# Area 4 Validation and Optimisation Programme

**<u>Introduction</u>**

Highways England's Area 4 covers Kent, Sussex, and parts of both Surrey and Hampshire – **Figure 1** refers. Aone+ have been responsible for the highways maintenance and traffic management of the motorway and trunk road network in Area 4 since 2016. The key strategic routes within the area are the M2, M20, M23, A2, A21 and the A27, as well as key strategic transport hubs such as the Port of Dover and Gatwick Airport.

To ensure that the Area 4 network operates as efficiently as possible, Highways England currently fund a traffic signal validation and optimisation programme which began in April 2017. The Highways England Project Sponsor for the programme is Paul Canning, Project Manager from A-one+ is Andrew Reynolds, and the Project Engineers are Shane Collins and Tom Siddall from 4way Consulting and Leon Gibson from Telent.

The project has been deemed a success with congestion down, the number of complaints significantly reducing, sites previously not running the preferred control strategy now doing so, and sites running at their optimum operation. Andrew Reynolds of Aone+ stated *"….remember just how far we have come with the optimisation programme in Area 4 which is a very successful collaboration between Telent, 4way and myself whereby we have gone from annual complaints in their hundreds to literally a handful of complaints about sites that are under our control is testament to our capabilities….."* In addition, the team have been able to ensure mitigation measures previously considered, such as additional lanes etc, are now no longer required through undertaking successful validation.

This paper will look at the processes and methodology that the team undertook to ensure that the project provided real benefits and were able to provide real benefits to the Area 4 network.

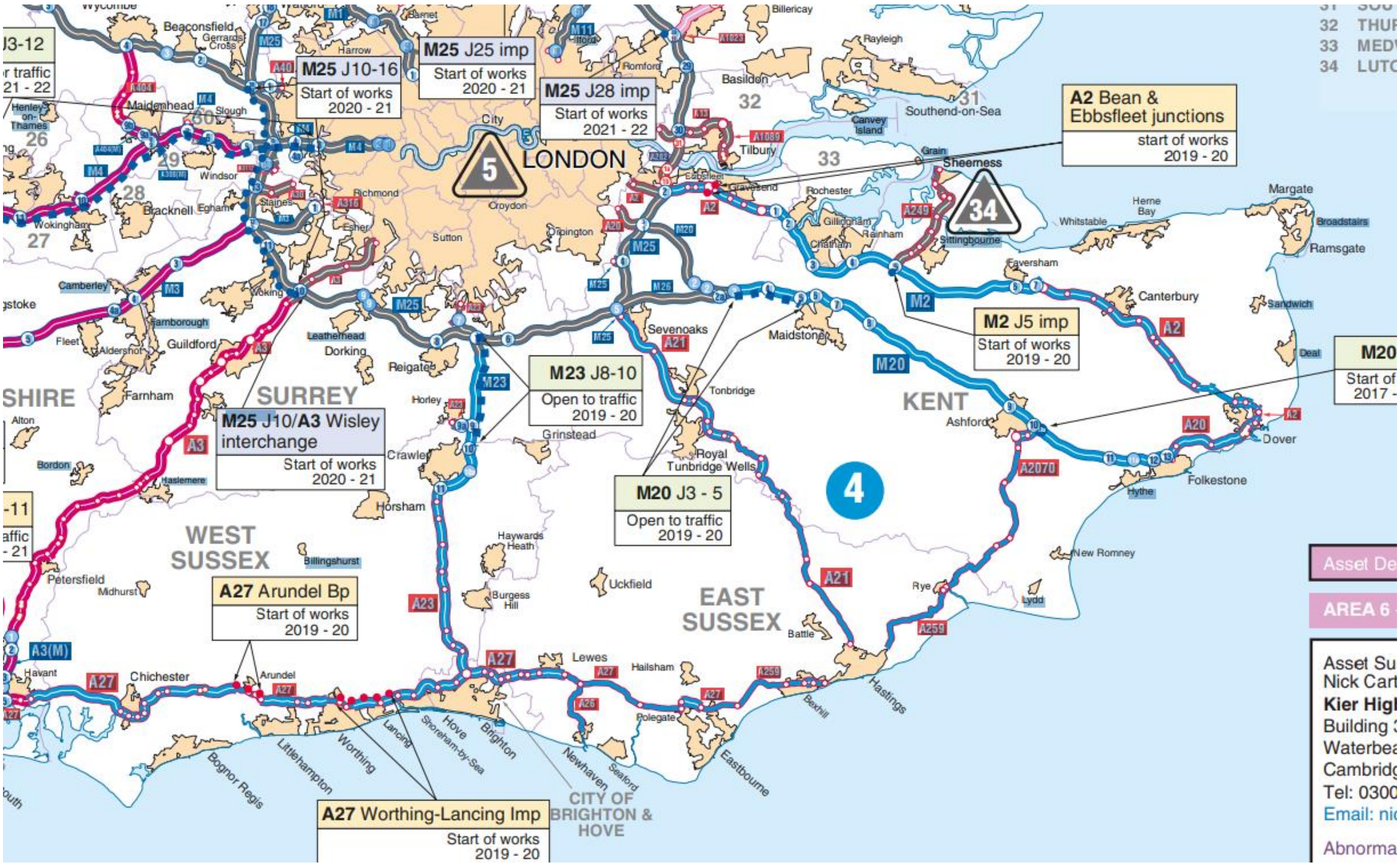


*Figure 1 - Area 4 Network Map (www.gov.uk 2019)*

## Background

Highways England took over the operational control of several sites within Area 4 from various Local Highway Authorities and put the sites on their own Urban Traffic Control (UTC) system. By the time these sites were taken back in-house, they had become a serious source of complaints from the public. With that in mind, the aim of the programme is the validation of all the primary and fallback control strategies serving the traffic signal sites on the network, striving to ensure that each site is able to operate to its maximum capacity (without compromising safety) within existing geometric layouts and utilising the existing operational equipment. In addition, providing a further level of resilience if the site was ever to fallback to a lower priority method of control.

The primary control strategies operational at the traffic signal sites within Area 4 vary between Microprocessor Optimised Vehicle Actuation (MOVA), Split Cycle Offset Optimisation Technique (SCOOT), and Cableless Link Facility (CLF) and typically all sites operate either CLF or Vehicle Actuation (VA) as the initial fallback methods of control.

The 2017/18 validation and optimisation programme focused primarily on undertaking initial primary and secondary control strategy validation at all sites within the network. The 2018/19 programme, which this paper will focus on, specifically targeted the "top ten" highest profile sites within the region. The aim of the 2018/19 programme was to undertake further validation at each of these sites, as well as assess and recommend how the site operation could be improved further with various innovative quick win solutions.

## The Sites

The location of the sites which formed the 2018/19 programme are shown in **Figure 2**. With reference to **Figure 2** the sites and their primary method of control are shown in Table 1.

| Site reference (Figure 1) | Site Name | Site Type | Control Strategy |
|---|---|---|---|
| **1** | A27 Crossbush Roundabout | Grade separated roundabout | MOVA |
| **2** | A27 Grove Lodge Roundabout | At grade roundabout | SCOOT |
| **3** | A27 Upper Brighton Road/Sompting Road | 4 arm crossroads | SCOOT (linked with site 4) |
| **4** | A27 Upper Brighton Road/Lyons Farm | 4 arm crossroads | SCOOT (linked with site 3) |
| **5** | A27 Shoreham Bypass/Old Shoreham Road/Coombes Road (Sussex Pad) | 4 arm staggered crossroad | MOVA |
| **6** | A249/M2 J5 Stockbury Roundabout | Grade separated roundabout | MOVA |
| **7** | M2 J7 Brenley Corner | Grade separated roundabout | Linked MOVA |
| **8** | A2 Lydden Hill | 3 arm junction | MOVA |
| **9** | A27 Ashcombe Roundabout | At grade roundabout | MOVA |
| **10** | M20 J10 | Grade separated roundabout | SCOOT |

*Table 1 – Area 4 'top ten' traffic signal sites*

## Validation and Optimisation Overall Methodology

The following processes and project outputs were put in place by the project team for each site in order to ensure that the site control strategies were validated competently and appropriate 'quick win' optimisation solutions were identified – Initial peer review of site and undertake validation; production of technical note identifying 'quick win' solutions; production of design documentation; factory acceptance testing; site acceptance testing and revalidation.

Initial peer review and validation – the validation team undertook an initial site visit covering the peak periods and inter peak. The aim of the site visit was to review the improvements identified by the 2017/18 validation team and undertake a further validation of both the primary and secondary control strategies. Whilst on site the team observed traffic conditions and behaviour and were able to identify 'quick win' solutions to maximise capacity (without compromising safety) at each site.

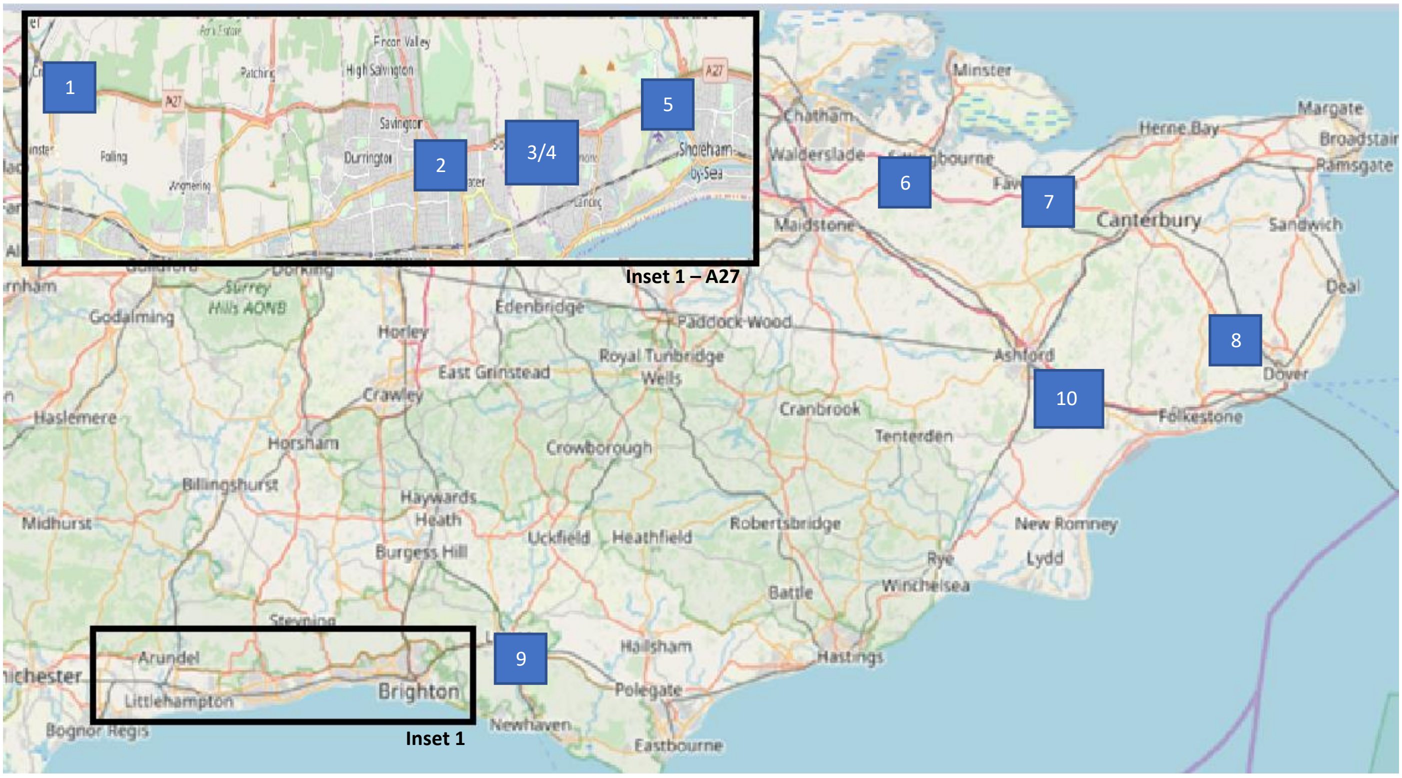


*Figure 2 - Area 4 Top Ten Sites (©OpenStreetMaps Contributors)*

Production of technical note identifying 'quick win' solutions – Following an initial peer review, a technical note was put together by the validation team and issued to the client. The technical note advised the client of findings on site, what actions were taken, and identified next steps on how the site could be improved utilising innovative solutions.

Production of design documentation – All design documentation, consisting of design drawings, design methodology documentation, and MCH1827 forms. for the innovative solutions were developed by the validation team.

The final part of the process was the commissioning of all elements and a revalidation of the site following the implementation of the design solutions.

**On Site Validation – Right First Time Approach**

To ensure that a right first-time approach could be adopted during the initial peer review and validation, the following methodology was adopted at each validation –

- Sufficient preparation time before going to site by validation team – thorough review of the existing site data, UTC database, and MOVA datasets ensured that the validation team knew what to expect at the site beforehand;

- Experienced Engineers with complementing skillsets– all validation activities were carried out by experienced Engineers with sufficient experience in site-based validation activities and knowledge of traffic signal design and latest industry developments;
- Two-people validation team – by deploying a two-person validation team it meant that the basics could be done correctly ensuring the site would be working to its optimum utilising the existing set up. A two-person team allowed the following –
    - Thorough detector checking allowed intermittent detector problems and detector cross wiring to be identified.
    - Full visibility of the junction – having two people at the site ensured full visibility of what was going on. Issues which may not have been picked up by a single person were able to be identified and reactive prevention implemented.
    - Two brains are better than one – by having two experience Engineers on site, proposed innovative solutions were able to be discussed and agreed ensuring that they knew exactly what they wanted to do before they left site. Also, any issues experienced during the validation were able to be discussed and resolved very easily.
    - Health and safety – by adopting a no lone working policy staff were safe on site. As the sites were generally high-speed roads with significant amounts of traffic and sometimes relatively isolated, this no lone working policy was deemed essential and it aligned with the clients lone working procedures.
    - Continuous improvement – having two Engineers on site allowed then to learn from each other. Everybody tends to do things differently and by seeing others do things ensures that you can adapt and better your skillset.
    - One team member watching traffic and one watching MOVA messages – this approach allowed the Engineers to have full visibility of what MOVA was seeing and whether that replicated what was being seen on street. The team were able to react quicker to unexpected situations.
- Intermittent detection – On MOVA sites, any intermittent traffic detection that was not seen as being 'suspect' was set PD in the controller allowing MOVA to use alternative upstream/downstream detection. This approach allowed the site to run considerably better than it was previously
- Saturday and seasonal validations – where deemed appropriate, Saturday validation activities were completed at selected sites on the network. These sites typically consisted of junctions located adjacent to retail parks where links that were not typically busy during the weekday AM and PM peak periods but were busy on a Saturday. In addition, sites that serve a large amount of holiday traffic were identified for seasonal (non-term time) validation. This approach ensured that the network ran as efficiently as possible in all conditions with maximum resilience throughout the year

**Typical Findings on Site**

There were a number of findings on site by the validation team, that were typical across a number of sites. At several sites MOVA detectors had been cross wired e.g. the IN detector in lane 2 (offside) was wired in the controller as the IN detector in Lane 1(nearside). The validation team rectified this in the dataset by switching the detection such that it mirrored exactly what was being seen on site. It is notoriously difficult to get faulty loops recut on the trunk road network, so a few of the sites had faulty detection. In addition, some of the detection was intermittent and 'sticking'. The validation team were able to improve the site operation by allocating alternative upstream and downstream X detection for any link which had a faulty X detector. Intermittent X detection was also set (PD) in the controller RAM allowing MOVA to set the detector suspect and use alternative detection.

Early end of saturation decisions in MOVA were frequent at several sites, typically, due to the high number of HGVs using the site, also the cross wiring didn't help matters. The validation team were able to assist with the early ESLI decisions in MOVA by increasing the CRITG parameter. This however did mean that MOVA sometimes held on green too long, but this was deemed a better alternative to MOVA ending green too early. The functionality of MOVA 8 should help assist with this issue going forwards. MOVA 8 will allow MOVA to re-establish end of saturation if it has found saturation too early, and will also allow the user to temporarily increase the time in which MOVA looks for the end of saturation critical gap.

At a number of sites, MOVA parameters such as SATINC, CRITG, and SATGAP were found set such that MOVA operated very aggressively, resulting in MOVA rarely holding green sufficiently and making stage change decisions on smaller gaps than was expected. In these scenarios, the validation team set the parameters back to default and revalidated, removing the aggressive behaviour of MOVA. These parameters may have been relevant at the time of the previous validation.

In addition, XSINK loops were frequently used on links when combination detectors (COMBX) were probably the better alternative. The validation team amended the dataset in this scenario, which showed a marked improvement in the operation of the site. Furthermore, at some sites the X detection was set too close to the stop line resulting in laggy end of saturation decisions as the CRITG value was often higher than the CRUISX time

**Case Study 1 – A27 Upper Brighton Road/Sompting Road/Lyons Way**

*Figure 3 - A27 /Lyons Way*

The A27/Sompting Road is a 4 arm crossroads which also provides access and egress to the Lyons Farm retail park. The A27/Lyons Way site, **Figure 3,** is also a 4 arm crossroads directly adjacent to the A27 Sompting Road junction. Both sites are controlled together in a single SCOOT region, with CLF fallback should SCOOT control fail.

During the peak periods significant queues form on both the eastbound and westbound A27 approaches. The queues result in significant exit blocking due to a combination of the volume of traffic and the western side of the A27/Sompting junction merging from two lanes into one. On the eastbound approach of the A27/Sompting Road junction approximately 70m before the signals, a single approach lane quickly flares to 2 ahead, 1 right and 1 left turn lane. Once green time has extended beyond approximately 20-30s performance on this approach is 'throttled' by the single lane. Effectively, once green times are above 20-30s, this approach acts as only a single lane and this limits capacity. This leads to significant eastbound queues forming. **Figure 4** refers. There is little that could be done within SCOOT, without implementing upstream 'gating' to mitigate the impact of this exit blocking.

Weekend Validation

Whilst the validation team were not able to improve the site operation noticably during the AM and PM peak periods, they were able to improve the site operation during the weekend. Following reports from the client and retail park representatives weekend validation of SCOOT was carried out on Saturday 24th November from approximately 10:00-14:00. There had been reports of significant queues for traffic exiting the retail park during the weekend peak hours, with these queues 'locking up' the retail car parks.

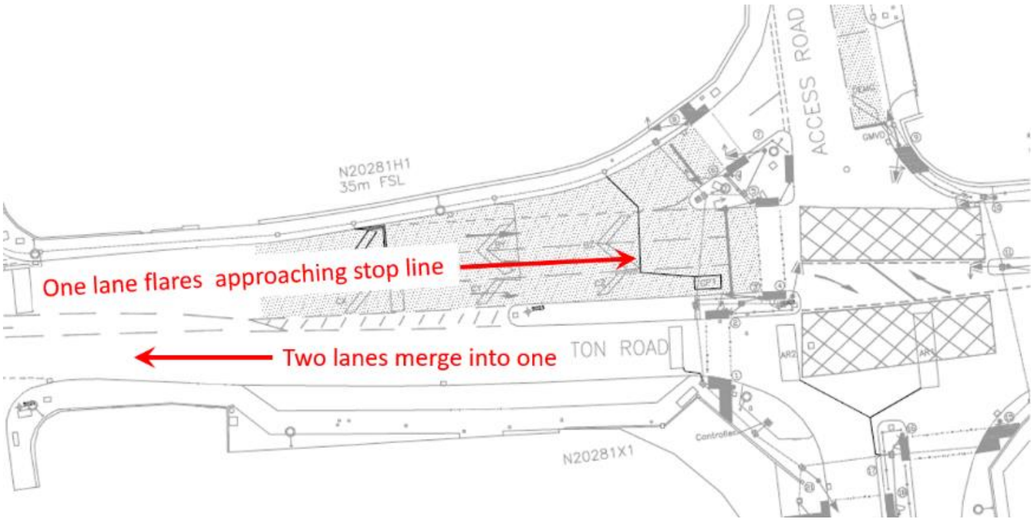


*Figure 4 – A27/Sompting Road western edge merges*

During validation a very rarely used SCOOT setting was found to have been previously set and this was preventing the green time for the retail park extending beyond its minimum green time. The resulting short green times would have previously caused congestion to the retail park during peak shopping times (Saturday and Sunday, Christmas and potentially Easter, maybe bank holiday Mondays). The above setting was amended and further SCOOT validation carried out. This aimed to allow additional green time to the retail park when needed, but not to the detriment of A27 movements. Post the changes made, the worst retail park exit queue was seen to briefly extend back to the mini roundabout in the retail park. The queue never extended to, nor blocked the car parks.

The retail park owners were in consultation with a third party, to provide additional lanes on the park egress, this is believed now no longer required following the validations teams visit to site at the weekend, providing a considerable cost and disruption saving.

Quick wins

Due to the exit blocking witnessed at the site, there is little that can be done in terms of 'quick wins' except making some minor modifications to the traffic signal controllers and the utilisation of some of the newer functionality available within the SCOOT kernel. The implementation a hybrid UTC/MOVA site in the future would give greater flexibility and responsiveness at quiet times.

**<u>Case study 2 – A27 Shoreham Bypass/Old Shoreham Road/Coombes Road</u>**

*Figure 5 – Westbound exit blocking at Sussex Pad*

The A27 Shoreham Bypass (Sussex pad) site is a 4 arm staggered crossroads, adjacent to Shoreham Airport. There are controlled pedestrian crossings over the A27. The junction is particularly busy on all ahead A27 movements, with movements into and out of the side road comparatively quiet. The sites operate MOVA control all day, seven days a week.

At the busiest periods A27 demand flows appear to be able to approach a true, unrestricted saturation flow figure i.e. there could be in the region of 1800 vehicles per hour per lane demand on the busiest lanes and approaches. Eastbound queues extend well to the west of the A27/A2025 roundabout, **Figure 6**. In the evening peak westbound queues can form again, but the site can also experience westbound exit blocking towards the A27/A2025 roundabout, **Figures 5 and 6** refers Eastbound queues are typically short in the evening peak.

Prior to validation activities it was noted that MOVA operation was not consistent - sometimes running too short green times for the traffic present, and sometimes the green time was excessive, up to 160 seconds, meaning unacceptable wait times for other users.


*Figure 6 - Sussex Pad Location Plan (@OpenStreetMap Contributors)*

## Validation and Observations

The site received the highest number of complaints on the Area 4 network due to the green split allocation to the A27 often being too short. Whilst on site, the validation team noted that the reason for this was the number of HGVs which used the site and the gaps which they left between the vehicle in front from a standing start.

The team carried out a detailed detector check at the site and a number of the detectors on the A27 arms links were cross wired. By 'crossing' these detectors in the MOVA dataset and tweaking various validation parameters the team were able to minimise the number of events when MOVA ran too short green times to the A27. Following the implementation of these 'fixes' it was noted that the green time at the site for the stage serving the A27 phases was frequently reaching 160 seconds resulting in unacceptable waiting times for those users not on the A27, this green time was capped to 100 seconds.

## Statistical Analysis

Some simple statistical analysis was performed of the 'before and after' durations of stage 1, to gain further insight into the impact made on site. Stage 1 gives green to both east and westbound A27 ahead movements, the heaviest movements on the site. This analysis is expressed below in the 'box and whisker' plots. Box and whisker plots are explained in **Figure 7.**

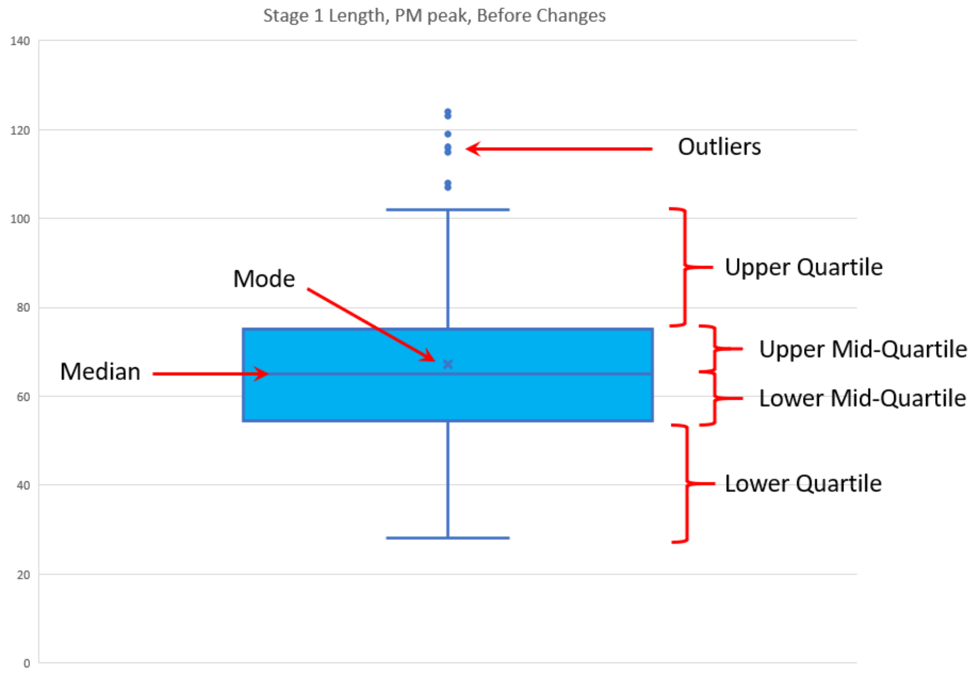


*Figure 7 - Understanding box and whisper plots*

**Figure 8** shows the how stage 1 (A27 phases) operated pre validation activities and post validation. The plots demonstrate a greatly reduced inconsistency in stage duration in the morning peak. The median and mode have also both increased slightly. (The distribution of stage durations is so 'tight' it is not possible to see the quartiles in the 'after changes' situation). Therefore, in the morning peak the main A27 ahead movements have a slightly increased stage duration, which is significantly more consistent in duration.

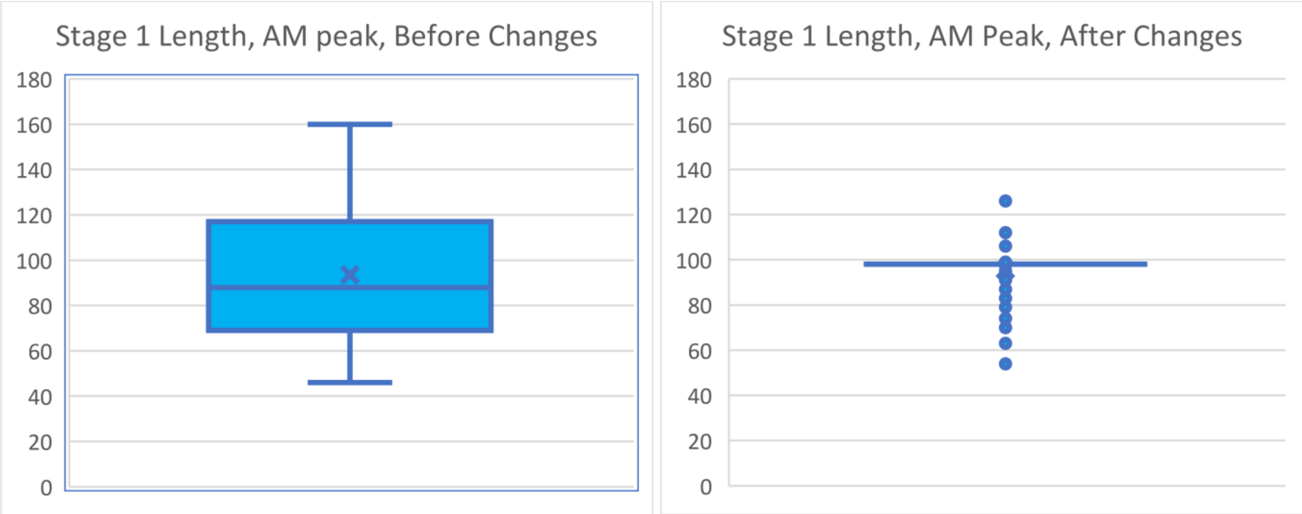


*Figure 8 - Stage 1 durations, AM, before and after*

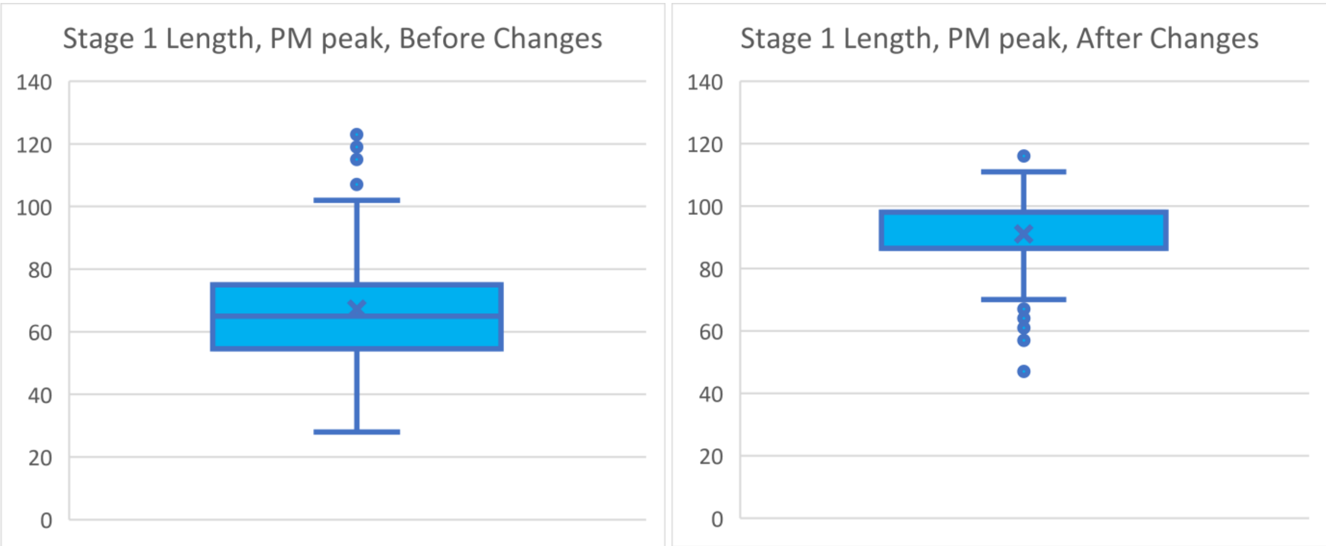


*Figure 9 Stage 1 durations, PM, before and after*

**Figure 9** shows the PM peak pre and post validation. It shows that the distribution of the stage lengths has again greatly reduced in the 'after' situation, demonstrating reduced inconsistency in the evening peak. The median and mode stage duration have both increased significantly. Therefore, in the evening peak the main A27 ahead movements have a significantly increased stage duration, which is more consistent.

Whilst we associate MOVA with variability, the flow in relation to the saturation flow on the A27 means that the junction operates over capacity. At over saturated sites, MOVA provides little additional benefit than fixed time control at the busiest periods. Preventing MOVA from finding end of saturation too early provided a significant improvement in the site operation, as lost time is reduced. In addition, the validation team were able to ensure that road users not on the A27 and pedestrians did not have to wait too long before their demand was served and that they received sufficient green time so that the signals could get back to the A27 as quickly as possible.

The validation has been a success with no known complaints being received following the validation visit as a result of the normal signal operation.

Quick wins

To compliment the validation, work the suggested 'quick wins' use 'every second counts' principles and look at implementing improvements which will help get the signals back to Stage 1 and the A27.

The provision of on-crossing detection would be beneficial to reduce the clearance time following pedestrian movements when possible, this would help reduce lost time at the junction, in turn improving capacity. Further considerations involve trialling minimum green times of 4 -5 seconds on the side roads in off peak conditions which could make the site slightly more reactive, reduce delays on the A27 and may help delay the onset of queues on the A27 in peak periods. Furthermore, the team are looking at the utilisation of above ground detection to implement variable intergreens where they may need to be higher in peak conditions due to exit blocking but are not needed to be so high in off peak conditions.

It may also be possible to consider an innovative and, it is believed, previously untried methodology for controlling and reducing intergreens at the site - Due to its nature, such an approach, if taken forward, should be considered highly innovative and would need careful (and potentially extensive) trialling to prove safe and successful operation. The intergreens at the site, as is typical for such sites, are calculated based on the geometric layout of the site, with further fixed extensions to take into account the potential high speed of vehicles. Under many conditions on site, this can lead to intergreens which are several seconds longer than actually needed to clear vehicles from the conflict areas, leading to inefficiencies. Using a very similar principle to that used by pedestrian on-crossing detection, it is thought possible to utilise cost effective radar or video detectors to monitor the conflict areas. With this, base intergreens could be reduced below those currently used and then using the additional detection extended back to conventional values only when needed. This could release several seconds of previously unused time back to the junction, increasing performance. To prove the safe and successful operation of such an innovative approach, a staged trial would be needed. he team are now developing ideas over how a successful trial of such operation can be safely carried out.

## Case Study 3 – A27 Ashcombe Roundabout

The A27 Ashcombe Roundabout site is a 4 arm roundabout to the west of Lewes, **Figure 10** refers. The A27 eastbound approach and Brighton Road approaches are signalised (along with the conflicting circulatory links). The other approaches are unsignalised. Whilst it has previously operated MOVA, upon arrival the site operated VA control and was monitored via UTC. The site has controlled pedestrian crossings over the A27 on the western side of the roundabout. The site was found to have detector faults, which meant that the site performance was unreactive, and the green times were too long. In the all periods the VA operation in use was considered poor. The detector faults present were causing long green times and the site performance was very unreactive. Some detector performance was found to be intermittent and not necessarily reporting as faults in the controller or MOVA logs, although their performance was incorrect.

Validation and Operation

The validation team looked into why the site was not under MOVA control and further investigations found that the configuration of the Stratos unit was preventing MOVA control from operating, in addition the active MOVA dataset did not represent the latest site layout, following resurfacing and white lining changes. A new MOVA dataset was written and a work-around solution was found that allowed MOVA to operate. As stated there were a number of detector faults present at the site with some detection intermittently sticking on but not sufficiently to report a fault in the controller. As this behaviour was not beneficial to good MOVA operation, this detector was turned on permanently, to ensure MOVA saw its state as faulty and used alternate detectors correctly.

*Figure 10 - A27 Ashcombe Roundabout*

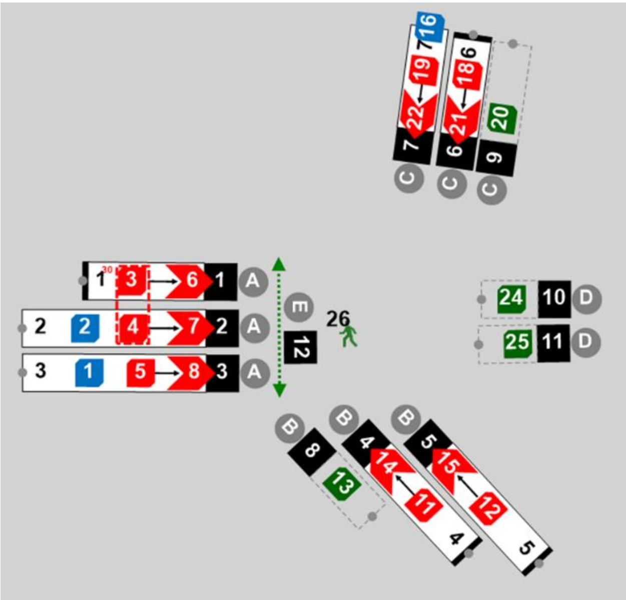

*Figure 11 - A27 Ashcombe MOVA Diagram*

MOVA was able to successfully operate with the relatively high number of detector faults at the site. MOVA correctly worked from each links 'alternate up' or 'alternate down' detectors to determine green times. The site performance was more heavily constrained by the physical position of the detectors than the level of faulty detectors. This is especially true for the X detectors on the A27 which are closer than ideal to the stop line. However, it was possible to configure MOVA to work well with the infrastructure present.

Once MOVA was operational and validation parameters established, every vehicle on a signalised approach cleared the junction within one cycle. The MOVA operation has led to a typical cycle time significantly lower than the fixed VA performance. This reduced cycle time has introduced more inter stages to the site, times when it is easier for vehicles on the unsignalised approaches to enter the roundabout. Consequently, queue lengths on those unsignalised approaches were relatively short. The site performance with MOVA control was found to be highly reactive, quick to respond to changes in traffic conditions and quick to cycle. Given that the site is operating within capacity (with no residual queues) appropriate variation was seen in stage lengths and cycle times. Under the previous VA control, with the faulty detection, fixed stage lengths and inappropriate duration could often be seen. The following comparison timings are shown in 'Box and Whisker' plots shown in **Figures 11, 12, 13, and 14**.

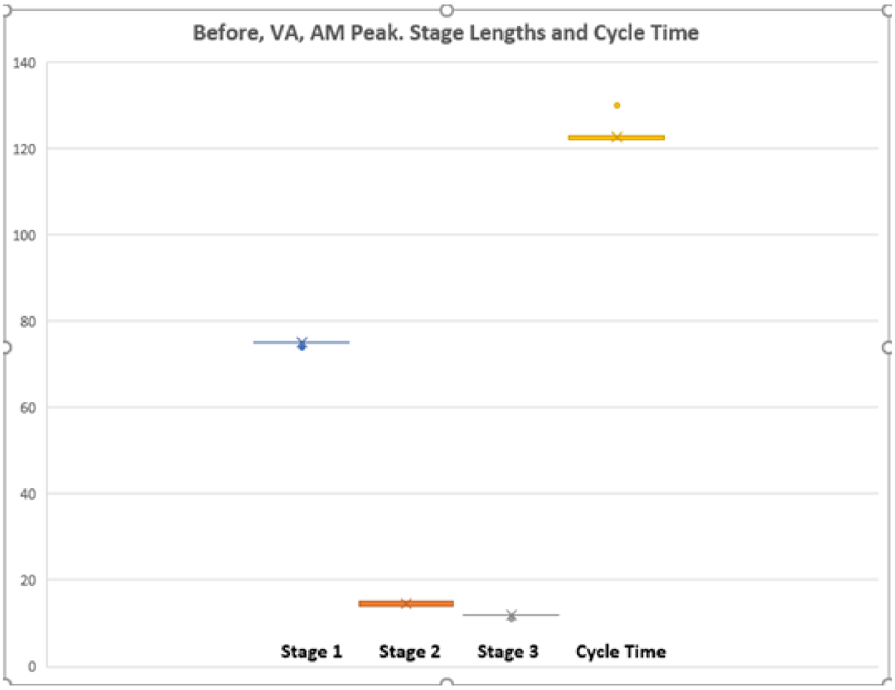


*Figure 11 – Box and Whisker Ashcombe AM peak VA Operation*

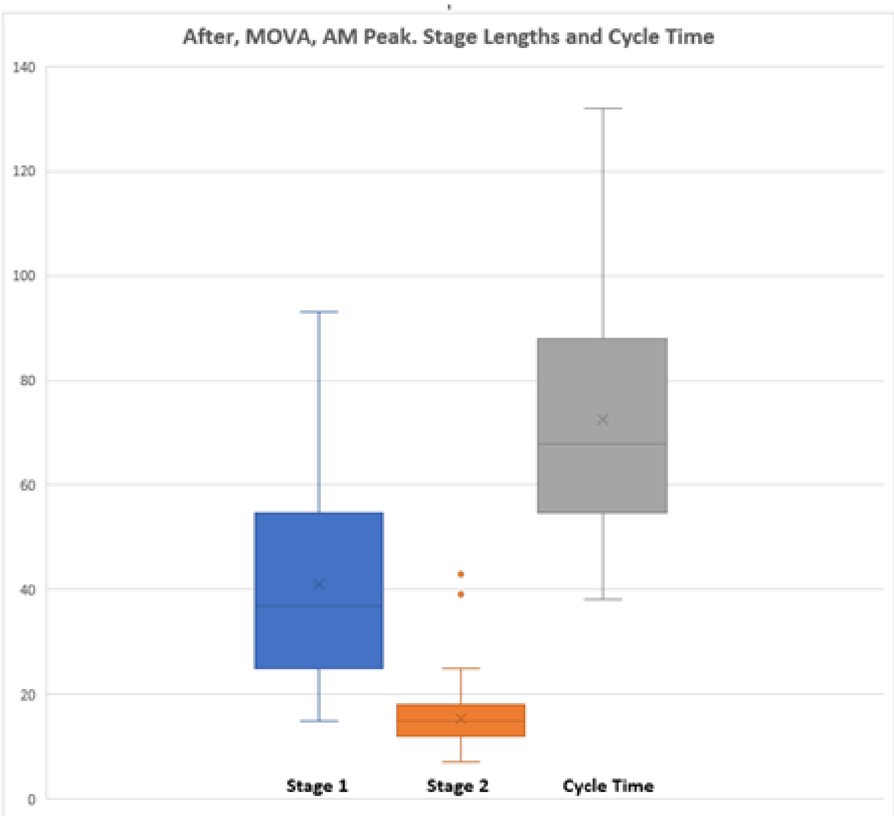


*Figure 12 - Box and Whisker Ashcombe AM peak MOVA Operation*

**Figures 11 and 12** above show the before and after timings for the morning peak. In the before situation, with VA control, fixed stage durations for stages 1, 2 and 3 can be seen, giving a virtually fixed cycle time of 122s. In the after situation, with MOVA control, queue clearance stage 3 was found unnecessary and does not operate. Stages 1 and 2 show much more variation, typically running much shorter green times than VA, but also having maximum durations above VA. The median cycle time is 68s, almost half than on VA, but again shows the ability to operate significantly shorter and longer than this, depending on traffic conditions.

**Figures 13 and 14** show before and after timings for the evening peak and show performance very much like the morning peak: VA control operates virtually as fixed time control, with a fixed 122s cycle time. MOVA shows significantly more variation again, with a median cycle time of 97s and stage durations typically shorter, but with much greater variation, in response to changes in traffic conditions. Again, queue clearance stage 3 was found unnecessary under MOVA control.

As the site was undersaturated the variability in MOVA provided considerable benefits, and the site operation resulted in significantly reduced queueing on both the A27 and in Lewes.

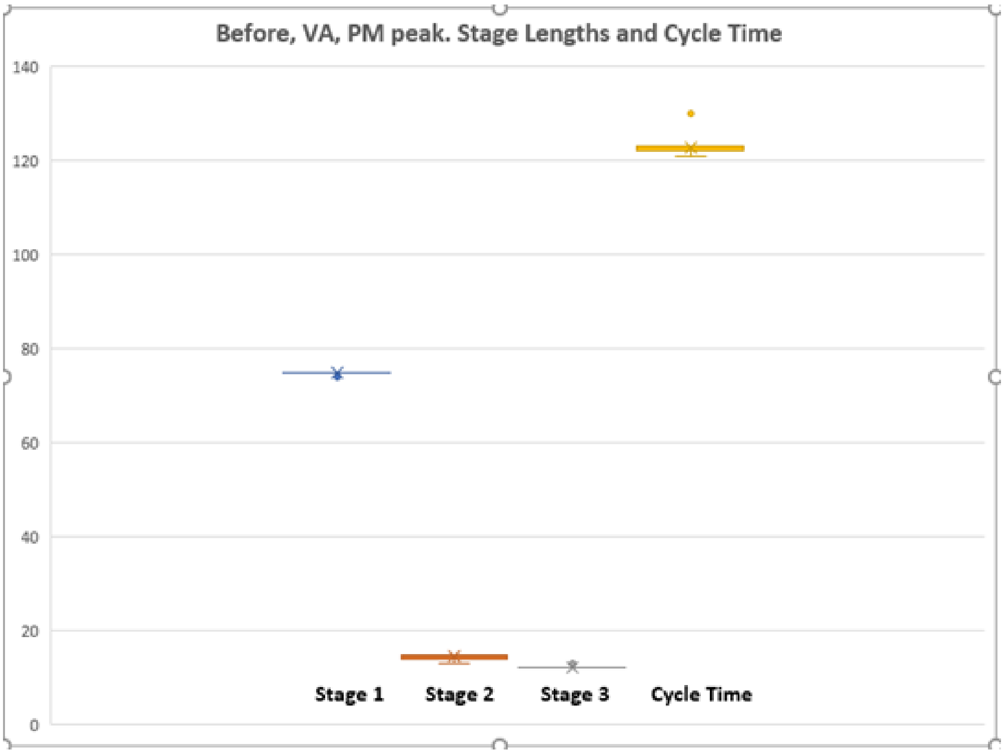


*Figure 13 - Box and Whisker Ashcombe AM peak VA Operation*

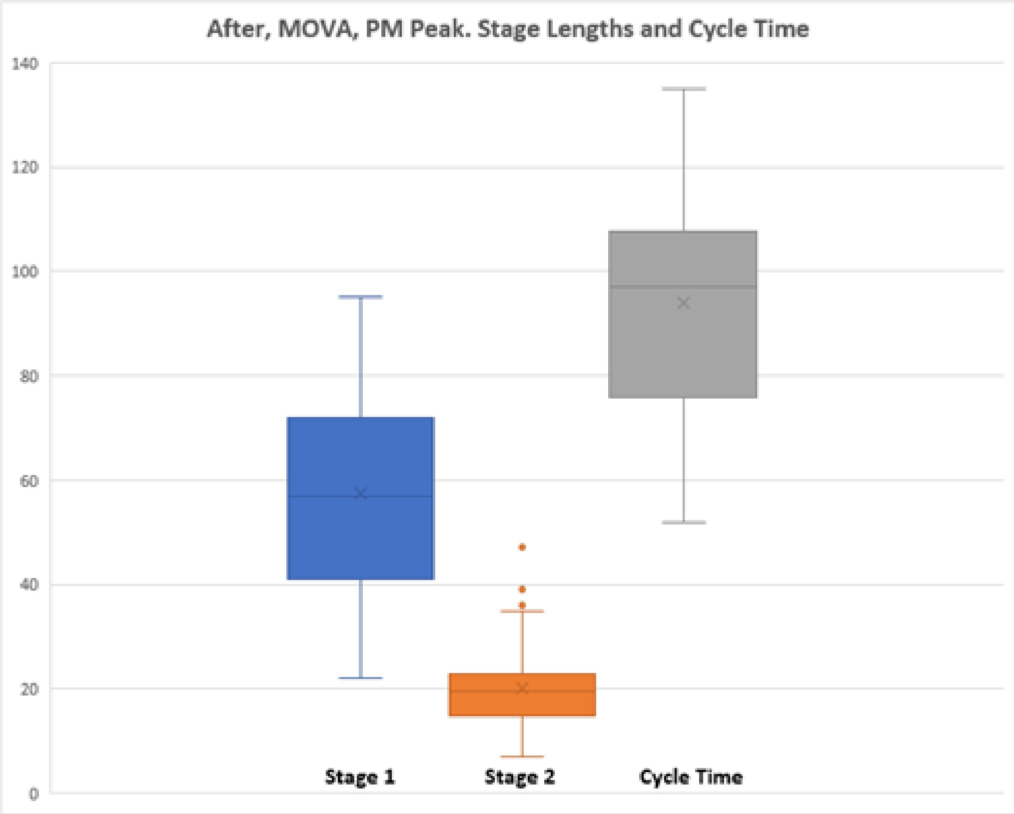


*Figure 14 - Box and Whisker Ashcombe PM peak MOVA Operation*

Quick wins

The only quick win identified at this site was to recut the faulty detection and reposition the detectors to the optimum location if feasible

**Lessons learned**

The lessons learned following the completion of the 2018/2019 validation and optimisation programme are shown below –

- Two person teams using experienced Engineers on site provides considerable benefits. The initial outlay may be more, but the number of repeat visits are minimised as a right first time approach can be adopted proving cost savings in the long term.
- Carrying out validation basics well and ensuring all detection is checked etc can provide considerable performance benefits.
- If there is one working detection on a MOVA link, the use of that detector as an alternative is still considerably better performance wise than VA.
- Carrying out validation activities on a weekend can ensure your network operates to maximum efficiency during all periods.
- If a site is not operating well, and physical improvements are being considered a revalidation completed successfully at the site may provide a considerable cost saving.

**Conclusion**

Following the completion of the 2018/2019 programme, the number of complaints on the network have been reduced from the hundreds, down to only a handful. The 2019/2020 programme is looking to implement the quick win improvements to optimise the site and improve customer journey time further.

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