# Temporary Detection in UTC: Keeping Sites Coordinated

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### 1.0. Summary

The loss of traffic detection at a junction within a city network can have a disruptive effect on the efficiency of that junction. This can have a significant knock on effect on the surrounding traffic signal network, causing an increase in congestion and driver frustration.

The failure of a traffic detector at a junction may occur for a range of reasons. When a failure occurs, the detector is usually repaired where possible. When this is not possible an alternative is sought. This may be to simply replace the detector or install an alternative detector type, or it may be to implement reduced detection techniques.

In some cases it is not possible to replace the detector, such as when a road surface has failed or where a site is being refurbished as part of a major highway improvement scheme. In these situations, the detector may be faulty for a prolonged period and the traffic signals team must find an alternative way to manage the problem. The solution is usually to implement default stage lengths for the affected approaches, or to drop the area onto fixed time plans. These options are less reactive and efficient than methods of control such as SCOOT and MOVA.

In this paper, the authors will detail the results of a trial into a re-deployable/ temporary SCOOT detection solution which can be deployed quickly and easily when required. The temporary solution uses above ground detection devices and a dedicated wireless/mobile data link, to a remotely located O.T.U. The O.T.U then passes the data into the UTC system in the appropriate format.

These temporary detectors provide the required data to the SCOOT system, allowing traffic signals staff to continue operating the sites under SCOOT control until the permanent detection can be repaired.

The results of the initial trials showed that the solution was suitable for use in a live deployment. Further trials will be beneficial, however the current conclusion of the trial is that the temporary solution developed provides a cheap, easy to deploy alternative where permanent detection is required but cannot be installed.

## 2.0. Introduction

Local Authorities across the UK are under budgetary pressure, resulting in a significant reduction in their maintenance budgets. This has contributed to difficulties with maintaining the highway assets they are responsible for. In the area of urban traffic control, this has led to difficulties around maintaining the detection required to operate sites under real time adaptive control, such as SCOOT.

Poorly maintained road surfaces can lead to the failure of inductive loop based detection and are a common cause of detector faults in urban networks. It is a poor economy to cut new

detection into a failing road surface as it is likely to fail again after a short time. For this reason it is common to have a policy that a SCOOT detector re-cut is not permitted if a road surface is failing, or if the area is due for resurfacing or remodelling within the next two years.

This can result in prolonged periods of time with failed detection, which must be managed by the SCOOT engineer. This can occur under normal conditions, or during a major scheme. When detection is damaged during a major highway engineering scheme, it may be up to two years before the completion of the scheme, when the detector will be reinstated. This is highly problematic as the SCOOT engineer must manage the impact of the faulty detection under a situation of reduced capacity due to lane closures for road works. In this situation, it is vital to maximise the usage of the remaining network capacity.

## 3.0. Traditional Options for a Faulty Detector

There are a wide range of options that can be implemented when a detector fault occurs. The SCOOT engineer must look at the site and determine the most appropriate option for the situation. The options available include:

- Swap to a Filter or Stop-line detector
- Swap to an alternative loop configuration:
    - MOVA ‘In’ or MOVA ‘X’ detectors
    - VA System D detection
    - SDE/ SA detection
- Set up a SCOOT Reduced Detector Proxy Link (RDPL)
- Install an alternative detector
    - Magnetometers
    - Above ground camera/ thermal based detection
    - Radar based detection

For further details on the advantages and disadvantages of each option, please see the 2018 JCT paper ‘Doing more for a lot less: Effective Cost Saving Measures in Urban Traffic Control’.

Despite all of the options available, it is common for there to be no suitable or affordable alternative. In these situations the SCOOT engineer must identify how to proceed with no detection. The remaining options include:

- Implement a SCOOT Reduced Detector Proxy Flow (RDPF)

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 are measured for the morning peak, off peak and evening peaks and the measured values are entered into the UTC timetable, so that the SCOOT model reflects the traffic conditions at each time of day. The model will then change the time required on that approach by time of day. This method allows the SCOOT model to run, but with one approach relying on measured values, so it can be expected to see a small reduction in capacity.

- Default Stage Lengths (DEFS)
  To implement this option, the SCOOT engineer enters a set of stage lengths into the timetable. This usually includes a set of stage lengths for the AM peak, off peak and PM peak. When a detector fails, the SCOOT model runs the default stage length on the faulty stage. Again, this method allows the SCOOT model to run, but with one approach relying on measured values, so it can be expected to see a small reduction in capacity.
- UTC fixed time plans
  The SCOOT engineer can take the site (and any other sites as appropriate) off SCOOT and run them on fixed time plans instead. This is less efficient than SCOOT as it is not a traffic responsive form of control. Furthermore, the plans for the sites must be regularly updated as traffic flows change throughout the year.
- Fall back to local control
  The SCOOT engineer can timetable changes to the site so that it will fall back to local control, such as VA. This can be helpful off peak if the VA detection is in working order, but during peak times this can result in a significant reduction of capacity for the site due to the loss of coordination.

Each of the options is likely to result in a loss of capacity and generates significant additional work for the SCOOT engineer, in terms of the set up and maintenance of the solution.

## 4.0. Temporary SCOOT Detection

### 4.1. The Solution Criteria Required

In order to overcome the issue of prolonged SCOOT detection faults affecting the network, Bristol City Council (BCC) requested the development of a temporary/ re-deployable detector. The criteria set by BCC for the solution were as follows:

- The sensor must be easily/ cheaply re-deployable, so that it can be moved from one site to another as required.
- The sensor must not require a configuration change at the controller in order to work, as this would be time consuming and expensive.
- The sensor must not require the provision of additional cabinets, ducting, cabling or poles in order to work. I.e. it must be powered from spare cores available at the traffic signal pole cap (24v), and it should be possible to clamp it to an existing traffic signal pole top. This is to make it quick and easy to deploy and to avoid the issues caused by blocked/ full/ collapsed ducting.
- The sensor will contain its' own transmission equipment, so it will not need to be connected back to an existing O.T.U. This would mean that it could be hung anywhere there is available power, irrespective of the presence of duct runs/ detector packs/ space on an existing O.T.U/ configuration issues, etc.
- The sensor will detect vehicle presence/ absence (irrespective of whether the vehicle is moving or stationary) and will send this data back to UTC using the same UG405 protocols as a standard inductive loop based detector on a 'normal' O.T.U.

Bristol City Council stated that it is important that the solution adopted offers a similar level of performance to a permanent detector, because the provision of bad data into the SCOOT model can be more detrimental than no data being provided.

## 4.2. The Solution Proposed

The solution proposed makes two changes to the conventional architecture.

The first change is predicated on the IoT model, i.e. exploiting the near ubiquity (at least in an urban environment as in this application) of reliable, low cost, low latency mobile data services. A self-contained IP65 sealed dedicated wireless interface module (WIM) with an integrated SIM and internal antenna is co-located with and connected to a detector and requires only access to the usual 24V d.c. supply to operate. In effect, the WIM replaces the wired link from the detector to the O.T.U with a link that uses mobile data.


The second change is to implement an isolated and dedicated O.T.U that is not located on site but at a location convenient to either the user or the service provider. A communication path is set up using the detector WIM to link to the O.T.U, and thence to the user's back office UTC (much as would occur for any roadside O.T.U). Detection events are sent as mobile data packets, by the WIM to the O.T.U location. Packets are received, unpacked and the detection events passed to the O.T.U which is connected by a VPN or other secure means to the user's back office. Set up of the O.T.U is by the standard browser to allocate individual WIM/ detector units to specific on-street sites/ locations. As a result, a single O.T.U can accept data via individual WIMs from multiple detection sites and route them to the UTC system appropriately, so one O.T.U can service multiple replacements for real on-road failed detectors. Each WIM is uniquely identified at the O.T.U by its SIM IMEI number.

The choice of mobile data service provider is largely dependent on the user's policies, but several service providers address machine to machine (M2M) requirements and provide different business models for aggregated data use over multiple SIMs.

While in principle any detector may be used, it is important that the performance of the temporary detector closely mimics that of a SCOOT loop. In this particular case Bristol City Council had already investigated the potential for the AGD 645 detector to be configured for SCOOT loop replacement and on that basis proposed it for these trials. As this detector is provided with the standard TOPAS2505 cabling connection, this supported simple and interchangeable interfacing to the WIM.

As well as supporting an internal SIM and antenna and the TOPAS standard detector interface the WIM has a dedicated IP67 power connector for 24V DC. This 24V supply both powers the detector and the WIM leading to a very compact, self-contained, and therefore simply and rapidly deployable roadside replacement for a failed detector.

## 4.3. The Deployment Process for the Proposed Solution

The activity sequence for employing this temporary SCOOT detection product can be divided into the following:

- The first time/ one time set up of the O.T.U, which includes:
  - Setting up the O.T.U and router so they connect into the UTC system.
  - Setting up all the WIMs and temporary detection devices for a user.
- The individual set up of each detector and WIM as they are sent into the field, (or at the end of a period of use, removed from the field). This includes:
  - Allocating the temporary SCOOT detector to a reply position on the O.T.U
  - Allocating the temporary SCOOT detector to the appropriate SCOOT link.

  The user can retain/ reallocate the WIM and detector units as required depending on local preferences, by repeating the individual set up steps.

## 4.4. The Business Case & Costs for the Proposed Solution

The activities and therefore costs associated with deployment of this service can be related to the stages of the deployment process described above.

There are costs for the O.T.U. and the setting up of the connection to the user's back office. At normal levels of secure VPN access, this is a straightforward task.

As each temporary detector is deployed, the user (or their contractor) can access the O.T.U to set the specific detector/ WIM pair up on the O.T.U and back office system.

A mobile data service charge will be payable for each detector/ WIM pair. As with other services that include mobile data, a bundled package can be procured including a number of years' use, but other arrangements are equally possible.

The use model for this service is currently seen as each user owning a modest number of WIM and detector units and moving these from site to site on an 'as required' basis.

## 4.5. Potential Additional Uses for the Solution

The highly portable and flexible nature of this solution does mean that data from other devices that are not necessarily vehicle or pedestrian detectors can also be routed to the user's UTC back office allowing them to inform or influence the control strategies applied to the traffic, or by extension, inform the UTMC system.

The specific needs of temporary SCOOT detection require a self-contained roadside facility, however with relatively little modification different device types could be connected, or a very limited set of command bits sent from the back office to the roadside. Specific users are then largely down to the imagination of the user.

## 5.0. The Initial Trial Methodology

## 5.1. Selecting an Appropriate Detector Type

The project team looked into different detector types available that could meet the requirements. It was identified that an AGD 645 detector could be powered from a spare core on a traffic signal pole and that they can work as detectors for both stationary and moving vehicles. An opportunity became available to trial an AGD 645 as a SCOOT detector as part of a normal controller installation, so this route was pursued. An AGD 645 detector was installed in a non-critical location in Bristol where a 'normal' inductive loop detector could not be installed due to missing ducting issues. The detector was then tested to determine if it worked sufficiently as a SCOOT detector or not.

The validation of the SCOOT link was carried out in the same way it would be for a link using an inductive loop. The parameters entered were unaffected by the detector type, with the Saturation Occupancy (STOC/ SATO) value being slightly higher, but still within the expected range for a single lane junction approach.

The initial findings were:

- The detector was 'hanging on' for too long after the vehicle had cleared the detection zone, resulting in the SCOOT model seeing too many link profile units (LPU's) for each vehicle.
  To mitigate this, the 'hold time' on the unit was reduced to zero, which resolved this.
- The detection zone appeared to be too large in direction of travel. It was concluded that because the detector was a three dimensional detector rather than a two dimensional detector, the standard 2m detection zone was too large, as we need to account for the height of vehicles as well as their length in our detection zone. The width of the detection zone seemed to have no bearing on this issue, it was length of the zone in direction of travel that appeared to be relevant.
  To mitigate this, we reduced the detection zone to 1m in the direction of travel, which brought the performance of the detector in line with a standard loop detector.
- The positioning of the detector needed to take into account the height of the vehicle, as the detector is looking at a height 1m above ground level. This meant that where the detector was acting as a stop line detector, it would sometimes fail to detect the first vehicle in the queue at the stop line. This was because only the car bonnet was within the detection zone, and this was not always high enough to trigger the detector.
  To mitigate this, the detection zone was moved back, so the windscreen and roof of the first vehicle queuing at the stop line were within the detection zone, causing the detector to trigger correctly.
- The sensor detected people crossing the road as well as vehicles. To mitigate this as far as possible, the sensors need to be set up at a point where few pedestrians choose to walk.

Once the amendments had been made to the sensor, it was found that the detector worked effectively as a SCOOT detector and UTC count site. The sensor accurately detected the presence or absence of a vehicle and did this without 'hanging on' and without missing smaller vehicles, motorcyclists and cyclists.

The conclusions from the initial trial were that an AGD 645 detector can be used as a SCOOT detector provided the sensor is installed appropriately, ie, it is positioned away from locations where pedestrians cross the road, is configured with a hold time of zero, with a smaller (1m) detection zone, that is appropriately positioned. It was clear that the sensor was easy to deploy due to the availability of a traffic signal pole in the appropriate location. The detector had no additional power or cabling requirements, as it could be powered from spare cores available within the traffic signal head.

Following this successful trial, it was decided that the AGD 645 could be used as the sensor type for a temporary detection installation and that further testing should be carried out.

## 5.2. The Initial Temporary Detection Trial

The initial trial aimed to assess the communications reliability of the solution, against a normal inductive loop detector, replying via a permanent Outstation Transmission Unit (O.T.U). The installation was carried out as follows:

- A traffic signal pole with 2x spare 24v DC cores was located within 15m of the required detector location.
- BCC's traffic signals maintenance contractor attended and installed both the AGD 645 unit and the WIM onto the appropriate traffic signal pole.
- The AGD 645 was configured for operation as a SCOOT detector.

This operation took around two hours in total (subsequent installations were quicker, as the officers were more familiar with the process).

Once the detector was live within the UTC/ SCOOT system, a SCOOT Engineer observed the detector replies received by UTC from the detector and compared these in real time with the traffic passing under the detector on street. Two areas were then focussed on to assess the performance of the detector. These were:

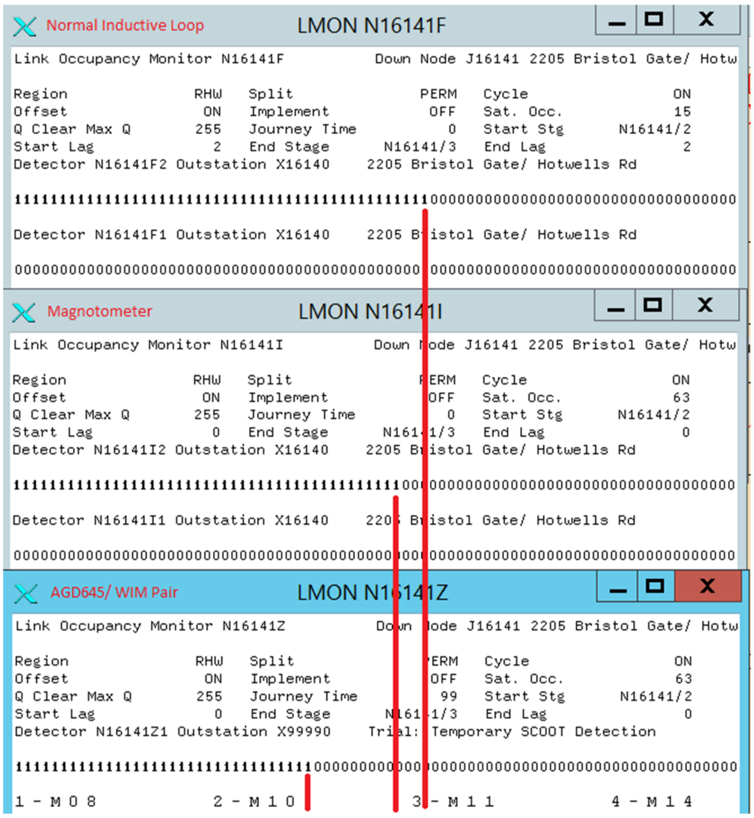
- Latency in Communications:
  The lag in communications between the AGD 645 detecting the vehicle and the UTC system receiving the data was checked to ensure that the temporary solution was suitable for SCOOT operation. Some monitoring of data packets was carried out, which demonstrated that the communications delays were within acceptable limits. A visual check was also carried out, which compared the amount of time taken between a vehicle passing over the detector on street until the change of state is output onto the link monitor (LMON) within the UTC system. On the Bristol UTC system, with a 'normal' O.T.U, this takes between 3-4 seconds. The delay time for this was checked by observing the vehicle passing under the detector and measuring the delay until the change of state appeared on the temporary O.T.U.
- Communications Failures:
  The O.T.U was monitored to ensure that it was not suffering from communications failures over and above what is 'normal' for a 3G O.T.U. This was done by monitoring the logs for the O.T.U. The link between the WIM and O.T.U was also checked by observing the traffic conditions and the link monitor to ensure that the changes of state received by the UTC system were appropriate and correct.

## 5.3. The Initial Trial Results

The initial findings of the trial were as follows:

- Latency in Communications:
  The delay between a vehicle passing over the detector on street until the change of state on the link monitor was 5-6 seconds, rather than the 3-4 seconds which is 'normal' for a traditional detector.

  This is shown in the figure below, which compares three detector types in the same location:
  N16141F is a pair of permanent inductive stopline loops
  N16141I is a pair of permanent magnotometers.
  N16141Z is the temporary detector/ WIM pair.




Communications Failures:

The UTC communications logs for the O.T.U were collected for the first month of the trial. In this time, there were no communications failures that affected this site. As a result of this, the O.T.U and the router configuration were therefore accepted as fit for purpose.

The secondary check to monitor the traffic conditions and ensure the changes were received by the UTC system was to check the connection between the WIM and the O.T.U was stable and passing the data correctly. The result of this check indicated that there were short periods of time when there were communications failures between the WIM and the O.T.U. Resolving this issue is critical to the success of the project, as it can be more harmful to have an intermittently working detector sending bad data to the UTC system, than to have a permanently faulty one. Both the AGD645 and the WIM were swapped out to ensure the issue was not being caused by a genuine fault.

It was also observed that the detection zone for the AGD unit was somewhat restrictive, as it reaches out to around 10m from the traffic signal pole. This impacts the locations where temporary SCOOT detectors could be deployed. The AGD645 is not the only detector type that could be used with the WIM unit and other detector types would have different ranges. Furthermore, the WIM and detector could be powered from a street lighting column, rather than a traffic signal pole, which would significantly increase the range of locations where a detector could be sited.

## 5.4. Further Trials Proposed a Result of the Initial Trial

The priorities and actions required following the initial trial were as follows:

- To resolve the problem of detector data intermittently failing to reach the O.T.U from the AGD645. The possible solutions for this are to:

    - Change the SIM cards in use in an effort to improve the 3/4G communications.
    - Re-examine the WIM build to look for possible causes for the intermittent fault.
    - To consider the option of adding a facility within the O.T.U to record traffic flow details and when necessary, to 'plug' the gaps in transmission with dummy data.
- To add further detectors to the O.T.U, in order to prove that the O.T.U can receive and process multiple detector inputs from different locations at once.
- To assess the performance of the temporary SCOOT detector against a permanent one to ensure that the SCOOT link models correctly and makes appropriate stage change decisions.
- To trial a unit mounted on a street lighting column at a 4m mounting height to ensure that this type of installation also worked effectively from a technical and work process perspective.

## 6.0. Further Temporary Detection Trials

### 6.1. Improving the SIM in Use

A second trial was carried out to address the data transmission issues. A trial was devised which installed a dedicated machine to machine SIM from Mobius into two WIM units and these were then installed at two different locations around the city. Locations with good mobile phone reception were selected.

A repeat test was then carried out to observe traffic conditions at the detector location and watch the link monitor to ensure that the changes of state were received by the UTC system.

The outcome of this trial was that the new SIM card was not fully effective at reducing the number of communications failures between the WIM and the O.T.U. A further trial with a revised WIM unit was required. Changes were proposed to the antenna in order to improve the signal.

### 6.2. Improving the Antenna

A third trial was carried out to trial an improved antenna, to see if this improved the reliability of the 3/4G communications. A trial unit was adapted and installed on a city centre traffic signal scheme where there was a requirement for a temporary detector.

A repeat test was then carried out to observe traffic conditions at the detector location and watch the link monitor to ensure that the changes of state were received by the UTC system.

The outcome of this trial was that the improved antenna significantly reduced instances of communications failures, reducing the issues to a much reduced level.

This was deemed to be an acceptable level of performance. This meant that the trial could move on to a more detailed assessment of the performance of the SCOOT detectors.

## 6.3. Checking that multiple WIM units can reply to via a single O.T.U simultaneously.

A fourth trial was then carried out which added further detectors to the O.T.U, in order to prove that the O.T.U can receive and process multiple detector inputs from different locations at once. Three detectors were installed and monitored to ensure that the O.T.U still worked effectively. No issues were identified as a result of this, so the trials could be progressed to the next stage.

## 7.0. Further trials awaiting completion

At the time of writing, there are two trials that are currently outstanding. These are detailed below.

## 7.1. Detector Comparison

This trial is to assess the performance of the temporary SCOOT detector against a permanent one to ensure that the SCOOT link models correctly and makes appropriate stage change decisions.

At each stage of the trial process, the SCOOT links have been visually monitored to ensure that the data being returned to the UTC system looks similar to that which would be expected from a permanent detector. Additionally, each SCOOT link has been validated and the link performance visually assessed. The visual checks of the data have shown that (aside from during communications failures), the data returned to the UTC system is approximately what would be expected. The validation parameters have been close to the expected ranges and the performance of the link has appeared to be normal.

The only issue identified with the SCOOT modelling was that the additional 1-2 second delay in receiving the detector data did have a slight impact on the offsets between junctions. If this was an issue, it is likely that the offset could be adjusted by adding default offsets and bias, which would assist to push the offset back to where it should be.

However, this checking has been an informal process to date. There is a need to conduct a formal trial to compare the performance of a normal detector against that of a temporary sensor, providing data to support the preliminary conclusions that have been drawn.

At the time of writing, a trial is currently being set up which will compare a temporary sensor with the modified antenna against a permanent loop detector and permanent magnetometer at the same location. This has been delayed due to scheme delays and staff resourcing issues. It is now planned for October/ November 2019.

## 7.2. Street Lighting Installation

This trial will test a temporary SCOOT detector unit mounted on a street lighting column at a 4m mounting height, to ensure that this type of installation also works effectively from a technical and work process perspective.

This trial has been delayed due to resourcing issues within the council's street lighting department. It is now planned for November/ December 2019.

## 8.0. Conclusions

The conclusions of the study are currently as follows:

- The temporary sensor is quick, inexpensive and easy to deploy (or redeploy).
- The temporary sensor works within acceptable performance parameters and provides a viable alternative to a permanent SCOOT detector at problem sites.

Further trials would be beneficial to provide more data and to investigate whether there are installation types that would be problematic.

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