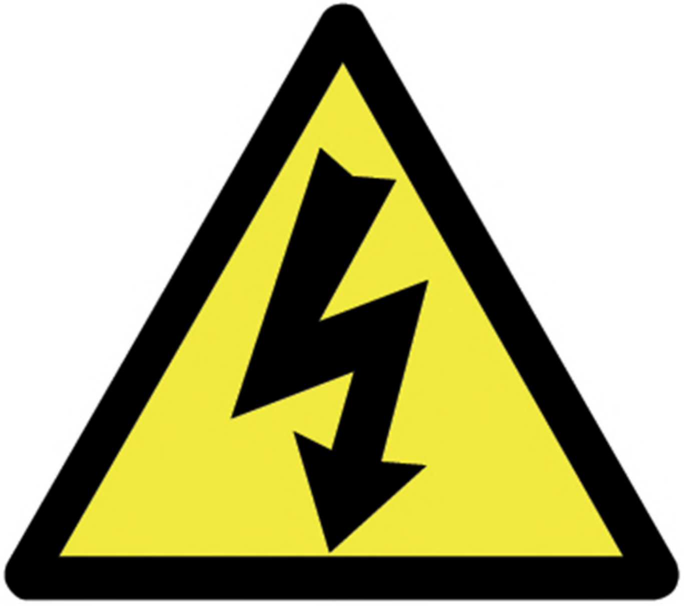
Introduction to Traffic Signals (UK)

Safety Moment

ONLY SUITABLY COMPETENT PERSONS SHOULD ACCESS LIVE TRAFFIC SIGNAL EQUIPMENT (NHSS8 / HERS Card Holders UK ONLY)



REMEMBER ELECTRICITY CAN KILL

Course Contents

- Why do we use Traffic Signals
- Traffic Signal Terminology
- Control Modes
- Detection
- Pedestrian Facilities

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Why do we use Traffic Signals

Quick History Of Traffic Signals

- First Traffic Signal installed on 9th December 1868 outside Houses of Parliament, Westminster London.
- Gas Powered using semaphore arms (based on railway signals) operated by police. Removed in 1869 after they exploded due to gas leak, killing the policeman operating it.
- First electric traffic signals installed 5th August 1914 in Ohio, USA.
- First electric traffic signals in UK were installed in 1926 at Piccadilly Circus, London

What are Traffic Signals

Traffic signals, known technically as traffic control signals, are signalling devices specifically positioned at road intersections, pedestrian crossings and other locations to control conflicting flows of traffic.

Why Do We Have Traffic Signals

- Safety - To allow road users to safely navigate through an intersection and allow pedestrians to cross roads safely.
- Priority - To give priority to a particular direction / mode of travel.
- Coordination – To allow large volumes of traffic to pass through a network with minimal delay.

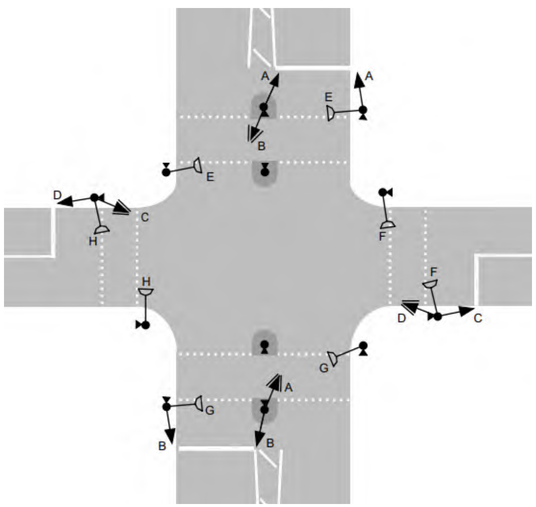
Why Do We Have Traffic Signals

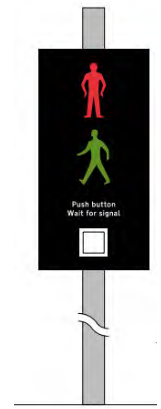
- To provide for safe and orderly movement of road users;
- To reduce the frequency of accidents;
- To enable traffic from minor roads to enter through routes without undue delay;
- To meet the needs of vulnerable road users;
- To facilitate the needs of public transport;
- To reduce overall delay;
- To increase the handling efficiency of a junction;
- To promote driving comfort and convenience by simplifying decision making at complex intersections.

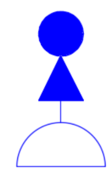
Traffic Signals Terminology

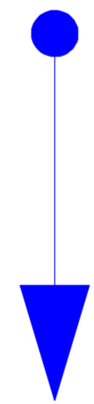
Traffic / Pedestrian Phase

A phase can be thought of as a unique electrical circuit from the controller to one or more signal heads. As it is on the same circuit, all signal heads for that phase will change at the same time.



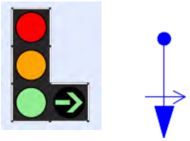




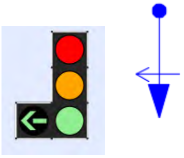


Types of Typical Traffic Signal Phases

- Traffic phase with additional right turn indicative phase:

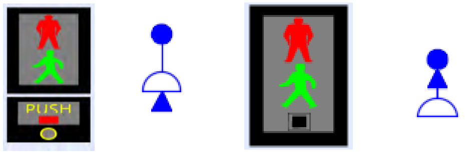


- Traffic phase with additional left turn filter phase



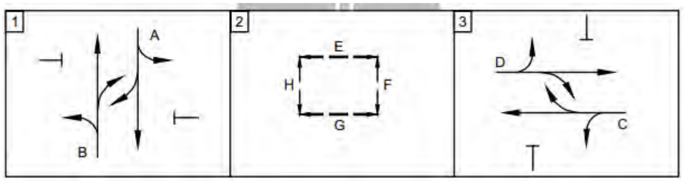
- Traffic phase with Box Sign (Box sign not a phase)

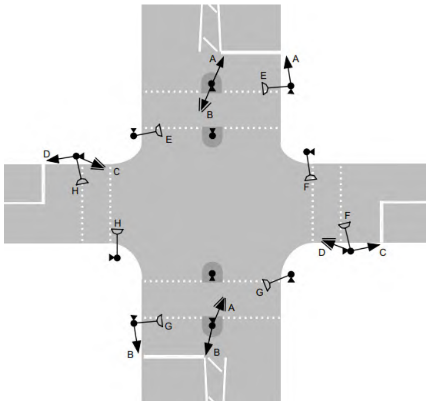
- Nearside Pedestrian Phase with Separate & Combined PPBU



Traffic Signal Stage

Phases are assigned to a stage or stages. A stage can be defined as a period of time when one or more non-conflicting phases are given a green signal at the same time. Stages usually run in a specific, pre-determined order within the cycle. They can be demand-dependent, only running if called, and can be omitted if not required.





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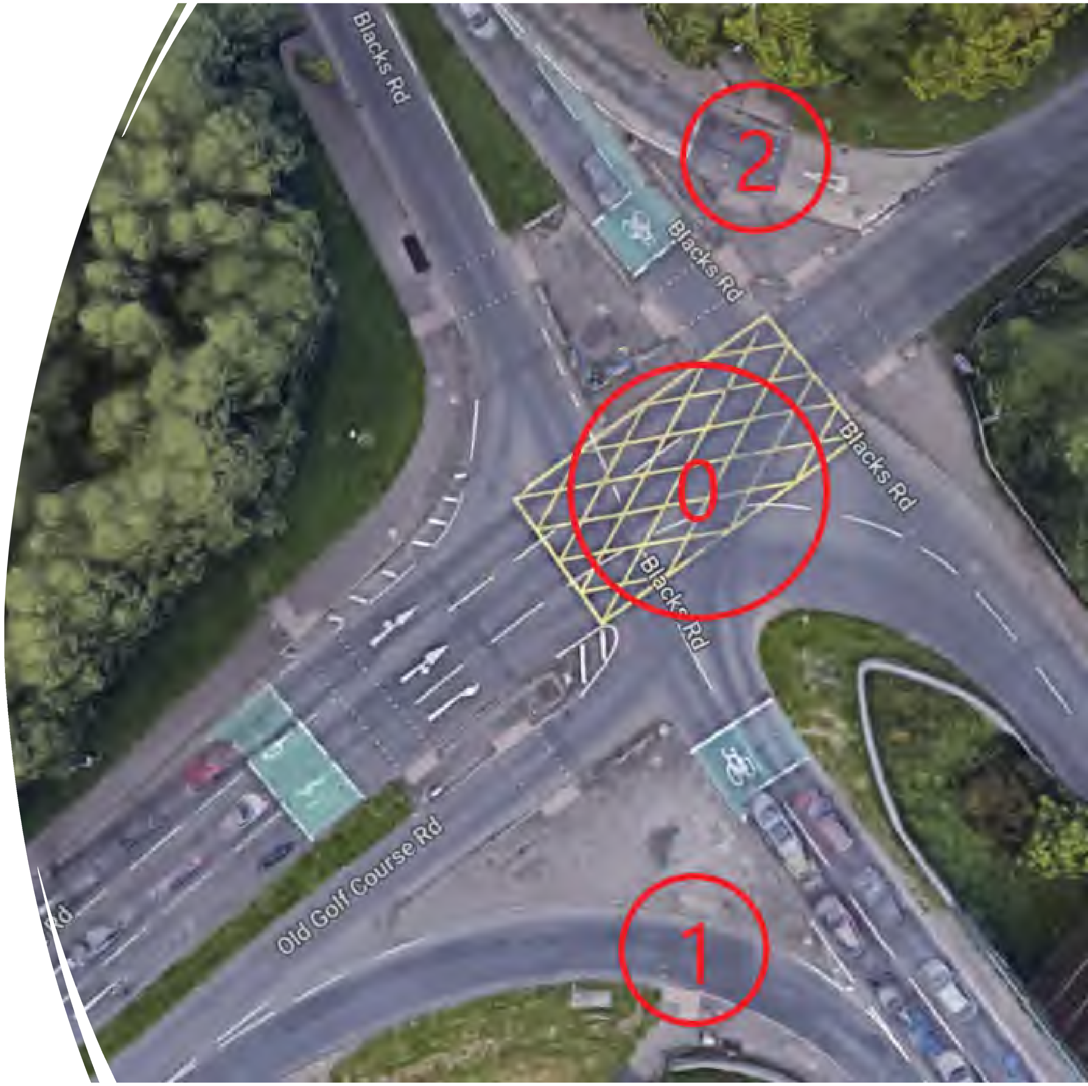
Traffic Signal Stage Stream

- A stage stream facility

This is basically taking one signal controller and making two or more separate controllers, within one housing using the same handwear. This is normally applied to closely associated junctions, pedestrian/Cycle crossings. This technique saves on both Capital & Revenue expenditure, as no additional controller, power supply, communications or maintenance are required for the additional stream(s).

Detailed in the picture:
- Main Junction Stream 0
- Stream 1 Separate pedestrian crossing
- Stream 2 Separate pedestrian crossing



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Capacity Assessment – LinSig / Transyt

- PRC: Practical Reserve Capacity

Is the difference between the capacity of a junction and the current demand (usually expressed as a percentage)

- Sat-Flow: Saturation Flow

At the start of the green period, vehicles queuing at the stop line will take some time to move off and to accelerate to a normal running speed. After a few seconds, any remaining queuing traffic will discharge at a more or less constant rate known as the saturation flow. This is the flow which would be obtained if there was a continuous flow of vehicles and they were given a constant green signal.

- Deg Sat: Degree of Saturation

This is the ratio of the actual flows to the maximum possible flows on the approaches to a junction, and will give a good indication of whether a junction will function well or be subject to delays. It is usually expressed as a percentage and is given by the following: Degree of saturation = (demand x cycle time) / (saturation flow x effective green time) Although degrees of saturation below 100% are within theoretical capacity (i.e. demand flow does not exceed capacity), random traffic arrivals throughout time may result in shorter time periods where the degree of saturation exceeds 100%. Therefore, an arm is generally considered to be over capacity once the degree of saturation exceeds 90%.

- Cycle Time:

Traffic signal installations operate a cycle time made up of stages. An amount of green time is allocated to each approach, to allow traffic to pass through the junction. The cycle time will vary from site to site depending on circumstances, and should be matched to actual demand. Relatively short cycle times are generally better for traffic management. At junctions, cycle times greater than 120 s are not recommended. Cycle time is detailed as the time it takes the junction to rotate through all stages E.G. Start of Stage 1 to when Stage 1 starts again.

Traffic Signal Control Terminology

- UTC: Urban Traffic Control System

A UTC system controls signalised junctions and crossings across a network, these sites are connected to a central computer system. UTC is generally used in an urban situation to control a group of two or more junctions which are closely linked, normally less than 200 metres apart.

- SCOOT: Split Cycle Offset Optimisation Technique

Used as an add on module to make UTC systems adaptive, allows the UTC system to deal with the every changing flows, the system responds automatically to these flows. The changes are applied by the UTC SCOOT algorithm from information being received from SCOOT detectors at every signal installation within a network. The system attempts to minimise the overall delay in the network by constantly changing the phase and cycle timings at each junction, and modifying offset times between adjacent signal installations. Adaptive control allows the system to automatically adjust to take account of time of day variations, roadworks, poor air quality and so on. Compared with a fixed-time system, SCOOT is more efficient and can reduce unnecessary delays to road users.

Green Wave – Emergency Vehicle Requests:

Placed via remote requests such as a Fire Station – Depending on location, a fire officer simply presses a button within a Fire Station, these area normally as simple as North, South, East or West grouped. When actioned this places a Green Wave request long a defined corridor with suitable offsets being applied between junctions etc.

Traffic Signal Control Terminology

- TLP: Traffic Light Priority

External request received into either the signal controller or via the UTC system – Normally associated with Passenger Transport Vehicles.

- MOVA: Microprocessor Optimised Vehicle Actuation

Is a localised traffic control system, developed by TRL (www.trl.co.uk). MOVA is capable of rapidly responding to all conditions and to varying traffic patterns, in particular rapidly changing traffic flows. It is particularly well suited to sites with high traffic flow, particularly where these are seasonal or intermittent, such as diversion routes or holiday routes.

- VA: Vehicle Actuated

VA mode – is based on local detection via basic vehicle detection methodology – System D inductive loops (more details on this in the 'Detection Module' to follow in the presentation).

- CLF: Cableless Linking Facility

Linking across a small number of sites such as neighbouring junctions in close proximity, or roundabout. Can be achieved via CLF, two or more installations are linked by synchronisation with the mains supply frequency. Different combinations of stage timings, cycle times and stage off-set periods between junctions can be selected according to the time of day and day of week to cater for variations in overall traffic flows. CLF may also be used as a fall-back mode at UTC controlled sites and signal-controlled.

Traffic Signal Terminology

- Intergreen

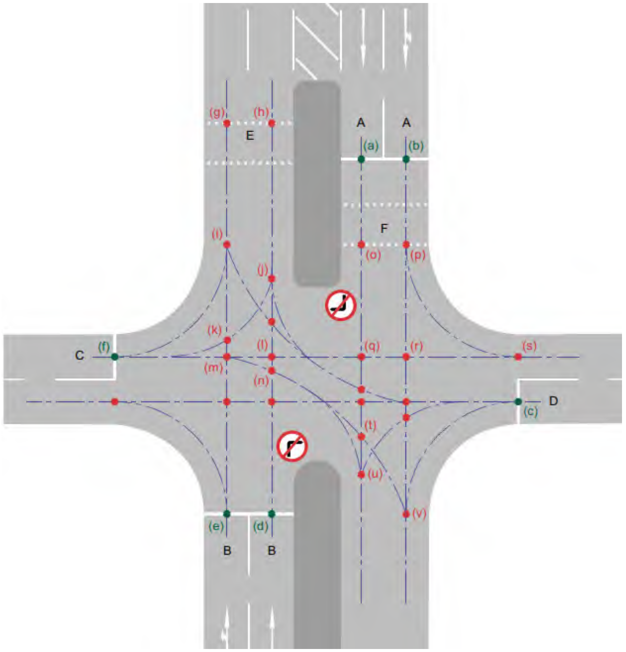
The intergreen is the period between the end of the green signal giving right of way for one phase, and the beginning of the green signal receiving right of way for the next conflicting phase. It can be thought of as the ‘safety margin’ to allow traffic and or pedestrians time to clear the junction safely. It can be extended by external factors, but never shortened.

- Min-Green

The minimum green time allows drivers in front of the detector to clear the junction, or to allow the moving queue to reach the minimum speed for detection.

- Max-Green

The maximum green time is calculated using a combination of layout and traffic flow parameters. It may also be set by the designer for a given cycle if site circumstances require it. Under Vehicle Actuation, the maximum green normally starts on the receipt of a demand for an opposing stage.



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Control Modes

Control Methods

- Traffic signals in the UK operate with various control methods.
- Controllers are configured with phases, stages, intergreens and other information for operating a junction or stand-alone crossing.
- Stages can appear in a fixed cyclic order or vary by demand and the duration of each stage can be fixed, varied by detectors or pre-determined for network coordination.
- The choice of stage and duration is determined by the control method used.
- A junction can operate a single method all the time or operate different methods changing by time of day and/or week.

Control Modes

- Testing and event / incident management
  - Manual
  - Fixed Time (FT)
- Normal isolated:
  - Vehicle Actuation (VA)
  - Microprocessor Optimised Vehicle Actuation (MOVA)
- Coordinated:
  - Cableless Link Facility (CLF)
  - Urban Traffic Control (UTC)
- Special modes:
  - Hurry Call
  - Priority

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Control Modes

- Manual
  - Manual mode enables an engineer or police officer to operate traffic signals manually using a set of control buttons in the controller cabinet.
  - This mode is mainly used for testing and event / incident management.

- Fixed Time
  - Fixed time mode enables the controller to operate stages in a fixed cyclic order with each stage appearing for a fixed duration.
  - This mode is rarely used after commissioning.

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Control Modes

- VA
  - Common control method for isolated junctions and also usually a fallback mode for many junctions.
  - VA mode uses detectors to demand phases (which in turn demand stages) and vary phase (and stage) durations.
  - When a phase starts green, it will run for the minimum green time, which can then be extended further, until a preset maximum green time is reached.

Control Strategies

- VA
  - On high speed roads in VA control, there are two methods used to reduce changes for vehicles caught in the “dilemma zone”.
  - Speed Assessment (SA) uses 2 loops per lane around 3.6m apart placed at 151m from the stop line to detect vehicle speeds. Based on the vehicle speed, a delay time is calculated in which the signals can safely change, following which a 5 second fixed extension is applied to get the vehicle well within the “system D” detection area.
  - Speed Discrimination (SD) gives a fixed extension if a vehicle is travelling above a minimum speed. There are two types, Double SD for 85th percentile approach speeds between 35mph and 45mph giving a 3 second extension from a pair of loops 79m from the stop line, and Triple SD for 85th percentile approach speeds above 45mph giving a 3.5 second extension from two pairs of loops at 159m and 91m from the stop line.
  - With SA and SD, if an unexpired high speed extension is terminated on a maximum change, the intergreen is automatically increased by 2 seconds.

Control Modes

- MOVA (Microprocessor Optimised Vehicle Actuation
  - More advanced version of VA
  - Signal timings to vary more widely in response to traffic conditions
- Why MOVA?
  - VA operation can hold the green ineffectively. MOVA doesn't
  - MOVA cuts the green when saturation flow drops below specified value
  - Improved detector failure and reporting of faults
  - Little need to revisit once set up properly as adjusts to fluctuations in traffic
- When used
  - High flows / large and complex junctions
  - High speed sites
  - Sites with unpredictable flows
  - Specifically requested by Client / LA

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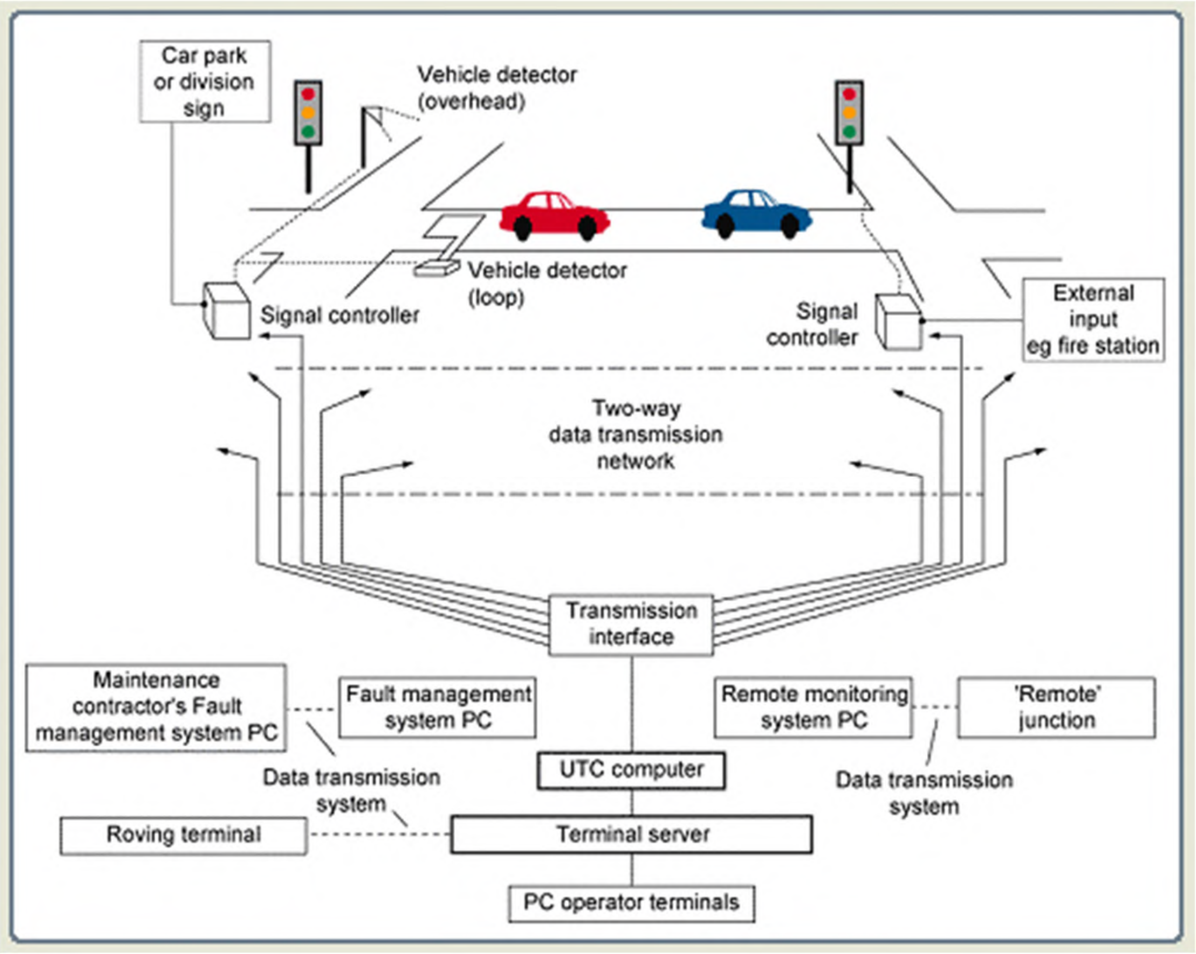
Control Modes

- CLF
  - CLF is often used for small coordinated networks consisting of a few closely spaced junctions including signalised roundabouts, and as a fall back mode. The (50Hz) mains frequency of the electricity supply is used to synchronise the clocks of each controller in the network. Fixed time plans that can be varied by time of day and/or week are prepared for each controller, which provide the desired coordination.
  - Demand dependency can be applied if using detectors

Control Modes

- Urban Traffic Control (UTC)
  - Coordination of traffic signals through use of central computer



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Control Modes

- Urban Traffic Control (UTC)
  - **Fixed Time UTC**: Base fixed time plans are input to the central computer and are usually based on timings derived from a traffic model.
  - **Adaptive UTC** responds automatically to traffic fluctuations, based on data collected from detectors at every signal installation within a network.
    - SCATS – **S**ydney **C**oordinated **A**daptive **T**raffic **S**ystem
    - SCOOT – **S**plit **C**ycle **O**ffset **O**ptimization **T**echnique
    - UTOPIA – **U**rban **T**raffic **OP**timization **I**ntegrated **A**utomation
      - SPOT – **S**ystem for **P**riority and **O**ptimization of **T**raffic

Control Modes

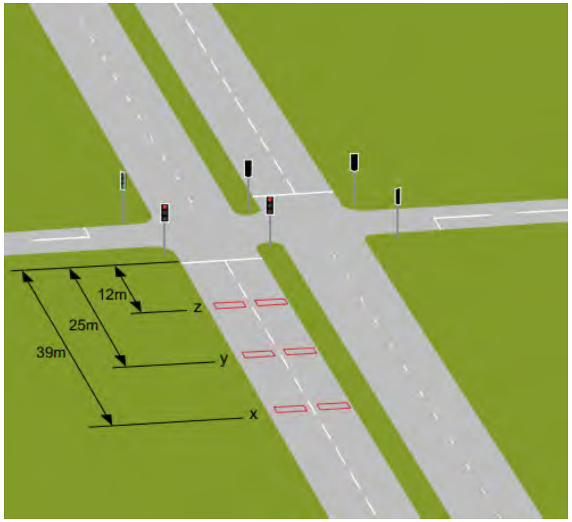
- Hurry Call (Priority)
  - Hurry call is triggered by an event and used to demand an immediate change to a particular stage (without overriding minimum greens, intergreens and prohibited stage moves). The most common applications for hurry call mode are:
    - Fire or ambulance station
    - Queue detectors
    - Level crossing
  - A hurry call will operate for the configured usually short duration and frequently followed on reversion to the normal operating mode by a short inhibit period to prevent continually repeated hurry call demands.
  - Priority Call is similar to Hurry Call but less aggressive

Traffic Signal Detection

Traffic Signal Detection

- Vehicle Actuated (VA) Inductive Loops – System 'D'

Used for VA control, normally made up of three separate loop detectors, being spaced at 12, 25 & 39 metres from the stopline. Used to demand and extend a traffic phase / stage (up to the maximum green period).



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Traffic Signal Detection

- Speed Assessment (SA) / Speed Discrimination (SD)

SA gives a speed related output to extend the phase green sufficiently to allow a vehicle travelling at a constant speed to reach the System 'D' detection area, these detectors then extend the green further. If the inputs from detectors indicate a speed of 28 mph or more are present as the phase / stage ends, a predetermined intergreen extension is applied (151 metres from stop-line).

SD is simpler, giving a fixed extension period if a vehicle is travelling above a minimum speed.

- There are two types:
  - "Double SD" for 85th percentile speeds between 35 and 45 mph, giving a 3 s extension (79 metres from stop-line),
  - "Triple" for 85th percentile speeds over 45 mph, giving a 3.5 s extension at both additional detection points (91 & 159 metres from stop-line).

Once the vehicle reaches the System D area the extensions run in parallel.

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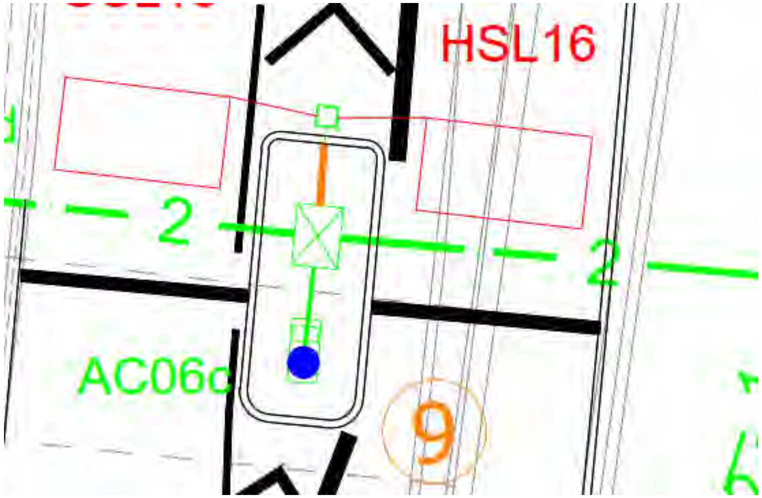
Traffic Signal Detection

- Stop-Line Detection

Stop-line detection is used to detect any vehicle that may have been caught between the last loop and the signal stop-line and / or any vehicle entering the carriageway downstream of the last vehicle detector. These loops are also used for detecting cyclists.

- Queue Detection

Where an approach arm has protentional safety issues relating to queue length such as on a motorway off-slip. The use of queue detection allows a hurry call to be made to that approach phase. This request is based on location of the detector v up-stream storage capacity, a delay is normally placed on the 'call request' to minimise false calls. An inhibit period is applied following the call request, this is to allow the junction time to recover.



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Traffic Signal Detection

- Call / Cancel Detection

Traditionally a call / cancel detector (as detailed as DP12) is used to call a right turn arrow phase / stage at a junction. The call function is based on vehicle occupancy over the loop + X seconds, this is to minimise unnecessary demands and is site specific.

The cancel function is normally a shorter period of time than that of the call – but sufficient to allow the next vehicle to be detected should there be one. Should the request for the right turn phase/stage be active, and the vehicle turns in a gap in traffic, then the request for the right turning arrow phase / stage is cancelled subject to no other vehicles occupying the loop.

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Traffic Signal Detection

- MOVA Detectors (Inductive Loops)

MOVA control requires the vehicle detection to be located at specific distances from the stop-line.

These locations are based on 85%ile speeds that are measured on site. This provides the MOVA algorithm with sufficient information in order to make appropriate stage changes.

Specific Vehicle Detection

- Specific Vehicle Detection

It is possible to use a type of vehicle detector that allows a given type of vehicle to be identified from other back-ground vehicles.

This allows identification of a specific vehicle type, in this case a passenger transport vehicle. BBUS1 & BBUS2.

This allows a local application of traffic light priority request to be made.

In addition this detector type can be utilised to identify heavy goods vehicles (HGV's) – this provides a benefit where an up-hill approach to a signal controlled junction applies, or where known loaded HGV's travel along a specific route.

The use of these detectors allows MOVA to be configured to provide additional time on any given approach (provided this type of detector has been incorporated).

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Overhead Vehicle Detection

- Microwave Vehicle Detection (MVD)

The most common type of above ground detection is microwave vehicle detectors (MVDs). Above ground detectors are easily maintained or replaced when faulty, and access does not generally require a lane or road closure.

This type of detection supersedes the use of inductive loops, it is only recommend for use on low speed roads (30 MPH or below).

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Overhead Detection

- Infrared Vehicle Detection (IR)

Infra-red detectors are commonly used for pedestrian, cyclist and equestrian detection. Above ground detectors are easily replaced and maintained as access does not generally require a lane or road closure.

Kerbside detectors
Common use at pedestrian crossings is for the kerbside detector to work in conjunction with the pedestrian push button unit – once a demand has been placed, should the pedestrian(s) exit the detection area, the pedestrian demand is cancelled.

On-crossing detectors
These detectors monitor pedestrians as they cross the carriageway, and extend the associated intergreen. This provides more flexibility within the cycle-time, as the pedestrian crossing cycle can be either shortened or increased to suit demographic of user.

Overhead Vehicle Detection

CCTV Vehicle Detection

Newer types of detectors coming onto the market are video or image-based processing units.

These units are easy to programme and adjust via Bluetooth connectivity, meaning less working at height is required. Units can be quickly adjusted to suit changes to local conditions such as road works or trial layout.

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Magnetometer Vehicle Detection

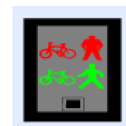
Magnetometer Vehicle Detection

This method of vehicle detection makes use of a detector (detailed in upper left pic) installed into the highway – the units are normally back-filled with a coloured bitumen (red in this case) in order to identify location as detailed in upper right pic)!

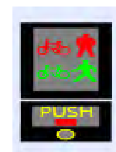
As a vehicle is detected by the magnetometer, a digital pulse is transmitted to a locally mounted receiver (as detailed in lower pic), this is then forward transmitted to a receiver located at the traffic signal junction and the pulse demands / extends the phase / stage, applied to UTC SCOOT or MOVA.

Pedestrian / Cycle / Equestrian Detection

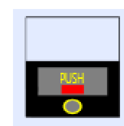
- Nearside Combined Pedestrian / Cycle Display & Demand Unit



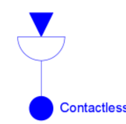
- Nearside Separate Pedestrian Display / Cycle & Demand Unit



- Pedestrian Demand Unit



- Nearside Pedestrian Contactless Display & Demand Unit



Application of Traffic Light Priority for Passenger Transport Vehicles

- On Board Ticket Machines

- This system make use of the latest developments in both GPS transmissions and software located within the on board ticket machine and operators back office system. Example is given at the end of this section. Does not require any intervention to Highway assets other than possible communications upgrade to IP based and controller modification. Operates via virtual loops.

- Transponder Units

- This is a unit that is installed onto the vehicle, transmits to or is read by a receiver on approach to the signal controlled junction.

- Radio Based Units

- Transmitter is installed onto the vehicle, transmits to the receiver on approach to the signal controlled junction.

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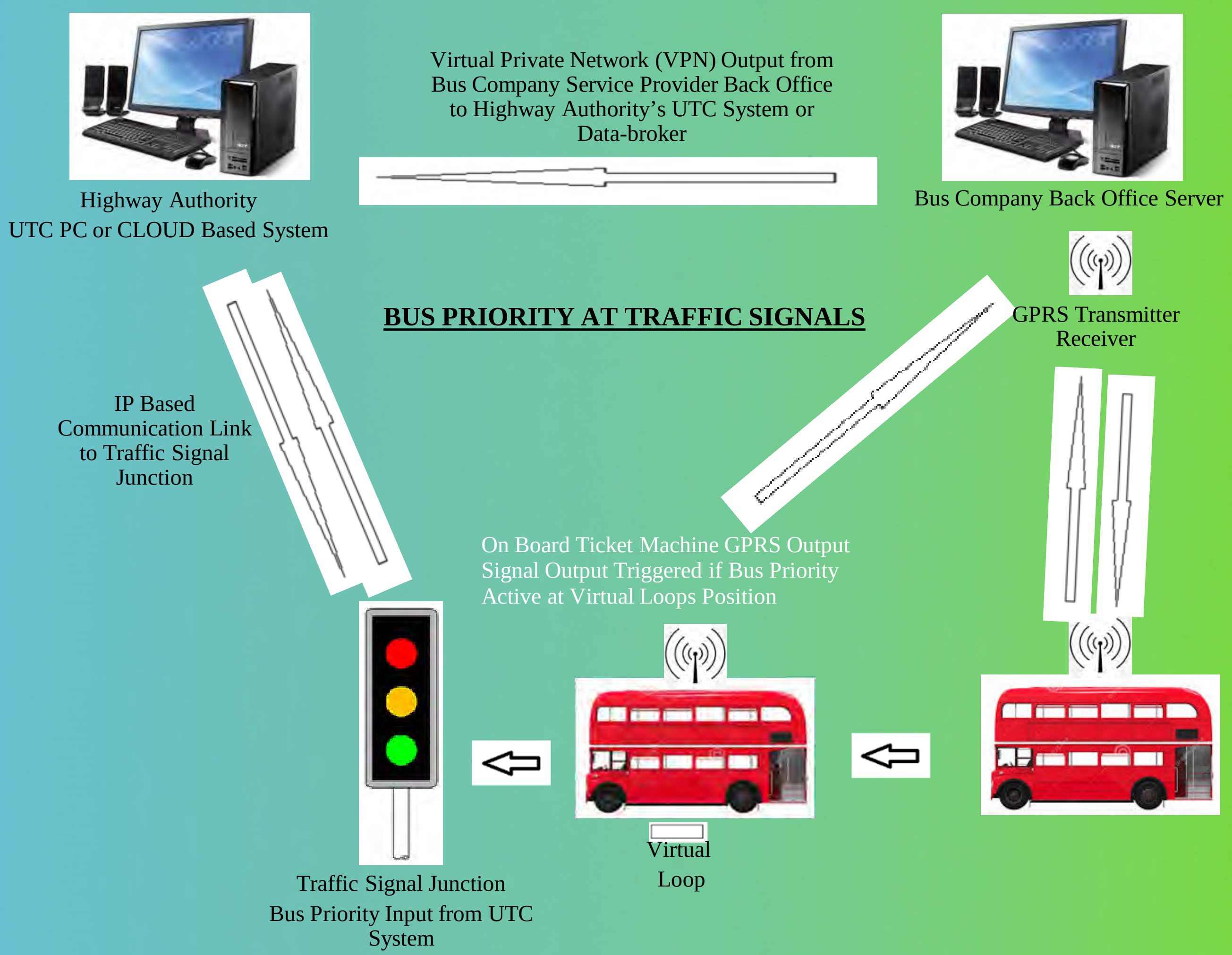

Virtual Private Network (VPN) Output from Bus Company Service Provider Back Office to Highway Authority's UTC System or Data-broker
Highway Authority
UTC PC or CLOUD Based System
Bus Company Back Office Server
BUS PRIORITY AT TRAFFIC SIGNALS
GPRS Transmitter Receiver
IP Based Communication Link to Traffic Signal Junction
On Board Ticket Machine GPRS Output Signal Output Triggered if Bus Priority Active at Virtual Loops Position
Virtual Loop
Traffic Signal Junction
Bus Priority Input from UTC System

Pedestrian Facilities

Pedestrian Facilities
Different Types of Signal Controlled Crossing

Pelican

Toucan

Pedestrian @ Junction

Pedestrian Countdown

Pegasus

Puffin

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Pedestrian Facilities

- **Pelican Crossing**
  - **PED**estrian **LI**ght **CON**trolled
  - Far side pedestrian signals
  - No pedestrian detection other than pushbuttons
  - Mid-block crossing only
  - <u>**Flashing Amber / Green Man**</u>

Pedestrian Facilities

- **Toucan Crossing**
  - Far side pedestrian signals
  - **Two Can Cross (pedestrian & cyclist)**
  - Additional cycle aspect added to far side signal
  - Also, near side signal

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Pedestrian Facilities

Pedestrian Facilities

- **Pedestrian @ Junction**
  - Far side signals
  - 2 aspect, red / green man 3
  - No other pedestrian detection apart from pushbuttons

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Pedestrian Facilities

- **Pedestrian Countdown (PED-X)**
  - **<u>Additional Countdown Units</u>**
  - In UK they are used to countdown to Red man appearance
  - Can not be used where Pedestrian intergreen is extendable (On-Crossing Detection in use)

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Pedestrian Facilities

- **Pegasus Crossings (Equestrian)**
  - Operates same way as Toucan crossing
  - Additional aspects (Red & Green Horse)
  - **<u>Horse crossing </u>**point is usually parallel to Toucan crossing point.
  - Pushbuttons mounted high due to riders position.
  - Usually Far side signals but near side signals are available

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Pedestrian Facilities

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Pedestrian Facilities

- **Puffin Crossing**
  - (**P**edestrian **U**ser **F**riendly **INtelligent**)
  - Nearside pedestrian signals
  - The new standard
  - Mid block and junctions
  - Kerbside detectors to cancel demand
  - On-crossing detectors to extend the clearance red period

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Traffic Signal Controlled Pedestrian Facilities

	Near Side	Far Side	Junction	Stand Alone	Standout Feature
Pelican	✗	☺	✗	☺	Flashing Amber & Green man
Puffin	☺	✗	☺	☺	Intelligent
Toucan	☺	☺	☺	☺	Pedestrians & Cycles
Pegasus	☺	☺	✗	☺	Horses
Ped-X	✗	☺	☺	☺	Countdown Units

Questions?