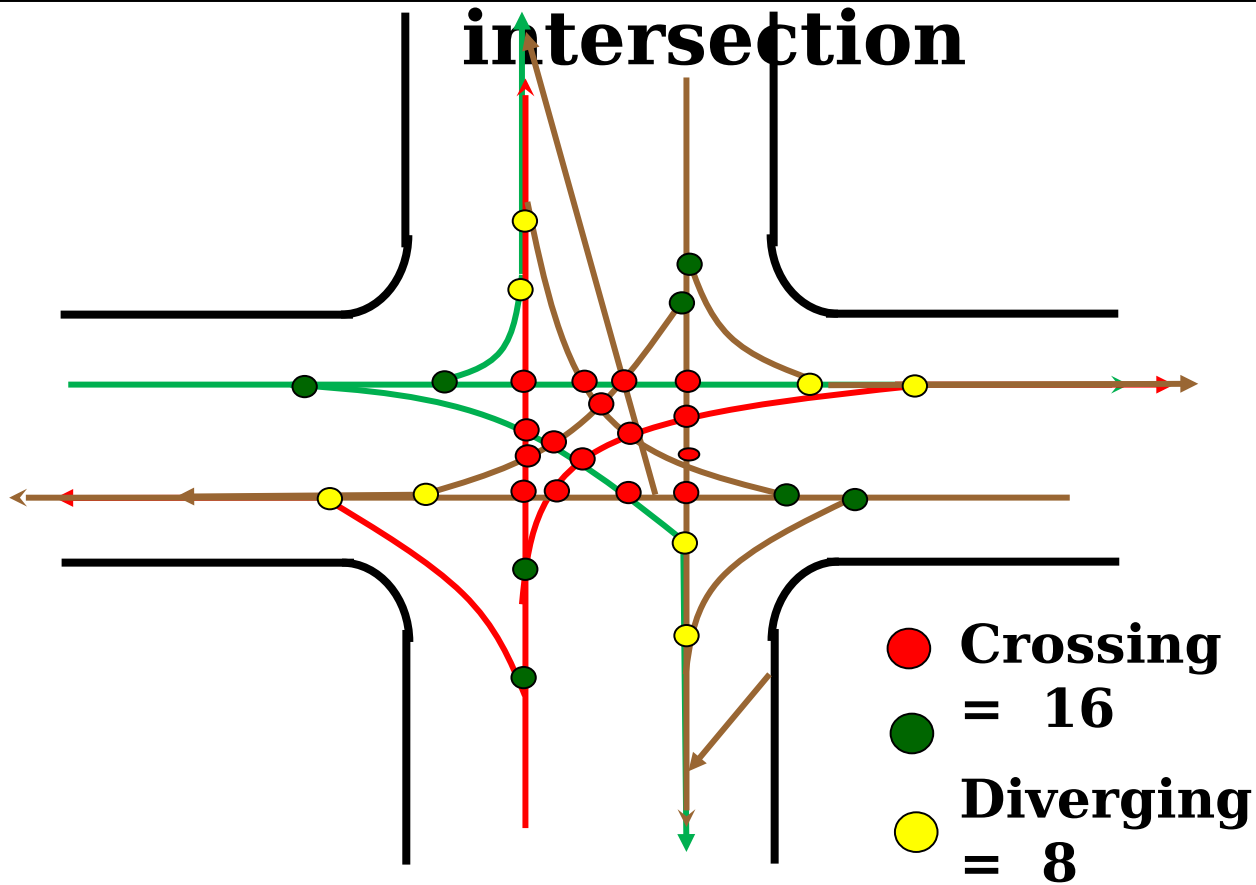
**Merging
= 8**



Conflicts Points at Unsignalized Intersections

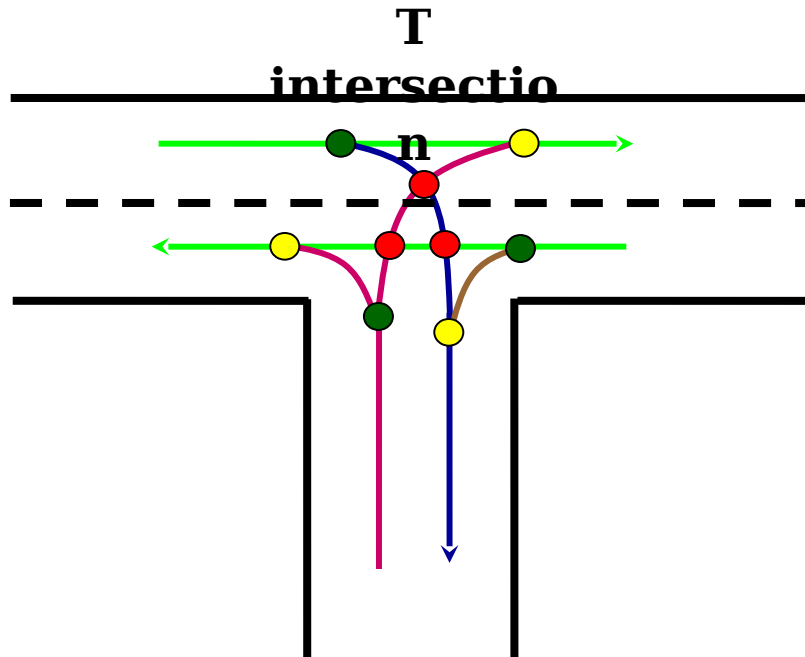
4-leg

intersection

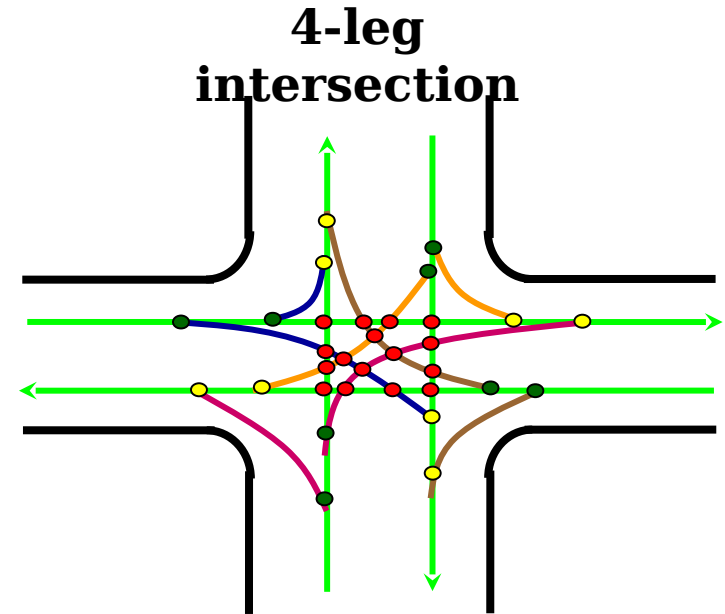




Conflicts Points at Unsignalized Intersections



● Crossing
 = 3
 ● Merging =
 3
 ● Diverging =
 3



● Crossing
 = 16
 ● Merging =
 8
 ● Diverging =
 8



Types of Intersection Control

Yield Signs Main road relatively low volume; minor road – low volume. Not warranted when the approach speed on the minor road is 10 mph or less. Warranted with a right-turn lane but not enough acceleration lane.



Stop Signs Main road high speed approach, relatively high volume; minor road – low volume, with restricted view, previous right-angle accidents.



Intersection Channelization Used mainly to separate turn lanes from through lanes.





Traffic Signal (Warrants)

Eight-hour
vehicular volume



MUTCD has 8 (11) warrants for a traffic signal. They are guides, not specifications. Use professional judgments

- | | |
|---|--|
| <ul style="list-style-type: none">➤ Minimum vehicular volume➤ Interruption of continuous traffic➤ Combination of warrants➤ Four-hour vehicular volume➤ Peak-hour volume➤ Peak-hour delay | <ul style="list-style-type: none">➤ Minimum pedestrian volume➤ School crossing➤ Coordinated signal system➤ Crash experience➤ Roadway network |
|---|--|

Peak-hour
vehicular volume



Signal Warrant 1

Eight-hour vehicular volume: Condition A (Minimum vehicular volumes)

Condition A - Minimum Vehicular Volumes Warrant

Number of Lanes for Moving Traffic on Each Direction		Vehicles per hour on Major Street (total of both approaches)				Vehicles per hour on Higher-Volume-Minor-Street approach (one direction)			
Major St.	Minor St.	100 %	80 %	70 %	56 %	100 %	80 %	70 %	56 %
1	1	500	40	35	280	150	12	10	84
2 or more	1	600	0	0	336	150	0	5	84
2 or more	2 or more	600	48	42	336	200	12	10	11
2 or more	2 or more	500	0	0	280	200	0	5	2
1	2 or more		48	42			16	14	11
			0	0			0	0	2



Signal Warrant 1

Eight-hour vehicular volume: Condition B
(Interruption of continuous traffic)

Condition B - Interruption of Continuous Traffic

Number of Lanes for Moving Traffic on Each Direction		Vehicles per hour on Major Street (total of both approaches)				Vehicles per hour on Higher-Volume-Minor-Street approach (one direction)			
Major St.	Minor St.	100 %	80 %	70 %	56 %	100 %	80 %	70 %	56 %
1	1	750	60	52	420	75	60	53	42
2 or more	1	900	0	5	504	75	60	53	42
2 or more	2 or more	900	72	63	504	100	80	70	56
2 or more	2 or more	750	0	0	420	100	80	70	56
1	2 or more		72	63					
	1		0	0					



Signal Warrant 1

If either condition is fulfilled, Warrant 1 is met, use 100% columns.

May reduce the value to 70% if the 85th percentile speed on the major approach is greater than 40 mph (70 kph) and population less than 10,000 (built-up area of isolated community)

columns.

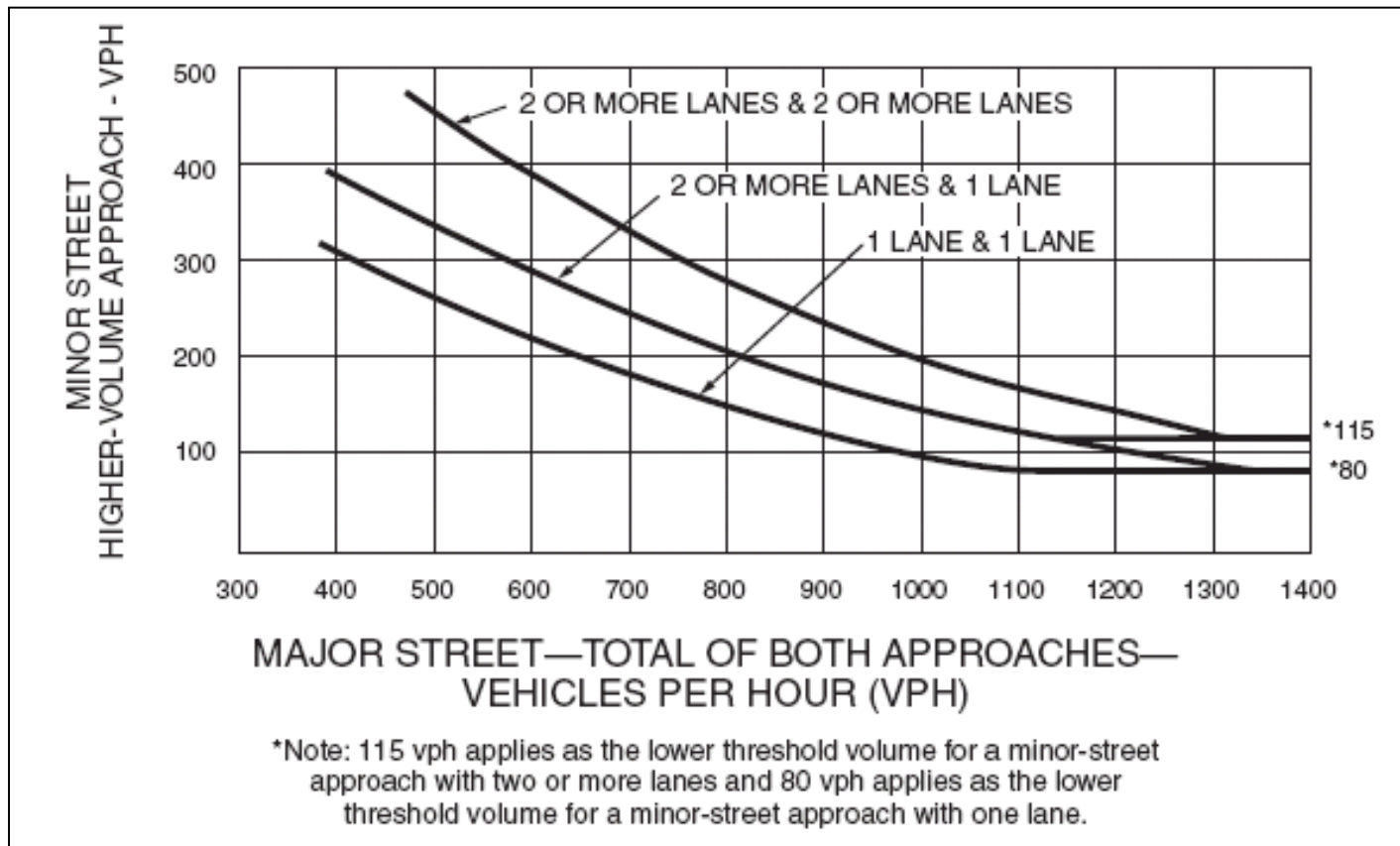
The vehicles per hour given in both of the 80 percent columns of Condition A exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection **AND** the vehicles per hour given in both of the 80 percent columns of Condition B exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection.

May reduce the value to 56% if the 85th percentile speed on the major approach is greater than 40 mph (70 kph) and population less than 10,000 (built-up area of isolated



Signal Warrant 2

Four-hour vehicular volume: Check for each of any 4 hr of an average day

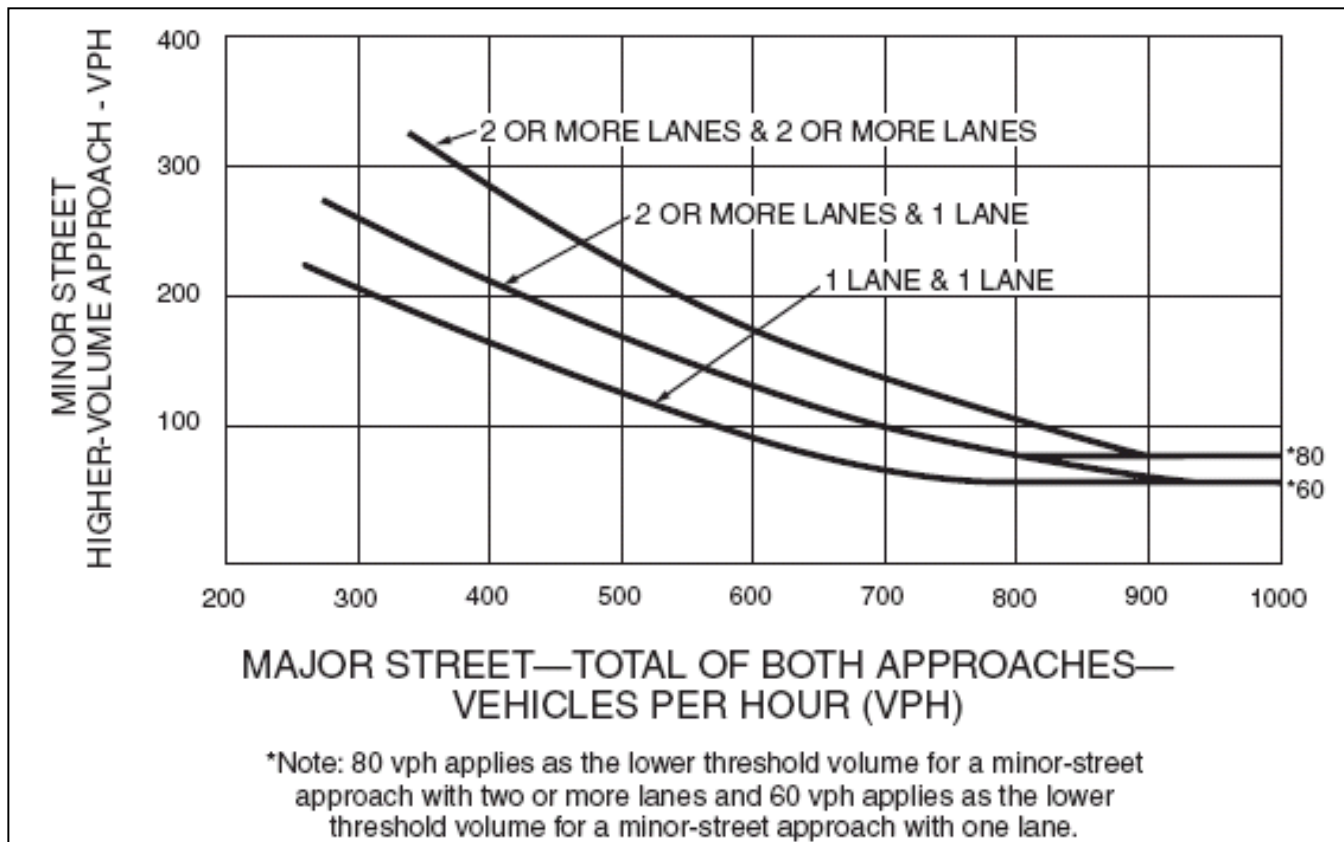




Signal Warrant 2

Four-hour vehicular volume: Check for each of any 4 hr of an average day

COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 70 km/h OR ABOVE 40 mph ON MAJOR STREET)





Signal Warrant 2

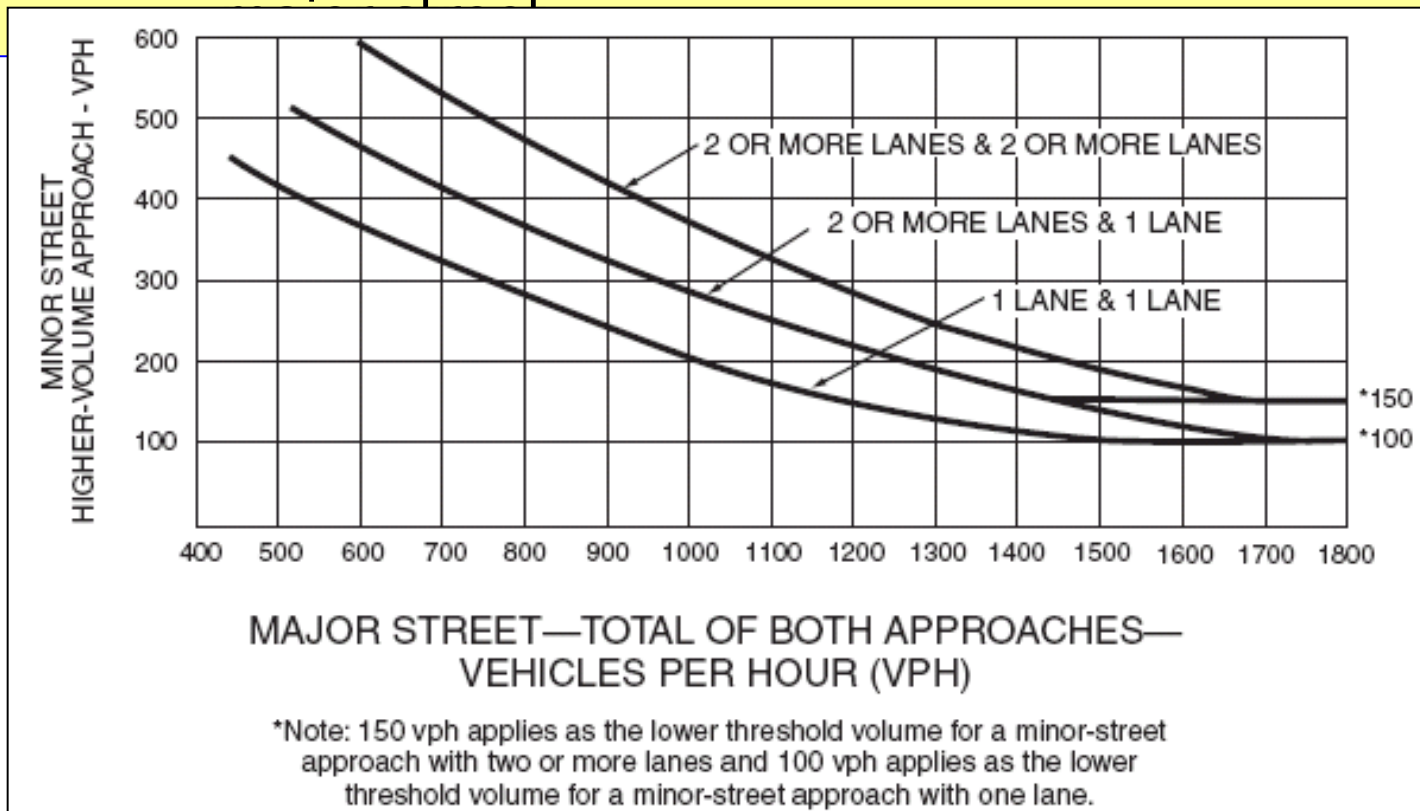
For any 4 hours of an average day, the plotted points all fall above the applicable curve (first curve)

May use second curve if the 85th percentile speed on the major approach is greater than 40 mph (70 kph) and population less than 10,000 (built-up area of isolated community)



Signal Warrant 3

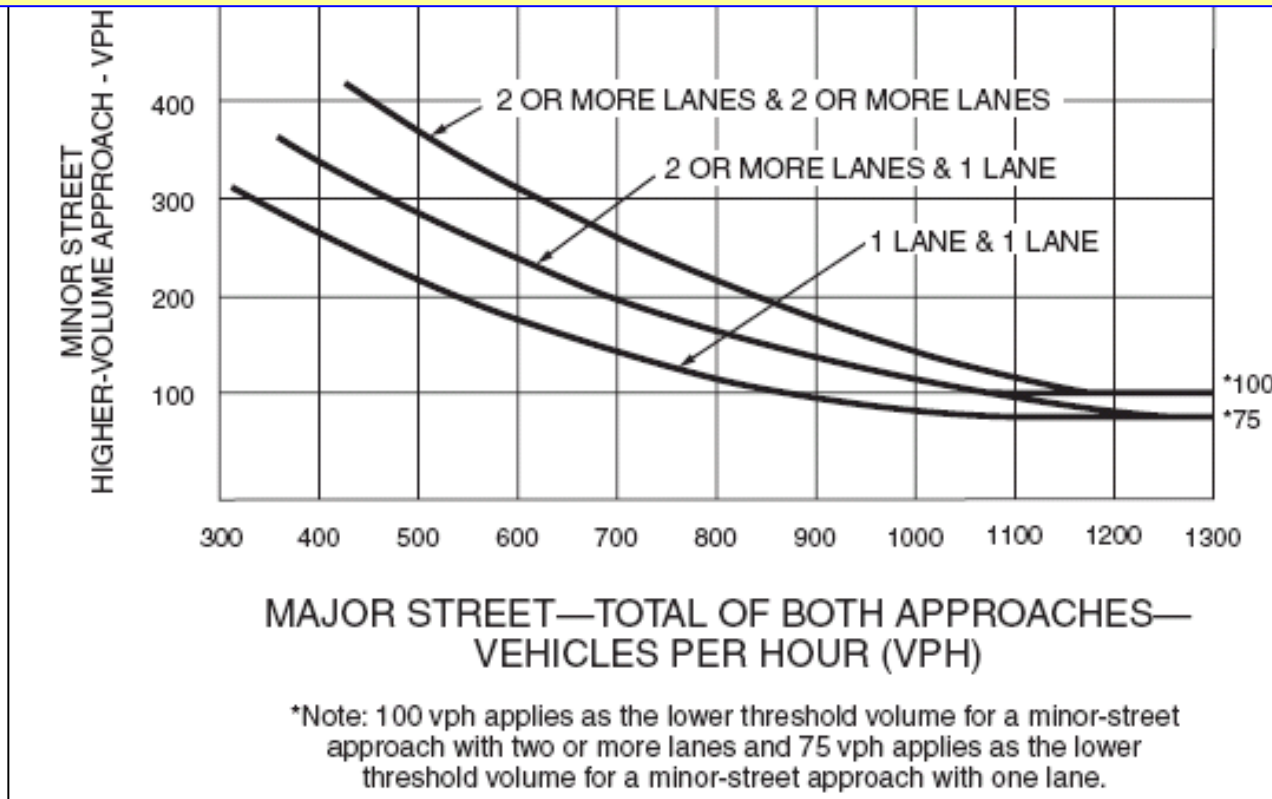
Peak Hour : for use at a location where traffic conditions are such that for a minimum of 1 hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the





Signal Warrant 3

COMMUNITY LESS THAN 10,000 POPULATION OR
ABOVE 70 km/h OR ABOVE 40 mph ON MAJOR
STREET





Signal Warrant 3

Condition A (must fulfill ALL):

1. The total stopped time delay experienced by the traffic on one minor-street approach (one direction only) controlled by a STOP sign equals or exceeds: 4 vehicle-hours for a one-lane approach; or 5 vehicle-hours for a two-lane approach, **AND**
2. The volume on the same minor-street approach (one direction only) equals or exceeds 100 vehicles per hour for one moving lane of traffic or 150 vehicles per hour for two moving lanes, **AND**
3. The total entering volume serviced during the hour equals or exceeds 650 vehicles per hour for intersections with three approaches or 800 vehicles per hour for intersections with four or more approaches.



Signal Warrant 3

Condition B :

The plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve for the existing combination of approach lanes.



Signal Warrant 4, 5

4. Minimum pedestrian volume	The pedestrian volume crossing the major street. At least 100 for each of any 4 hr or 190 during any 1 hr AND there are fewer than 60 gaps per hr that are acceptable by pedestrians for crossing . AND, the nearest signal along the major street should be at
5. School crossing	The frequency of occurrence of gaps and the lengths of gaps are inadequate for safe crossing of the street. The number of acceptable gaps is less than the number of minutes in that period, e.g., if the crossing lasts 30 minutes, there must be at least 30 occurrences of critical gaps for children to cross. Use a pedestrian-actuated signal



Signal Warrant 6

6. Coordinated signal system	A. On a one-way street or a street that has traffic predominantly in one direction, the adjacent traffic control signals are so far apart that they do not provide the necessary degree of vehicular platooning. B. On a two-way street, adjacent traffic control signals do not provide the necessary degree of platooning and the proposed and adjacent traffic control signals will collectively provide a progressive operation
---	---



Signal Warrant 7

7. Crash experience

- A. Adequate trial of alternatives with satisfactory observance and enforcement has failed to reduce the crash frequency; and**
- B. Five or more reported crashes, of types susceptible to correction by a traffic control signal, have occurred within a 12-month period, each crash involving personal injury or property damage apparently exceeding the applicable requirements for a reportable crash; and**
- C. The traffic and pedestrian volumes should not be less than 80% of the requirements of Warrants 1 and 4.**



Signal Warrant 8

8. Roadway network

- A. The intersection has a total existing, or immediately projected, entering volume of at least 1,000 vehicles per hour during the peak hour of a typical weekday and has 5-year projected traffic volumes, based on an engineering study, that meet one or more of Warrants 1, 2, and 3 during an average weekday; or
- B. The intersection has a total existing or immediately projected entering volume of at least 1,000 vehicles per hour for each of any 5 hours of a non normal business day (Saturday or Sunday).



Types of Intersection Control (JKR - 11/87)

INTERSECTION TYPE	TOTAL OF TWO-WAY TRAFFIC ON MAJOR ROAD AND HEAVIER APPROACH VOLUME ON MINOR ROAD (VPH)						
	1000	2000	3000	4000	5000	6000	7000
STOP CONTROL							
SIGNALIZED INTERSECTION							
INTERCHANGE							
ROUNDAABOUT	MINI	SMALL	CONVENTIONAL				

1) ROUNDAABOUTS ARE USUALLY RANGED IN SIZE AS FOLLOWS.

- a) MINI - LESS THAN 20m IN DIAMETER OF INSCRIBED CIRCLE, LESS THAN 4m. IN DIAMETER OF CENTER CIRCLE.
- b) SMALL - 20 TO 50 m, 4 TO 25 m
- c) CONVENTIONAL - MORE THAN 50m, MORE THAN 25m.

TABLE: 2-2A. SELECTION OF INTERSECTION TYPE



Traffic Signal (Warrants - JKR)



Traffic control signals should generally not be installed unless one or more of the warrants are met.

- Vehicular Operations
- Pedestrian Safety
- Accident Experience



JKR Warrant 1

Vehicular Operations

A. Total Volume

If traffic volume for any 8 hour of an an average day meets the minimum requirements in Table A-1 (JKR - 11/87)

For the major road, the total volume of both approaches is used. For the minor road, the higher volume approach (one direction only) is used.

Number of Lanes Each Approach		Minimum Requirements			
		Major Road Flow (vph)		Minor Road Flow (vph)	
Major Road	Minor Road	Urban	Rural	Urban	Rural
1	1	500	350	150	105
≥ 2	1	600	420	150	105
≥ 2	≥ 2	600	420	200	140
1	≥ 2	500	350	200	140



JKR Warrant 1

Vehicular Operations

B. Peak Hour Volume

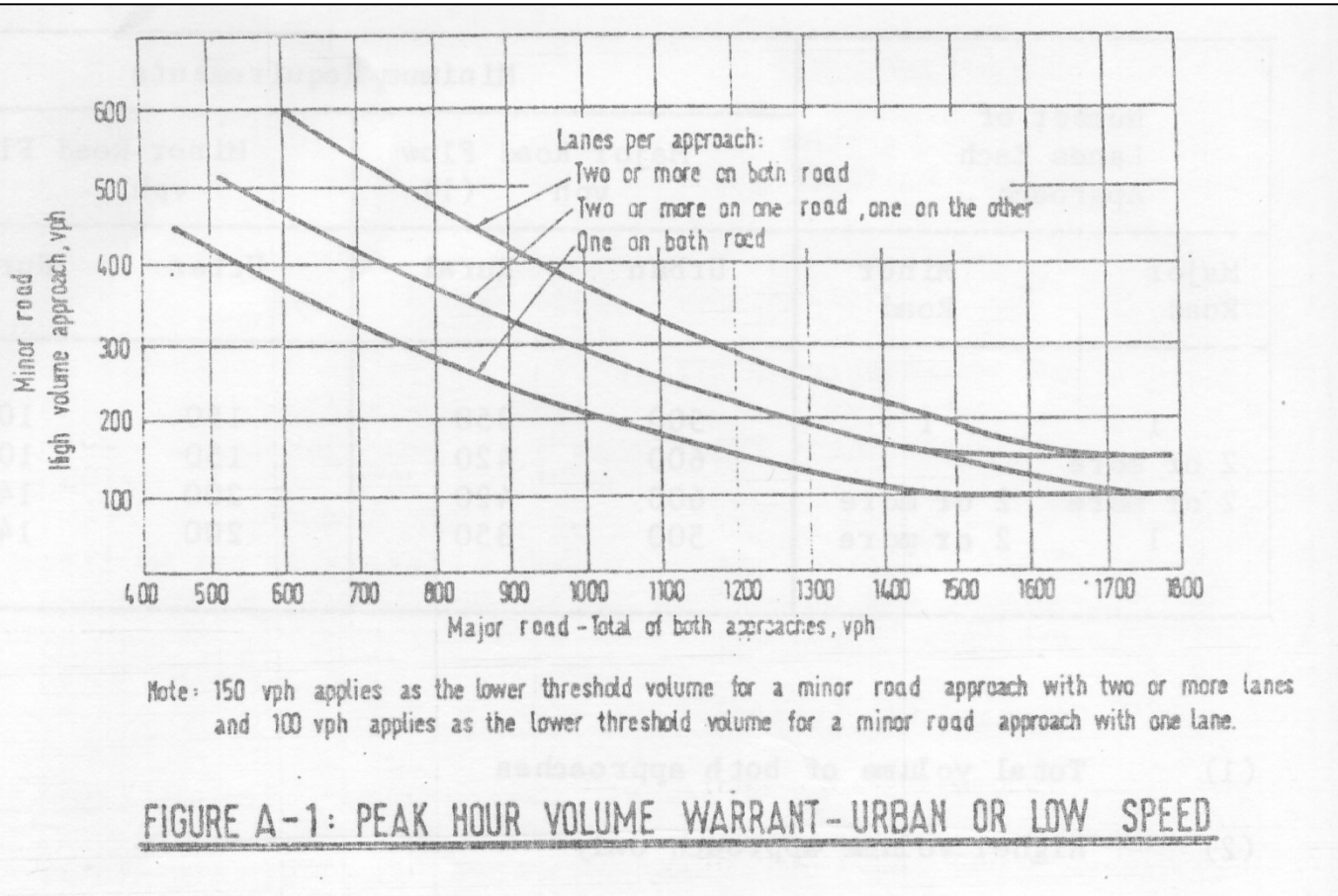
The peak hour major road volume (total vehicles per hour for both directions) and the higher volume minor street approach (vehicles per hour for one direction only) fall above the curve for a given combination of approach lanes shown in Figure A-1 (JKR - 11/87)

Lower requirements when the 85th percentile speed of major road exceeds 60 kph, or when the intersection lies within an urban area. Figure A-2 (JKR - 11/87)



JKR Warrant 1

Vehicular Operations





JKR Warrant 1

Vehicular Operations

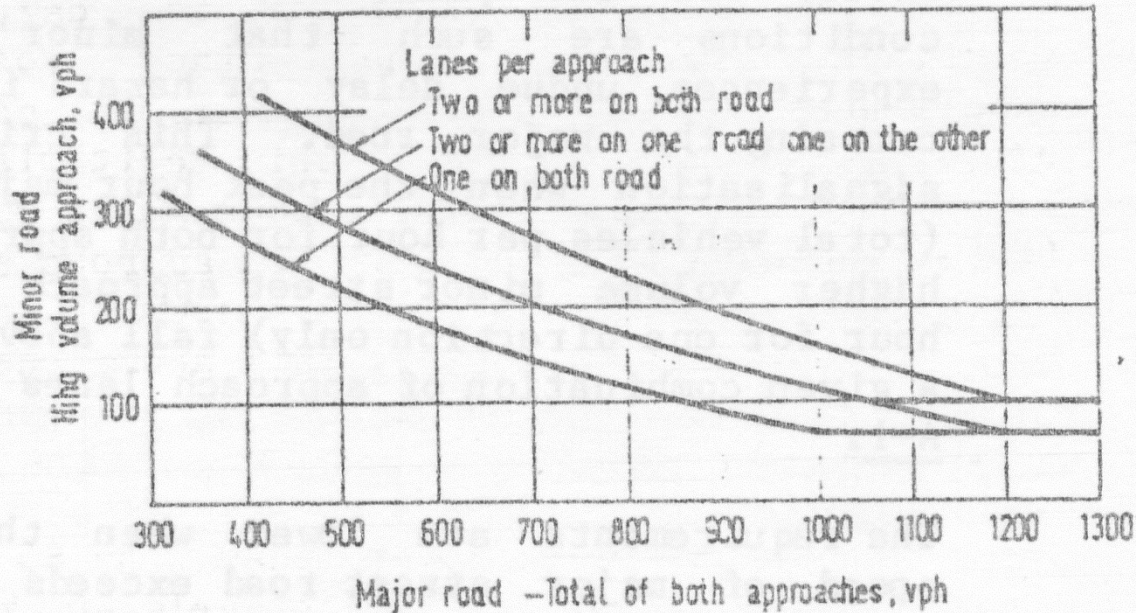


FIGURE A-2: PEAK HOUR VOLUME WARRANT-RURAL OR HIGH SPEED



JKR Warrant 1

Vehicular Operations

C. Progressive Movements

To maintain a proper grouping or platooning of vehicles and regulate group speed.

On one-way road, when the adjacent signals are far apart

On two-way road, when the adjacent signals do not provide the necessary degree of platooning and speed control

Signal installation should be based on the 85th percentile speed.



JKR Warrant 2

Pedestrian Safety

For each of any 8 hours of an average day the following traffic volume exists:

(A) Major road, 600 or more vph (total both approaches) enter the intersection, or with raised median island 1.2 m or more, 1,000 vph.

(B) During the same 8 hour of (A) above, 150 or more pedestrians per hour on the highest volume crosswalk crossing the major road.

When 85th percentile speed of the major road exceeds 60 kph, or intersection lies within the built-up area of an isolated community having a population of less than 10,000, the minimum pedestrian volume is 70% of the requirement above.



JKR Warrant 3

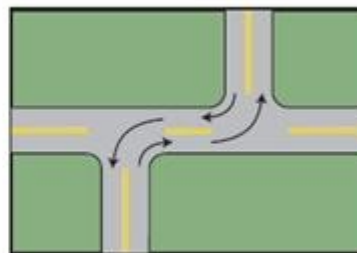
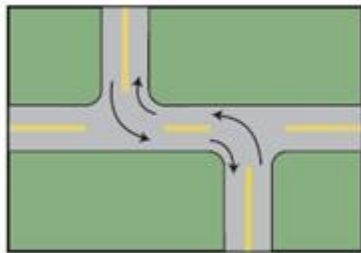
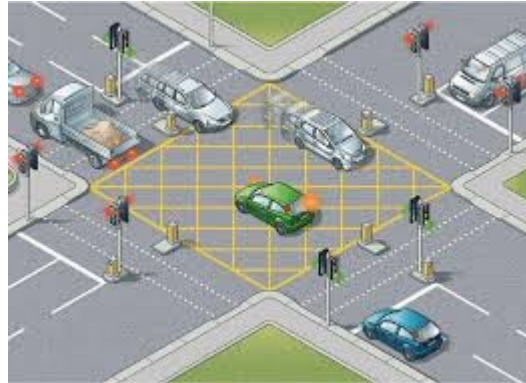
Accident Experience

At accident prone areas with accident type which are correctable by signal control. Claim to be substantiated by accidents records for a period of 2 to 3 years. The requirements are satisfied when:

- (a) Adequate trial of less restrictive remedies with satisfactory observance and enforcement has failed to reduce the accident frequency.
- (b) 5 or more accidents per year. These accidents should be of the types correctable by traffic signal control
- (c) Volume of vehicular and pedestrian traffic not less than 80% of the requirement in Warrants 1 and 2
- (d) Signal installation will not seriously disrupt



Junction Capacity





Procedure...

1. Basic Structures

- (a) Define existing geometric and volume conditions**
- (b) Determine the conflicting traffic**
- (c) Determine the size of the gap**
- (d) Determine the capacity of the gaps**
- (e) Adjust the capacity to account for impedances and shared lanes**
- (f) Determine the reserve capacity and hence the LOS**



Procedure...

2. Input Data Requirements

- (a) Number and use of lanes**
- (b) Channelization**
- (c) Approach gradient**
- (d) Kerb radius and approach angle**
- (e) Sight distance**



Procedure...

3. Conflicting Traffic (Figure 4-1)

4. Critical Gap Size (Table 4-3)

- (a) The type of manoeuvre being executed**
- (b) The type of minor road control (STOP or GIVE WAY)**
- (c) The average running speed on the major road**
- (d) The number of lanes on the major street**
- (e) The geometrics and environmental conditions at the intersection**



Procedure...

5. Potential Capacity for A Movement (Figure 4-2)

- (a) Traffic on the major roadway does not block the minor road**
- (b) Traffic from nearby intersections does not back up into the intersection under consideration**
- (c) A separate lane is provided for the exclusive use of each minor road movement under consideration**
- (d) No other movements impede the subject movement**



Procedure...

6. Impedance Effects (Figures 4-3 & 4-4)

7. Shared Lane Capacity

$$C_{SH} = \frac{V_l + V_t + V_r}{(V_l / C_{ml}) + (V_t / C_{mt}) + (V_r / C_{mr})}$$

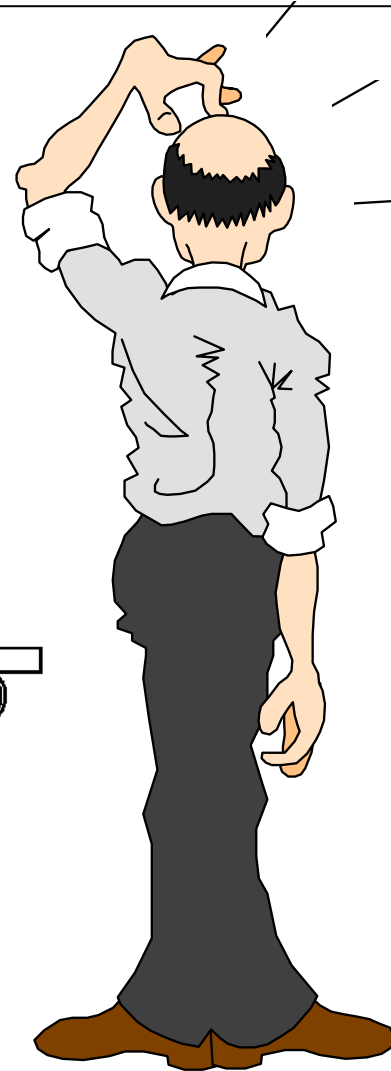
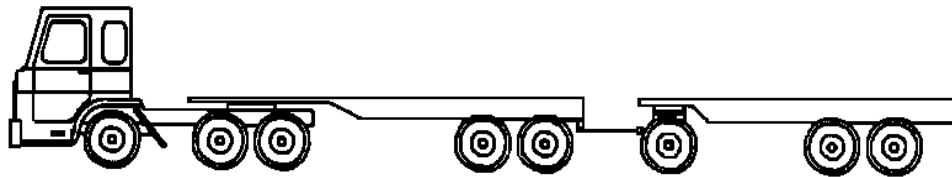
8. Reserve Capacity

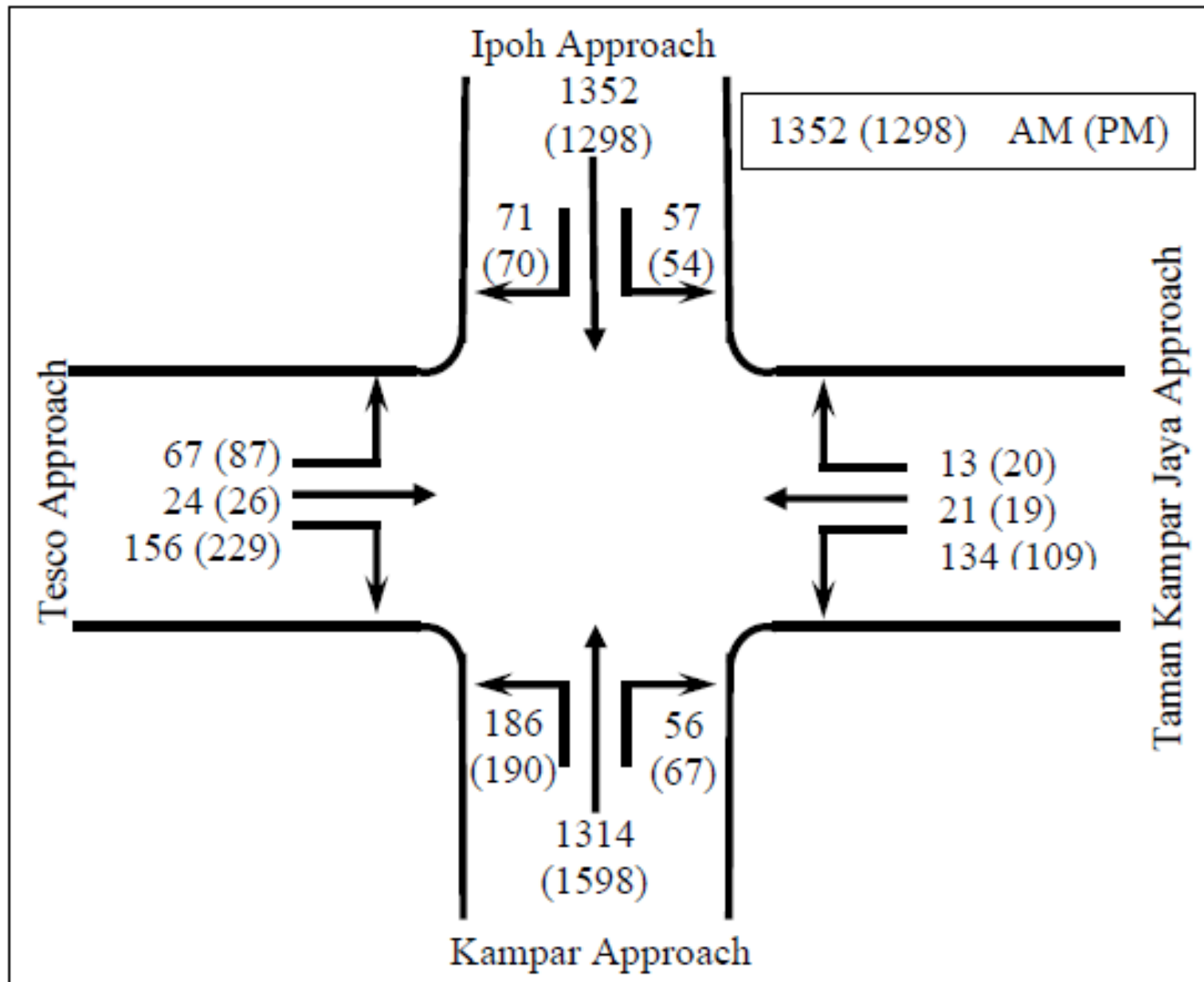
$$C_R = C_{SH} - V$$

9. Level of Service (Table 4-4)



Questions?





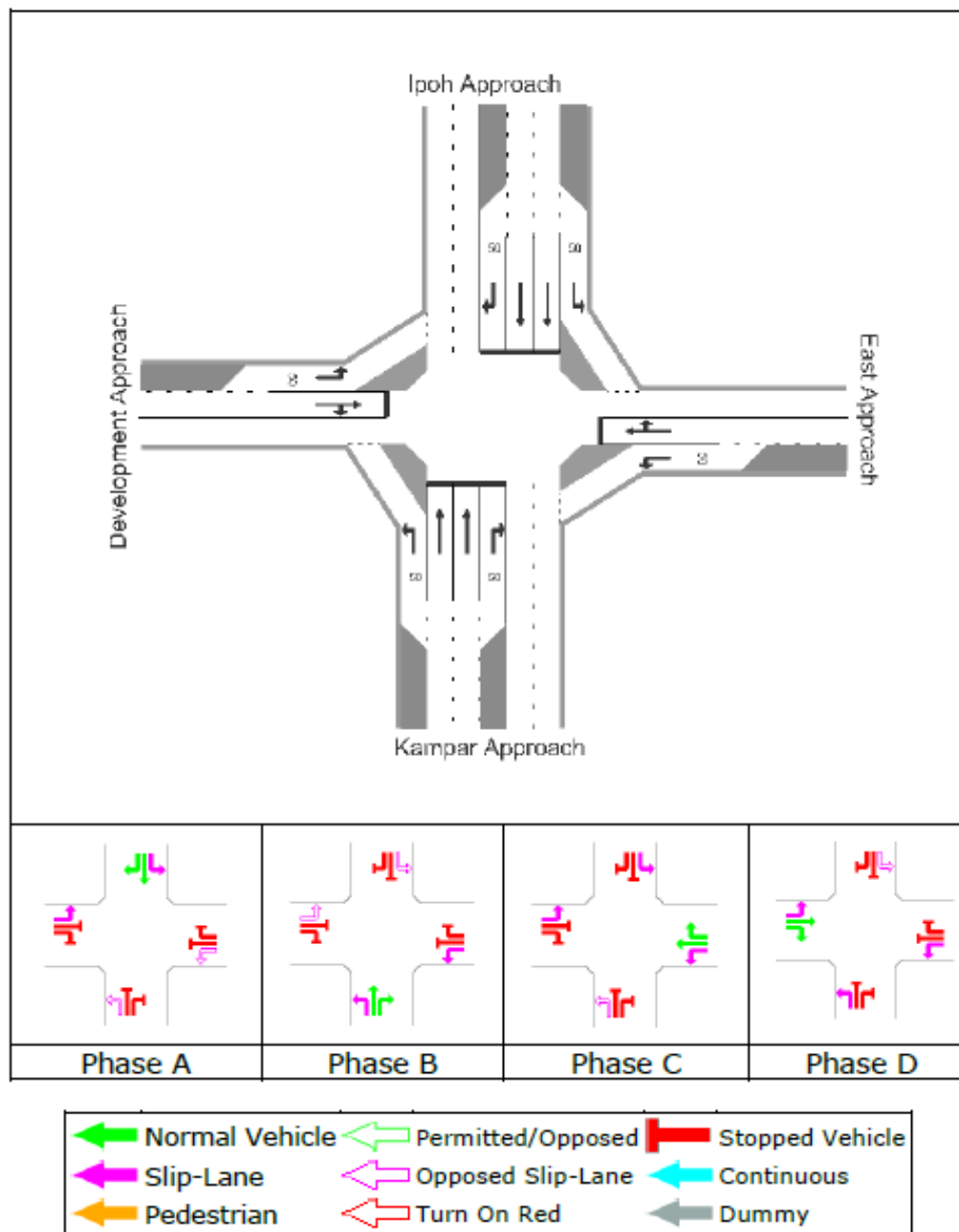


Figure 13 Schematic Layout and Signal Phasing of Signalized Junction 1

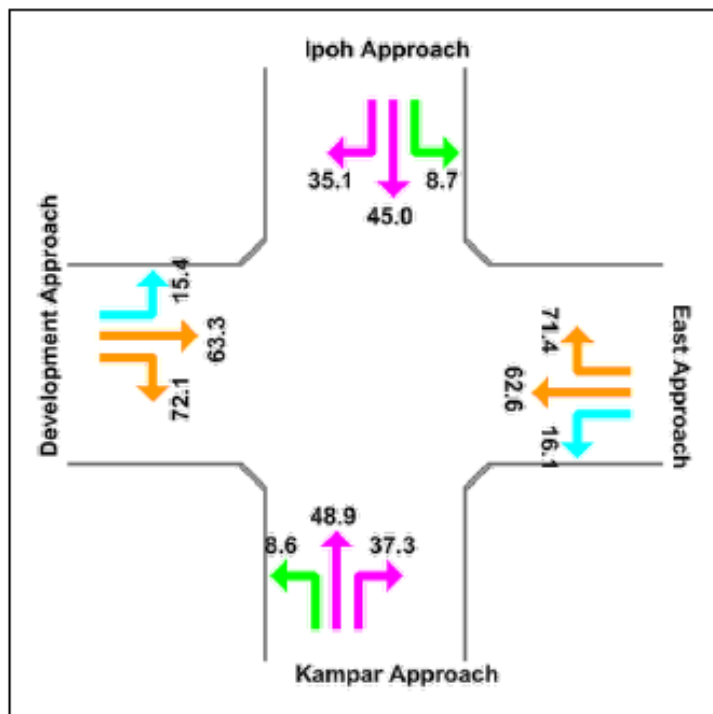


Figure 15(a) Delay (sec) at Junction 1 – Existing Weekday Traffic (AM Peak)

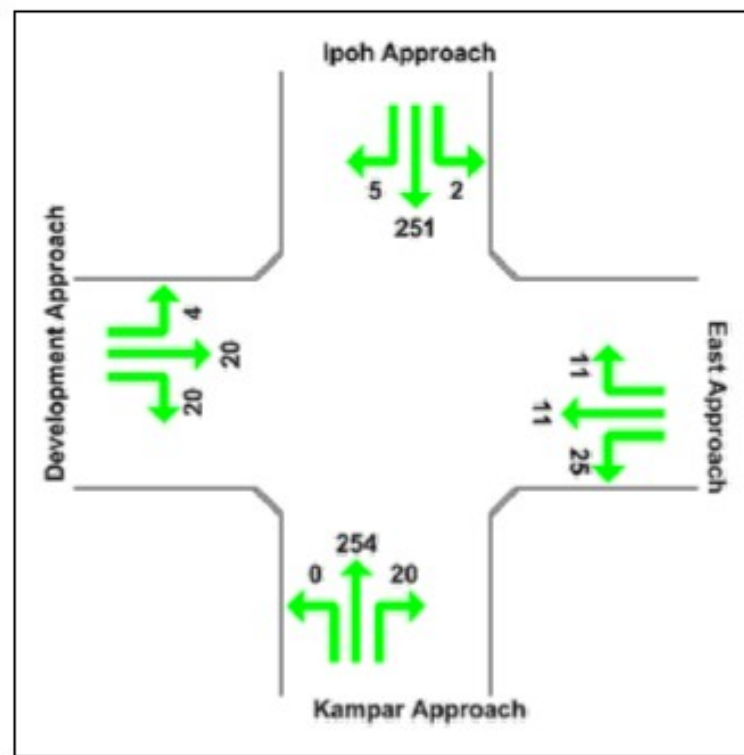


Figure 16(a) Queue (m) at Junction 1 – Existing Weekday Traffic (AM Peak Year 2007)

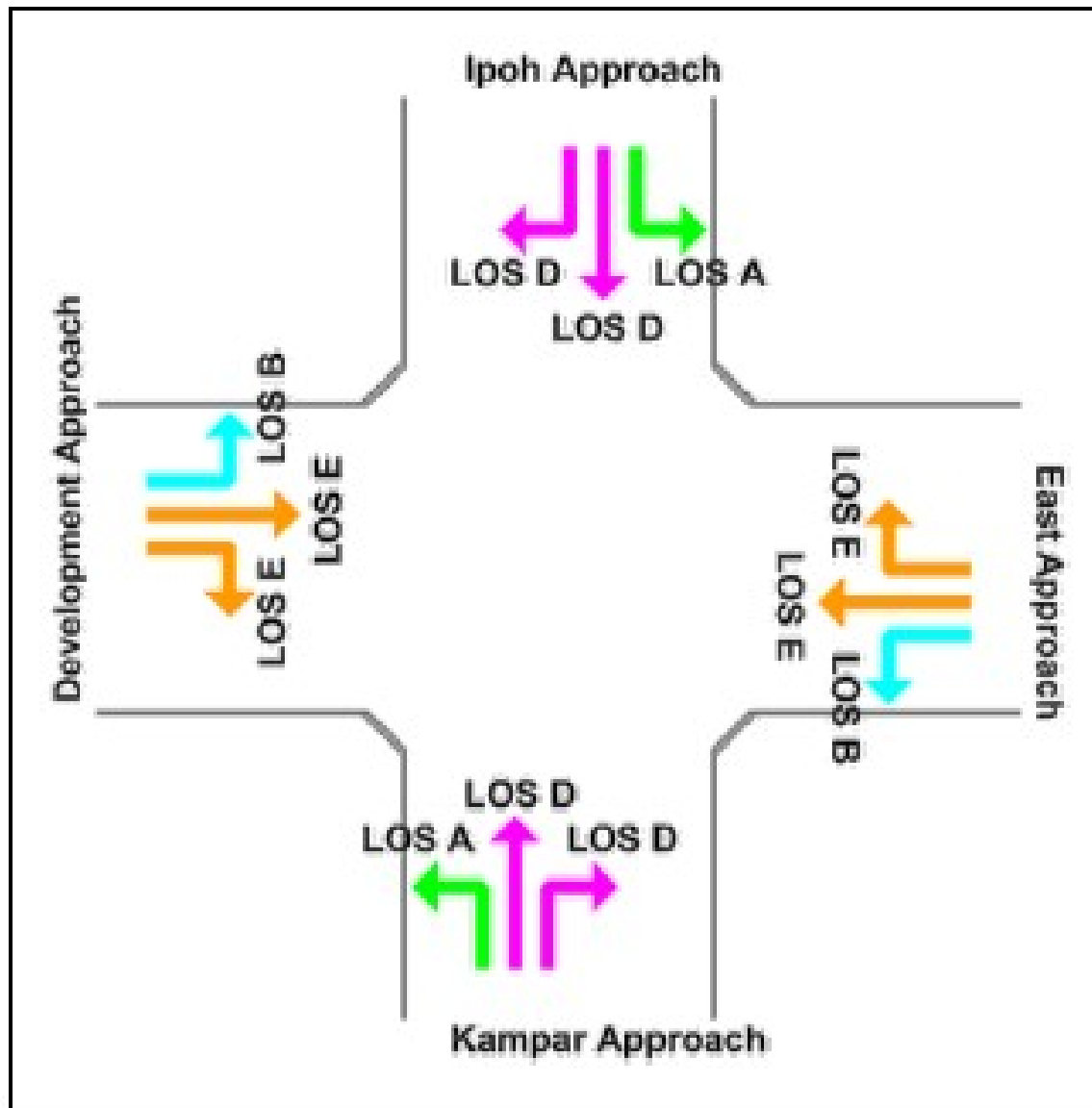


Figure 14(a) LOS at Junction 1 – Existing Weekday Traffic (AM Peak Year 2007)