TRAFFIC ENGINEERING

SAB3843

TRAFFIC SIGNAL CONTROL SYSTEM

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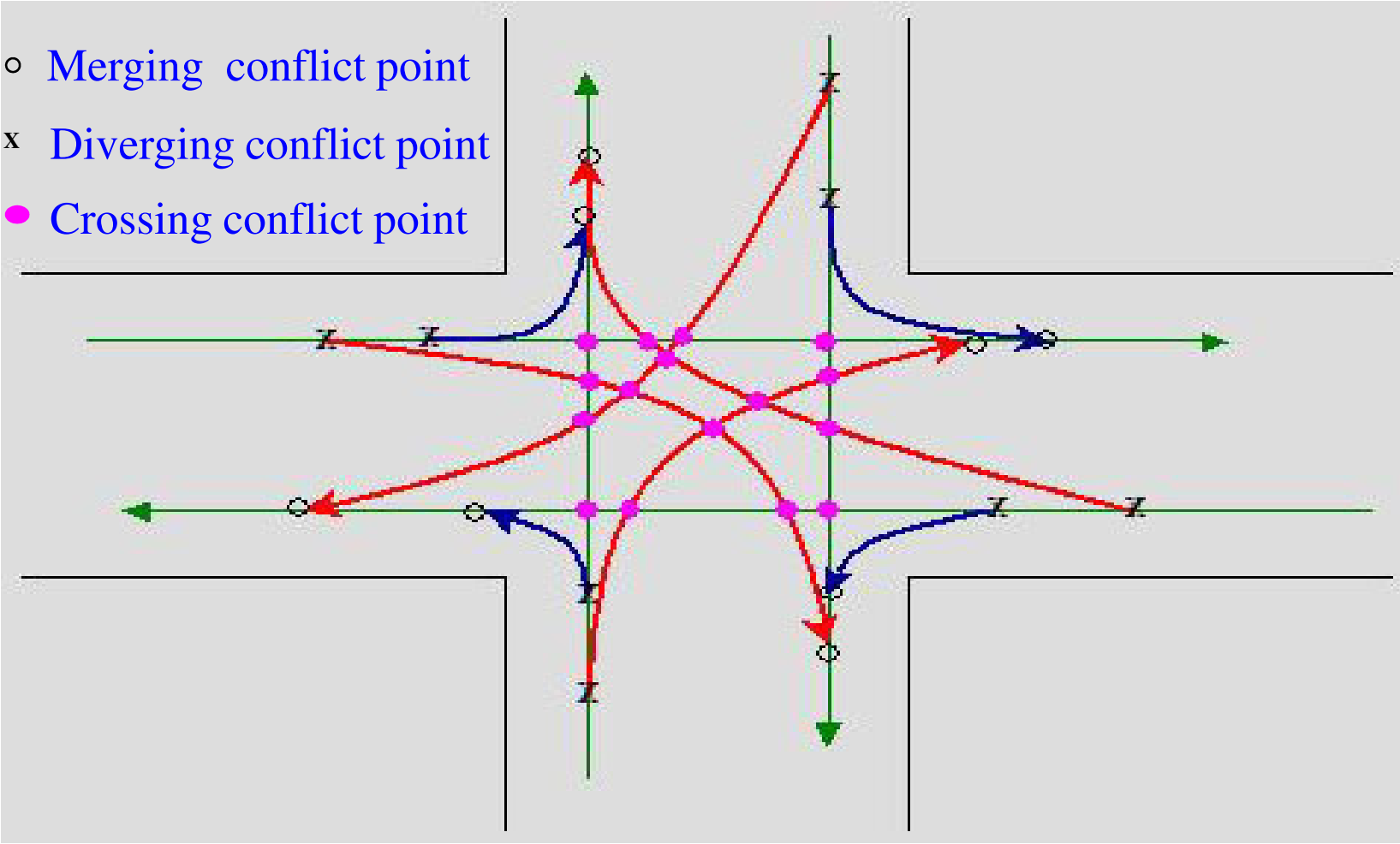
TRAFFIC SIGNAL CONTROL SYSTEM

Traffic signal - all mechanical or electrical–controlled devices used to control, direct, or warn drivers or pedestrians

Main function of an installation of a traffic light/signal at an intersection is to provide right–of–way to vehicles on each approach to increase traffic handling performance – i.e., for efficient traffic movement, safety, reduced traffic conflict points, reduced traffic delay, etc.

REDRAW

Conflict points - points at which there are possibilities of two or more vehicles collide if allowed to move simultaneously.



Benefits of Traffic Signals

1. Provide orderly traffic movement through appropriate assignment of right-of-way.
2. Provide for the progressive flow of a platoon of traffic along a given route.
3. Interrupt heavy traffic at intervals to allow pedestrians and cross-street traffic to cross or to enter the main street flow.
4. Increase the traffic-handling ability of a junction.
5. Reduce number of conflict point, i.e., to reduce frequency of occurrence of certain types of accidents

Drawbacks of Traffic Signals

Improper design or unwarranted signal intallations may cause:

1. Excessive delay for motorists and pedestrians, particularly during off–peak periods.
2. Increased accident frequency (i.e., rear–end–collisions).
3. Disregard of signal indications.

General criteria for selecting the type of junctions

Type of junction	Total 2–way traffic on major road and highest volume on minor road (veh/h)
	1000 2000 3000 4000 5000 6000
Stop–controlled	→
Traffic Signal	← →
Interchange	←
Roundabout	MINI → SMALL → CONVENTIONAL →

WARRANT FOR THE INSTALLATION OF A TRAFFIC SIGNAL SYSTEM

- Warrant #1 – Vehicle Operations
- Warrant #2 – Pedestrian Safety, and
- Warrant #3 – Accidents Record.

Installation of a traffic signal is warranted if one or more requirements specified in any of the warrants are satisfied.

Warrant #1: Vehicular Operations

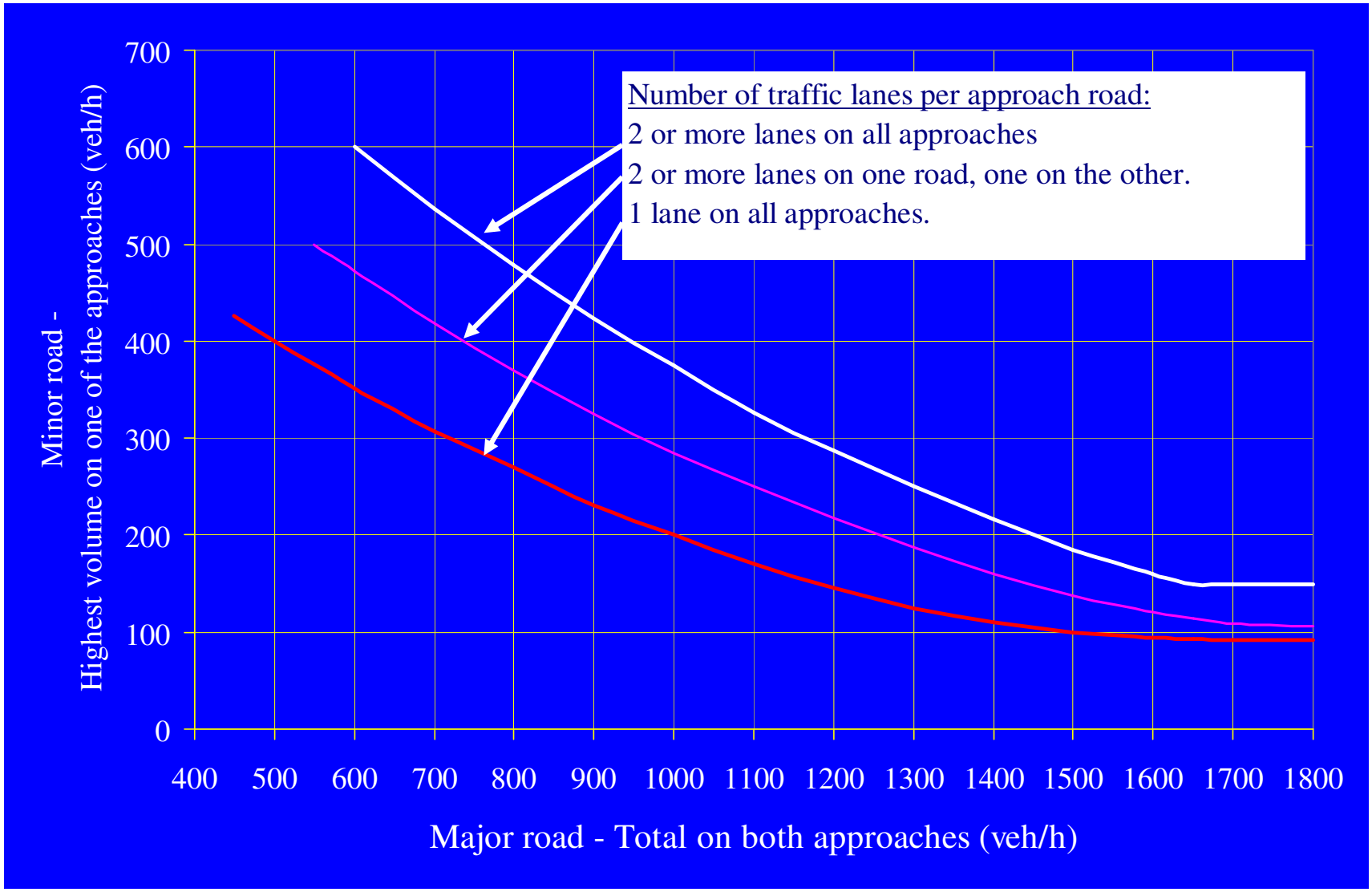
(a) Total Volume (PCU): Traffic volume for each of any 8 hour of an average day meets the minimum requirements in Table 1

Number of Lanes on each approach		Minimum on Major Road (1)		Minimum on Minor Road (2)	
Major Road	Minor Road	Urban	Rural	Urban	Rural
1	1	500	350	150	105
2 or more	1	600	420	150	105
2 or more	2 or more	600	420	200	140
1	2 or more	500	350	200	140

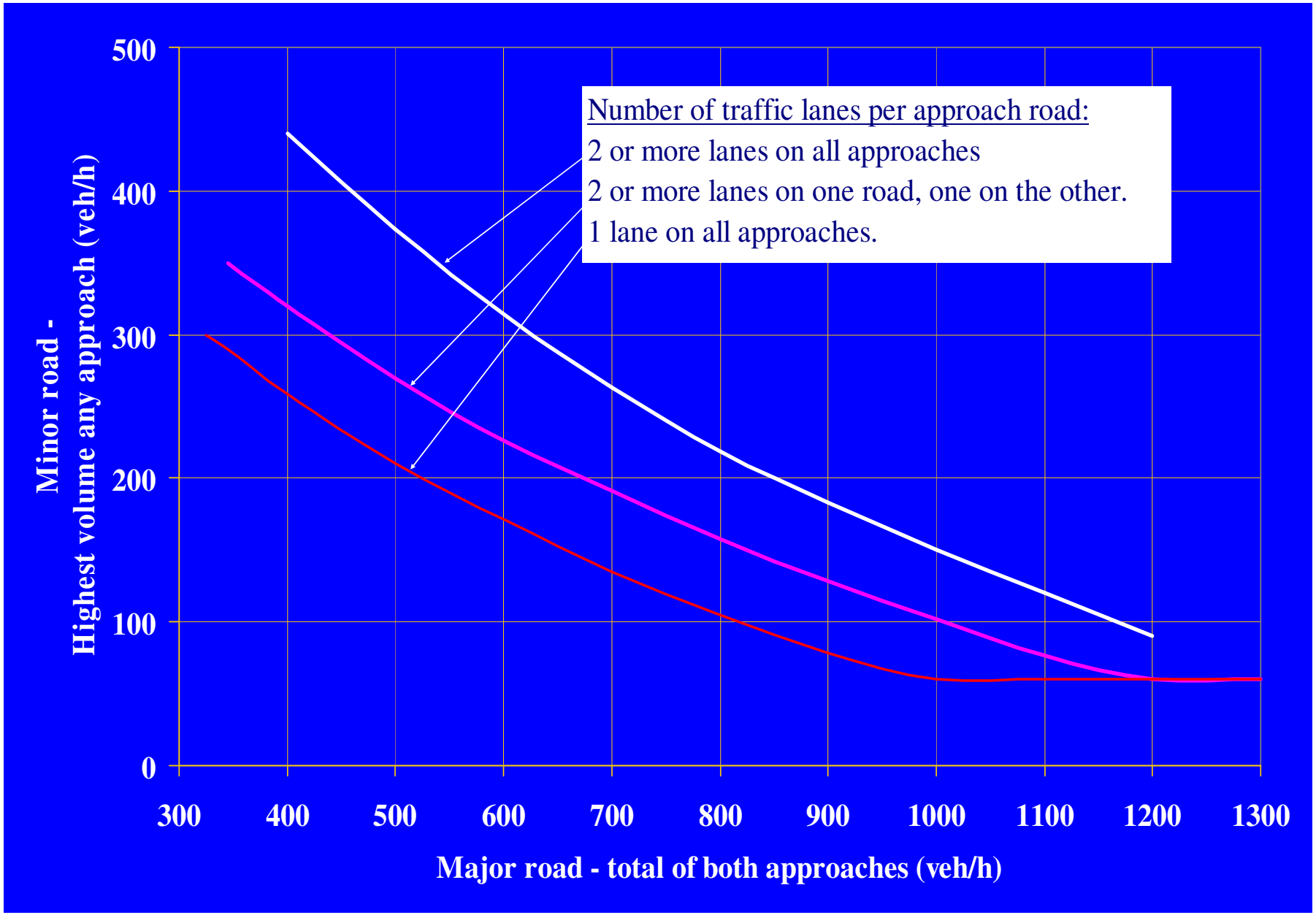
(1) Total volume of both approaches

(2) Higher volume approach only

(b) Peak Hour Volume



b (i) Urban or Low Speed Roads



b (ii) Rural or High Speed Roads

(c) Progressive Movements

Where it is desirable to install a signal to *maintain a proper grouping or platooning* of vehicles and *regulate group speed* even though the junction does not satisfy other warrants for signalisation.

Warrant #2: Pedestrian Safety

a) Total traffic on major road ≥ 600 veh/hour or where there is a raised median island 1.2 m or more in width, 1,000 or more veh/hour, and

b) 150 or more pedestrian/hour crossing the road

Warrant #3: Accident Record

The requirements for signalisation are satisfied when (based on at least a period of 3 years):

1) There exist a record of 5 of more accidents in a year.
   Accidents types susceptible to correction by traffic signal control.

2) There exist a volume of vehicular and pedestrian traffic not less than 80% of the requirements specified in warrants 1 and 2.

3) The signal installation will not seriously disrupt progressive traffic flow

4) Other methods found not effective to reduce accidents

Note:

Traffic signal installed for this warrant should be semi vehicle-actuated if installed at a junction within a coordinated system, or

Fully vehicle-actuated if installed at an isolated junction.

TERMINOLOGY & DEFINITIONS

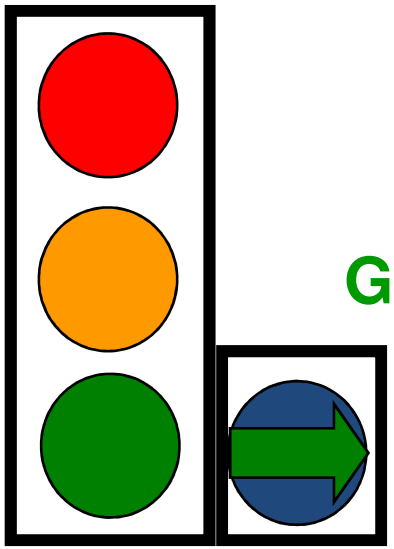
(1) Signal Aspects (color indications):

RED: STOP

AMBER: (i) Slow down, ready to stop, ROW to end soon – drivers approaching stop line

(ii) Proceed and clear the junction - already crossed the stop line.

GREEN: Drivers have the right of way

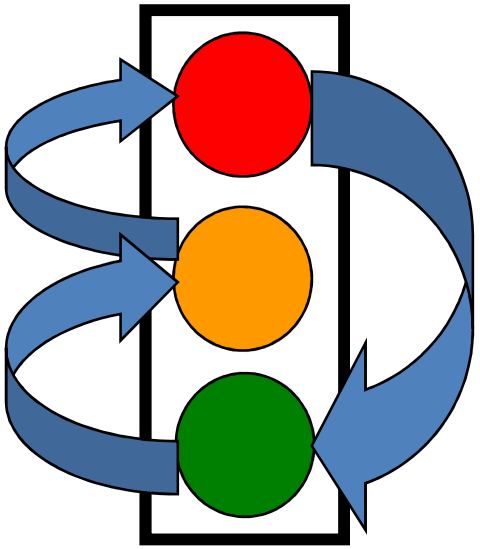


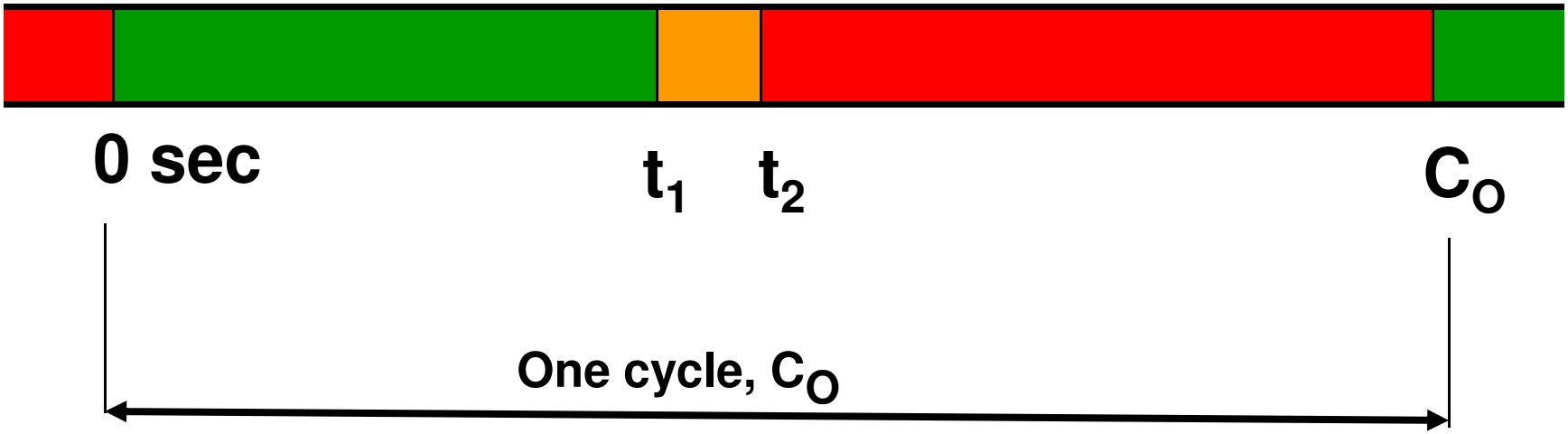
GREEN ARROW: Proceed as indicated

(2) Cycle time (C_o)

A period for a complete sequence of signal indications:

green >> amber >> red >> green.





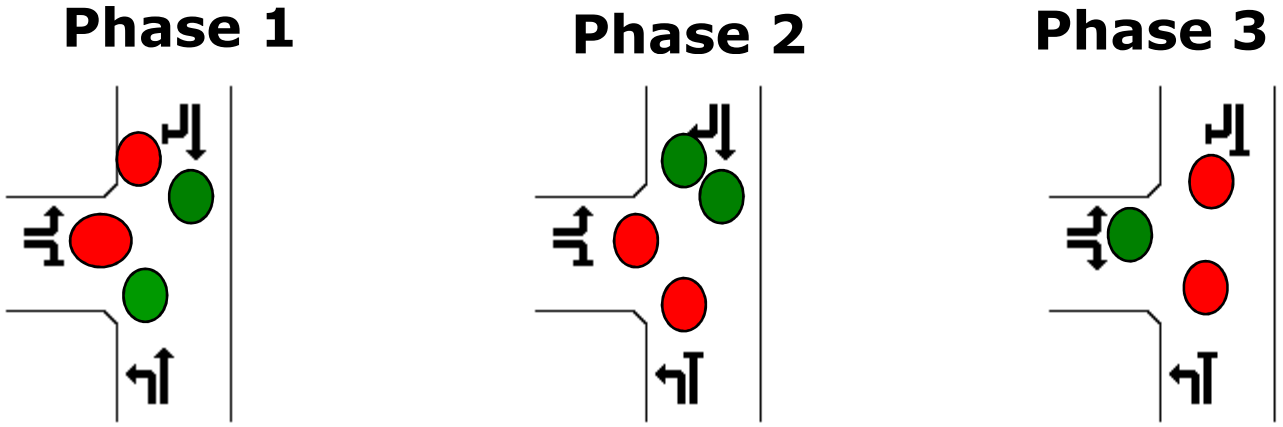
(3) Traffic Signal Phases

The **portion** of a signal cycle time allocated to **any single combination** of one or more traffic **movements** simultaneously receiving the right-of-way during one or more intervals.

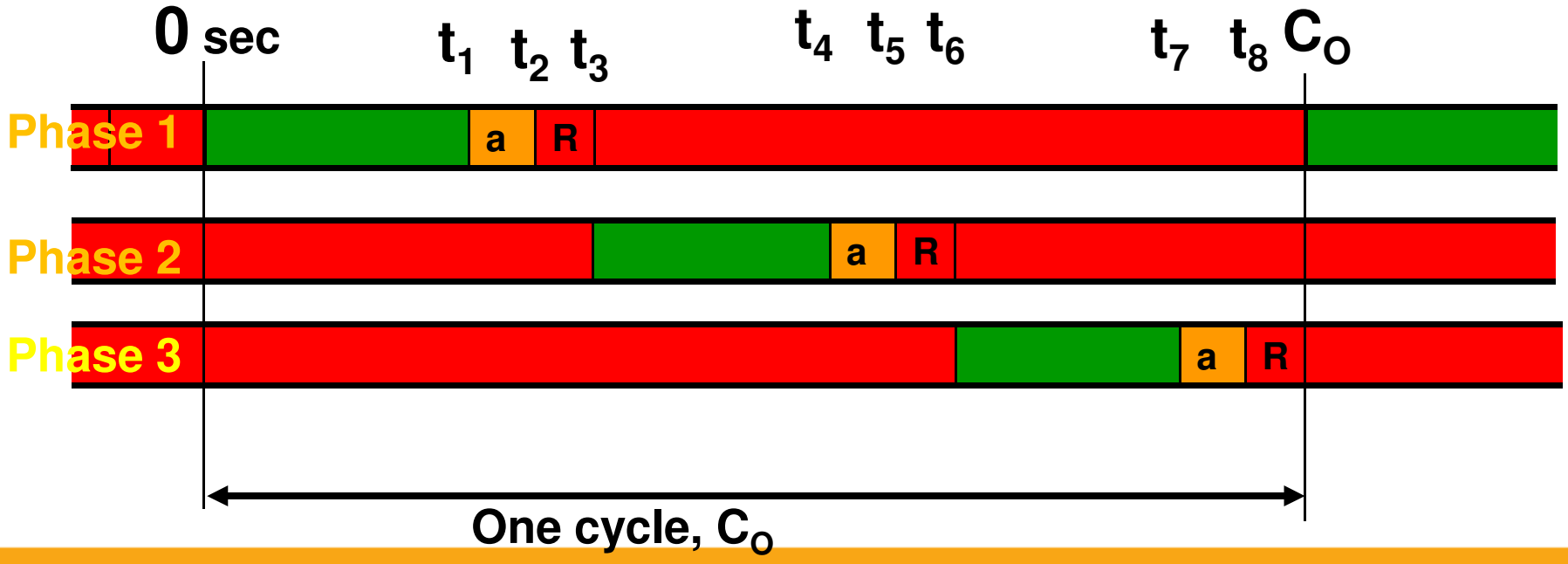
Phase Sequence:

A predetermined **order** in which the phases of a cycle occur.

Phasing Diagram

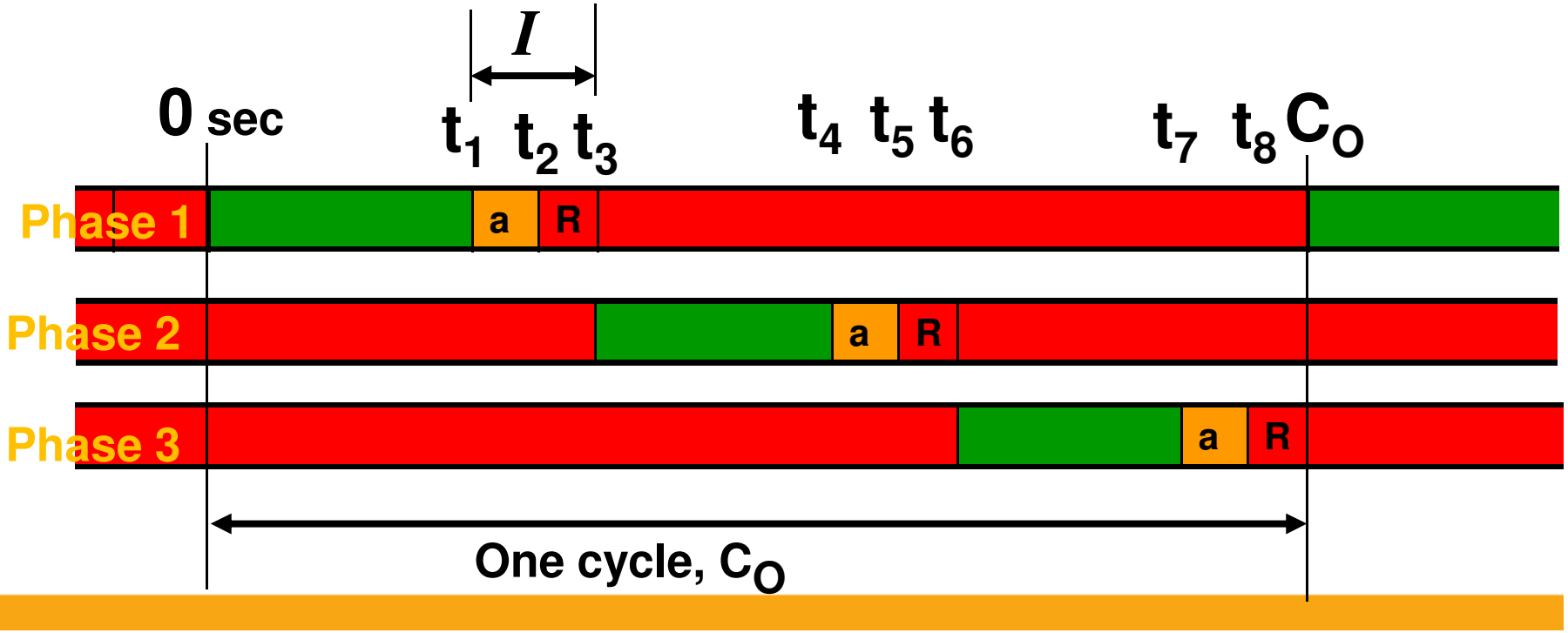


Timing Diagram



(4) All-Red Period (R)

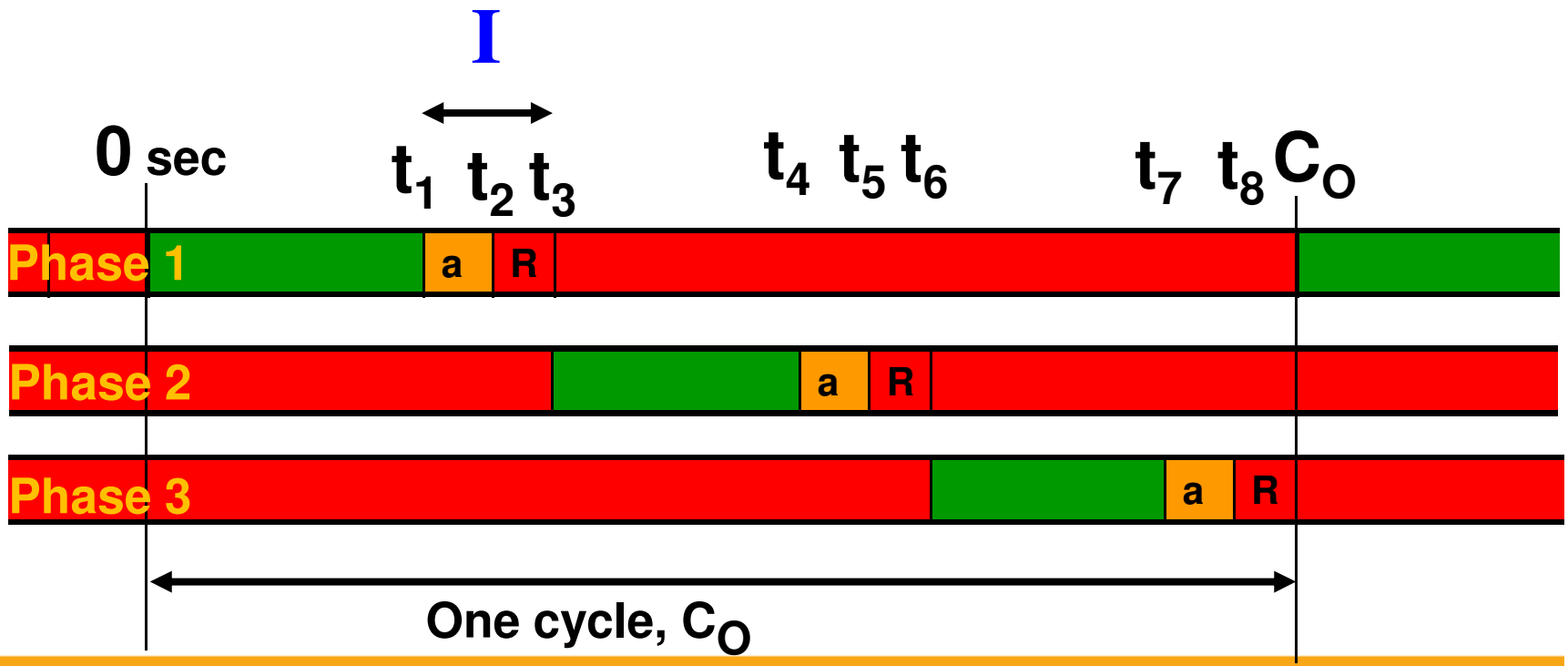
- Part of signal cylce time which signal indication do not change.
- To ensure all vehicle/pedestrian have cleared the junction before next traffic phase given ROW
- All indications shows RED



(5) Intergreen (I)

Period of time frome end of green of phase to beginning of green indication for the next phase

$$I = a + R$$



Types of Traffic Signal

1. Pre-timed or Fixed Time
2. Vehicle-actuated
3. Traffic Adjusted

Design Principle of a Pre-Timed Traffic Signal System

Merits of the system:

1. Easy to maintain
2. Can be coordinated with neighboring signalized junctions for porgressive flow
3. Cycle time cam be adjusted at site
4. Possibilities of “multi-timing system”

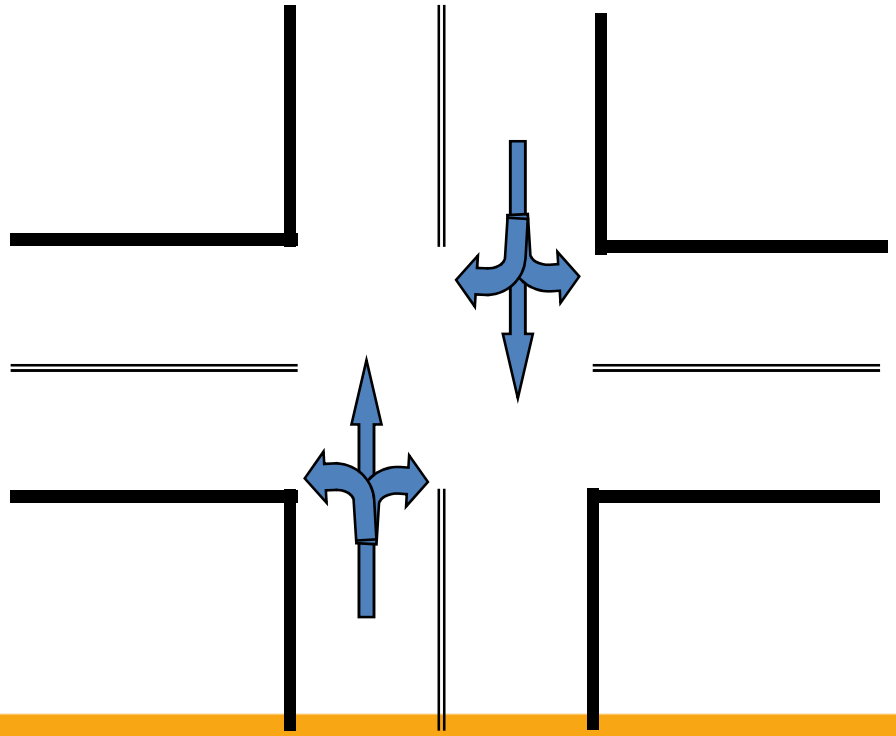
Elements to consider in the design of a traffic signal control system

(1) SELECTION OF TRAFFIC PHASES

Minimum number of phase: 2

BUT, need to consider the needs to provide separate right-turn phase based on these criteria:

1. Traffic Volume
2. Delay
3. Accident record
4. Intersection geometry



General guideline for provision of separate right–turning phases:

(a) Traffic Volume

i. Product of right–turning traffic volume and through volume of the conflicting direction ≥ 50,000; or

ii. Total right –turning traffic ≥ 100 veh/h during peak hour; or

iii. Number of right–turning vehicles left in queue ≥ 2 veh/cycle at the end of green period.

(b) Traffic Delay

i. Average delay to the right–turning vehicles ≥ 35 sec/veh.

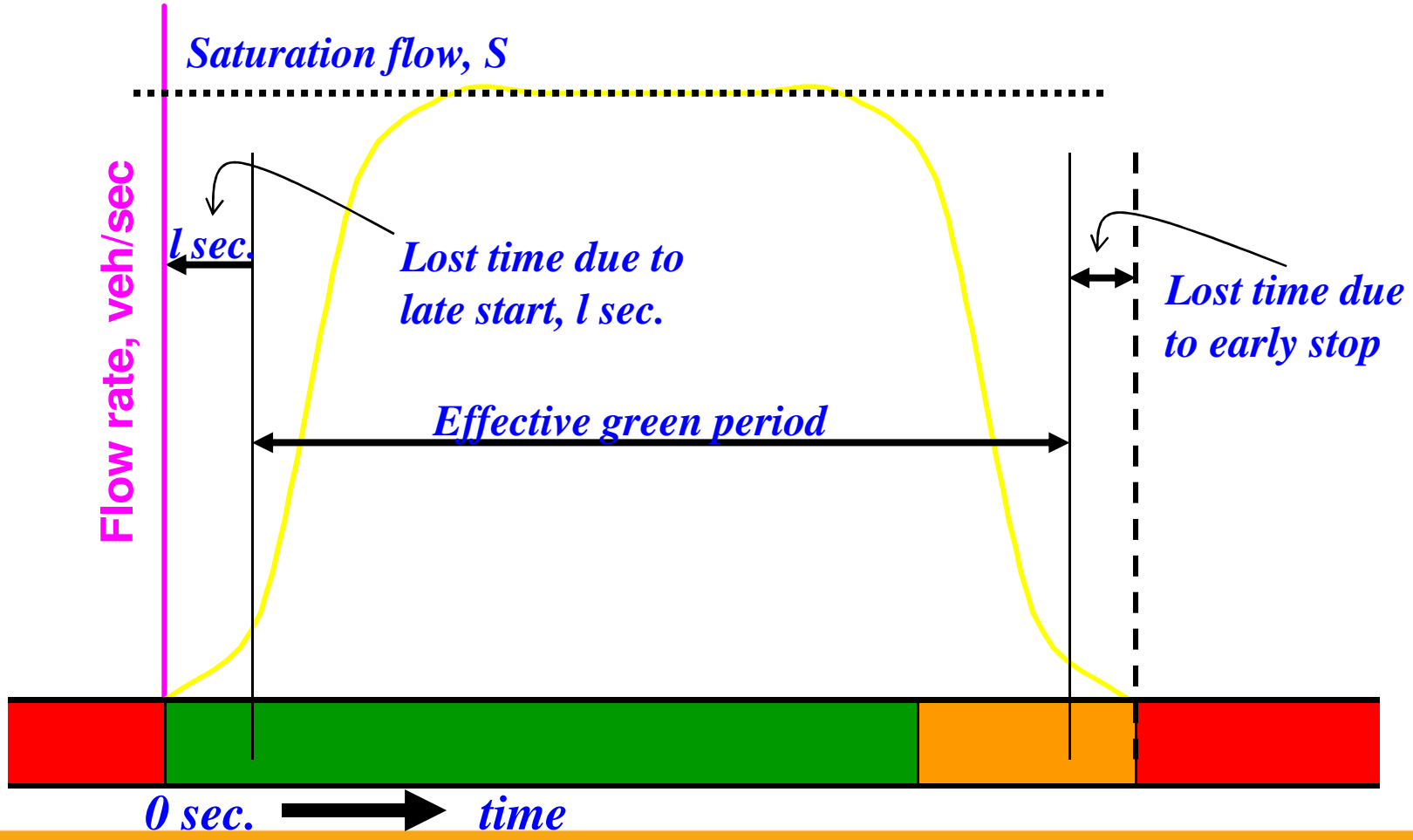
(c) Accidents involving right–turning vehicles

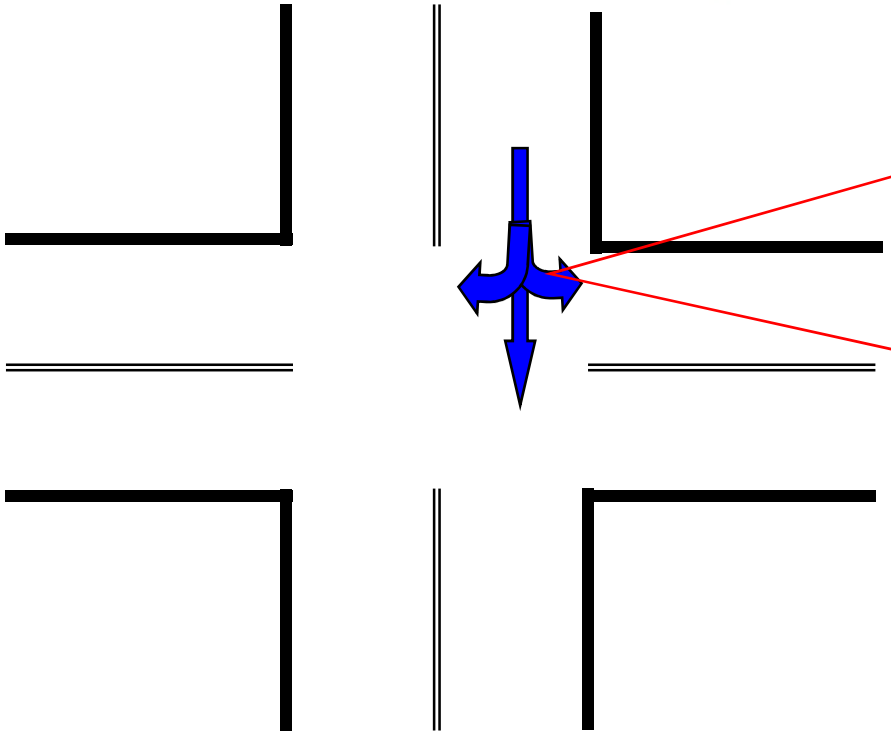
i. 4 or more accidents/year or 6 or more accidents for a period of 2 years on one particular approach; or

ii. 6 or more accidents/year or 10 or more accidents for a period of 2 years on both opposing approaches.

(2) SATURATION FLOW, S

Variation of vehicle flow rate passing the stopline during a green period





Q_N = OBSERVED OR EXPECTED TRAFFIC FLOW IN THE GIVEN MOVEMENTS, PCU/H

S_N = SATURATION FLOW FOR THE GIVEN MOVEMENT(S), PCU/H

W = WIDTH OF THE LANE FOR THE MOVEMENT(S), in METER

IF W ≥ 5.5 METER THEN: $S = 525*W$ PCU/H

IF W < 5.5 METER THEN: *REFER TABLE BELOW FOR S*

W	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25
S	1845	1860	1885	1915	1965	2075	2210	2375	2560	2760

* W in m, S in pcu/h

The actual saturation flow (S) of a particular movement is governed by several factors:

- Percentage of right–turning traffic (FR)
- Percentage of left–turning traffic (FL)
- Turning radius (FT)
- Gradient (FG)

Therefore, S must be corrected to take account of the effects:

(i) Saturation flow for mixed movements lane:

$$S' = S \times FR \times FL \times FG \quad pcu/h$$

(ii) Saturation flow for exclusive turning lane:

$$S' = S \times FT \times FG \quad pcu/h$$

FR, FL, FT, and FG can be obtained from the respective Tables given.

(3) OPTIMUM CYCLE TIME, CO

$$CO = \frac{1.5L + 5}{1 - Y} \quad \text{SECONDS}$$

WHERE:

$$L = \sum_{i=1}^{n}(I - a) + \sum_{i=1}^{n} l \qquad \text{and} \qquad Y = \sum_{i=1}^{n} y_i$$

L = TOTAL LOST TIME PER CYCLE, SECONDS

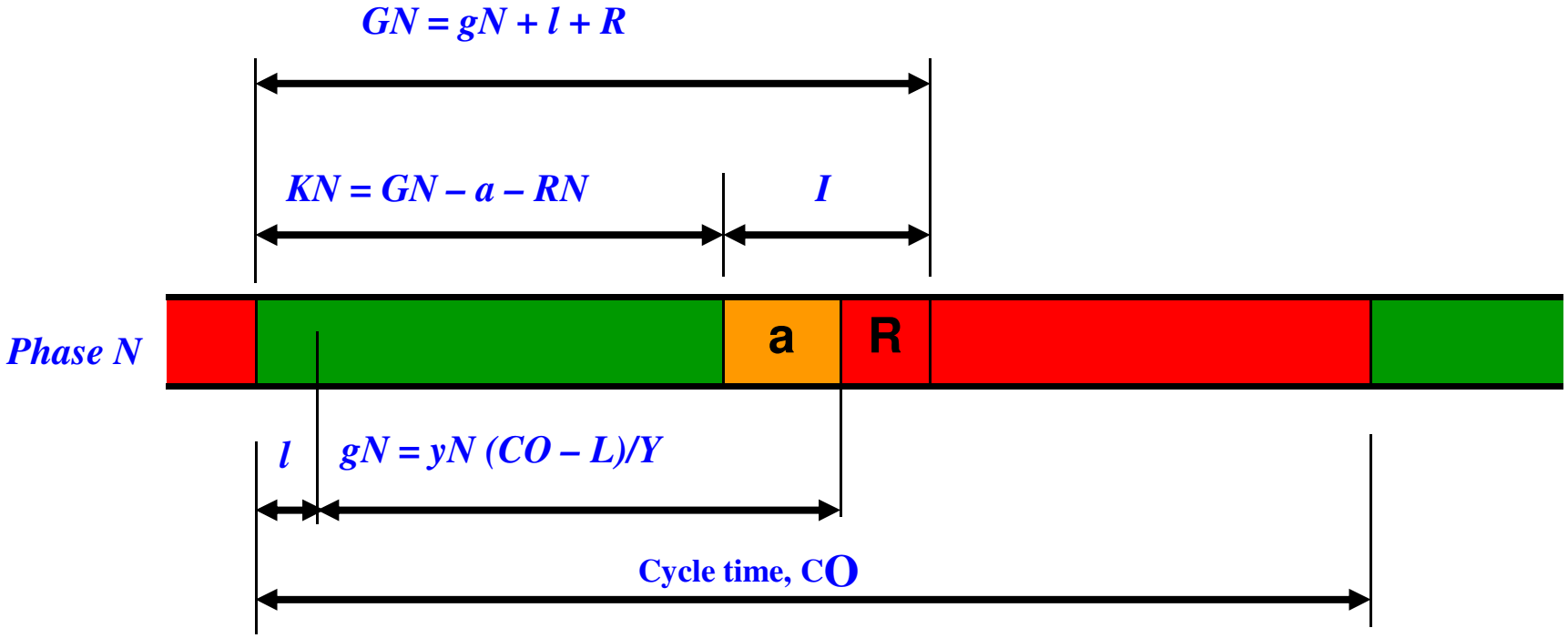
I = INTERGREEN PERIOD, SECONDS

a = AMBER PERIOD, SECONDS

l = LOST TIME DUE TO STARTING DELAY, USUALLY 2 SECONDS

yi = DEMAND/SATURATION FLOW RATIO = qi / Si

(4) TIMING SETTING



gN = effective green period for phase N

GN = actual green period for phase N

KN = controller setting green period or the displayed green period for phase N

l = lost time due starting delay

Design Steps

Step 1 - Identify Traffic Flow Volumes - including turning movements.

Step 2 - Identify Junction Layout, Lane Geometry and Site Characteristics
It may be necessary, if revealed in Step 4 or Step 7, to modify the layout to cater for turning movements, pedestrians or to enhance capacity and/or safety.

Step 3 - Identify Signal Phasing

Step 4 - Check Turning Movements and Pedestrians
Adequate provision for turning movements and pedestrians should be checked.

Step 5 - Estimate Saturation Flows
The saturation flows for various approaches/movements are identified.

Step 6 - Compute Y, L
The lost times, flow factors and sum of the critical flow factors are computed.

Step 7 - Compute Reserve Capacity
If this is not satisfactory, then it may be necessary to go back to Step 2, modify data and layouts and recalculate.

Step 8 - Compute Co, Cm, and Cp.

The optimum, minimum and practical cycle times for operating the junction are then computed for further analysis, if necessary.

Step 9 - Select C

It is then necessary to select a cycle time for operating the intersection.

Step 10 - Compute Green Times, Degree of Saturation

The green times of the various phases are then computed.
Degree of saturation may be computed as well if detailed analysis of signal operation is required.

Step 11 – Determination of Signal Setting

Calculate effective green and actual green for overall and each phase

Step 12 – Draw timing diagram

Check should confirm with C used.

Junction performance analysis

Based on capacity, delays and queue length of the junction

Determination of Capacity

1. Practical capacity, Yprac

   Ymax = 1-(L / Cm) (practically, Cm = 120s)

   Yprac =0.9 Ymax = 0.9-0.0075L

2. Reserve capacity, RC

   Diff between capac and actual flow (% of present flow)

   RC = (Y_p –Y)/Y * 100 (Y is the actual value at the junction)

3. Design life of Junction, n

   n= [log (Q_1/Q_0)/log (1 + GR)]

   n = # of years

   Q_1 = 90% of ultimate capacity

   Q_0 = present flow

   GR = growth rate

- Maximum capacity of each arm, Q = $g_i S/C_o$

Junction performance analysis

Determination of delays and queues

1. Average delay per vehicle

$$d = \frac{9}{10}\left[\frac{C(1-\lambda)^2}{2(1-\lambda x)} + \frac{x^2}{q(1-x)/1800}\right]$$

2. Average maximum queue at start of green

N = q x r

or

N = q(r/2 – d) whichever greater

N = # of vehicles

q = flow (veh/sec)

d = avg delay/veh for that arm

r = C-g = effective red (secs)

Level of Service for Signalized Intersection

- LOS based on delay/veh
- To ensure the intersection has the same LOS as the road system

LOS for signalized intersection

LOS	Stop delay for vehicle (sec)
A	< 5.0
B	5.1 – 15.0
C	15.1 – 25.0
D	25.1 – 40.0
E	40.1 – 60.0
F	> 60.0

Suggested minimum roadway LOS

Areas	Category of road	LOS
Rural	Expressway	C
	Highway	C
	Primary	D
	Secondary	D
	Minor	E
Urban	Expressway	C
	Arterial	D
	Collector	D
	Local	E

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