Lecture on Traffic Signals

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

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.

Warrants for the Use of Traffic Signals

The Manual on Uniform Traffic Control Devices (MUTCD) lists several sets of conditions that warrant the installation of a traffic signal:

- Traffic volume on intersecting streets exceeds values specified in the MUTCD.
- The traffic volume on the major street is so heavy that traffic on the minor intersecting street suffers excessive delay or hazard in entering or crossing the major street.
- Vehicular volumes on a major street and pedestrian volumes crossing that street exceed specified levels.
- Inadequate gaps
- Peak hour
- School crossing
- Coordinated signal system
- Crash experience

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) $\geq$ 900 vehicles/hour and
  - Flow on the minor road (3) or (4) $\geq$ 100 vehicles/hour.

Types of Signal Controller

- **Fixed time controller (off-line system)**
  - With fixed-time signals the green periods, and hence the cycle times, are predetermined and of fixed deration.
  - The controllers are simple and relatively cheaper but they are necessarily inflexible and require careful setting.

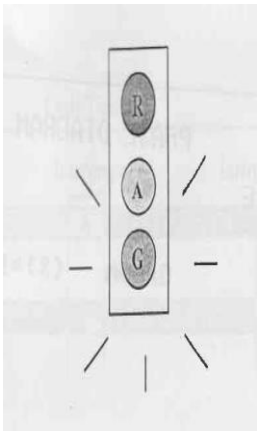
- The controllers can accommodate more than one signal plan to make it more demand responsive.
- **Can be used as:**
  - Isolated con system- for a single intersection.
  - Linked/coordinated con system- for closely spaced junctions in a corridor.

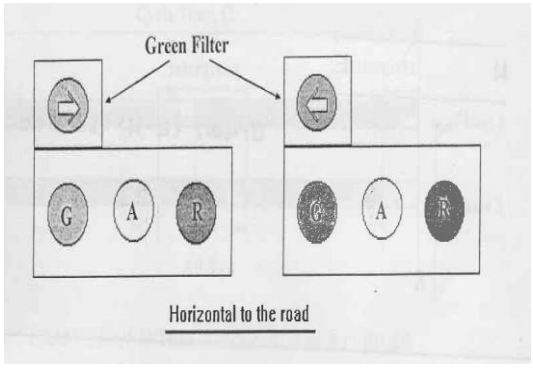
Linked/coordinated con system- for closely spaced junctions in a corridor.

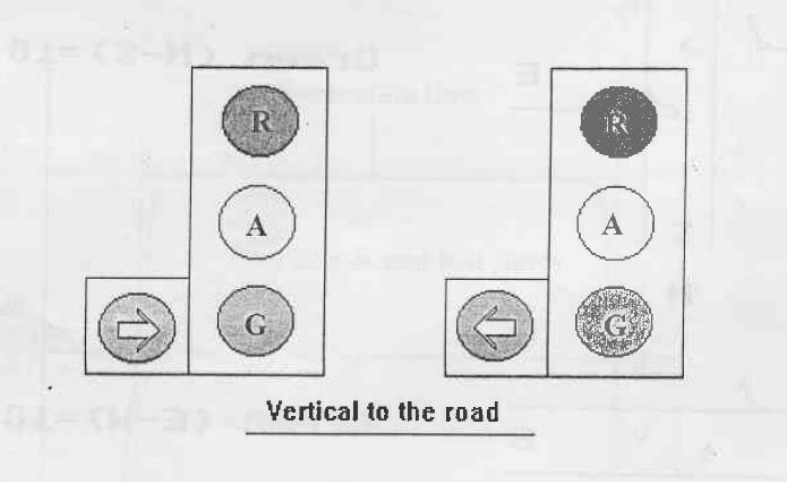
- **Simultaneous**- All the signals along the controlled section display the same aspect of signal to the same traffic stream at the same time. This type of system encourages speeding as some drivers try to pass as many intersections as possible before the signal changes.
- **Progressive**- The cycle time for each intersection in the system is common but the green periods are staggered in relation to each other according to the distance between intersections and the desired road speed. This system is suitable for streets where distances between intersections are almost equal.

- **Vehicle Actuated Demand Responsive Controllers [Online/ real time system]**
  - With this the green times are related to the traffic demands and provision is there to omit a particular phase if there is no traffic.
  - Need to install detectors on all approaches.
  - Delay is minimized globally.
  - Used as isolated and as well as coordinated system
- **Modern Computer Based Area coordinated Controllers**
  - Area Traffic Control (ATC) System- With this system green time calculation is made instantly based on prefixed delay algorithm.
  - Adaptive/ Self Optimizing Traffic Control System- with this system green time calculation is made beforehand using smart prediction model. It uses Artificial Intelligence (AI) to acquire knowledge and to refine existing prediction model.

PLACEMENT OF SIGNALS PROPOSED BY BRTA







Pedestrians: Signals (In-Roadway Warning Lights)

In-Roadway Warning Lights are special flashing lights installed on the roadway surface to enhance driver awareness at uncontrolled pedestrian crossings. This includes, but is not limited to, school crosswalks, mid-block crosswalks, and crosswalks at uncontrolled intersection approaches.

Warrants for the use of traffic signals

For Pedestrian safety:

The Department of Transport in the UK advises that a pedestrian stage is required:

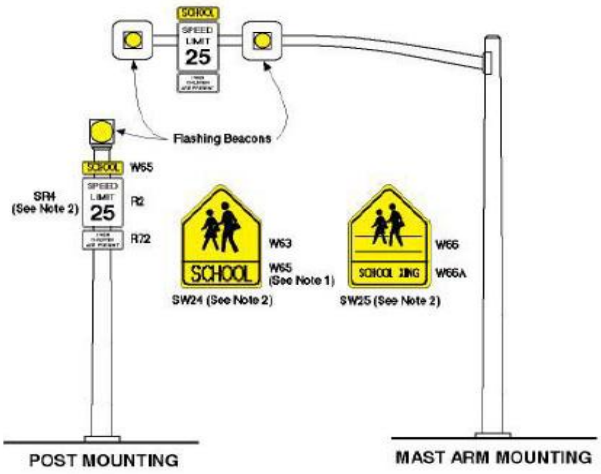
- If pedestrians across any arm of the junction is $\geq$ 300 ped./hour
- or if turning traffic flow into any arm has an average headway of < 5 seconds and conflicting with a pedestrian flow of $\geq$ 50 pedestrian/hour

PEDESTRIANS: SIGNALS (FLASHING YELLOW BEACONS)

Flashing yellow beacons may be installed to supplement standard school signing and markings for the purpose of providing advance warning during specified times of operation when justified.

A flashing yellow beacon may be justified when ALL of the following conditions are fulfilled:

1. The uncontrolled school crossing is on the Suggested Route to School"; and
2. At least **40 school pedestrians use the crossing during each of any two hours** (not necessarily consecutive) of a normal school day; and
3. The crossing is **at least 180 m** from the nearest alternate crossing controlled by traffic signals, stop signs or crossing guards; and
4. The vehicular volume through the crossing **exceeds 200 vehicles per hour in urban areas** or **140 vehicles per hour in rural areas** during the same hours the students are going to and from school during normal school hours; and
5. The critical **approach speed (85 percentile) exceeds 35 mph (56 km/h)** or the approach visibility is less than the stopping sight distance.



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.

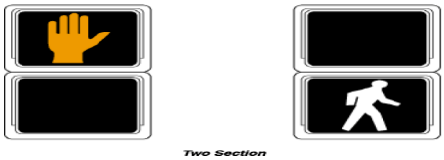




PEDESTRIANS: SIGNALS [SIGNAL FACES]







PEDESTRIANS: SIGNALS [SIGNAL TIMING]

MUTCD standard identifies a “normal” walking speed as 1.22 m/s (4 ft/s). However, researchers have found that older pedestrians cross more slowly than younger pedestrians, approximately 2.8 ft/s, and within both age groups, women walk more slowly than men. The same relationships are found in start-up times.

Isolated Traffic Signal Design Terms:

- Sequence- Green>Amber>Red>Red/Amber
- Phase
- Filter signals
- Amber pd/clearance time (a)
- Inter green pd (i)
- Optimum cycle length (C_0)
- Lost time (L)
- Effective green time (g)
- All red pd
- Saturaion flow (S)

Phasing

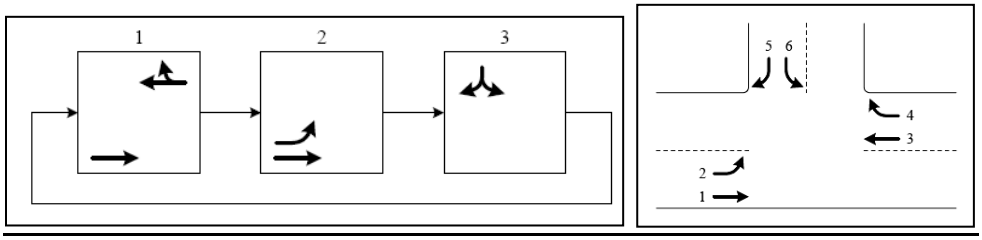
Conflicts are prevented by a separation in time by a procedure called phasing.

- **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.

Signal aspects

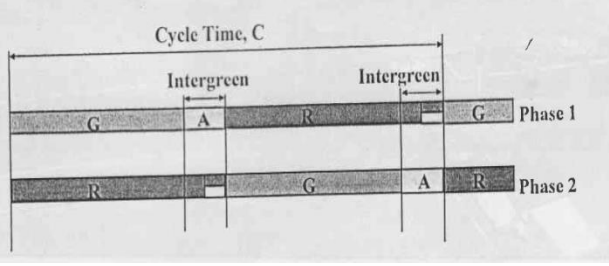
- The indication given by a signal is known as the signal aspect.
- The usual **sequence** of signal aspects or indications is the UK is:
  - Red
  - Red/Amber
  - Green and
  - Amber

Potential Phase Diagram

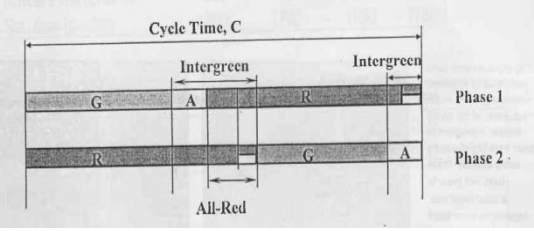


A potential phase diagram for this intersection is shown. In this example, the cycle is divided into three phases. Movements 1, 3, and 4 are active in phase 1; movements 1 and 2 are active in phase 2; and movements 5 and 6 are active in phase 3. Each phase represents a distinct time period within the 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.

A Two Phase Signal/ Example Of Inter-Green Period



A Two Phase Signal/ Example Of All-Red Period

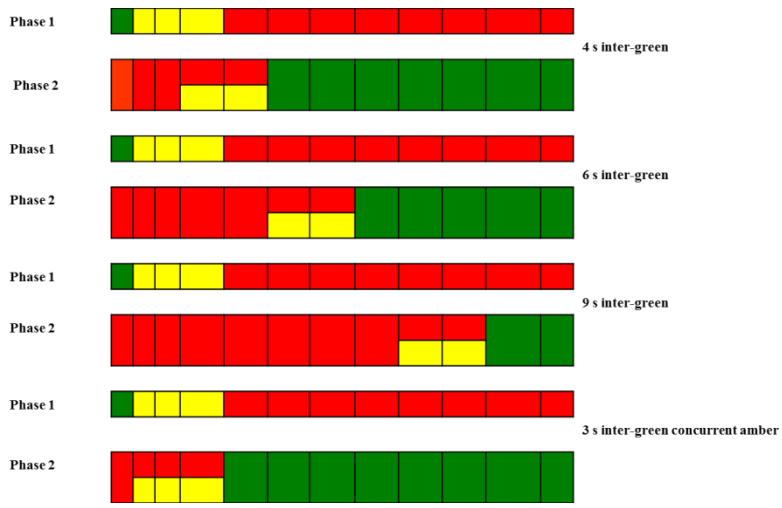


Signal aspects

The amber period is given a standard duration of 3 seconds 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



- 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.

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.

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.

Determination of the effective green time.

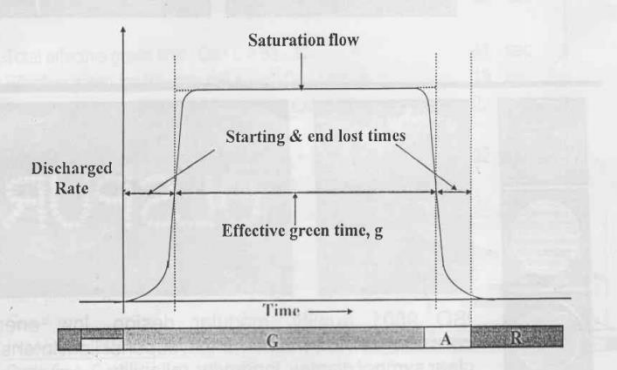
- The number of vehicles crossing the stop line depends on:
  - Traffic composition
  - Saturation flow
  - The effective green time.
- Definitions:
  - Effective green time is the time during which the signal is effectively green.
  - A cycle is a complete sequence of signal indications, green, red and amber.
- The concept of effective green time was introduced as a means of determining the number of vehicles that could cross a stop line over the whole of the cycle.
- In practice flow cannot commence or terminated instantly.

Note: During amber time vehicles may cross the stop line!!.

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.



- **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.

<u>Optimum Cycle Time for an Intersection (C_o)</u>

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

The cycle time is longer when the intersection is heavily trafficked

- **<u>Degree of trafficking</u>**
  - The degree of trafficking of an approach (*y*)

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

<u>Cycle time and delay</u>

Minimum cycle time = 25s. for safety considerations

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

<u>How to determine the optimum cycle time (Co)?</u>

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.

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

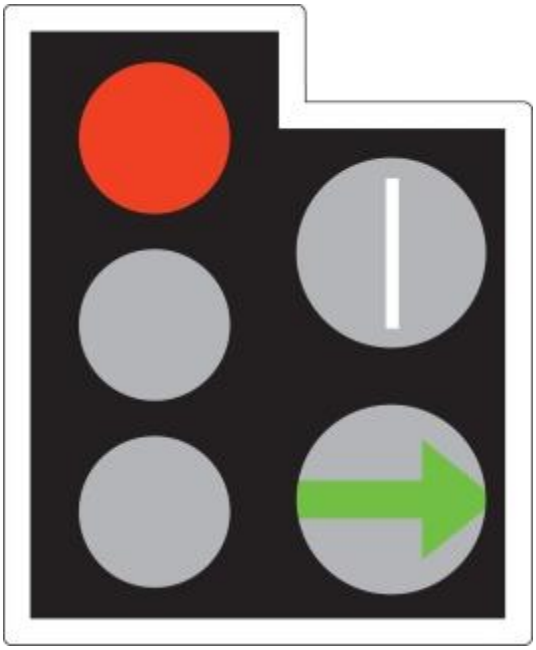
Where:

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.

Local Problems

- **No standards for signal setting and design.**
- **Set at far away from the intersections and encourage drivers to stop beyond the signal mast.**
- **Signals are installed even when they are not warranted.**
- **Signal light size (lens dia) and lumination is inadequate.**
- **Cycle times and phasing are judgment based, amber clearance phases are short and inadequate for safe rickshaw clearance and above all a signal timing plan is maintained throughout the day.**
- **Traditionally, drivers watch the policeman rather than the signals.**
- **Un-enforced signals discourage drivers' compliance in general and thereby weakening the overall level of respect for traffic signals.**



A GREEN ARROW may be provided in addition to the full green signal if movement in a certain direction is allowed before or after the full green phase. If the way is clear you may go but only in the direction shown by the arrow. You may do this whatever other lights may be showing. White light signals may be provided for trams