Simulating and Implementing a SCOOT UTC Strategy for a Planned Event

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A UTC strategy for the SCOOT region within the Surrey town of Esher was developed to improve the management of event traffic during the Hampton Court Palace Flower Show. Following Biora et al. (1995) 'A Best Practice Manual for Innovative UTC Schemes', potential strategies were identified and screened based on the 'Delphi Approach' with four successful strategies tested within an S-Paramics microscopic simulation model emulating SCOOT control. A multi-criteria analysis identified a gating strategy as the most successful event strategy. During the 2008 flower show the gating strategy was successfully implemented. It performed as predicted by the offline modelling, resulting in an improvement to traffic flow. No further interventions were found necessary for the duration of the event.

INTRODUCTION

Event management, the planning, monitoring and implementation of strategies designed to minimise the impact of events on the transport network, has become an important priority for highway authorities both nationwide and overseas.

The UK Traffic Management Act Network Management Duty Guidance states: 'It is important that local traffic authorities promote pro-active co-ordination of the network, adopt a planned, evidence-led approach to known events, and develop contingencies for the unforeseen' [p6: DfT, 2004].

This paper describes the development of a SCOOT (Split Cycle Offset Optimisation technique) UTC (Urban Traffic Control) strategy designed to alleviate problems during the Hampton Court Palace Flower Show within the Surrey town of Esher. The development of an event strategy was achieved through the simulation of UTC within a microsimulation model and was subsequently implemented on-street during the 2008 flower show. Figure 1 presents a map of the key locations described in this paper.

HAMPTON COURT PALACE FLOWER SHOW

Hampton Court Palace Flower Show is an annual event organised by the Royal Horticultural Society (RHS). Sited at Hampton Court Palace in south west London, it is the world's largest annual flower show and takes place in early July over a period of 6 days. On average, 179,000 visitors attend the event each year, approximately 30,000 per day. Although this is an average of only 3,500 vehicles per day, the difficulty is the peaked nature of the flow.

Year on year the show poses a problem in Esher. The advertised route for those who travel to the event from the South or East is via the A244 which passes through the centre of Esher. In 2007, this resulted in an additional 21,000 vehicles travelling through the town during the 6-day event.

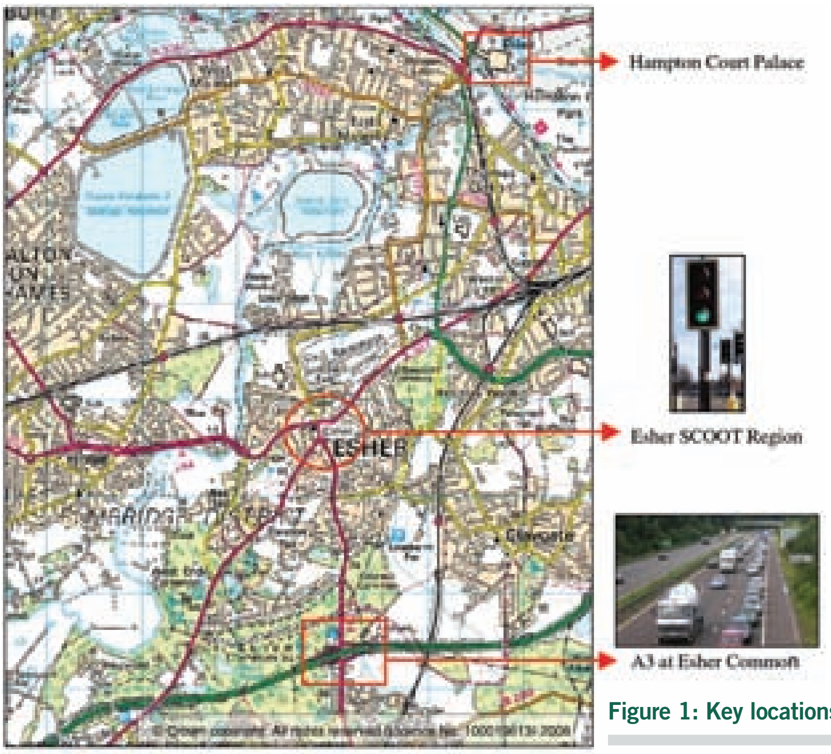

Figure 1: Key locations

Figure 2: Queuing traffic for the A3 northbound off-slip during the 2007 flower show

The main problem is that a queue extends back from the Esher SCOOT region along A244 Claremont and Copsem Lanes over 2 km to the Esher Common grade separated junction with the A3 trunk road. This typically occurs between the hours of 09:00 and 12:00 during weekdays, and is exacerbated when the queue extends onto the A3 northbound off-slip and the A3 mainline, as exhibited in Figure 2. This can result in erratic driver behaviour and dangerous driving conditions for those travelling on the mainline.

Therefore, an event UTC strategy to manage the additional demand entering the town centre from the south was developed. The objective was to prevent the queue from the SCOOT region extending onto the A3 and interrupting the mainline.

Although the A3 is the responsibility of the UK Highway's Agency, the county took the view that the local highway authority should be proactive in addressing the issue in the interest of partnership working.

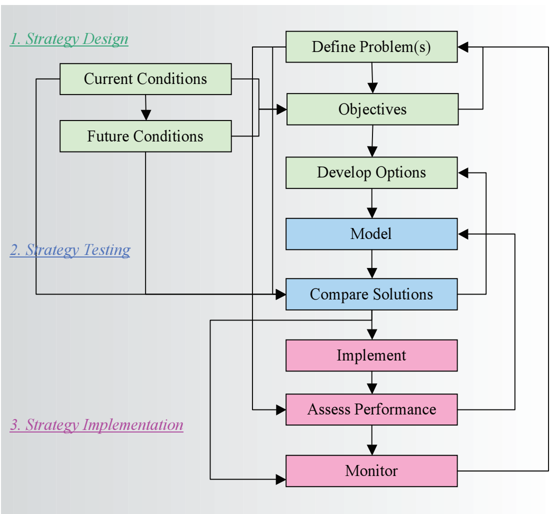

Figure 3: A problem-oriented approach to strategy formulation (adapted from Biora et al., 1995)

The formulation of an event strategy followed the guidance of Biora et al. (1995) in 'A Best Practice Manual for Innovative UTC Schemes', produced as part of the DRIVE II Project V2016: PRIMAVERA. The overall method is shown in Figure 3 and was adapted to be a problem-orientated approach.

STRATEGY DESIGN

The 'Delphi Approach' was adopted for the listing and screening of potential strategies. This approach was applied to provide a list of strategies that may achieve the study objective, filtering the most promising strategies for testing in a traffic model, as outlined below.

A team of experts was identified from a range of complimentary fields, including a UTC engineer, a road safety auditor and a traffic manager. Strategies identified during an anonymous brainstorming exercise were collated and presented in a subsequent meeting. Inevitably, not only UTC strategies were suggested. At the meeting, each idea was discussed openly to enable all team members to express their expert opinions. Evidence of strategies being implemented in other locations and potential application benefits and disbenefits apparent from a literature review were also presented.

Impact variables were agreed and weighted according to what was considered important for the town, the A3, traffic composition and impacts from the event. The team members scored each variable within a range of +2 to -2 to reflect their opinion of importance, with +2 giving the highest importance and -2 the lowest importance. These were averaged to determine the weighting value for each variable.

Air and noise pollution was weighted the highest as Esher is an Air Quality Management Area (AQMA), which was closely followed by safety given the event driving conditions. Both driver comfort/stress and vehicle operating cost (VOC) were viewed as unimportant for the objective and received negative weightings. Notably, travel time for commercial and local users was regarded with greater significance than travel time for event users.

Each member then scored ±2 for every impact variable against each proposed strategy, with +2 giving the greatest benefit and -2 the least benefit. The average of these scores was multiplied by the corresponding impact variable, with all weighted scores summed to provide an overall total score. Table 1 presents a summary of the total weighted scores for each strategy together with their ranks.

The UTC strategies that received positive scores from the Delphi screening were taken forward to be simulated within the model. These were:

- Gating strategy;
- Improve SCOOT's ability to 'see' and manage congestion;
- Forced and held greens; and
- Shorter cycle times.

STRATEGY TESTING

The model's development, interrogation and strategy testing followed the Biora et al. (1995) simulation procedure depicted as a flow diagram in Figure 4. Biora et al. (1995, p20) also stated that the overall objectives of an offline evaluation are to:

- Conduct an operational analysis of the performance of the strategy;
- Allow a first tuning of the parameters of the strategy; and
- Allow a comparison of different strategies in repeatable and known traffic conditions.

SCOOTLINK

The S-Paramics microscopic simulation modelling program, developed by SIAS Ltd, was used together with a SCOOT alpha holding UTC. The SCOOT alpha and S-Paramics communicated via a simple network management protocol (SNMP) administered by SCOOTLink. This advanced control interface, jointly developed by SIAS Ltd and Siemens, facilitates two-way synchronised communication, enabling on-street SCOOT control to be mirrored within a microsimulation environment, as shown diagrammatically in Figure 5.

Model Development

The model period was determined as 07:30 to 12:00 to encompass:

- Normal traffic flow conditions prior to the need for the event strategy;
- Event traffic flow conditions (the time at which event conditions developed and prevailed); and
- The return to normal traffic flow conditions (the recovery).

Consequently, any unforeseen impact on the highway network that may have occurred during the transition between normal and event strategy was apparent. This also enabled the operation of the strategy to be assessed throughout its deployment.

Traffic data was an important element of the study and was collated for base conditions (pre-event) and during the 2007 flower show to fulfil the following objectives:

- Facilitate comparative analysis;
- Understand the changes in demand and traffic behaviour resulting from the event;
- Identify the traffic problems generated by the event;
- Comprehend the changes required to the existing UTC strategy, and hence assist with the design of an event strategy; and
- Provide traffic data for input, and to calibrate and validate the traffic model. In this instance, non-event traffic flow data was used to validate the model.

The model encapsulated the entire SCOOT region and extended to the A3 in the south. The base model output met local model validation criteria and competently reflected observed conditions which made it a suitable tool for testing event strategies. The model output and visualisation assisted in the understanding of SCOOT's operation on-street and its response to event demand.

Strategy Development

The development of each strategy involved an iterative process of defining, simulating and evaluating individual parameters, making best use of model and SCOOT visualisation and output. The final optimum design was either where the objective had been met satisfactorily, or it was felt that the objective could not be met, and the best configuration had been presented.

Strategy	Score	Rank
Gating strategy	3.141	1
Improve SCOOT's ability to 'see' and manage congestion	1.986	2
Use A3 hardshoulder for those exiting at Esher Common	1.786	3
Cone off lane 1 A3 northbound for those exiting at Esher Common	1.642	4
Forced and held greens	1.506	5
Warning signage	1.190	6
Shorter cycle times	0.510	7
Police control	-0.155	8
Two right turning lanes from Claremont Lane to High Street	-0.327	9
Maximum capacity flow - extended greens	-1.156	10
Longer cycle times	-1.293	11
Negative offset - reverse green waves	-3.102	12
Green waves	-4.228	13

Table 1:
Screened strategies and scores with modelled UTC strategies highlighted in red

The model was used to determine the optimum signal timing parameters. For example the optimum trigger and reduced green time for gated links were determined in the model. The 'improve SCOOT's ability to "see" and manage congestion strategy' investigated the shortcomings of existing detector location. More appropriate SCOOT detector locations were trialled in the model as well as various green split weightings via SCOOT congestion importance factors. Similarly, the ideal network conditions to operate the more evasive strategy of forced and held greens were determined using the model visualisation and various lengths of held green time were tested. A range of cycle times was also tested in the model for the shorter cycle time strategy. This optimisation of parameters was a quick process aided by the controlled and interactive model environment in which SCOOT was operational.

MULTI-CRITERIA ANALYSIS

A multi-criteria analysis (MCA) was performed on the final design of each strategy to target the analysis and overcome the limitations of the standard practice of cost benefit analysis.

Thus, a MCA was developed based on the impact variables considered important to the local area and

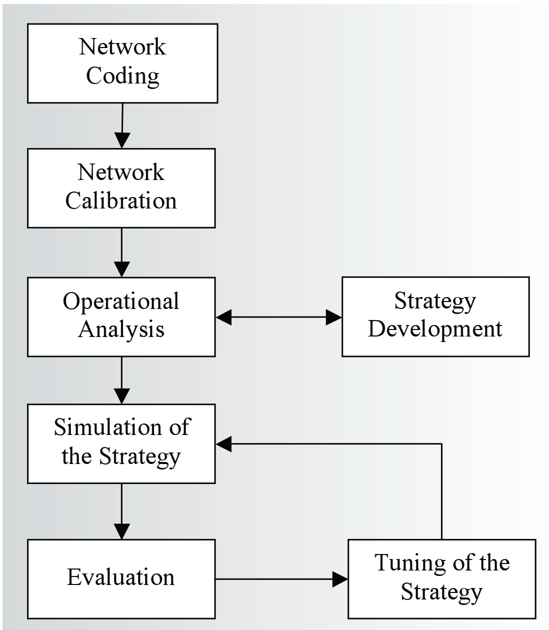

Figure 4:
The simulation process (Biora et al., 1995)

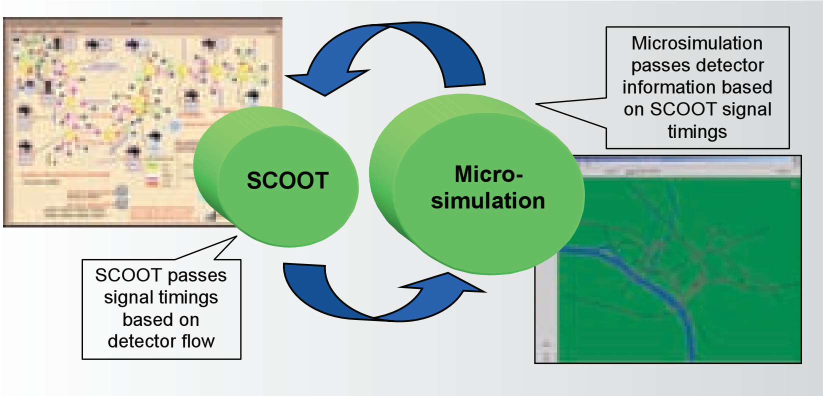

Figure 5: SCOOTLink

event users determined during the initial strategy design stage. For each impact variable an assessment was devised, as described in Table 2.

The MCA provided a comparison for those 5 days each year when the strategy would be required to prevent vehicles from queuing on the A3 mainline between 08:00 and 12:00. All results were an average of multiple runs following the approach described by Seaman (2006).

THE GATING STRATEGY

The MCA identified the gating strategy as the most beneficial. In the model it continuously met the objective to prevent the queue from Esher town centre extending onto the A3 mainline.

Gating controls the flow of traffic into a region by temporarily prioritising certain links and the demotion of others once a certain level of saturation and/or congestion has been attained. This strategy was designed to provide more green time to the A244 Claremont Lane entry link which receives traffic from the A3. In return, the green time for the opposing entry link, the A307 Portsmouth Road, was reduced. The strategy was triggered in SCOOT when the congestion level on the A244 Claremont Lane reached a critical level; this was determined from the model to be a threshold of 10%. As a result, part of the queue length along the A244 Claremont Lane was relocated to the A307 Portsmouth Road. This is a more appropriate location for queue storage as the next major upstream junction is situated more than 5km from the SCOOT region.

Furthermore, the model enabled the scope of the strategy to be quickly assessed. This was beneficial because improving the route could induce further trips. Subsequent testing indicated that the gating strategy could accommodate a 6% increase in demand. Past this point, a more evasive strategy, such as forced & held greens may be required together with the gating strategy.

Table 2: Indicators for the multi-criteria analysis of the strategies

Impact Variable and Weighting		Indicators	
		Measure	Units
Air pollution	1.944	Levels of different pollutants within the modelled network between 08:00 and 12:00: - Carbon Monoxide - Carbon Dioxide - Total Hydrocarbons - Oxides of Nitrogen - Particulate Matter	Grams (g)
Safety	1.667	Average maximum number of unreleased vehicles on the A244 Copsem Lane, 08:00 – 12:00. This was used as a proxy; any unreleased vehicles would exit-block the Esher Common grade separated junction that could result in the queue extending onto the A3 mainline and thus would not meet the strategy objective.	Vehicles
Travel time for all users	0.917	Cost of the total journey time for all vehicles that travel through the network, 08:00 - 12:00.	£
Mode choice	1.000	Qualitative assessment	n/a
Mitigating measures cost	0.444	Estimated cost of the implementation of the strategy.	£
Pedestrian & cyclist comfort/stress	0.111	Qualitative assessment	n/a
Driver comfort/stress	-0.467	Ratio of reliability (DfT, 2003) = $\frac{\textit{Value of Standard Deviation of Travel Time}}{\textit{Value of Travel Time}}$	n/a
VOC	-1.778	Fuel and non-fuel cost between 08:00 and 12:00	£

STRATEGY IMPLEMENTATION

As stated by Biora et al. (1995, p28), despite advance planning and simulation, the on-street implementation of new techniques will produce some unforeseen problems, because:

- Equipment may perform differently in the uncontrolled on-street environment;
- A model is never a perfect copy of real life; and
- On-street trials involve real vehicles and people, and thus can concentrate the mind in a manner that probably could never be accomplished with models.

Although the UTC strategy has been designed to better manage event traffic, it was trialled on-street prior to the event during a typical AM peak to expose any potential weaknesses and to assess driver response to restricting green time for certain phases. This also provided an opportunity to alter the strategy, although this was not required in this case.

As determined by the model, the event UTC strategy was activated between 08:00 and 12:00 hours from Tuesday 8th July through to Saturday 12th July during the 2008 show. The strategy was only triggered in SCOOT during these times when the congestion level on a critical link exceeded a preset threshold. On average, this occurred approximately one out of every two cycles.

The event strategy was managed from Surrey County Council's Network Management and Information Centre (NMIC) in Leatherhead. Its operation was continuously monitored via SCOOT messages and through links to Surrey Police CCTV in Esher town centre and CCTV provided by the Highways Agency at the A3 Esher Common interchange.

In the event of the strategy causing an unanticipated adverse effect on the highway network the UTC strategy would have been returned to that which is run every day within Esher and in previous years during the flower show. This, however, was not required and the strategy objective to prevent the queue from Esher town centre along the A244 Claremont and Copsem Lanes extending onto the A3 mainline was achieved. Furthermore, no alterations were required to the modelled strategy throughout its deployment on-street. It performed as predicted by the offline modelling and no further interventions were found necessary for the duration of the 2008 show.

During its employment, Surrey County Council received no public correspondence regarding the operation of the affected traffic signals or congestion within the study area. The assumption has therefore been made that the UTC strategy, which restricted traffic flow from A307 Portsmouth Road south into Esher town centre, was not sufficiently severe or noticeable that members of the public felt the need to communicate a problem.

The success of the strategy is reflected in Figure 6 which compares vehicle speeds observed during Wednesday, the second day of the show, in 2007 and 2008. The vehicle speeds have been obtained from an inductive loop situated on the exit slip for the A3 northbound at Esher Common (HA, 2008). It has been assumed that there was no queuing on the exit slip when the speed rose above 40mph. Between 20mph and 40mph indicates that there was a small queue on the slip road of less than half its length. Finally, it has been assumed that there was a substantial queue along the exit slip when vehicle speeds fall below 20mph. These assumptions have been verified through CCTV.

There is a profound difference between the two graphs; Figure 6 shows that speeds on the exit slip were considerably greater in 2008 compared with 2007. CCTV at the time verified that there was queuing on the slip road between 10:00 and 12:00 in 2008 but it did not reach the mainline unlike in 2007. In 2007, between 07:00 and 13:00, more than 1300 vehicles recorded a speed less than 20mph; in 2008 this was reduced to just over 200 vehicles. Moreover, similar traffic flows were experienced during both years.

In comparison, vehicle speeds on the slip-road average 50mph on a typical weekday during the same period of time with very little or no queuing.

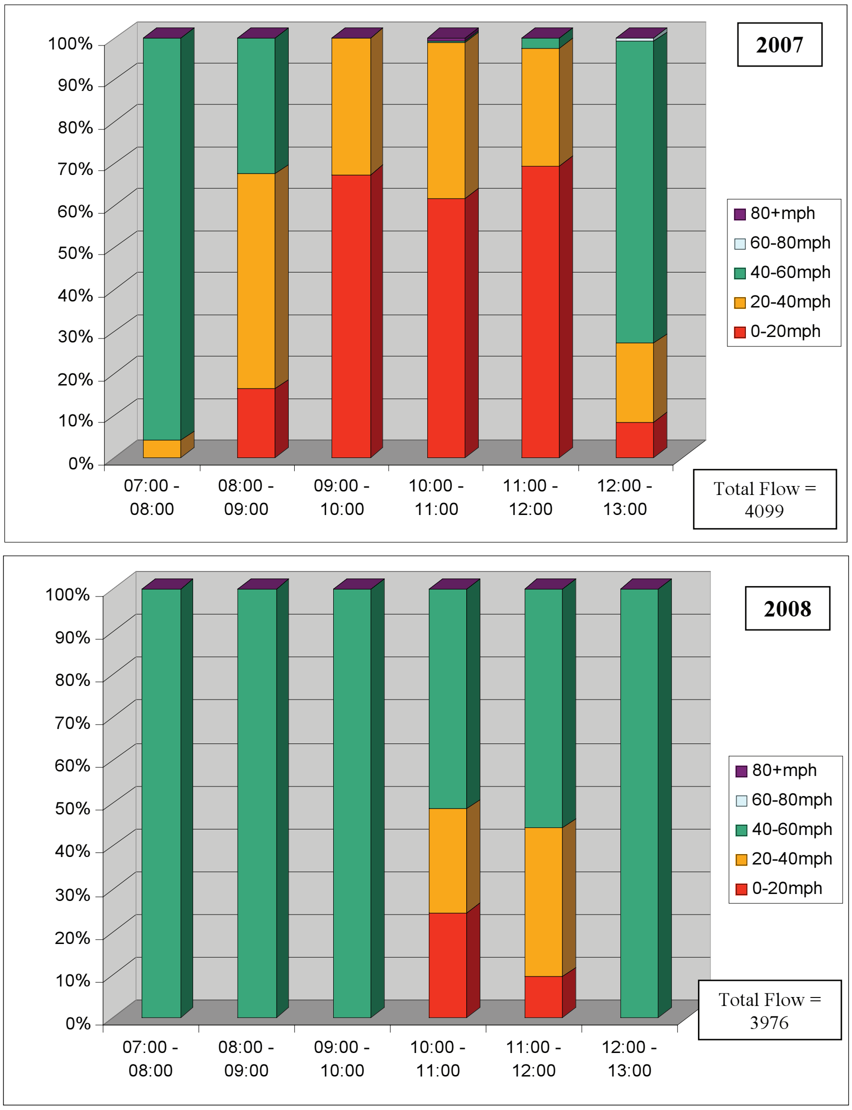

Figure 6: Vehicle speeds at A3 northbound exit slip at Esher Common on Wednesday, the 2nd day of the show in 2007 and 2008 (HA, 2008)

FURTHER APPLICATION

Due to the event strategy's success in 2008, it is aimed for it to be employed during future RHS flower shows at Hampton Court Palace.

Similar problems also occur during large events held at Sandown Racecourse situated within Esher. Consequently, the strategy is available for use during other events that create similar problems. This includes an unplanned incident on the A3 which would result in the closure of the northbound carriageway and traffic being diverted through the town. Hence, specifically designing the strategy for a planned event has provided the necessary data and opportunity to develop and test strategies within a controlled environment for unplanned events.

CONCLUDING REMARKS

One of the greatest advantages of testing strategies in a microsimulation environment was the ability to observe and assess its effects on the entire network at any one time through its visualisation. This simultaneous view cannot be achieved on-street across a series of signalised junctions, and reliance is placed on SCOOT's estimation of the network state. Hence this led to a quick dismissal of forms of strategies that did not meet the objective or displayed great disbenefit to the network. This also enabled several strategies to be developed and tested quickly within a controlled environment, which would not have been attainable if the same strategies had been trialled on-street during the same period of time, with or without event conditions.

Furthermore, the assessment provided vast scope in the evaluation by visual and numerical means provided by both SCOOT and the model, and without any disruption to the real transport network. This also created an environment that enabled more radical strategies to be developed.

A good understanding, however, was required of both SCOOT and the microsimulation program. If resources permit, much benefit can result from partnership working. In this study, confidence and understanding was gained through the testing of different strategies in the model, which transpired to on-street implementation.

SCOOT received perfect vehicle presence measurements from the model. Hence, this 100% acquisition of vehicle measurements was unrealistic, particularly in congested conditions. For example, Quinn and Topp (1990) found that SCOOT underestimated vehicles during highly congested conditions because in these conditions the tail of the leading vehicle sometimes fails to clear the detector before the front of the following vehicle arrived at the detector installation. In this study there was an average difference of 5% between detectors and manual counts, with underestimation present on congested links such as A244 Claremont Lane. Moreover, town centres are prone to vehicles obstructing the carriageway due to unloading and parking, which can affect both throughput and flow predictions particularly when parked over the detector. These 'natural' inadequacies, together with imperfect simulation of arrival profiles, have not been reflected in the microsimulation model. Therefore, it is likely that SCOOT manages event conditions better within the model than it can on-street. This was borne out when the modelled strategy was implemented on-street.

This study, which aimed to improve the management of event traffic during the RHS Hampton Court Palace Flower Show, has illustrated the ability to simulate UTC strategies within microsimulation models as part of an event management process. The strategy performed successfully as predicted by the offline modelling and no further interventions were found necessary for the duration of the event.

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ACKNOWLEDGEMENTS

We would like to acknowledge the assistance provided by the Royal Horticultural Society, Surrey Police and the Highways Agency.

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