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The SCATS and the environment study: introduction and preliminary results

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Abstract

This paper introduces a running study titled 'SCATS and the environment' (SatE) by the Roads and Traffic Authority of New South Wales (RTA) (NSW). (SCATS is a comprehensive traffic management system that provides adaptive traffic control, amongst other functionality. SCATS is used in all states of Australia, in New Zealand, and in many cities, internationally.) The SatE study is tasked to rigorously demonstrate the transport, environmental and economic value that the SCATS installation provides to the people of NSW. We identify that the study is required to be realistic and representative to real world SCATS operation to ensure that results are defensible. We show how this stringent requirement has motivated the development of a novel: (1) study experimental design, (2) model verification, (3) scenario calibration and (4) study validation – which all focus on achieving appropriate traffic control operation. We describe how the study demonstrates the novel use of travel time estimations from vehicle electronic tag measurements. We present the current, preliminary results of the demonstrated performance of SCATS in modelled traffic and environment terms. This paper provides a novel insight for managers, operators and stakeholders of SCATS (and other sophisticated traffic control systems–generally) on the technique and results from a comprehensive study that investigates the value derived from automated traffic control.

1. Introduction

This paper explains the current status and provides the preliminary results from a running study titled 'SCATS and the environment' (SatE) by the Roads and Traffic Authority of New South Wales (RTA) (NSW).

SCATS is an area wide traffic management system developed by the RTA (RTA 2011a; Chong-White et al 2011). SCATS is currently used in 42 countries and 142 cities around the world.

The RTA manages the majority of the motorways and arterial roads across NSW, including some approximately 3500 SCATS signal controlled sites.

The SatE study is tasked to rigorously demonstrate the transport, environmental and economic value that the SCATS installation provides to the people of NSW. The study is required to be realistic and representative to real world SCATS operation to ensure that results are defensible (see Chong-White et al 2011 for background to the SatE study.)

The paper explains the SatE study study process as a structured workflow, and the study results as the modelled traffic and environment performance. It also describes how the SatE study demonstrates the novel use of travel time estimations from vehicle electronic tag measurements for model calibration purposes.

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2. Study process

We will explain the SatE study process using the following work flow:

1. Study experimental design – designing the model, runs and scenarios;
2. Model verification – verifying the modelled road network and traffic infrastructure;
3. Scenario calibration – calibrating the base scenario; and
4. Study validation – validating the study is realistic and representative.

However, before discussing that work flow we will first explain the study evolution – to provide background.

2.1 Study evolution

The SatE Study has evolved through a number of iterations (see Chong-White 2011 for details of the evolution of the study). Two different traffic simulation applications have been used to develop the traffic models that underpin the study. The road network scope of the models has also evolved through the course of the study; however, all models cover – to varying degrees – the Military Road / Spit Road (MRSR) corridor in Sydney. The MRSR corridor is a critical access route between the north east of Sydney that connects the North Shore to the central business district (Chong-White, Millar, Johnson and Shaw 2011).

The project commenced with a Pilot study. The Pilot study used an existing RTA traffic model – that was developed in the traffic simulator – Quadstone Paramics (Quadstone Paramics Ltd. 2011). That stage concluded with a finding that the results were inappropriate due to a number of reasons but particularly that the experimental design was considered inadequate to defensibly analyse traffic control results. Accordingly, a number of recommendations were given that steered the next stage (refer to Chong-White, Millar, Johnson and Shaw 2011 for a summary of the recommendations).

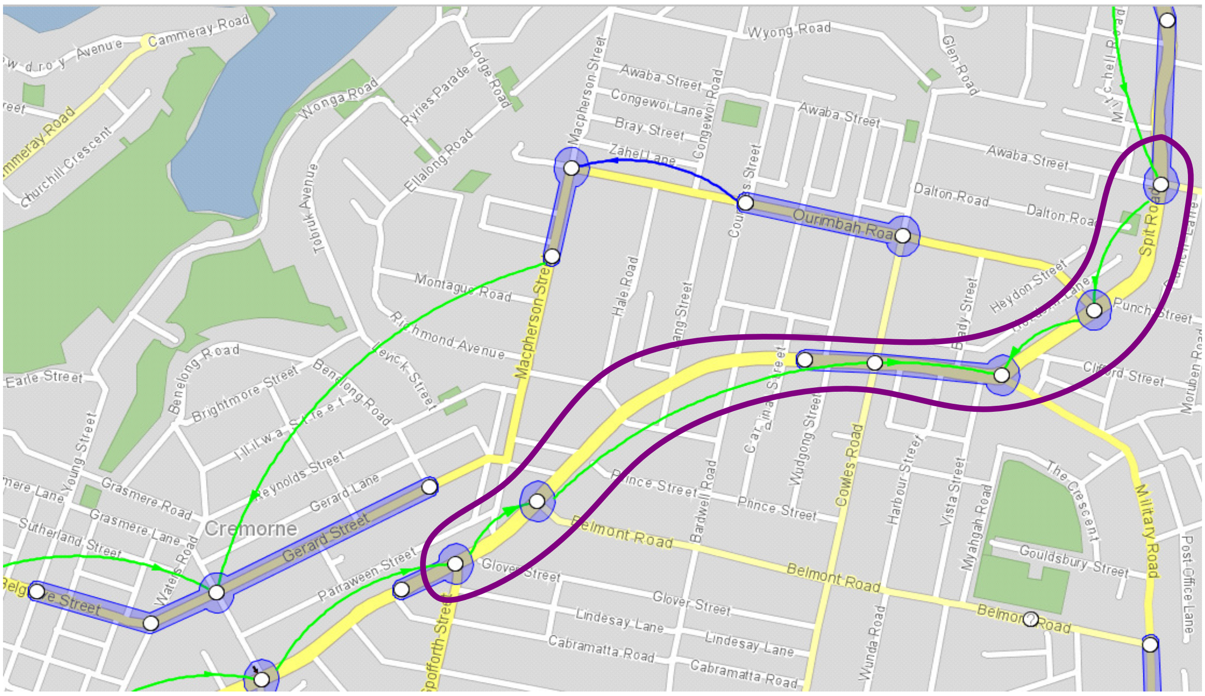
The response to the Pilot study recommendations led to the creation of a new traffic model and novel experimental design that was specifically targeted at the analysis of the traffic, environmental and economic performance that was derived from the operation of the NSW SCATS installation. The new traffic model was developed using the traffic simulator – Azalient Commuter (Azalient 2011).

The current project is termed the Main study and comprises of two phases. Phase 1 of the Main study simulates a small section of the MRSR corridor that includes 7 SCATS intersections. Phase 2 is currently at the development stage and will simulate a larger section of MRSR corridor that includes 21 SCATS intersections. This paper reports on the Main study - phase 1.

2.2 Study experimental design

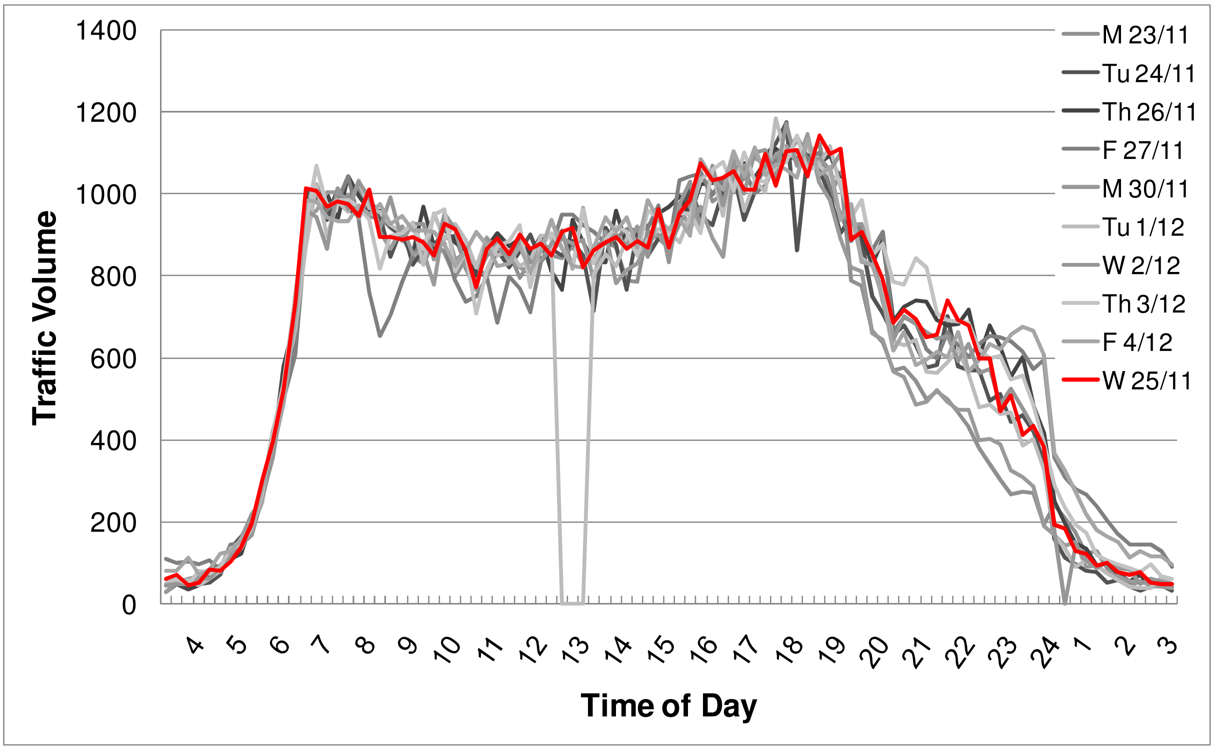
Phase 1 of the Main study saw the creation of a traffic model consisting of 7 SCATS-traffic controlled intersections located in the MRSR corridor, using the Commuter traffic simulator (Azalient 2011). The MRSR corridor is the enclosed region shown in Figure 1. This model models a linear (or corridor) road network, with no modelled parallel routes and therefore no route choice. The modest scope was intended to “start small” to first develop and prove an appropriate experimental design, before embarking on the analysis of a more complicated and broader traffic problem. In contrast, the model used in the Pilot study was a 34 intersection, network model with route choice; and phase 2 is using a 21 intersection, linear model.

Figure 1: Model area of the 7 intersection model from the Main study - phase 1



The Main study model used a 24 hour period – from 0300 on the Wednesday 25 November 2009 to 0300 26 November 2009 – as the calibration day. The choice of that day was made based on an analysis of the flow profiles across a two week period taken from SCATS detector data, as shown in Figure 2. The 24 hour model starting and ending at 0300 aims to minimise the artificial edge effects of starting SCATS and to ensure the full spectrum of traffic demand dynamics and transport outcomes are considered (Chong-White 2011).

Figure 2. Two week of surveyed diurnal traffic flow profiles highlighting calibration day choice



The aim of the study was to demonstrate the value that the SCATS installation provided on the calibration day. In terms of the experimental design, this required the development of a base scenario that reproduced what occurred in the real world on that calibration day to the highest accuracy possible, given resources and constraints. The SatE study operates the SCATS installation – in terms of software executables and traffic control configuration – within traffic simulation. This operation is provided using the SCATSIM facility (RTA 2011, Chong-White, Millar and Johnson 2010) that allows SCATS controller software to interface directly to a SCATSIM-compliant traffic simulator.

By using the real adaptive traffic control system (in this case, SCATS), the need to imitate the control system behaviour in simulation is removed. Only simulation of the road network and road users is required. This ensures accuracy of control decision-making within the simulated world. However, when using SCATSIM, there remains the considerable challenge of ensuring the modelling experimental design considers the intricacies of the relevant SCATS installation (Chong-White, Millar and Johnson 2010).

2.2.1 Design of scenarios

The base scenario implements SCATS with a SCATS operating mode – called Masterlink – that was used on the calibration day. Masterlink provides the full adaptive signal control capability of SCATS. This is referred to as the base scenario or simply ML1 in this paper, where 'ML' refers to 'modelled'. Empirical results are labelled observed or simply, RW1, where 'RL' refers to 'real world'.

A key question that faced the SatE project was how to determine an appropriate method to defensibly articulate 'SCATS operational value', i.e. "how can we show the value that SCATS operation is providing today?" This question drew much discussion by project stakeholders.

The project team eventually concluded (in the later stage of the study) to use the configured fallback mode of the SCATS installation as a valid 'contrary' traffic control policy for comparison to normal SCATS operation. This will be referred to as the contrary scenario or simply FB1 in this paper. The SCATS fallback mode is often configured to operate when there is a systems fault, e.g. communications break between the controller and regional computer. The fallback mode is a simplistic form of adaptive traffic control – compared to normal SCATS operation. The fallback mode can often have fixed time characteristics that are triggered by day and time of day – but also some level of local adaptive traffic control behaviour that responds in real-time to detector measurements. Different sites may have different fallback characteristics based on the local conditions and constraints, i.e. some sites have no fixed time plans and are only locally adaptive. The fallback mode including fixed time plans are maintained by RTA Network Operations. This modelling choice to use the fallback mode as a contrary scenario means that normal SCATS operation was compared to an alternative, maintained and relied upon, traffic control policy Chong-White et al 2011. The fallback scenario can be considered an indicative of the capability of a semi-adaptive, fixed time traffic control system.

2.3 Model verification

The term model verification – as used in this paper – means verifying that the static aspects of the model are appropriate for the aims of the study. The static aspects are parameters that are defined in advance of running the model, i.e. the simulator inputs. Static aspects include: the modelled road network and traffic infrastructure; the configurations of the simulation including the mappings between the simulator and SCATSIM interface and the assumptions coded into the properties of the simulator for the purposes of the model. For practical reasons, this assessment is usually made in advance of obtaining modelling results.

The SatE model was developed using aerial photographs, site drawings and intersection layout schematics taken from the SCATS installation. The overlaying of the aerial photographs on the model itself provides a qualitative verification of the spatial dimensions of the modelled road network. The requirement to map the SCATS configuration to modelled detectors and signal groups provides another implicit verification.

A review of the corridor – that included site inspection – was undertaken to record traffic management policies, which included investigating matters associated with: parking lanes, barred turns, high occupancy vehicle (HOV) lanes (known as T3 lanes in NSW), bus lanes, reversible lanes, bridge openings (Spit Bridge opens blocking traffic to allow tall yachts to pass through), turning movements and turn bays. When developing the Main study, it was found that the time-of-day HOV lane restrictions were strongly influential to the modelled traffic performance outcomes.

2.4 Scenario calibration

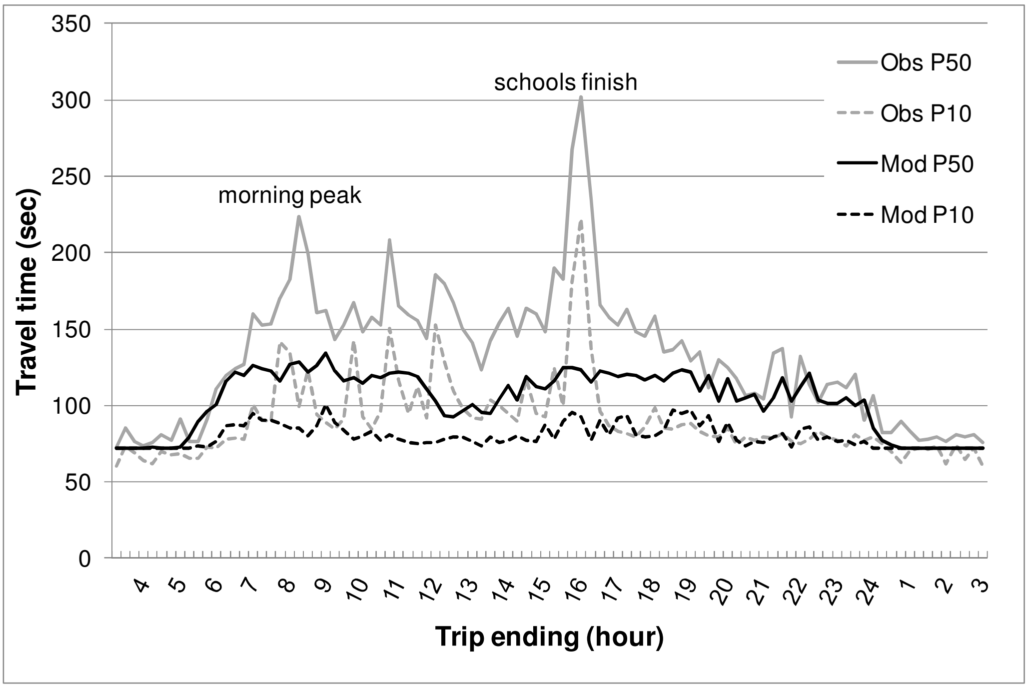
The calibration of the base scenario to the calibration day is critical to the defensibility of the study results. The quality of calibration indicates the level of realism and representativeness achieved, and hence, the level of relevance the results pose for the influence of policy matters concerning the SCATS installation.

2.4.1 Calibrating traffic performance outcomes

The MRSR corridor was previously instrumented by the RTA with electronic tag readers at select locations for traffic travelling inbound towards the city. These instruments read a select type of electronic tag that drivers install in their vehicles to be used for tolling purposes on other NSW routes. The tag readings can be interpreted to provide detailed estimations of the travel time of individual vehicles. This provided the SatE study with a rich source of travel time data.

For calibration purpose, the distributions of the observed travel times measured in the real world were then compared to the travel times measured at equivalent locations within the model. Figure 3 demonstrates the 10th and 50th (median) percentile travel times that were estimated from electronic tag measurements and modelled each 15 minutes over the model duration. The 10th percentile (compared to the median) trend-line could be considered the 'leading edge' – a shorter travel time and fast average speed – that is less influenced by measured trips where the vehicle may have stopped on route, e.g. parking to stop at shops or schools. However, the correlation in peaks with both real-world observed trend-lines, e.g. 'school finish' time, suggests that there is a congestion component that is perturbing the travel time of the broad traffic distribution.

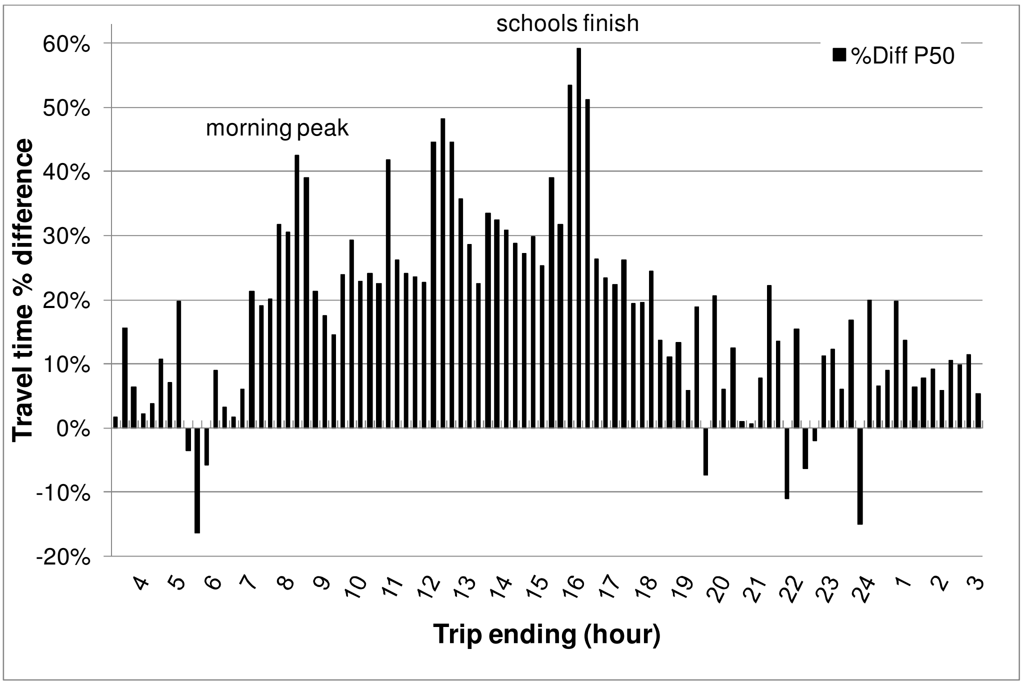
Figure 3: Plots of observed and modelled percentile travel times

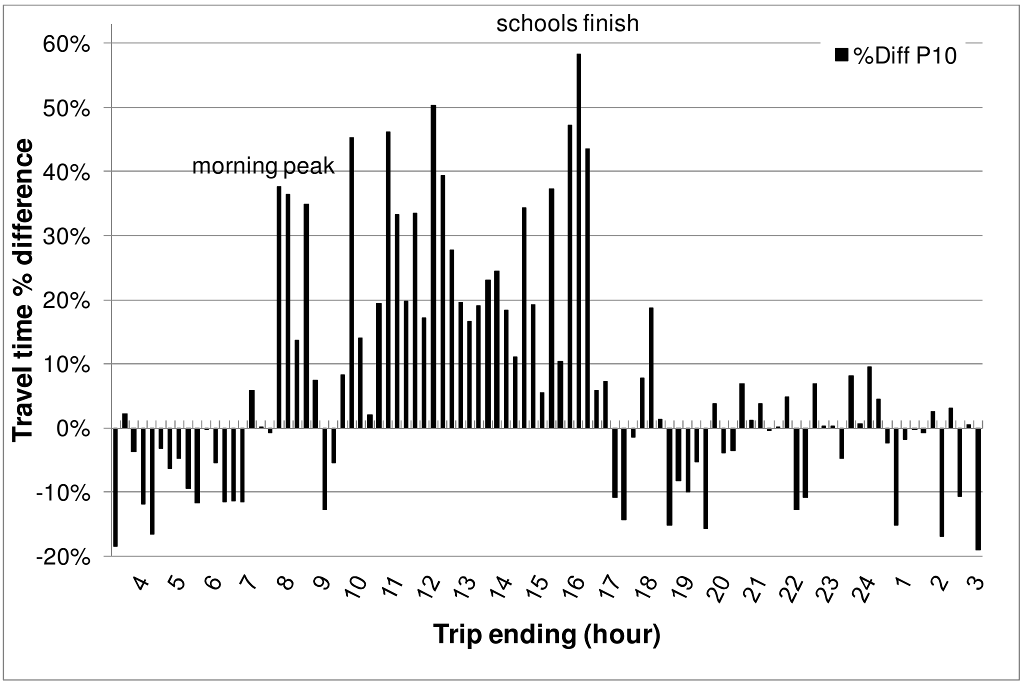


(units: percentile travel time sec, per 15 min interval.)

Figure 4 provides matching plots of the percentage differences of those percentile trendlines in Figure 3; the effect is to make obvious the model errors. The lack of defined 'peaks' in the model trendlines in Figure 3 and the matching difference peaks in Figure 4 indicates that the model fails to reproduce equivalent travel time perturbations; the reason is yet to be determined. For the case of the 'school finish' peak, the current conjecture of the modelling team – yet to be tested – is that in the real-world there may be moving and/or stationary queues blocking back onto the main route from schools on the side roads. The focus of the model development to this point has been primarily focussed only on the main route itself as the dominant source of congestion.

Figure 4: Plots of percentage differences between observed and modelled percentile travel times



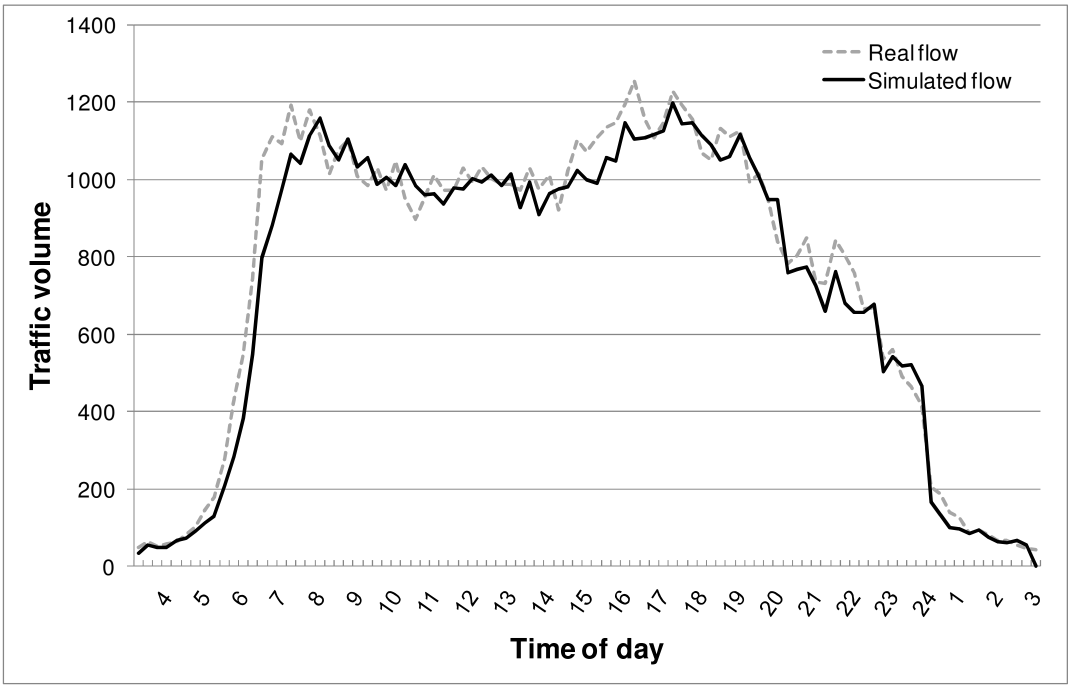


(units: percentage travel time difference, per 15 min interval.)

The travel time estimations were augmented with loop detector measurements that are reported by the SCATS installation. All the controlled intersections that lie within the scope of the model are engineered in the usual RTA practice with inductive loop detectors installed at the stop-line to each approach lane. These detectors provide good observability of lane-based traffic counts and time gaps between vehicles. Figure 5 presents a comparison of the observed versus the modelled flow for the total volume measured at Military Road / Spit Road intersection. This plot raised suspicion – since confirmed – that the generation of the demand matrices was erroneously time-shifted by 15 minutes. The error was the assumption that detector measurements were provided as 15 minute 'period starting' rather than 'period ending'. The significance of this error has not been fully explored and the error is yet to be rectified; however this shift in modelled demand will be corrected in due course. Given the error, the match of flows are reasonable, well within published calibration stanards (e.g. DMRB (Design manual for roads and bridges) Volume 12 Guidelines (Department for Transport 2011)) and in stark contrast to the match of travel times in Figure 3.

A limitation of this comparison is that the flows are at an intersection level representing an aggregate of all lanes of all movements whereas travel times are only inbound for all lanes of that one movement. That is, the flow is measured at (effectively) a point whereas the travel time is measured over a greater distance where the loop point is only a small part; therefore, any inference of a travel time versus flow relationship must acknowledge this issue.

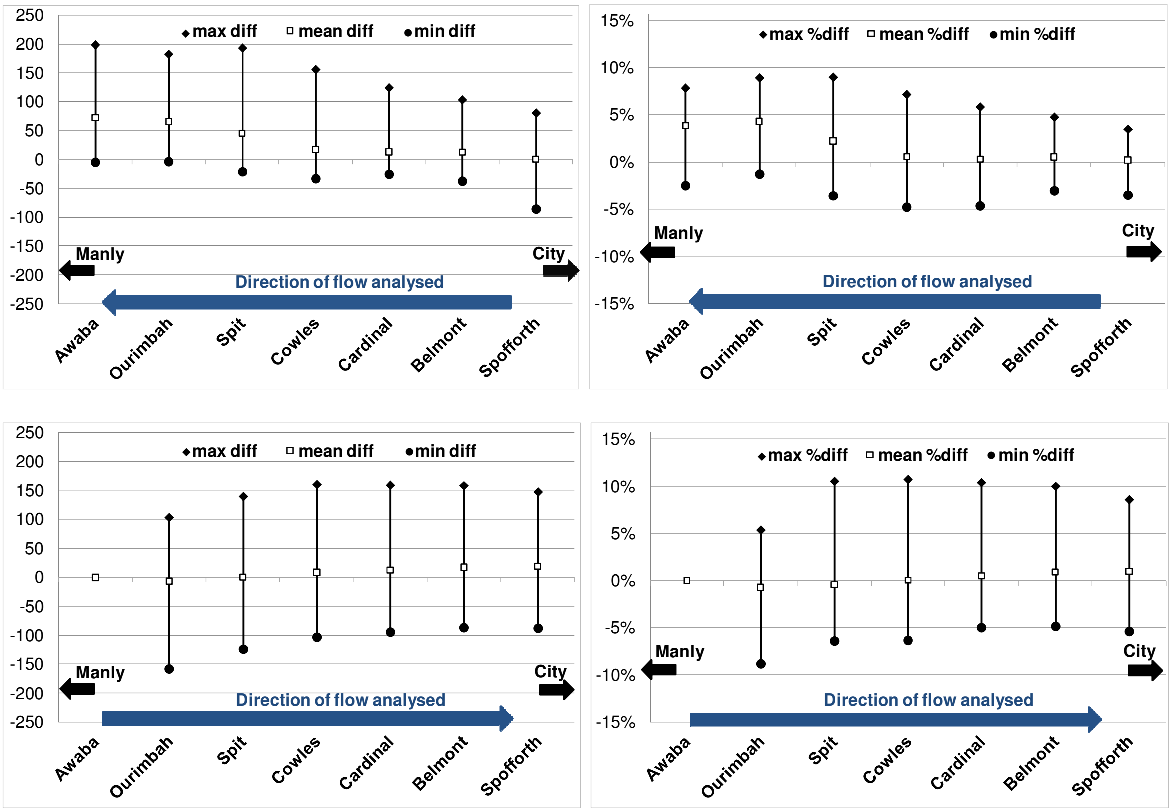
Figure 5: Plots of observed and modelled percentile flows



(units: flow, per 15 min interval.)

Figure 6 shows the range of differences – between observed and modelled – of flows measured on the main route approach of each modelled intersection for each 15 minute interval. The top two plots consider outbound flows and the bottom two inbound flows – to the city. The graphs show a reasonable fit with a slight positive bias (<5%) for outbound flows at intersections away from the city. In comparison, the inbound flows have little bias across all intersections; however, the range of differences is greater. The range and bias has been deemed acceptable by the project team – with the mentioned characteristics noted as an opportunity for scrutiny and improvement.

Figure 6. Plots of differences between observed and modelled approach flows



(units: difference flow per 15 min interval | difference percentage.)

In addition to flow, SCATS reports other measures from loop detectors that are a function of measured time gaps and occupancies (in time) of vehicles passing over those detectors. These metrics have proved useful in the SatE study for calibration purpose. Two key SCATS metrics – known by the SCATS nomenclature, DS (termed “degree of saturation”) and VO/VK – are interpretations of the degree of efficiency of the measured traffic state. These metrics are each reported as a percentage of the calibrated efficient conditions for each detector. The underlying SCATS algorithms are proprietary; however, for the purpose of explanation in this paper, simply, the metrics can be understood as:

(1) DS – representing the efficient use of time gaps between vehicles, and

(2) VO/VK – representing an efficient use of vehicle (time) occupancy.

Simply stated, VO is the count of actuations measured during the traffic signal phase; VK is an estimate of the counts that would otherwise be expected to have occurred if the traffic was travelling at efficient conditions. A DS=100% indicates that the average time gap between traffic is efficient; a VO/VK=100% indicates the average occupancy is efficient. For both metrics, a value not equal to 100% indicates the traffic on average is not efficient, where <100% is over-consuming time; and a value >100% is under-consuming time – compared to calibrated efficient conditions. The multiplication of the two metrics DS*VO/VK, in percentage terms, represents the efficient use of (time) headway, i.e. sum of both average time gaps and average occupancy.

Table 1 shows the statistics of the SCATS metrics across all detectors in the model for all cycles in the model and the real-world equivalent. The mean DS values are similar in magnitude indicating that on average the efficiency of time gap, compared to efficient conditions, is representative in the model. The mean VO/VK is higher in the model indicating that on average in the real-world drivers/vehicles are more-often able to achieve faster speeds and/or vehicle lengths are longer compared to the model. The DS*VO/VK are similar meaning the efficiency of headways are representative in the model.

In terms of variability, Table 1 shows similar standard deviations (SD) for DS and DS*VO/VK, but a higher standard deviation in the real-world compared to the model for VO/VK. The latter implies that the model is delivering less variabilty of occupancy that may be due to comparatively less variability of average speed and/or less variability of vehicle length to the real-world equivalent. (NB Occupancy is a function of speed and vehicle length.) The synopsis of less variability of average speed aligns with the interpretation of the lack of modelled perturbations of travel time that was discussed with respect to Figure 3

Table 1: Tables of statistical summaries of the observed and modelled percentile distributions of SCATS efficiency metrics

RW1
Statistical Summary of DS, VO/VK and DS×VO/VK

TCS	SA		Min	Median	Mean	Max	CI @ 95%	SD	Total	Length
All	All	DS	3	35	43	169	{43, 44}	32	1562779	36034
		VO/VK	3	100	114	500	{113, 114}	42	4099705	36034
		DS×VO/VK	3	36	42	199	{41, 42}	26	1501343	36034

ML1
Statistical Summary of DS, VO/VK and DS×VO/VK

TCS	SA		Min	Median	Mean	Max	CI @ 95%	SD	Total	Length
All	All	DS	1	30	42	170	{41, 42}	34	1611953	38710
		VO/VK	4	100	99	400	{99, 100}	30	3843843	38710
		DS×VO/VK	2	29	41	199	{41, 41}	36	1588327	38710

(RW means real world, or observed; ML means modelled)

(units: percentage, across all detectors, across all cycles in the model and real-world equivalent.)

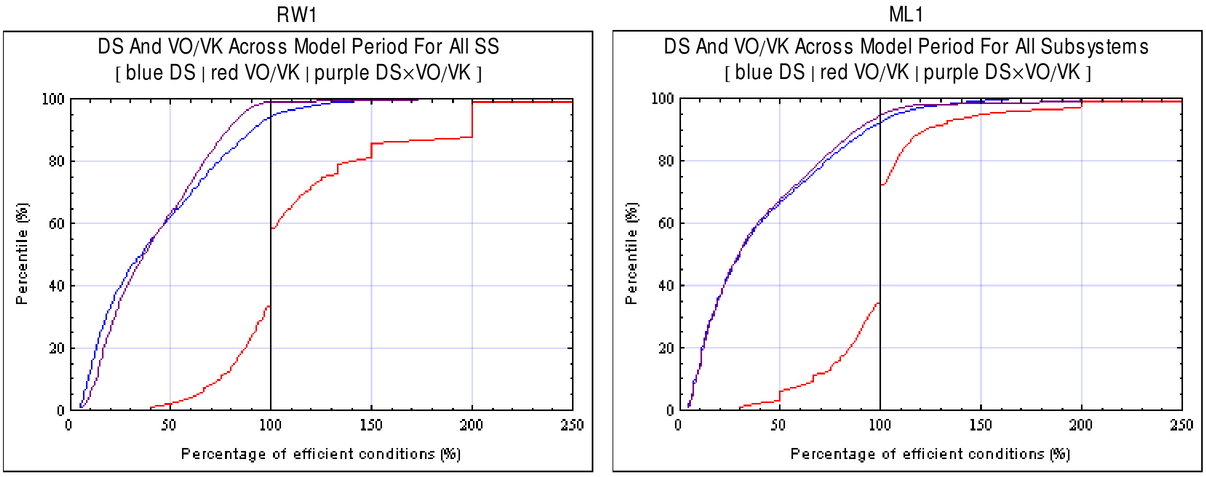
Figure 7 shows the percentile distributions of the SCATS efficiency metrics across all the detectors and all cycles in the real-world (RW1) and modelled Masterlink scenario (ML1) equivalent. The differences in the shapes of the profiles in those two plots is informative about the differences the detectors are measuring and that the real-world and modelled SCATS will be exposed to and therefore make adaptive traffic control decisions from. In general, the shapes are reasonably consistent; however, some notable differences in shape include:

- If the two plots are compared to assess the extent that the red VO/VK trendline resides on the 100% vertical axis (=100%), it is evident that the model is having drivers achieve efficient time gaps more-often over the modelled period, for the areas of the network observed by stop-line detectors. At face value, it is not surprising that a model is displaying more modelled drivers/vehicles that are able to achieve efficiency more often.

- The blue DS trendline intersects the DS=50% at the ~60th percentile on the observed and (just under) the 70th percentile on the model. This indicates the model more-often has time gaps that are significantly larger than efficient conditions. In other words, the modelled network has greater under-utilisation of the traffic signals.
- The 'high percentile end' of the red VO/VK trendline – where inefficiency results from under-consumption of occupancy (>100%) is shifted higher in the modelled plot. This difference in shape indicates that the model produces comparatively less under-consumption of occupancy and more occupancy at efficient conditions. Alternatively stated, in the model, drivers are either less-often achieving higher speeds and/or average modelled vehicle lengths are less than the real-world counterparts, for the areas of the network observed by stop-line detectors.
- The 'high percentile end' of the DS*VO/VK 'headway efficiency' trendline – where headways are approaching efficient conditions (100%) – is shifted (slightly) down on the modelled plot. This implies that the model is achieving shorter headways compared to the efficient conditions that were measured by SCATS in the real-world at the detectors.

The resulting synopsis from the analysis of Figure 7 – that requires testing – is that the model is delivering slightly less vehicle utilisation of the road network, less vehicle congestion and greater headway efficiency than the real-world equivalent. This is allowing the modelled drivers/vehicles to more-often achieve an efficient, free flow driving state. This synopsis aligns with the identification of the lack of travel time perturbations identified in Figure 3. However, in general, the similarity of the distributions of the SCATS metrics provides the SatE study project team with increased confidence in the appropriateness of: the experimental design of the SatE study, the integrity of the developed model, and the modelled driver/vehicle behaviour in the Commuter traffic simulator. The issues identified with respect to Figure 7 indicate aspects for potential improvement to the model.

Figure 7: Plots of the observed and modelled percentile distributions of SCATS efficiency metrics



(RW means real world, or observed; ML means modelled)

(units: percentage, across all detectors, across all cycles in the model and real-world equivalent.)

2.5 Study validation

The term study validation – as used in this paper – means validating that the implementation of the SatE study is appropriate for the task to which it is charged. This means assessing the appropriateness of the information that the study provides. This information is a function of the experimental design and its implementation that uses the modelling tools: SCATS/SCATSIM and Commuter. The aim of the SatE study requires that this assessment of validity be focussed on the representativeness and realism, and therefore relevancy, of the operation of the SCATS installation within the traffic simulation.

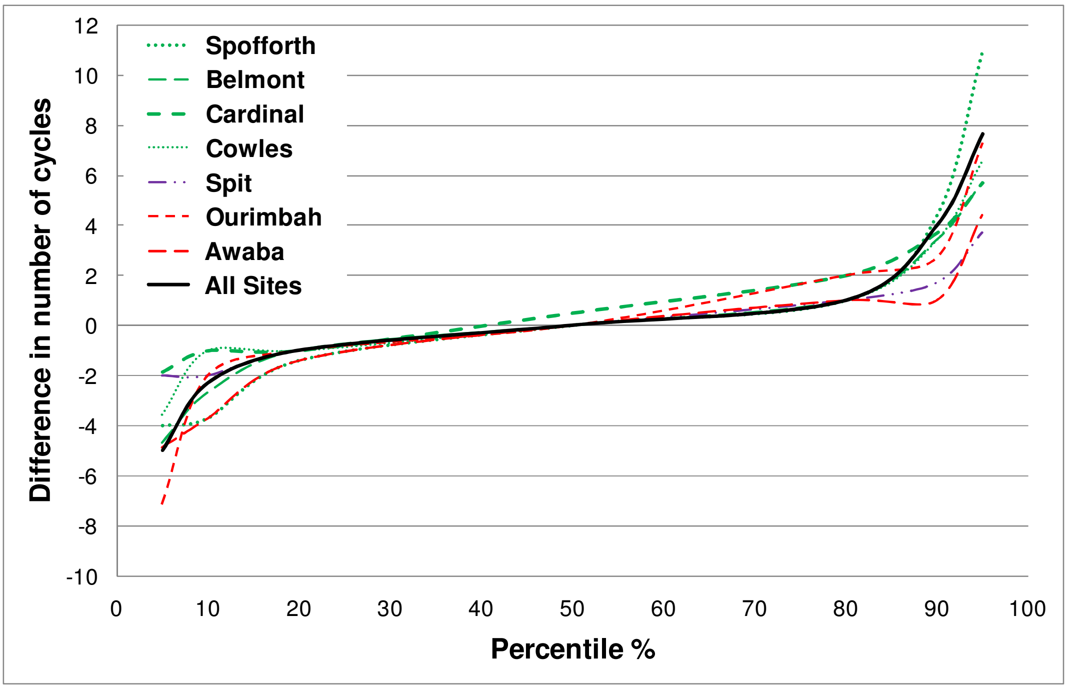
SCATSIM, that allows the modeller to operate the real SCATS software and configuration in simulation, ensures that the modelled SCATS operation is realistic. However, the quality of the modelled input data and simulation model will dictate how representative the model is of the real SCATS operation. This implies the need to calibrate the the non-SCATS aspects of the model and the need to validate the representativeness of the resulting SCATS operation captures the essence of the validation methodology employed by the SatE study. This validation will be used to argue that the results of the study are defensible for the influence of matters concerning the SCATS installation.

2.5.1 Validating traffic control outcomes

Figure 8 shows the percentile distrbutions of the difference between the observed and the modelled number of cycles for the signal controlled intersections. The intersections in the key – which are labelled by cross street names – are ordered top-down in the city outbound direction. The flatness of the plots indicates that there is a reasonable matching of cycle times across the intersections.

The distributions in Figure 8 indicate the intersections at the Spofforth St end of the model have greater missmatch. The end intersections in the model (at cross streets, Awaba St and Spofforth St) appear to have the most obvious deviation. This suggests that ‘edge effects’, arising from the artificial edge of the model, may be influencing the adaptive traffic control at those intersections. For example, the intersections at the edge of the model are not exposed to platooned and/or coordinated traffic flow from adjacent intersections that are not modelled. Moreover, this modelling phenomenon could be caused or magnified by the configured SCATS coordination. The configuration of the installed SCATS has the Military Road / Spit Road intersection (‘Spit’) the Master intersection for adaptive coordination on that corridor; this will mean that this intersection is less likely to be perturbed by coordination actions whereas the extreme intersections can suffer leveraged effects, i.e. “flicking of the tail”. Accordingly, it is considered that coordination outcomes should be analysed in further detail to ensure that model error is not being magnified by modelled SCATS to cause magnified SCATS operational outcomes at the intersections at the edge of the model.

Figure 8. Plot of the percentile distributions of the differences in the number of cycles



(units: difference in cycles count, per hour interval.)

Table 2 shows the statistical summaries of the cycles times across all subsystems and all cycles in the calibration day for the observed (RW1) and the modelled (ML1). Table 3 shows an equivalent table of percentiles. A SCATS subsystem is one or more usually-adjacent intersections that are controlled with a common cycle time. The Cycle Time row is with respect to the cycle time applied at each subsystem; the Rotation Time is a component of cycle time that can be considered to reflect the perturbation of cycle time applied to achieve coordination; and DS (-as explained earlier) is the measured value that contributed to the calculation of cycle time. The similarity of the mean and median values between the observed and model indicates, from the perspective of central tendency, that the model is reproducing representative cycle times and representative coordination effects (Rotation Time). However, the DS that controls cycle time is slightly higher in the real-world. The percentile distribution suggests that the model is producing more cycle times at a minimum value, i.e. compare 20^{th} percentile, and more cycle times at a high value, i.e. compare 60^{th} percentile. These two adaptive traffic control outcomes will eventually be considered by the modelling team with respect to the traffic performance issues discussed earlier. The aim will be to focus the improvements to the model to best achieve representative traffic control outcomes.

Table 2: Tables of statistical summaries of cycle times

RW1
Statistical Summary Of Cycle Times And DS From All Subsystems (sec)

	Min	Median	Mean	Max	CI @ 95%	SD	Total	Length
Cycle Time	26	63	82	181	{80, 83}	48	416220	5099
Rotation Time	−42	0	0	43	{0, 0}	4	−1775	5099
CT DS	5	68	72	199	{70, 73}	53	366354	5099

ML1
Statistical Summary Of Cycle Times And DS From All Subsystems (sec)

	Min	Median	Mean	Max	CI @ 95%	SD	Total	Length
Cycle Time	26	66	82	175	{81, 83}	49	401048	4895
Rotation Time	−41	0	0	35	{−1, 0}	4	−1880	4895
DS	5	70	67	199	{66, 69}	50	329257	4895

(RW means real world, or observed; ML means modelled)

(units: sec, across all subsystems, across all cycles in the model and real-world equivalent.)

Table 3: Tables of percentile summaries of cycle times

RW1
Percentile Summary Of Cycle Times And DS From All Subsystems (sec)

	0	5	10	20	30	40	50	60	70	80	90	95	100
Cycle Time	26	26	26	38	38	48	63	106	138	140	140	140	181
Rotation Time	−42	−2	0	0	0	0	0	0	0	0	0	1	43
CT DS	5	9	12	16	22	37	68	94	109	125	141	161	199

ML1
Percentile Summary Of Cycle Times And DS From All Subsystems (sec)

	0	5	10	20	30	40	50	60	70	80	90	95	100
Cycle Time	26	26	26	26	38	38	66	111	137	140	140	141	175
Rotation Time	−41	−2	−1	0	0	0	0	0	0	0	1	2	35
DS	5	8	11	12	18	28	70	96	108	117	130	148	199

(RW means real world, or observed; ML means modelled)

(units: sec, across all subsystems, across all cycles in the model and real-world equivalent.)

2.6 Scenarios implementation

At the time of writing, 15 runs of the base scenario and 3 runs of the contrary fallback scenario were used for the analysis. The SatE study results are considered preliminary because the modelling team considers that those numbers are insufficient to gain an understanding of the distribution of results with which to gauge the reliability of the model. This view is based on another RTA project that concerns the development of a statistical framework to guide traffic simulation studies (Shteinman et al 2010). The SatE study results will be updated in the future when more runs have been completed.

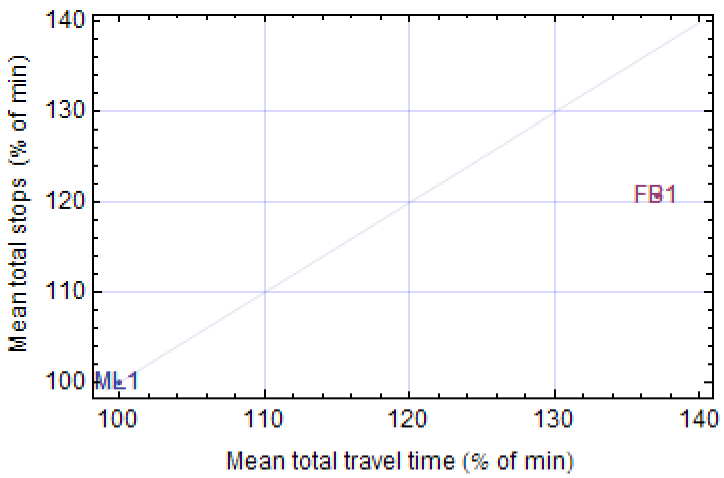
3. Study results

The salient information provided by the SatE study is: (1) the performances from the base scenario and contrary scenario; (2) the comparison of performances between those two scenarios; and (3) a statistically-defensible assessment of the uncertainty and confidence in (1) and (2). We will report only on (1) and (2) in this paper from the results of the SatE Main study – phase 1 (iteration 2). A rigorous reporting of (3) is left for a future paper.

3.1 Scenario analysis

Figure 9 shows the relative difference of the traffic performance measures – mean total travel time and mean total stops – between the base scenario (ML1) and the contrary scenario (FB1). For demonstration of the reading of that table: the difference from the base scenario to the contrary scenario indicated a 37% increase in mean total travel time and a 21% increase in mean total stops measured across all vehicles for the duration of the 24 hour simulation period. These increases result from a change in SCATS configuration from the normal Masterlink operation to fallback operation. This increase could be considered indicative of the opportunity cost if adaptive SCATS was substituted by a sophisticated fixed time traffic control system.

Figure 9: Plot of relative percentage mean total travel time versus relative percentage total stops



(key: ML1 - base scenario | FB1 - contrary scenario.)

Table 4 shows the traffic performance and environment performance of the base and contrary scenarios and the comparison between scenarios. The confidence intervals provide an indication of the uncertainty within the results. The larger confidence intervals of the contrary scenario reflects the comparatively fewer number of runs analysed. The contrary scenario produces a decrease in the traffic and environment performance measured within the model across all the reported metrics.

Table 4. Table of traffic and environment performance of scenarios

	Total travel time	Total stops	Total CO_2	Total NO	Total PM10
Units	(hour)	(stop)	(kg)	(g)	(g)
Base scenario (ML1) mean	5981	191775	38670	134683	3392
Contrary scenario (FB1) mean	8196	231343	40943	141735	3727
Base scenario (ML1) CI	{5931, 6030}	{190824, 192726}	{38637, 38703}	{134555, 134810}	{3385, 3398}
Contrary scenario (FB1) CI	{7616, 8777}	{219638, 243048}	{40126, 41759}	{138245, 145225}	{3553, 3901}
Base scenario (ML1) CI (%)	{99, 101}	{100, 100}	{100, 100}	{100, 100}	{100, 100}
Contrary scenario (FB1) CI (%)	{93, 107}	{95, 105}	{98, 102}	{98, 102}	{95, 105}
Scenarios mean difference	2216.	39568.	2273.	7053.	336.
Scenarios mean diff. CI	{1657, 2774}	{28270, 50867}	{1463, 3082}	{3589, 10517}	{163, 509}
Scenarios mean difference (%)	37	21	6	5	10
Scenarios mean diff. CI (%)	{28, 46}	{15, 27}	{4, 8}	{3, 8}	{5, 15}

(Confidence intervals (CI) are at 95% confident level.)

4. Conclusion

This paper introduced the running SatE study by the RTA that has been designed to rigorously demonstrate the transport, environmental and economic value that the SCATS installation provides to the people of NSW. We identify that the study is required to be realistic and representative to real world SCATS operation to ensure that results are defensible.

We explained the: (1) study experimental design, (2) model verification, (3) scenario calibration and (4) study validation – which all focus on achieving appropriate traffic control operation. We also described how the study demonstrates the novel use of travel time estimations from vehicle electronic tag measurements. Finally we presented the current, preliminary results of the demonstrated performance of SCATS in modelled traffic and environment terms.

This paper provides a novel insight for managers, operators and stakeholders of SCATS (and other sophisticated traffic control systems–in general terms) on the technique and results from a comprehensive study that investigates the value derived from automated traffic control.

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