Traffic Signals







Traffic Signals

Is a physical device which replaces the priority regulation of junction operation and is used to control the traffic movement at intersection.

Introduction to Traffic Signals

History:

- 1st traffic signal was erected in Westminster in 1868 in London
- It exploded because gas was used for its illumination. The use of traffic signals stopped.
- In 1918 a traffic signal was installed in New York, manually operated.
- In 1925 manually operated signals were installed in London.
- In 1926 the first automatic traffic signals were installed in Britain.

Traffic Signals

Advantage

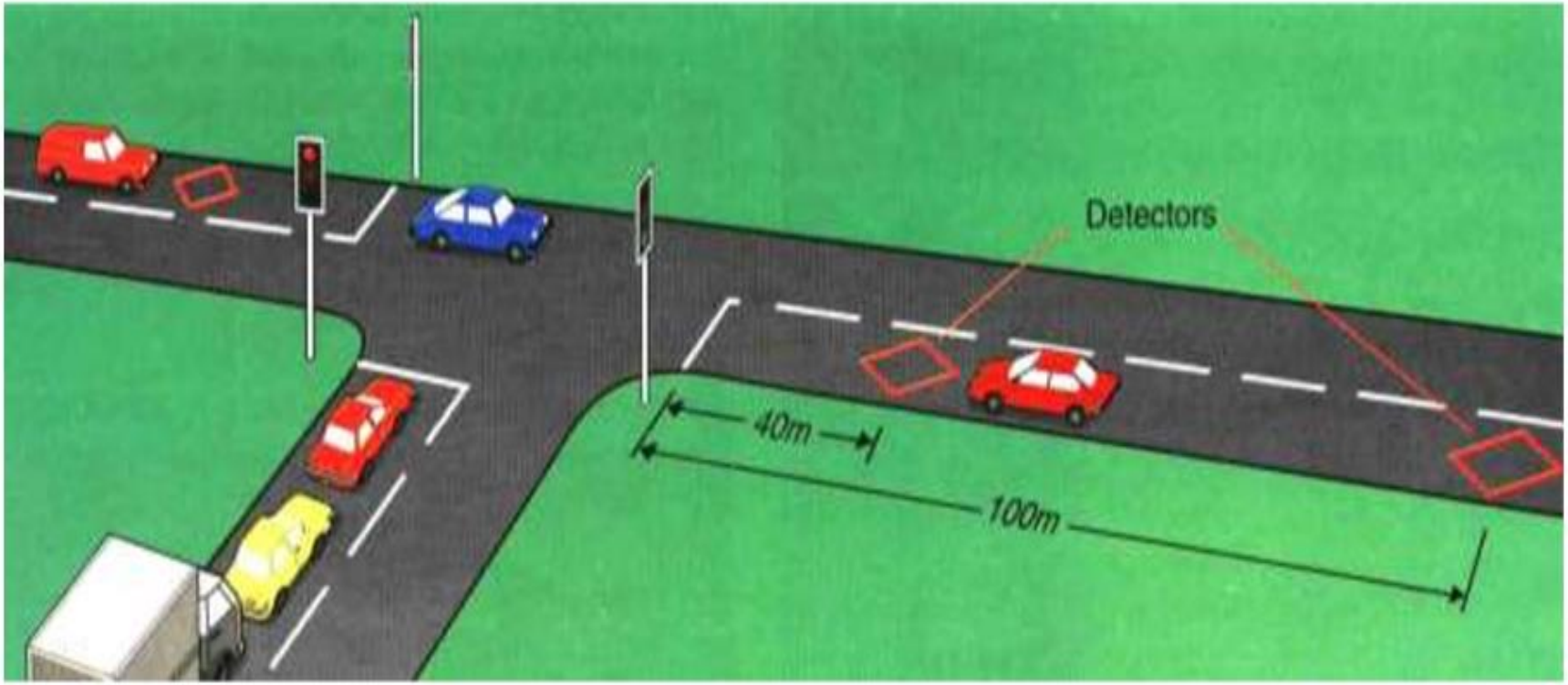
- Provide orderly movement of traffic
- Increase traffic handling capacity of the intersection
- Reduce frequency of accident
- Under favourable conditions, can coordinate continuous flow of traffic in priority direction
- Very effective in providing right-of-way to traffic from minor street in heavy traffic conditions

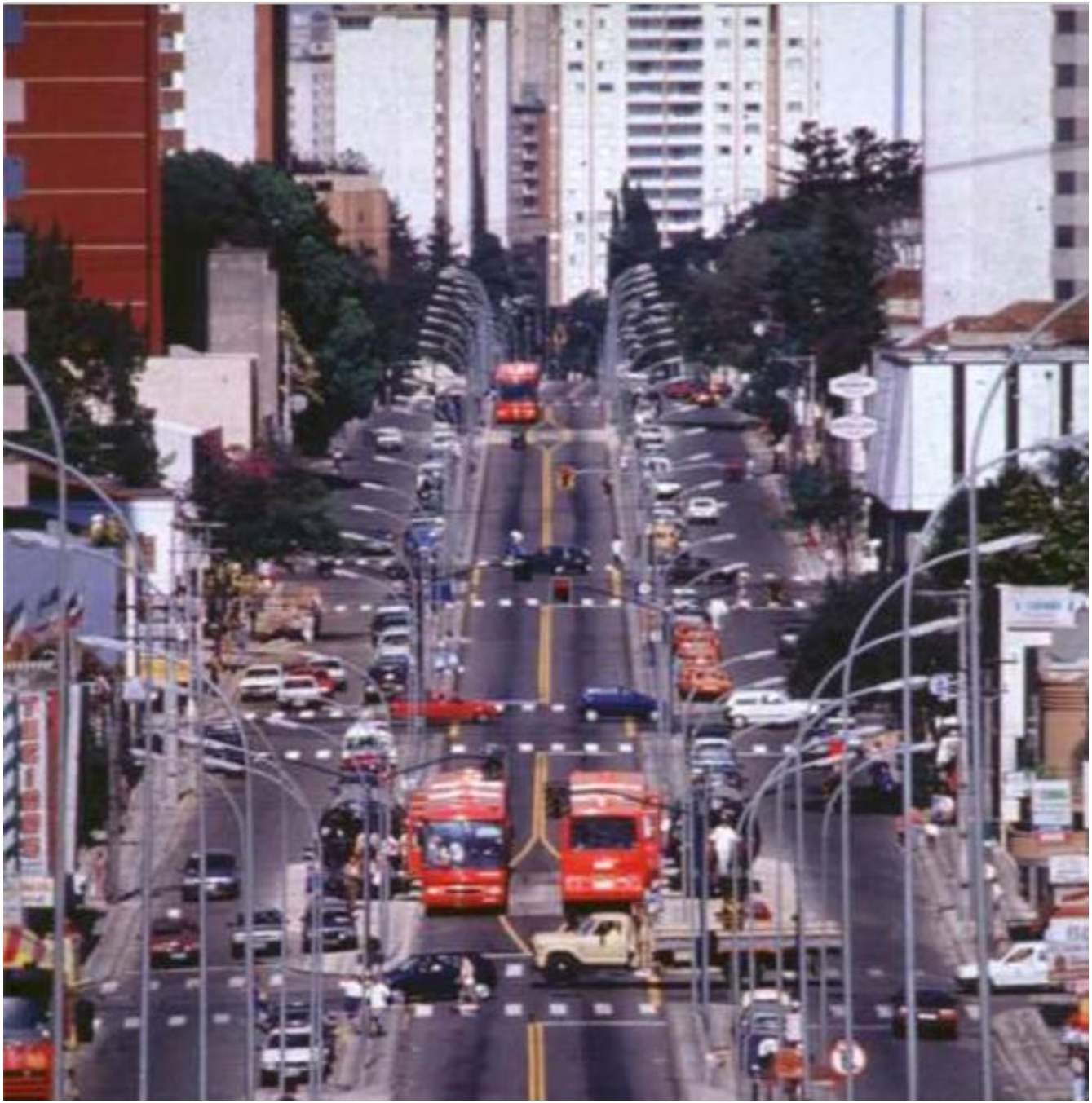
Disadvantage

- At off peak period signal with fixed time cause unnecessary delay and increase drivers irritation, promote disrespect
- Increase certain type of accident.

Types of Signal Controller

- **Fixed time controller (off-line system)**
  - Isolated con system- for a single intersection.
  - Linked/coordinated con system- for closely spaced junctions in a corridor.
- Vehicle Actuated Demand Responsive Controllers
- Modern Computer Based Area coordinated Controllers


Detectors
40m
100m



Warrants for the use of traffic signals

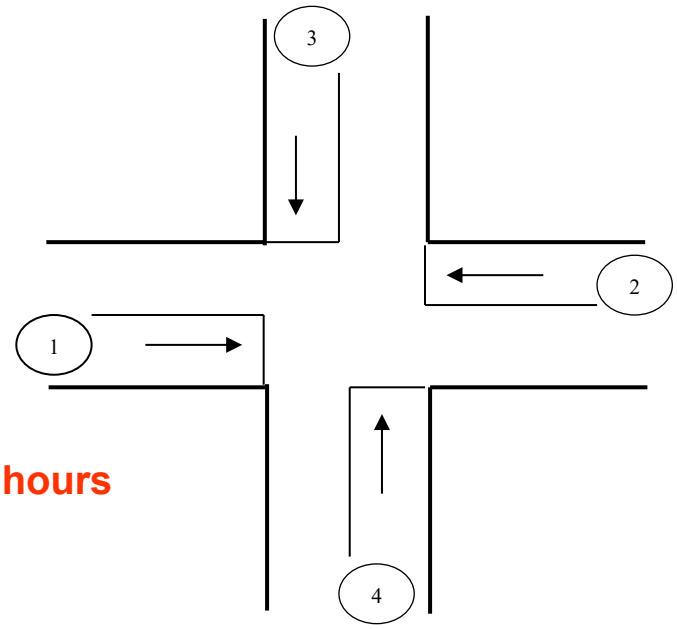
- A decision on the installation of traffic signals may be made on the basis of:
  - Traffic flow
  - Pedestrian safety
  - Accident experience
  - And the elimination of traffic conflict.

Warrants for the use of traffic signals

A Quick guide:

- For traffic flow:
  - Traffic signals are justified if the following traffic flow exists for **eight hours on an average day**.
  - Flow on the major road **(1+2) ≥ 900 vehicles/hour** and
  - Flow on the minor road

    (3) or (4) ≥ 100 vehicles/hour.



[The above figures are taken as the average of the 4 busiest hours over any weekday].

PEDESTRIANS: SIGNALS

COUNTDOWN SIGNALS

A pedestrian interval countdown display may be added to a pedestrian signal head in order to inform pedestrians of the number of seconds remaining to cross the street.





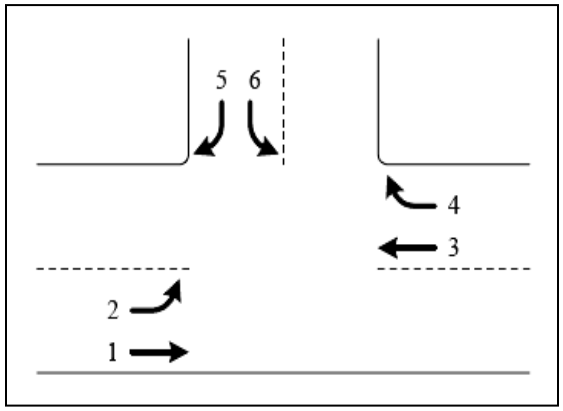


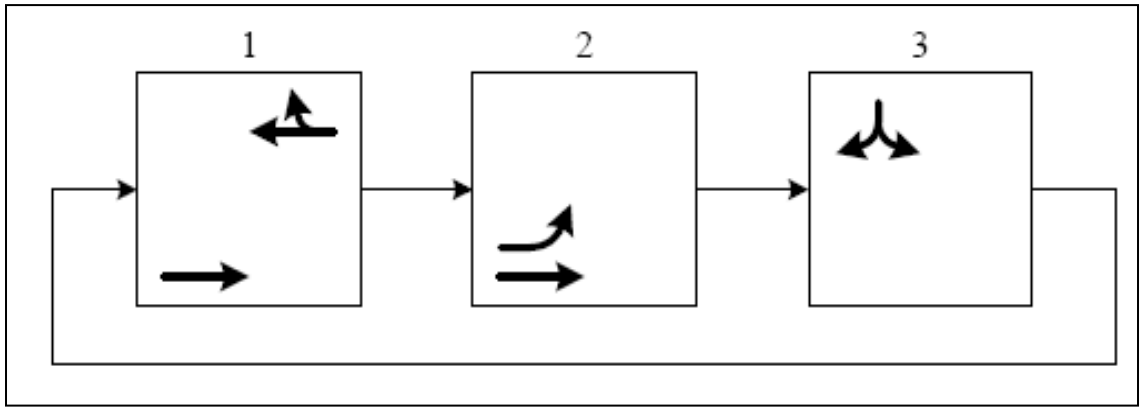
Phasing

Conflicts are prevented by a separation in time by a procedure called phasing.

- **Definition:**
  - A Phase is the sequence of conditions applied to one or more streams of traffic, which during the cycle receive simultaneous identical signal indications.
- **Examples**
  - **2-phase system**
  - 3-phase system
  - 4-phase system
  - The number of phases should be kept to a minimum in order to minimize delay.

Potential Phase Diagram





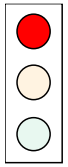
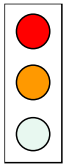
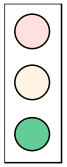
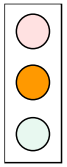
A potential phase diagram for this intersection is shown. In this example, the cycle is divided into three phases. Movements **1, 3, and 4** are active in **phase 1**; movements **1 and 2** are active in **phase 2**; and movements **5 and 6** are active in **phase 3**. Each phase represents a distinct time period within the cycle, and in operation the controller moves from one phase to another in the specified order. The timing for the signal is defined by specifying the phase *"splits,"* which are the percentages of the cycle length allocated to each phase. This split time is further divided among the intervals of each phase, resulting in a specified duration for every interval in every phase.

Signal aspects

- The **indication** given by a signal is known as the signal aspect.
- The usual **sequence** of signal aspects or indications is **the UK** is (USA…):
  - **Red**
  - Red/Amber
  - **Green** and
  - **Amber**

Signal aspects

Meaning of traffic signal indications

Color	Red	Red-Amber	Green	Amber
Signal indication				
Meaning	Stop & keep stopping	Prepare to go but do not move	Go	Clear the intersection but do not cross the stop line
Duration (s)		2		3

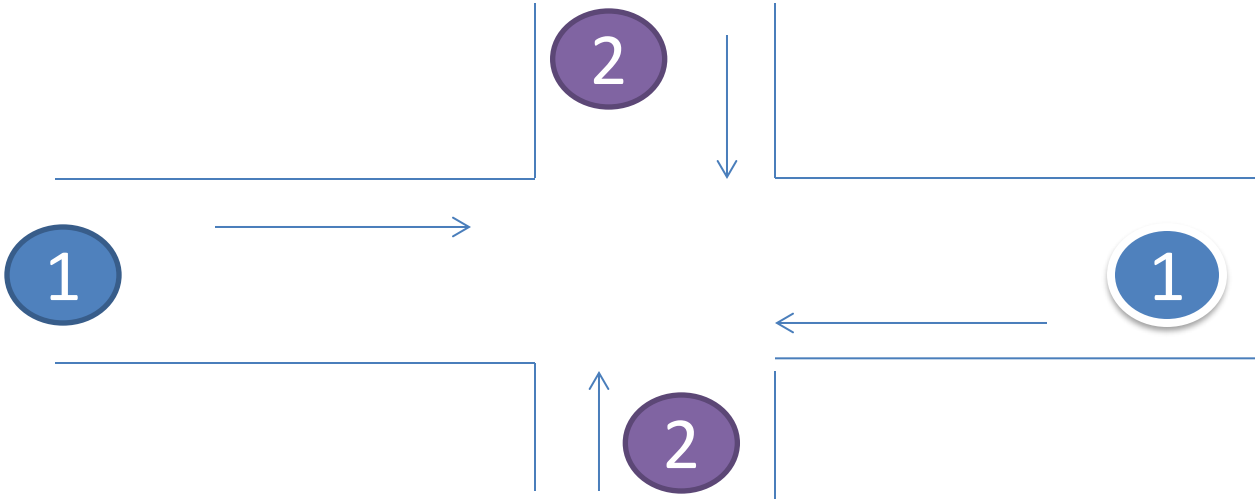
Signal aspects (Amber period)

The amber period is given a standard duration of **3 seconds** (High speed junc 3-6 sec) and the red/amber 2 seconds.

Inter-green period

- The period between one phase losing right of way and the next phase gaining right of way is known as the inter-green period. In other words it is the **period between the termination of green on one phase and the commencement of green on the next phase**
- Examples of inter-green periods at a two-phase traffic signal as shown below.

A Two Phase Signal/ Example Of Inter-Green Period [UK]

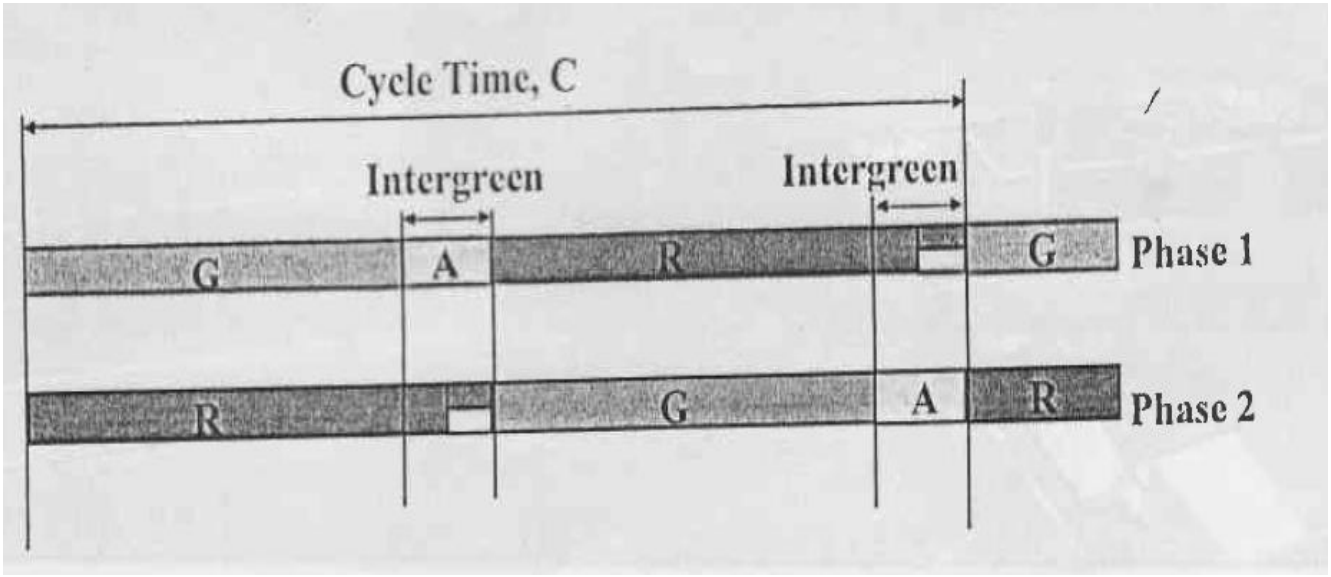


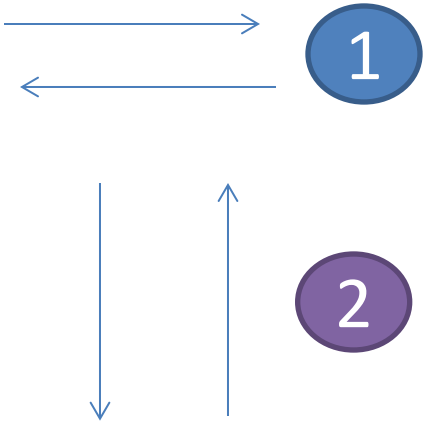
RED

RED-AMBER

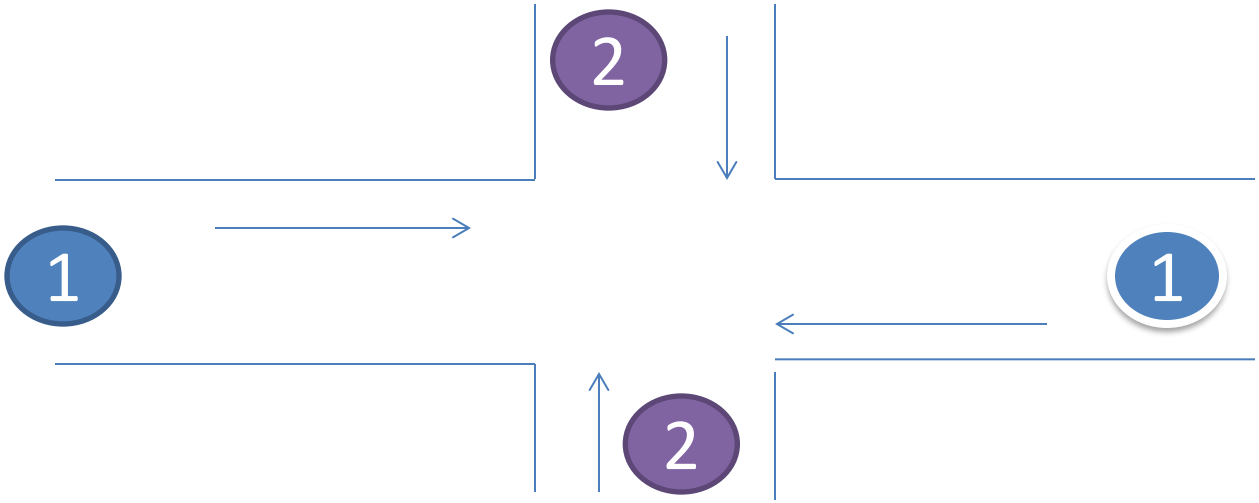
GREEN

AMBER





A Two Phase Signal/ Example Of All-Red Period [UK]

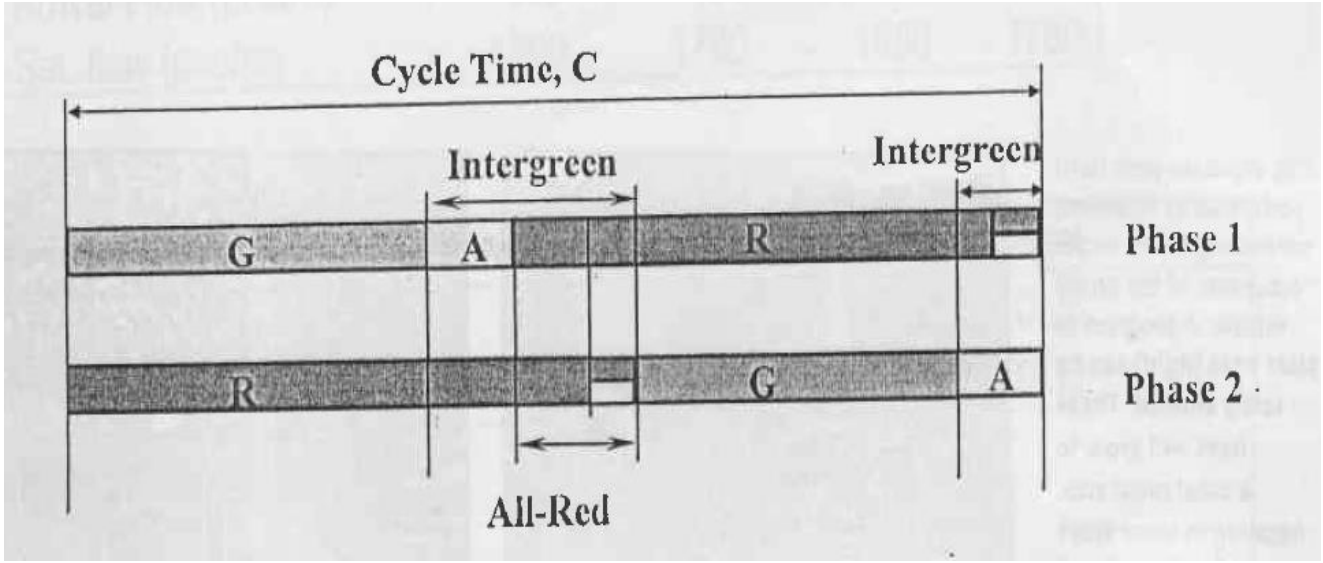


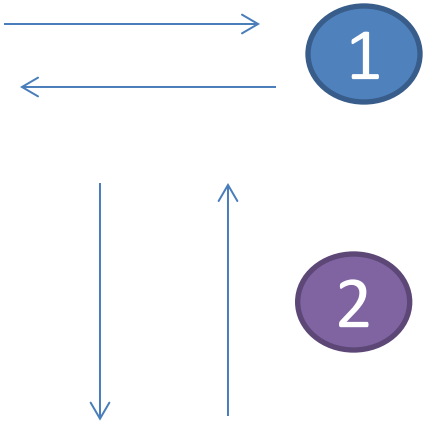
RED

RED-AMBER

GREEN

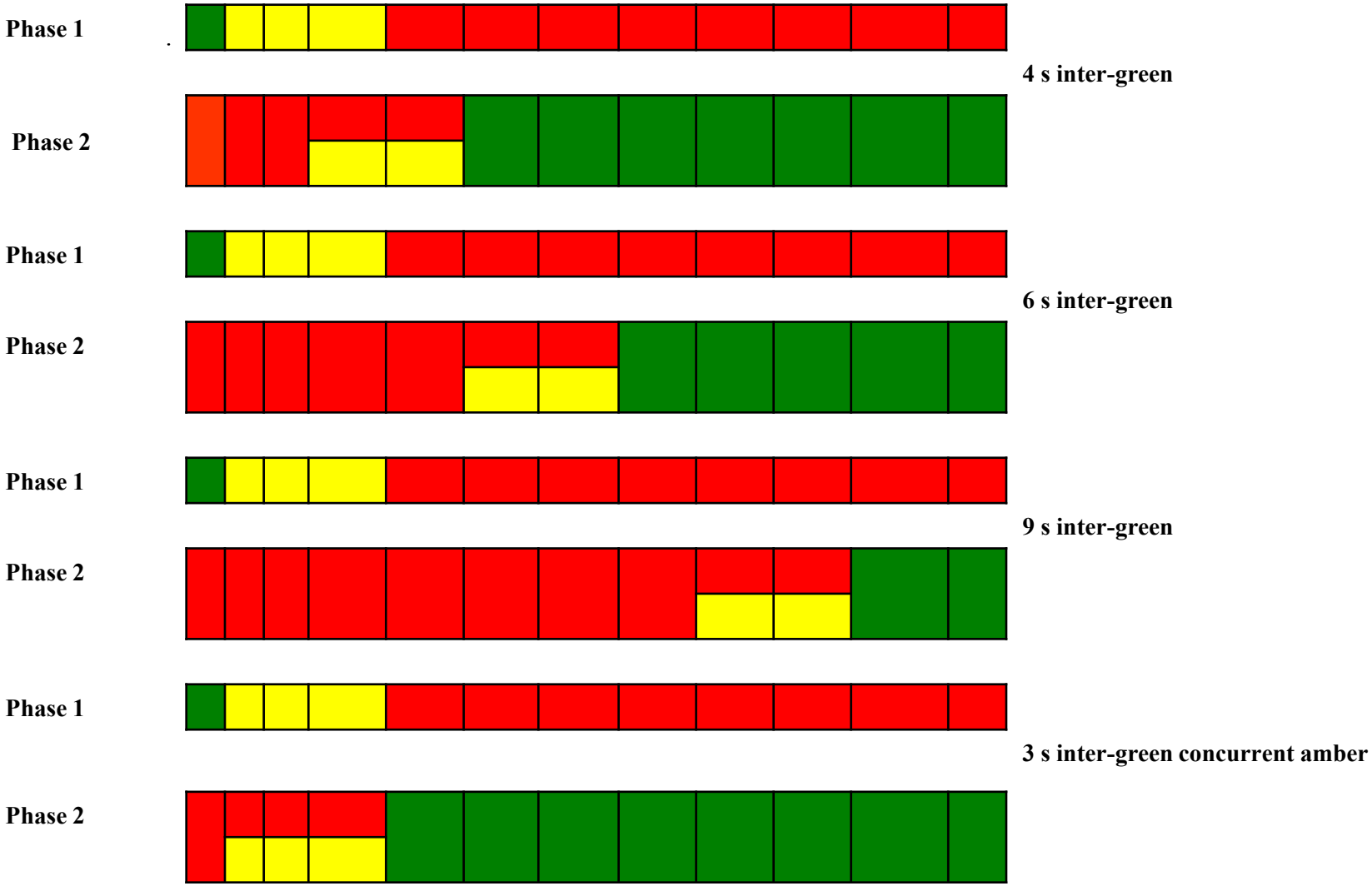
AMBER





Inter-green period

Salter p274



Minimum inter-green period = 4 s

Inter-green period

The Department of Transport in the UK recommends an inter-green period between **5 to 12 s for a distance of 9 to 74m** for straight ahead movements.

–Signals are located on **higher speed** roads; in this case a **longer inter-green period** provides a margin of safety for vehicles which are unable to stop on the termination of green.

Saturation flow: It is the maximum flow, expressed **in pcu's**, that can be discharged from a traffic lane when there is a continuous green indication and a continuous queue on the approach.

The saturation flow is independent of traffic and control factors.

PCU in Bangladesh

Vehicle Categories	PCU
Passenger Car	1.00
Light Good Vehicle	1.00
Truck	3.00
Bus	3.00
Auto-rickshaw/Motorcycle	0.75
Rickshaw/Van	2.00
Bicycle	0.50

Effective Green time (g)

Defn : The time during the cycle when the traffic flows freely, discharge through the green aspect at the maximum rate; it is the **sum** of green period and amber period less the lost time for the particular phase

Effective Green Time

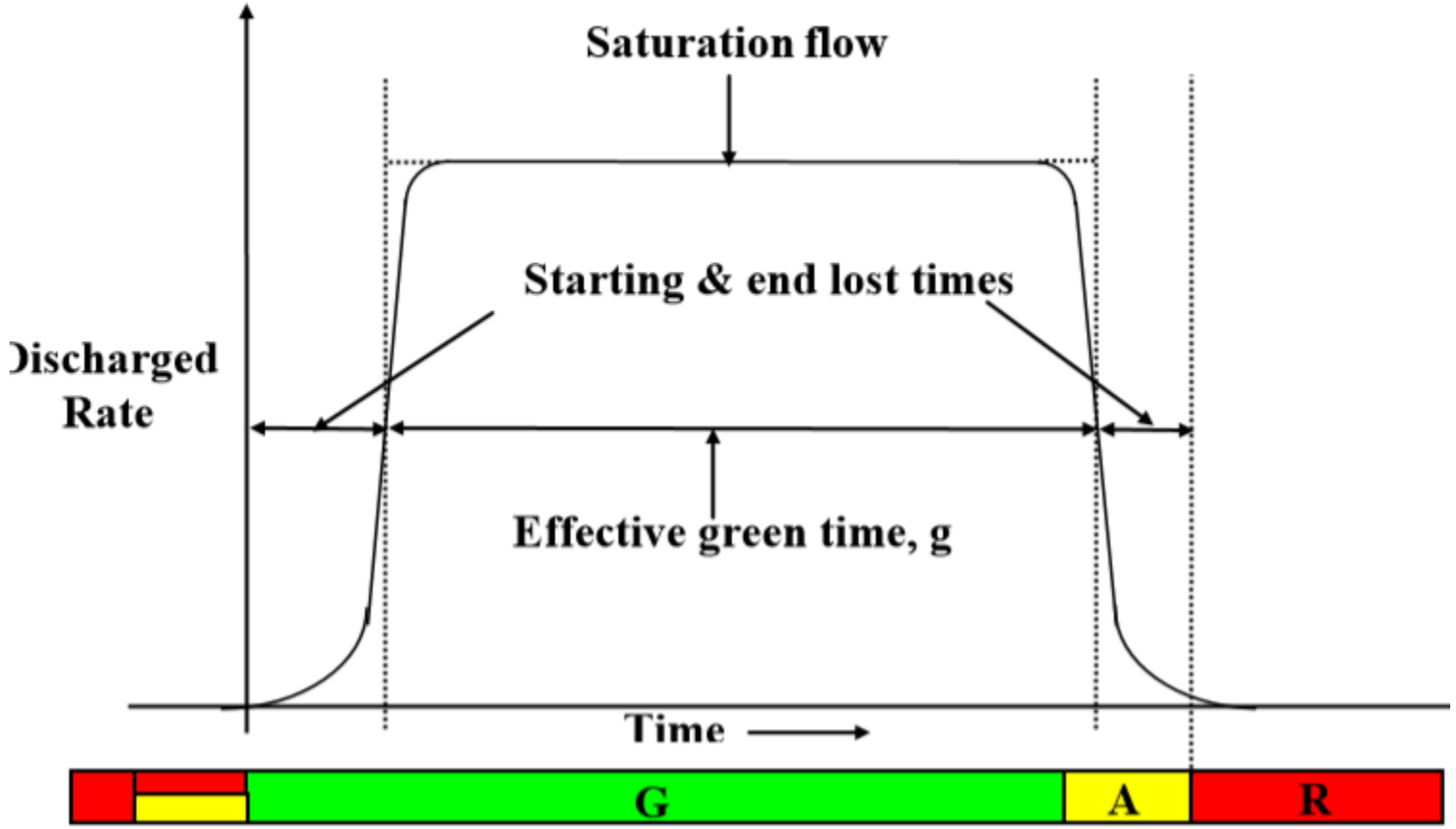


Illustration of saturation flow and lost times at traffic signals

Lost Time (L)

Definition (l): The time which is effectively lost to traffic movement in a phase because of starting delays and falling off discharge rate during amber period

- **Lost time due to change of phases:**

  It is the time when all vehicle movement is prohibited.

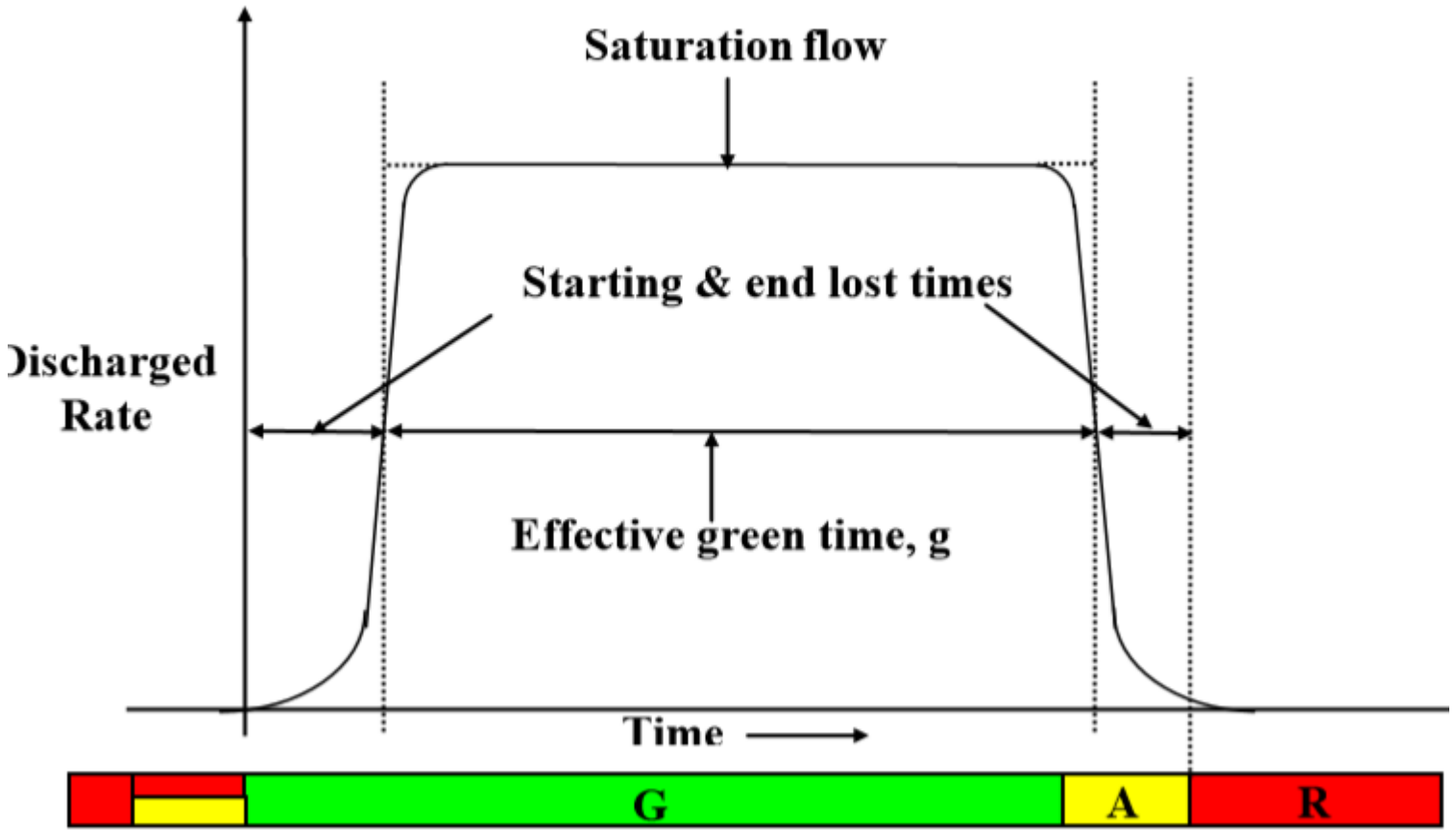
  Lost time due to **change of phases** =Inter-green period - 3 s (amber time)

  Thus, this lost time increases as the inter-green period increases.

Lost Time

- **Types of Lost time**
  - **Starting lost time:** the time interval between the commencement of green and the commencement of effective green.
  - **End lost time**: the time interval between the termination of effective green and the termination of the amber period.

Lost Time


Saturation flow
Starting & end lost times
Discharged Rate
Effective green time, g
Time
G
A
R

Lost Time

- **In practice:**
  - lost time per phase = starting lost time + end lost time
    ≈ 2 seconds
    Amber time = 3 seconds

Actual green time + amber period = Effective green time + lost time

Effective green time = Actual green time + amber time - lost time

Effective green time = Actual green time + 3 s. - 2s.

Traffic Cycle and Optimum Cycle Time (O.C.T, C_o)

A "traffic cycle" refers to the complete sequence of light changes at a traffic intersection, from the moment a light turns **green for one direction** to when it **turns green again** for that same direction,

"cycle length" is the **total time** it takes for this complete sequence to occur, essentially how long it takes for a traffic light to go through one full cycle of color changes.

C_o Definition: The cycle time which gives the **least average delay to all vehs** using the intersection.

The **O.C.T.** depends on traffic conditions.

The cycle time is longer when the intersection is heavily trafficked

- **Degree of trafficking**
  - The degree of trafficking of an approach (y)

$$y = \frac{\text{The flow on the approach}}{\text{Saturation flow of the approach}}$$

Cycle time and delay

The duration of the cycle time affects delay to vehicles passing through the intersection.

- If cycle time is too short:

  The proportion of lost time in the cycle time is high making the signal control inefficient and causing lengthy delays.

- If cycle time is too long then:

  Waiting vehicles will clear the stop line during the early part of the green period

Cycle time and delay

Minimum cycle time = 25s. for safety considerations

Maximum cycle time = 120s. to minimize delay and driver frustration

How to determine the optimum cycle time (Co)?

The Road Research Technical Paper 39 showed that the optimum cycle time (Co) can be determined by an empirical equation at a sufficient degree of approximation.

$$C_o = \frac{1.5\,L + 5}{1 - Y} \text{ seconds}$$

Where:

L is the total lost time per cycle.

Y is the sum of the maximum *y* value for all phases comprising the cycle as explained above.

Terminology

- ***Signal sequence*** – Green -> Amber -> Red -> Red/Amber
- ***Phase*** - That part of a cycle allocated to a stream or combination of two or more streams having the right of way simultaneously.
- ***Filter signals*** - it is mounted alongside the main signals to permit movement of vehicles in the direction shown by the green arrow even though the main signal is showing red.
- ***Amber period/Clearance time (a)*** - to allow vehicles to clear the junction. Usually 3 secs; ù high speeds junction 3-6 secs.
- ***Inter-green period (I)*** - the time from the end of the green period to the phase losing right-of-way to the beginning of the green period of the phase gaining right-of-way.
- ***Optimum cycle length (C_o)*** - the cycle time which gives the least average delay to all vehicles using the intersection
- ***Lost time (l)*** - the time which is effectively lost to traffic movement in a phase because of starting delays and the falling-off discharge rate during the amber period.
- ***Effective green time (g)*** - the time during the cycle when traffic flows freely discharge through the green aspect at the maximum rate; it is the sum of the green period and the amber period less the lost time for the particular phase
- ***All-red period*** - a red period between the amber and red/amber shown to all approaches in order to allow vehicles to clear the junction safely before starting of the next phase: it is usually needed:
  - when junction is large
  - when there are slow moving vehicles in the traffic stream
  - when there are right turning vehicles left over at the end of the phase
  - when pedestrian movements are high in all directions and demand "*pedestrian only*" phase
- ***Saturation flow (S)*** - the maximum rate of discharge for a particular approach.

Important Relationships

- Cycle time, $C = \int (s, q, L)$; where, s = saturation flow/capacity; q = arrival flow/demand; L = lost times
- Intergreen, $I = a + \text{all-red}$
- Cycle time, $C = \sum G + \sum I$
- green period, $G = g + L_I + L_F$; where, g = Effective green; L_I, L_F = initial and final lost time
- Total lost time/cycle, $L = \sum \text{all-red} + \sum \text{lost time}$

  $= \sum (I-a) + \sum (L_I + L_F)$
- Right-of-way $= G + A = g + \text{lost time}$
- Maximum/dominant ratio of flow (q) to saturation flow (s) for a given phase of critical lane, $y = q/s$
- Optimum cycle, $C_o = (1.5\,L + 5)/(1-Y)$ in seconds; where, $Y = y_1 + y_2 \ldots . y_n$; n = total no. of phase in cycle
- For optimum conditions,

  Green time split: $g_1/g_2 = y_1/y_2 = (C_o - L)/Y$

Local Problems

- No standard for Signal setting and design
- Set at far away from intersection and encourage drivers to stop beyond the Signal mast.
- Signals are installed even where they are not warranted
- Signal light size (lens dia) and lamination inadequate
- Cycle time and phasing are judgment base; amber clearance phases are short and inadequate for safe rickshow clearance.
- Driver watch policeman rather than the signal
- Un-enforced signals discourages drivers complaisance in general

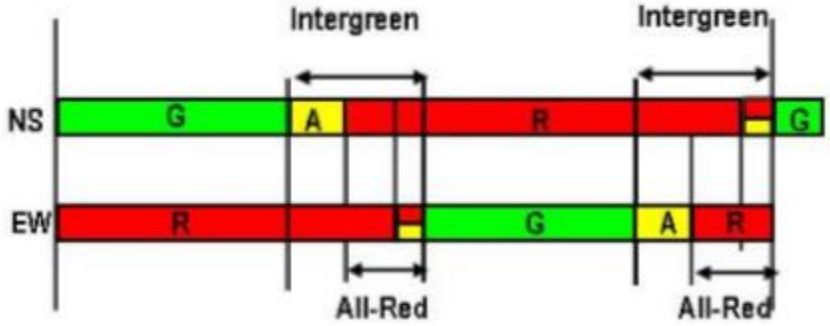
Problem 1:

Design a two-phase signal of an isolated cross-junction for the following data:

Amber (a) in sec	3
Red-Amber in sec	2

	N-S	E-W
Inter green, (i) in sec	6	7
Lost time, (l) in sec	3	2

	North	South	East	West
Arrival Flow (pcu/hr)	400	450	560	458
Sat. flow (pcu/hr)	1800	1780	1850	1780



Solution

	North	South	East	West
y = flow/sat.flow =	0.22	0.25	0.30	0.26
$y_{dominating}$ =		0.25		0.30
$Y = y_{NS} + y_{EW}$ =	0.56			

L = all red + green-ends lost times = sum(i-a)+sum(l)

= 3 + 4 + 3 + 2 = 12 sec

Optimum cycle time, Co = [1.5 L + 5]/[1-Y] = [1.5 * 12 + 5]/[1 - 0.56]

= 53 sec

Total effective green time, Co - L = 53 - 12 = 41 sec

Effective green for NS arm, $g_{NS} = y_{NS}*(Co - L)/Y$ = 19 sec

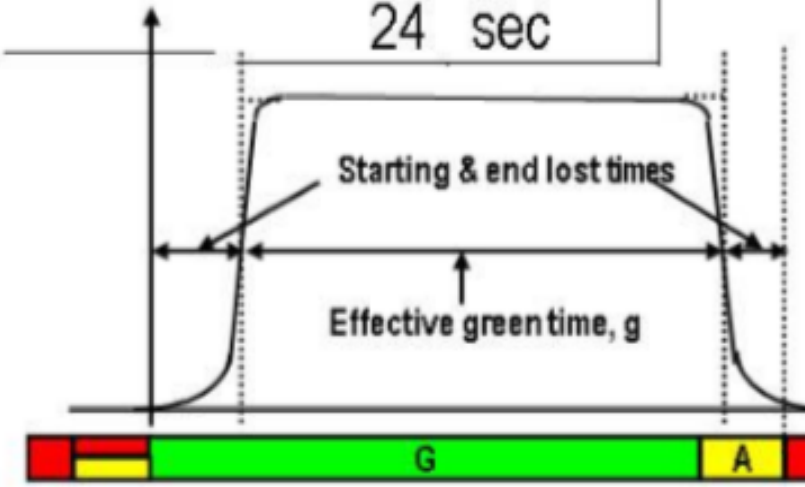
Effective green for EW arm, $g_{EW} = y_{EW}*(Co - L)/Y$ = 22 sec

Green + Amber period for NS arm = g_{NS} + I = 22 sec

Green + Amber period for EW arm = g_{EW} + I

= 24 sec

G_{NS} =	19	s
Inter-green, NS =	6	s
G_{EW} =	21	s
Inter-green, EW =	7	s
Cycle time, C_o =	53	s



Problem 2:

Design a two-phase signal of an isolated cross-junction for the

Amber (a) in sec	3
Red-Amber in sec	2

	N-S	E-W
Inter green, (i) in sec	9	6
Lost time, (l) in sec	3	2

	North	South	East	West
Arrival Flow (pcu/hr)	550	650	900	800
Sat. flow (pcu/hr)	2200	2300	2800	3000

Solution

	North	South	East	West
y = flow/sat.flow =	0.25	0.28	0.32	0.27
$y_{dominating}$ =		0.28		0.32
$Y = y_{NS} + y_{EW}$ =	0.60			

L = all red + green-ends lost times = sum(i-a)+sum(l)

= 6 + 3 + 3 + 2 = 14 sec

Optimum cycle time, Co = [1.5 L + 5]/[1-Y] = [1.5 * 14 + 5]/[1 - 0.6]

= 66 sec

Total effective green time, Co - L = 66 - 14 = 52 sec

Effective green for NS arm, $g_{NS} = y_{NS}*(Co - L)/Y$ = 24 sec

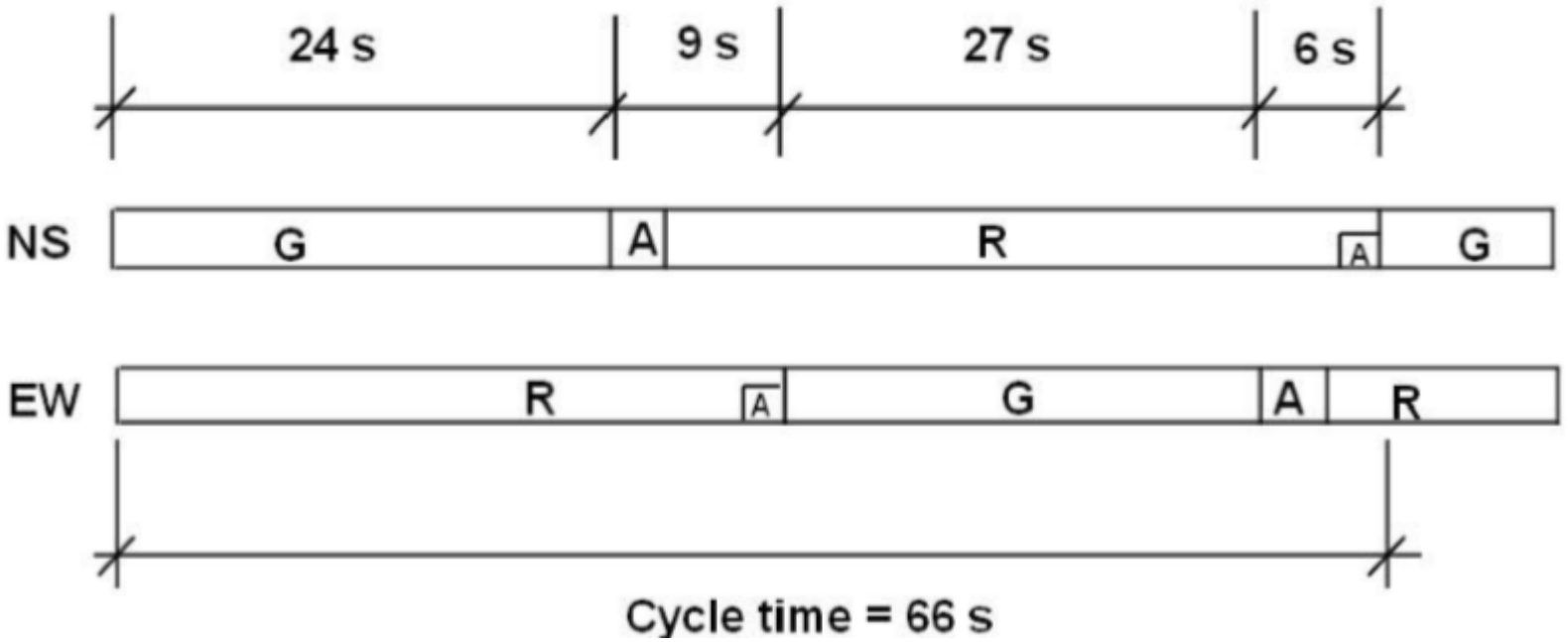
Effective green for EW arm, $g_{EW} = y_{EW}*(Co - L)/Y$ = 28 sec

Green + Amber period for NS arm = g_{NS} + I = 27 sec

Green + Amber period for EW arm = g_{EW} + I = 30 sec

G_{NS} =	24	s
Inter-green, NS =	9	s
G_{EW} =	27	s
Inter-green, EW =	6	s
Cycle time, C_o =	66	s

Bar Diagram: Problem 2



Cycle time = 66 s

Any Question