Doing more for a lot less: Effective Cost Saving Measures in Urban Traffic Control

Preamble

Local Authorities across the UK are experiencing significant budget cuts year on year, which puts increasing pressure on council services. The traffic signals work area has also been affected by this and many councils' are finding it very difficult to maintain the detection that is necessary to operate sites under the control of various systems including SCOOT, MOVA and VA. As a result, many Authorities are looking for ways to reduce their on-going revenue costs and are exploring Reduced Detection options.

The following paper details the Reduced Detection options that have been trialled by the author and are available in SCOOT. Each method is accompanied by a brief explanation of the option and some detail as to where they are most suited for use.

It is hoped that this paper will assist Local Authorities in a small way to tackle the challenge of delivering a quality service during a time of austerity.

SCOOT

Normal Detection in SCOOT

In order to understand the pros and cons of reduced detection methods, it is necessary to fully understand how SCOOT detectors work, along with their recommended installation details.

SCOOT detectors are traditionally inductive loops, 2 metres long in direction of travel, and not less than 1.2 metres wide. It is recommended that they should be cut 1 metre from the centre line, and 2.5 metres from the kerb. For multi-lane approaches, there should be a minimum of 2 metres between loops. It is also possible to use Magnetometers or Above Ground visual detectors, configured for similar detection zones.

The detectors are monitored 4 times a second and the information is sent back to the SCOOT system in ¼ second increments in binary form. This binary information allows the SCOOT system to obtain vehicle presence data for the detector, which is counted in Link Profile Units (LPU's). This is the number of 'detects' that each vehicle generates as it passes over the detector.

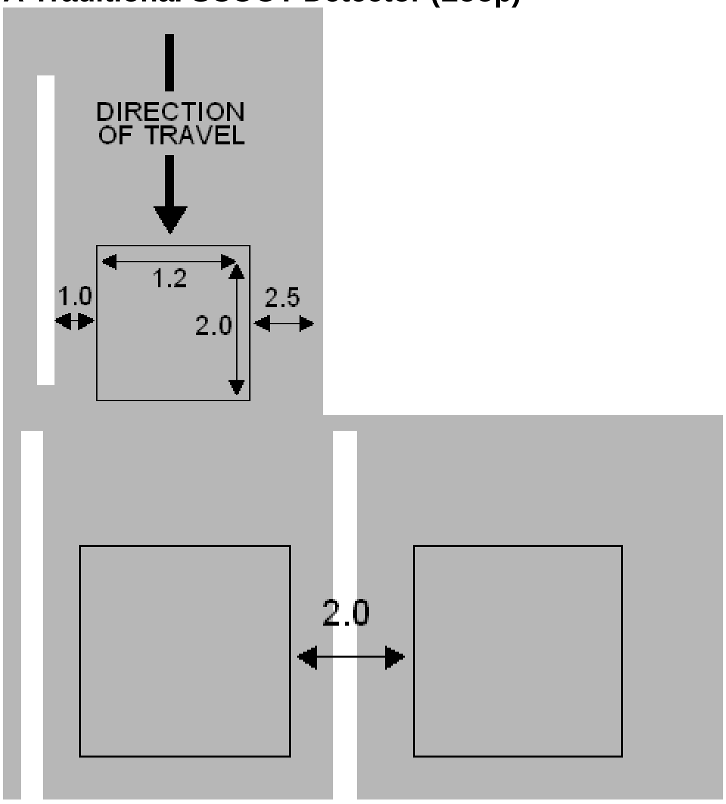
The detector should be positioned where vehicles on that approach cannot miss it, and where vehicles on other approaches cannot clip it. There should be no significant sinks or sources between the detector and stop-line (contributing more than 10% of traffic to the link), especially if the traffic flow is very variable on the sink/ source. For multi-lane approaches, one loop should cover no more than 2 lanes. Also, the cable run between the loop and detector pack should not exceed 150 metres.

The SCOOT model needs time to make its calculation, so the detector is recommended to be no less than 6 seconds journey time from the stop-line. The optimum is 8-15 seconds, or on the exit from the next junction upstream if it is reasonably close.

There should be a consistent journey time between the detector and stop-line. So the loop should not be positioned where traffic flow is often disrupted, such as where there is on-street parking or bus stops, as this affects the journey time, and reduces the efficiency of the model.

The average distance from a stop-line at which to position a loop is 100 metres, however as detectors should be positioned where traffic is normally free-flowing (except in very congested conditions), this should be increased where there is persistent queuing. This is because the SCOOT model measures congestion on the detector, and uses this as a multiplier against the saturation value via the Congestion Importance Factor (CGIF). In the SCOOT model, congestion is 4 seconds of continuous detector presence during green (not including the first 4 seconds of green). This quantitative measure in the SCOOT model allows the engineer to use it as a mathematical value against which it can calculate a degree of bias, thereby increasing green time on specific approaches based on queue lengths.

A Traditional SCOOT Detector (Loop)



Historic Detection in SCOOT

If a traffic movement has very poor lane discipline, or a very short flare lane, it may not be possible to position a detector on the link in the usual way. In these instances, historic detection may be used. This is where the loop is positioned downstream of the junction, rather than upstream. These loops are not as effective as normal links because they cannot measure congestion or effectively determine appropriate offsets between sets of signals. They operate by measuring how the effective green time on the link is used by the traffic, and generating a Saturation value for the previous cycle, which is then used to inform the stage length for the current cycle.

They are usually recommended only where normal detection cannot be used. There are two types of detector that are available in SCOOT and the following sections details where they can work effectively.

1. Filter Detectors

These detectors are positioned in front of the stop-line and an average journey time is entered for the link, giving the journey time from the stop-line to the detector. The SCOOT model then only looks at the detector during the effective green period, minus the journey time. The system then calculates the saturation value from the detector data and uses this to determine the appropriate stage length.

Filter detectors need a consistent journey time between the stop-line and detector and this does need to be a relatively short journey time. It is also important that exit blocking does not cause the detector to have traffic queued over it regularly, as this prevents the model from calculating the Saturation value effectively.

As the detector is positioned in front of the stop-line, it cannot measure congestion in the traditional sense, and this makes it difficult for the SCOOT model to bias towards Filter approaches during congested conditions, as a Congestion Importance Factor (CGIF) cannot be used. For this reason, Filters are not usually recommended on main road movements.

However, the SCOOT system does now include a facility to mimic the Congestion Importance Factor (CGIF), making it possible to bias the SCOOT model towards increasing the stage length on Filter links during congested periods. This has facilitated the use of Filter detection in a wider range of contexts.

The command needed to set this up are:
Filter Saturation (FSAT): This parameter specifies a Saturation level above which you want the SCOOT model to begin biasing towards this approach.
Filter Multiplier (FMUL): This parameter specifies how strongly you want the SCOOT model to bias towards the approach when it is above the specified Saturation value.

2. Stop Line Detectors

SCOOT Stop-line detectors can be positioned at the stop line or within 20 metres upstream of it. In order to set these detectors up, the journey time must be set to zero. On the Siemens UTC system, this can only be done via the Link Validation (LVAL) screen running in ‘Set up’ mode.

The detectors work in the following manner. During the first 6 seconds of effective green, the SCOOT model assigns an average LPU value to any vehicles detected, to reduce the impact of the slow moving traffic on the model. After the first 6 seconds, the model assesses the usage of the green time to determine the level of saturation. The Saturation value calculated in the cycle is then used to help determine the stage length for the next cycle.

Stop-line detectors can model offsets between sets of signals, with limited effectiveness, by applying the following parameters:
Stop-Line Link Bias (SLBI) & Default Offset (DFOF)
This is equivalent to BIAS, but for a stop-line link, it causes the model to move towards the DFOF. The value entered is 0 (No weighting) to 1023 (Strongest Weighting).
CHAN SLBI N00000A 0
CHAN DFOF N00000A 0
Stop-line Link Upstream Link (SLUL)
This parameter provides the model with an upstream link for it to use to manufacture a profile for offset optimisation. Enter the SCN of the upstream link to set it up. NB, the stop-line link must be a stop-line Normal type.
CHAN SLUL N00000A N00000B

As with Filter detectors, they cannot model congestion, so cannot use this to increase green during congested condition. However, unlike Filters, there is no alternative facility available. For this reason, stop-line detection operates best on side roads, or less important movements, as it will not increase green as effectively during congested conditions. However, the use of Stop-line detection is of value where the cost of ducting is high, and you need detection on side roads, right turns or similar minor movements.

Stop-line detectors installed for SCOOT, MOVA or VA sites can be used as SCOOT stop-line detectors. VA stop-line detectors are normally placed within 2 metres of the stop-line and are cut in a very similar way to SCOOT stop-line detectors. They are subject to the limitations of SCOOT stop-line detectors detailed above, however, VA stop-line detectors are effective as SCOOT loops and require no adjustment of the STOC value to make them work.

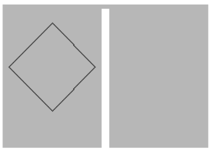
To use a VA stop-line detector as a SCOOT detector, the TR2500 configuration/ O.T.U configuration needs to be written in such a way that the VA detectors you want to use are available in the configuration as SCOOT detectors as well as VA detectors. For a Siemens configuration, this means adding the detectors to the Serial MOVA page, then adding the required detectors to the O.T.U configuration. Alternatively with Siemens controllers, if dealing with a faulty detector that there is no budget to re-cut, you can use the 'IOA' command to allocate the detector you wish to use as a substitute across to the input for the SCOOT detector that has failed

This is usually very effective where stop-line loops are required, and can save money as there is no need to duct or cut additional detectors.

Alternative Detector Types that can be used in SCOOT

MOVA Detectors

MOVA LOOP



Microprocessor Optimised Vehicle Actuation (MOVA) is a method of control that has up to three detectors cut into the road surface on each approach. There is an IN detector, which is placed 75m – 125m from the stop-line, and an X detector, which is placed 40m – 50m from the stop-line, then a stop-line detector. These detectors send traffic flow information back to the MOVA unit on site, which then calculates the optimum stage splits from the data and optimises the signals accordingly.

MOVA uses different shaped/ sized detectors, rather than the oblong shaped loops used for SCOOT. This means that the number of link profile units (LPU's) detected per vehicle is slightly different than with a SCOOT detector. The SCOOT model 'expects' a specific number of LPU's per vehicle on each detector, but where this number is different, due to the size of the detector or the speed of the vehicles, it is possible to adjust for this to a certain extent. The link is modelled by providing the model with a discharge rate for each link in link profile units per second, called a 'STOC value. It is therefore necessary for the validation engineer to correlate the number of LPU's with the discharge rate of the vehicles on street and to provide an appropriate 'STOC' value for the model. So, if the detector is seeing a higher number of LPU's per vehicle, then it's possible to simply enter a higher STOC value for the SCOOT link.

The stop-line detector can be used as a SCOOT detector, please see the above section for more on this. The MOVA X detector is quite close to the stop-line and for this reason its use is less effective, although it could be used if no IN detector is available. Whereas, the MOVA IN detector works very well as a SCOOT detector, due to its distance from the stop-line.

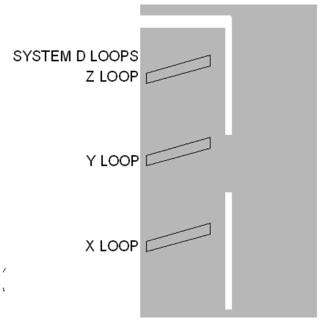
As with VA detectors, the TR2500 configuration/ O.T.U configuration needs to be written so that the MOVA detectors are also available as SCOOT detectors. Again, the 'IOA' command can be used (at Siemens sites) to move the detector across to act as a SCOOT detector.

MOVA IN detectors work well as SCOOT detectors on any junction approach, including main roads as well as side roads.

VA System D Detection (X/Y/Z Detectors)

Vehicle Actuated control (VA), which is a method of traffic control where (traditionally) three chevron shaped detectors are cut on each approach to the junction at 39, 25 and 13 metres from the stop line respectively. They detect whether traffic is approaching the stop-line and extend the green time up to a pre-determined maximum value, or allow the signals to change early if required.

System D consists of three detectors, the X, Y and Z detectors. The use of these detectors is not ideal, as they have a larger detection zone and they are very close to the stop-line. However with some adjustments, it is possible to use the X or Z detectors as SCOOT detectors.



The X detector can be used as a normal SCOOT detector, although I'd recommend against using the Y loop, as it is too close to the stop-line to work as a normal SCOOT detector, but too far from it to work as a stop-line detector.

For an X detector, the journey time is usually 5 seconds, which is slightly below the recommended value for SCOOT use, but does still work. Regarding the larger detection zone, adjustment needs to be made via the STOC value (usually by increasing it slightly).

As with the other detector types, the TR2500 configuration/ O.T.U configuration needs to be edited, or the 'IOA' command (Siemens sites) can be used to move the detector across to act as a SCOOT detector.

The use of these detectors is not ideal, but where budgets are tight and with the adjustments described above, they can be made to work effectively on side roads and minor approaches, bringing a site under SCOOT control with minimal expense.

SDE/ SA Assessors

These detectors are very effective as SCOOT detectors. They are cut in a very similar way to SCOOT detectors, and are positioned at a good distance from the stop-line for SCOOT purposes.

As they are very similar in their shape and size to SCOOT detectors, they require almost no adjustment to the STOC value to make them work effectively. They can also be used as normal SCOOT detectors, so the SCOOT model can use them to model congestion and appropriately balance the green during congested periods.

As with the other detector types, the TR2500 configuration/ O.T.U configuration needs to be edited, or the 'IOA' command (Siemens sites) can be used to move the detector across to act as a SCOOT detector.

This is an effective cost saving method on main roads, as only one set of detectors needs to be cut when building a new scheme. Or alternatively, where a lot of traffic management is needed for re-cutting a faulty SCOOT detector, swapping over to the use of an SDE/ SA detector can be done with a handset command and will save a lot of money.

Reduced Detection Facilities in SCOOT

Within the SCOOT system, there are two facilities that exist to assist SCOOT engineers where there is a lack of detection available. These are detailed below.

Reduced Detection Proxy Flow

Where there is no detector upstream that can be used to provide information for the link, for example if the site is an entry link, it is possible to set up a reduced detection proxy flow value. This is a traffic flow value in vehicles per hour that is entered into the SCOOT model. The model calculates the stage length required to discharge the specified amount of traffic and runs that stage length every cycle. The values should be calculated for the morning peak, off peak and evening peaks and then should be timetabled to change at the times of day when traffic flows change.

To set up the RDPF, enter the following:
Enter a traffic flow figure in vehicles per hour, timetabled to change for each period of the day:
CHAN RDPF N00000A 0

This should be applied cautiously as the model cannot react to changes in demand unless a manual change is entered or a change is timetabled. Therefore, the traffic flows on the approach also need to be relatively consistent during the time period. For this reason, this is best used only on minor side roads, or approaches with low traffic flows, where it can be an effective alternative to detection.

Reduced Detection Proxy Link

Where there is an upstream detector, this parameter allows the flow on the upstream link to be used to derive a flow value for the link concerned. The upstream link becomes a proxy for this ‘synthetic’ link.

In order for RDPL to work, the following conditions must be met:
A) The proxy link must have the synthetic link as its Main Downstream Link (MDSL)
B) The synthetic link must be a normal link and *must have no detection on it*.
C) It should not have large variations in flow or significant sinks or sources after the loop, as this reduces the accuracy of the data provided to the model.
D) Neither the Proxy nor Synthetic links can be part of a multi-node.

To set up RDPL, the following parameters should be entered:

Reduced Detection Proxy Link (RDPL)
RDPL is activated by this command, which assigns the synthetic link to the proxy detector, in the following example N00000Z is proxy for N00000A.
CHAN RDPL N00000A N00000Z

Journey Time (JNYT)
The journey time needs to be measured as a free flowing journey time from the Proxy link stop-line to the Synthetic link stop-line.
CHAN JNYT N00000A 0

Reduced Detection Flow Factor (RDFF) & Reduced Detection Flow Ration (RDFR):
These parameters identify the traffic lost and gained between the Proxy and Synthetic links. The values are calculated as shown below, and are then entered as follows:
CHAN RDFF N00000A 00
CHAN RDFR N00000A 00

How to calculate the above values:

If a proxy link is to be used, to determine the *synthetic flow factor* and the *synthetic flow ratio*, make the following measurements on the street for an appropriate number of cycles (e.g. 10). Start each cycle when the proxy link goes red. Record the following three values for each cycle:

1. While the proxy link is red, count f_{xs}, the number of vehicles which enter the synthetic link.
2. While the proxy link is green, count f_{ps}, the number of vehicles which leave the proxy link and enter the synthetic link.
3. Also while the proxy link is green, count f_{px}, the number of vehicles which leave the proxy link and do not enter the synthetic link.

After the appropriate number of cycles, sum the values of f_{xs} to give F_{xs}, the values of f_{ps} to give F_{ps} and the values of f_{px} to give F_{px}.

Then calculate the *synthetic flow factor* as $\frac{100F_{ps}}{(F_{ps}+F_{px})}$ to give a percentage.

Also calculate the *synthetic flow ratio* as $\frac{100F_{ps}}{(F_{ps}+F_{xs})}$ to give a percentage.

The *journey time* is determined in the normal way, but is measured from the *stopline of the proxy link to the stopline of the synthetic link.*

(From SCOOT Traffic Handbook, 0488, Functional Description: Reduced SCOOT, TRL).

The RDPL function works well where the offsets between sets of signals are not critical, and where the volume of traffic lost or gained on the Synthetic link is not too high.

This can be used on main road approaches as well as side roads, provided there is an upstream detector available. It offers a viable and flexible alternative to repairing SCOOT detection that provides effective results.

Sundry Notes

No Detection

It is possible to operate some junction approaches with no SCOOT detection, although only in very specific situations. Where a junction approach is a very quiet side road, for example a bus only road, or a small car park exit, it's possible that the traffic flow will be less than three vehicles per cycle. In this case, the junction would only ever need to run a minimum 7 second green on that approach. It is therefore not worth installing a SCOOT detector.

MVD's (Not recommended)

The use of an MVD for SCOOT was trialled briefly by the author. The results were that the detection zone appeared to be an area of around 15-20m (in direction of travel), so was significantly outside of the 2m detector that SCOOT is expecting. The detection of vehicles was also highly variable, due to the MVD only detecting vehicles travelling above a minimum speed, which is affected by the length of the queue and driver behaviour.

For these reasons, it was not possible to determine any clear relationship between the LPU's detected by the MVD and the actual number of vehicles this related to on street. Therefore it was not possible to determine an appropriate STOC value to account for the anomalous LPU read rate, and this meant that SCOOT could not correctly model the link.

Whilst it is strongly recommended against to use a standard MVD for SCOOT, there may be some new products entering the market that would be worth trialling as SCOOT detectors.

Closing Comments

The cost of installing and maintaining detection at Traffic Signals can be prohibitive for many Local Authorities, which can strongly affect the efficiency of their traffic signal networks. The above paper offers a range of alternative methods that can be adopted for SCOOT sites in order to provide the SCOOT model with the data it needs to model effectively.

All of the above techniques have been successfully trialled in a range of situations, demonstrating that it is possible to effectively model in SCOOT with alternative or reduced detection.

It is also possible to do similar work in MOVA, using MVD's, SCOOT detectors and other forms of reduced detection.