New initiatives for an ageing UTC system – Some of the innovative techniques TfL is using to improve traffic signal performance for buses, cyclists and pedestrians

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EVERY JOURNEY MATTERS

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Introduction

The Mayor's Transport Strategy, published in March 2018, sets out some ambitious targets to transform transportation in London. It sets out a Healthy Streets Approach to the whole of London for the first time, which encourages active, efficient and sustainable transport modes to be used to improve health and the human experience of using the streets. The aspiration to develop Healthy Streets and encourage more active travel is set out in a number of targets, including the target for 80% of trips to be taken using sustainable modes of transport (walking, cycling and public transport) by 2041, and the goal for all Londoners to do at least 20 minutes of active travel every day by 2041 (which is a big challenge, because only a third[1] report doing this now). The strategy wants to see a reduction in the dominance of motorised traffic on London's streets in order to improve air quality and reduce road danger.

Role of Network Managers and an ageing UTC system

Transport for London's Network Performance Delivery (NPD) team is responsible for setting up, operating and optimising London's traffic control system in order that the network suits everyone. Work-streams such as the annual traffic signal timing review programme, bus route analysis recommendation reports, customer enquiries and scheme implementations have been radically re-focused to enable Healthy Streets and create a better experience for people choosing to travel by sustainable modes. We have developed new signal control techniques and technologies to give advantage to people using sustainable modes, and rolled these out wherever possible.

NPD's Network Managers use a bespoke Urban Traffic Control system to operate traffic signals throughout London. This can trace its roots to a system first tested in West London in 1968[2], and has seen numerous mayoral policies and priorities. Necessarily it has been constantly adapted to meet the current needs of London. We are now using London's traffic control system in new ways that we never thought possible, to help people move around the capital and to meet the Healthy Streets objectives.

1. STUDI (SmarTerm Unified Data Importer)

STUDI is a tool created by Christopher Cockbill, a Network Manager in TfL NPD. Chris was inspired to develop this tool due to numerous short-comings in the standard outputs. This includes the lack of easily available sources of UTC / SCOOT data for quick analytical purposes, the inconsistency of the sources that did exist, and the difficulty in extracting any data from the UTC system. STUDI

[1] http://content.tfl.gov.uk/healthy-streets-for-london.pdf
[2] The Glasgow Experiment: Assessments under light and low flow conditions

collects data using the terminal interface and pastes it into Excel table. VBA macros are used to automate the process, and to allow Network Managers to quickly and easily analyse a standard-format 'snapshot' spreadsheet.

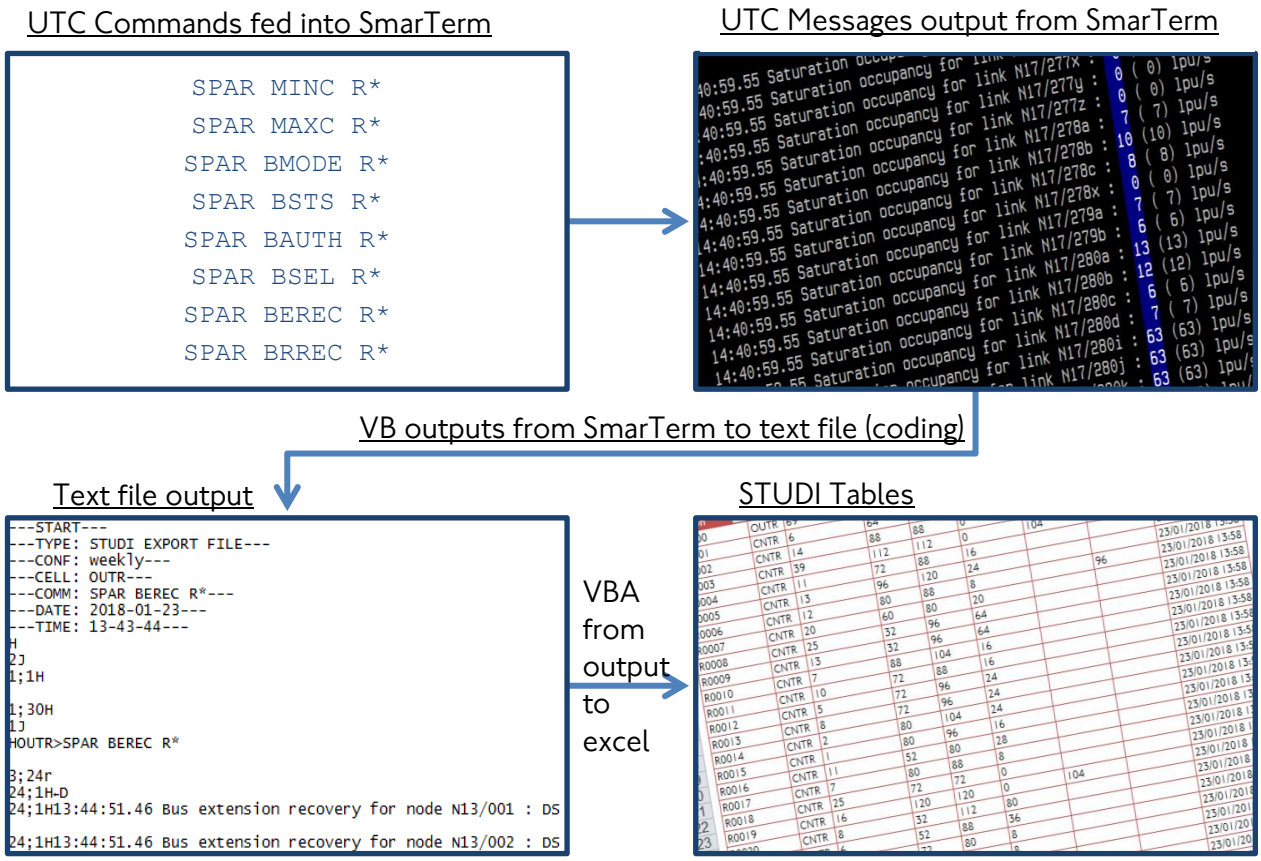

Figure 1: Flow diagram showing the STUDI Process

STUDI command list

PJA	SPAR BJYT R*	SPAR CGWT R*	SPAR FAST R*	SPAR INSM R*	SPAR NITH R*	SPAR SLAG R*
PJFD	SPAR BMODE R*	SPAR CHIN R*	SPAR FCLR R*	SPAR INSP R*	SPAR NLMS R*	SPAR SOFT R*
PJI05	SPAR BOAP R*	SPAR CLCG R*	SPAR FLAN R*	SPAR INTH R*	SPAR NOAP R*	SPAR SPWT R*
PJI06	SPAR BOLIM R*	SPAR CLCW R*	SPAR FLWR R*	SPAR ISAT R*	SPAR NSAP R*	SPAR STGS R*
PUNC	SPAR BOTU R*	SPAR CLNK R*	SPAR FRCE R*	SPAR ISSR R*	SPAR OFWT R*	SPAR STOC R*
PX	SPAR BPEXT R*	SPAR CLOG R*	SPAR FUPR R*	SPAR JLIS R*	SPAR OPNI R*	SPAR STPL R*
QJDA	SPAR BQCT R*	SPAR CLOT R*	SPAR GAIN R*	SPAR JNYT R*	SPAR OPSI R*	SPAR TRND R*
QPJA	SPAR BRREC R*	SPAR COMP R*	SPAR GASS R*	SPAR LDES R*	SPAR PEDP R*	SPAR TSAT R*
SPAR ALAN R*	SPAR BRSAT R*	SPAR CRTH R*	SPAR GNOD R*	SPAR LMSM R*	SPAR PINH R*	SPAR ULNK R*
SPAR ANIN R*	SPAR BSAP R*	SPAR DCIG R*	SPAR GOST R*	SPAR LMSO R*	SPAR PLNK R*	SPAR UNOD R*
SPAR ARIN R*	SPAR BSEL R*	SPAR DEFI R*	SPAR GSTG R*	SPAR LMSS R*	SPAR PPLK R*	SPAR UTCN R*
SPAR ASIN R*	SPAR BSTS R*	SPAR DEFS R*	SPAR GTLO R*	SPAR LMSV R*	SPAR PRLR R*	
SPAR BAUTH R*	SPAR BTYP R*	SPAR DFOF R*	SPAR GTUP R*	SPAR LTYP R*	SPAR RDES R*	
SPAR BBIT R*	SPAR BUCA R*	SPAR DNIB R*	SPAR INCF R*	SPAR MAXC R*	SPAR RLMS R*	
SPAR BEREC R*	SPAR BVARY R*	SPAR DOTU R*	SPAR INCY R*	SPAR MAXS R*	SPAR ROTR R*	131 commands
SPAR BESAT R*	SPAR BYCA R*	SPAR DRSM R*	SPAR INIF R*	SPAR MCLR R*	SPAR RSUB R*	
SPAR BIAS R*	SPAR CATR R*	SPAR DSDN R*	SPAR INMF R*	SPAR MDSL R*	SPAR SCYP R*	
SPAR BIKE R*	SPAR CBIN R*	SPAR DSTS R*	SPAR INMQ R*	SPAR MINC R*	SPAR SDLK R*	
SPAR BINCA R*	SPAR CGIF R*	SPAR ELAG R*	SPAR INOF R*	SPAR MINS R*	SPAR SIDF R*	
SPAR BINH R*	SPAR CGOF R*	SPAR FASM R*	SPAR INSF R*	SPAR NDES R*	SPAR SKSAT R*	

Figure 2: Commands which are run through the STUDI tool

There are numerous advantages to the use of STUDI, which has allowed Network Managers to utilise the UTC system more efficiently and ensure techniques align to the Mayor's Transport Strategy for Healthy Streets. STUDI provides a central resource for UTC / SCOOT data tables and associated calculated fields. This allows for linking between different tables and data types, which are now quick and easy to analyse, enabling techniques to be fine-tuning in great detail and allows the wider application of available techniques across London (e.g. Truncations as explained later). There is also now a historical data resource, which helps Network Managers to easier analyse changes made to any pedestrian crossing or junction.

STUDI Current Uses & Case Studies

A critical use of STUDI is the creation of the STUDI Site Report, which provides Network Managers an overview of any UTC node and analyse how it is set up to operate and optimise. Through a desire to look at some more niche elements of the UTC system which are often overlooked and to emphasise Healthy Streets techniques, the STUDI site report is now used to quickly and easily identify issues with the operation of a node to ensure it is set up to improve traffic signal performance for buses, cyclists and pedestrians. Rather than the Network Manager needing to collect and investigate numerous sources of data, which may not all match, the STUDI site report enables this data to be displayed consistently and quickly through a simple one button approach.

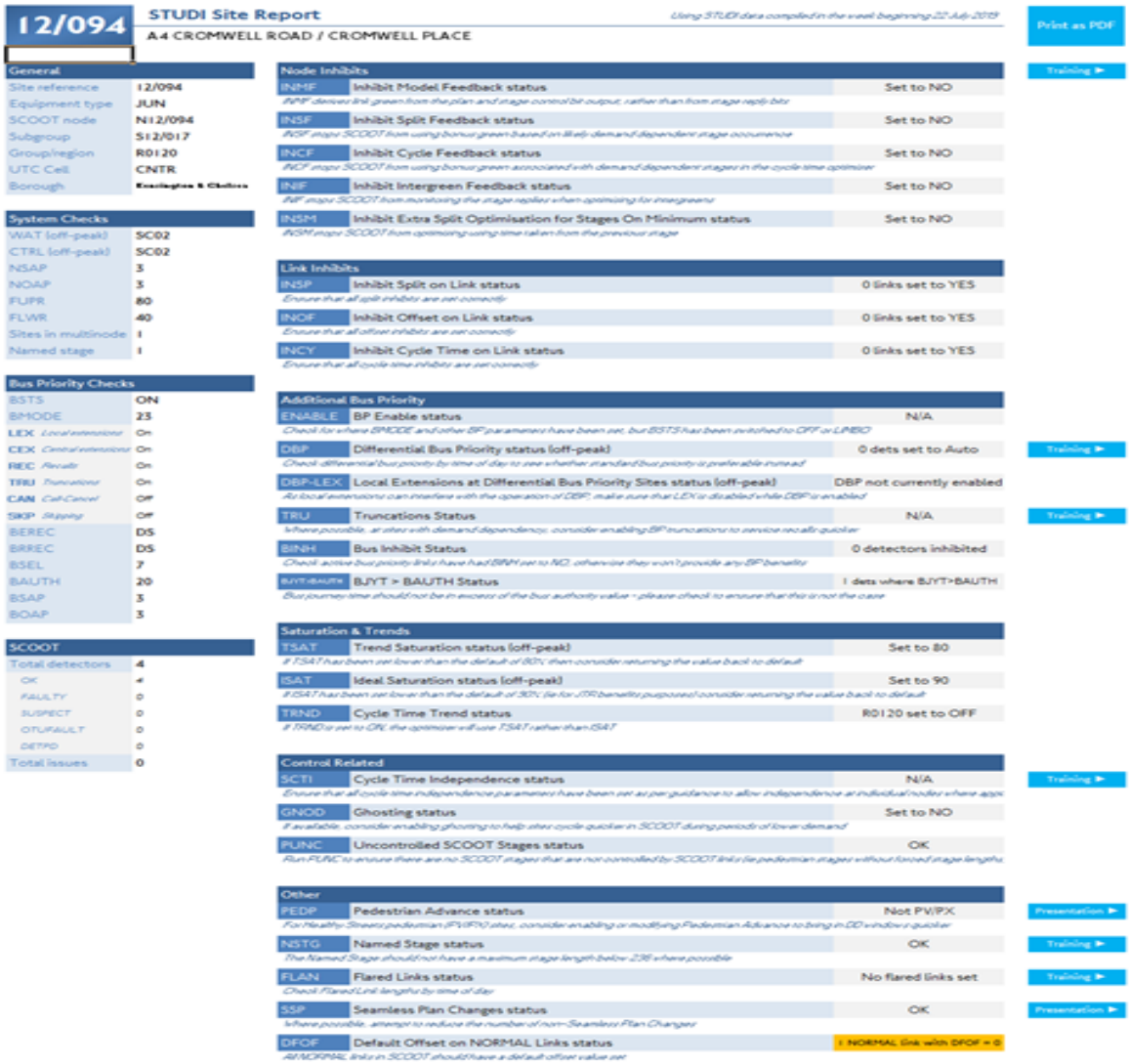

Figure 3: screenshot of STUDI Site Report

As well as displaying basic junction / node information such as SCOOT and Bus Priority, the STUDI site report also displays more complicated information such as pedestrian advance, ghosting, differential bus priority and cycle time independence – all of which allow Network Managers to make bolder decisions more easily, helping them to get more out of the ageing UTC system. More advanced techniques, which are more complicated to set up, review and audit have now been simplified, providing greater opportunities for Network Managers to implement and fine-tune them to deliver stronger benefits for sustainable road users. STUDI Site Report also automatically identifies possible errors in system configuration and highlights these to Network Managers for correction. Additionally, links to training documentation covering these complicated techniques are also available via STUDI Site Report to help Network Managers to analyse and review their set up.

STUDI has also been modified for the Bus Route Analysis Recommendation Report programme. This relatively new work stream focuses on particularly poor performing Bus Routes (based on 5 categories including bus speed, passenger numbers, journey time change, excess wait time and bus route kilometres lost). The STUDI tool has been specifically tailored to this work-stream and has enabled Network Managers to identify which junctions justify greatest attention and where issues contributing to poor bus performance exist.

2. Bus Priority – Stage Truncations

Bus Priority has been used by Network Performance to improve bus performance throughout London for many years. While more recently we have been implementing Differential Bus Priority, to provide a greater level of priority to buses which are late running, we have also now introduced stage truncations more widely. While Local Extensions, Central Extensions and Recalls have been commonly used to improve bus performance at junctions, Stage Truncations is a tool which is now being increasingly implemented.

Stage Truncation was developed with stage skipping for UTC v10 which was released in December 2002 and was described as *'A subtle, low key change that requires little effort by users, it should however achieve substantial saving for buses'*[3]. This technique, which has *'very little disbenefit … on general traffic or safety. It is therefore recommended that it is implemented at all sites where appropriate'*[4] is used by SCOOT to service Bus Priority Recalls quicker. It is designed to shorten (truncate) the length of SCOOT stages when their associated demand dependent UTC stage has not appeared. There are two ways in which Truncation can occur:

1. The Demand Dependent (DD) stage is not called so the controller remains on the previous stage
2. The Demand Dependent stage is not called so the next stage in the sequence is sent

Example – J20/005 (South Norwood Hill / Norwood High Street / Portland Road)

Consider a 3 stage junction: stage 1 is the main road, stage 2 is an all-round pedestrian and stage 3 is a side road with bus routes. If there is no demand for stage 2, the controller will hold on stage 1 (minimum of an extra 30 seconds). If a bus were detected on stage 3, stage 1 may be shortened by a recall, but nothing can be done to shorten stage 2. With truncations, SCOOT monitors the UTC

[3] TRL v10 Release Note. Dec 2002
[4] SCOOT Operational Guide 0471

stage replies during Demand Dependent stage 2. If no change to the reply is detected, it is assumed there is no demand for stage 2 and the controller has remained on stage 1. If a bus demand for stage 3 exists, SCOOT will now shorten or 'truncate' stage 2 by violating the stage MIN and send stage 3 much earlier than was previously possible.

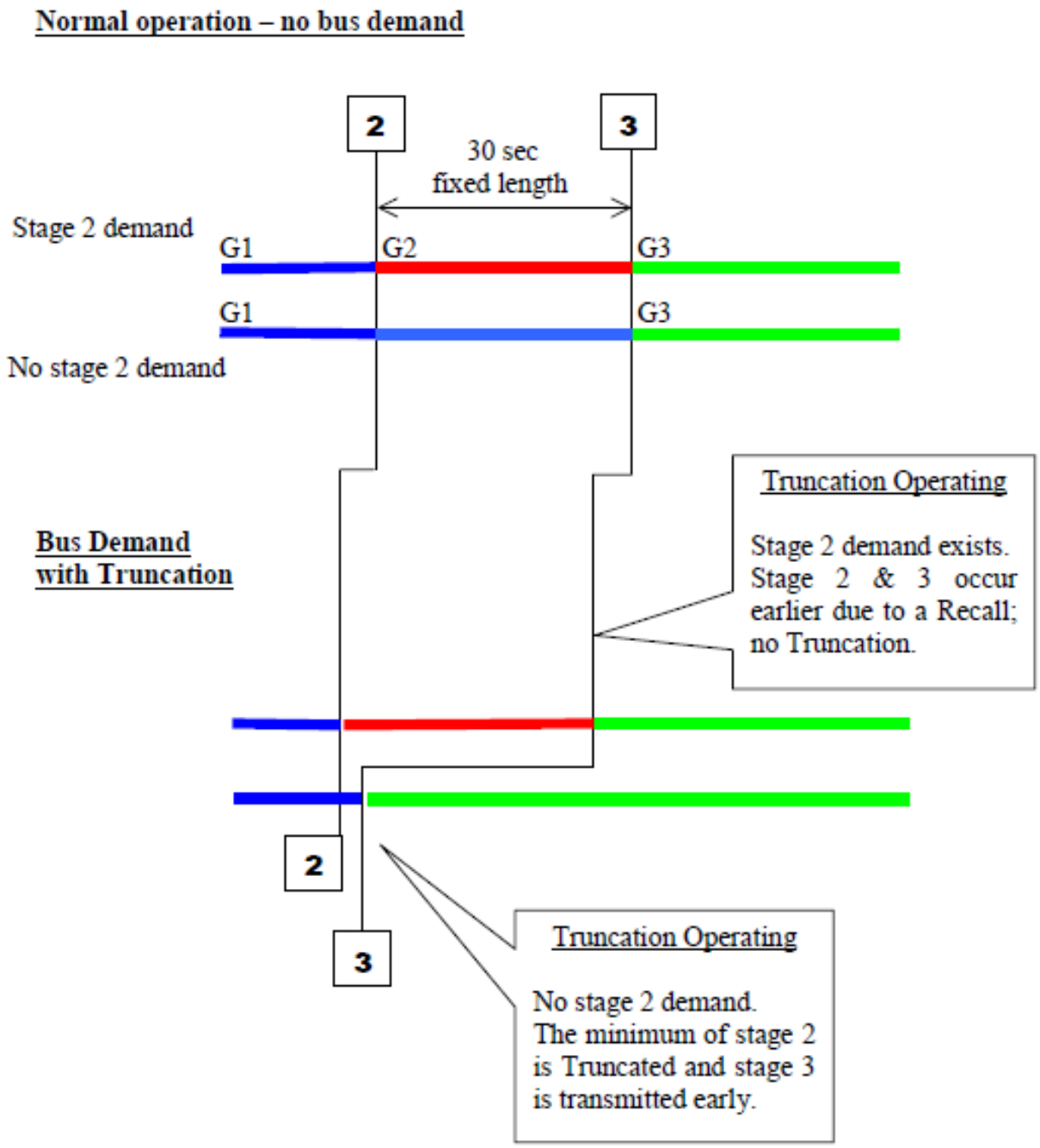

Figure 4: Example of how Stage Truncation can improve bus performance

At a trial site, South Norwood Hill – Norwood High Street – Portland Road, when a bus requiring stage 3 is detected during stage 1, and stage 2 is not demanded, stage 2 can be shorted (rather than running its plan MIN of 16 seconds) to get back to stage 3 faster. During one 24 hour trial period, a total of 99 recalls with truncations occurred, in which a total of over 10 minutes which would have previously been unnecessarily given to stage 2 was re-distributed to stage 3 and buses.

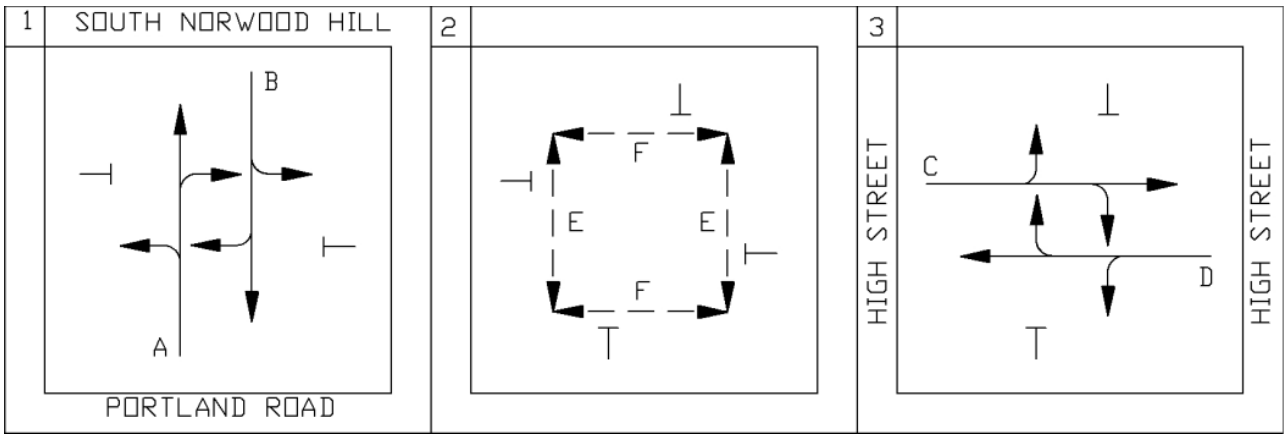

Figure 5: Method of control for 20/005

Example – J06/216 (John Harrison Way / Guideway / West Parkside)

Consider a 4 stage junction, but in this case, rather than holding on a Demand Dependent stage, a new stage is sent – either stage 2 or stage 3 will be returned during SCOOT stage 2. If UTC stage 2 is returned nothing happens but if UTC stage 3 returns then Truncations can occur. If the bus requires stage 3 there is no advantage to Truncations because the UTC stage is already green for buses, but if a bus requires SCOOT Stage 1, Truncations can shorten the intervening stages so the bus stage can occur earlier.

At a trial site, John Harrison Way – Guideway – West Parkside a bus requiring stage 1 is detected during stage 2, and if stage 3 is not demanded SCOOT shortens the intervening stages to get back to stage 1 faster (rather than running the plan MIN). In one 24 hour period 284 truncations occurred, through which a total of over 80 minutes which would have previously been unnecessarily given to stage 3 was re-distributed to stage 1 and buses.

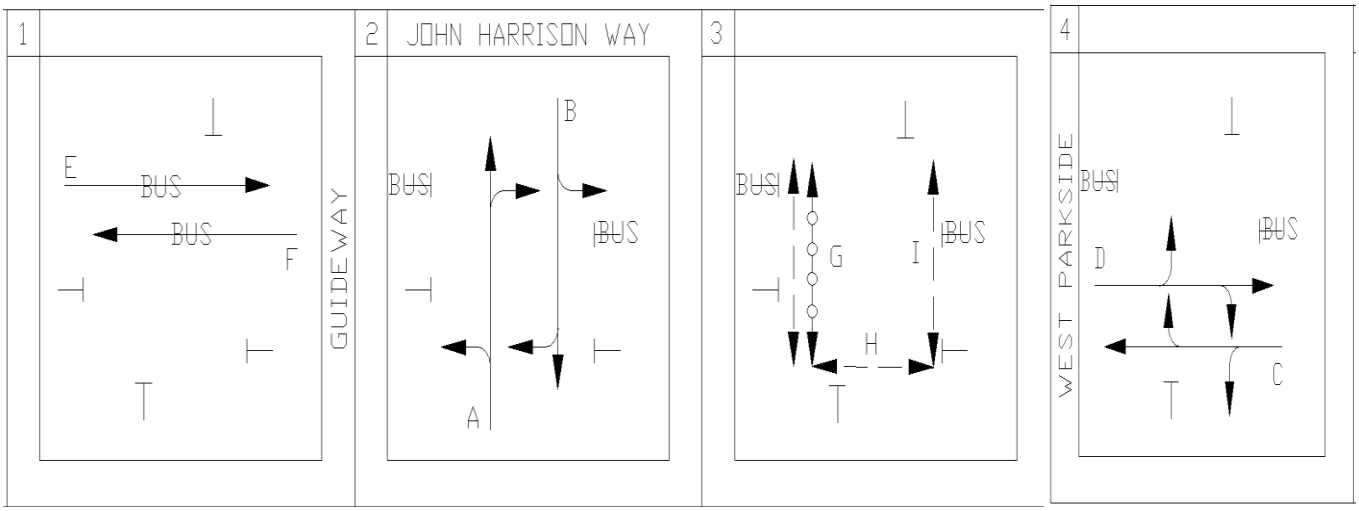

Figure 6: Method of control for 06/216

Truncations across London

Truncations are now being implemented across London where they are applicable. STUDI has been essential in identifying potentially suitable sites – comparing those sites which already have recalls

enabled. While site-by-site analysis and observations are required to ensure truncations are suitable and do not impact the network too greatly, STUDI has been a great benefit, quickly and easily highlighting sites across London which have recalls and therefore may be suitable for truncations.

In August 2018 only 29 nodes in London had truncations enabled and operating. As of August 2019, following the improved knowledge and understanding of Truncations, and the ease of which Network Managers can now identify suitable sites through STUDI, there are now 357 nodes with truncations enabled, with STUDI showing there are more to implement. Where Truncations have been implemented this year, they have helped contribute to the average 17 passenger hours saved per day which has been measured at bus nodes.

3. SCOOT Cycle Time Independence (SCTI)

SCOOT Cycle Time Independence (SCTI) was developed and released with UCT V17, 2011 and it allows nodes and / or a sub-group to be released from operating at the region cycle time based on delay calculations. The benefit of this technique derives from the fact that under normal conditions SCOOT maintains co-ordination between nodes by operating them on a common cycle time, but under certain flow conditions the benefits of co-ordination can be negated by having under-saturated nodes running at too high cycle times. SCTI allows SCOOT the opportunity to reduce the cycle time at certain nodes to reduce delay and pedestrian wait time.

SCTI can operate in two ways (mutually or exclusively):

1. Node Independence - This allows individually nominated nodes to operate at lower cycle times while remaining in their original region. Several nodes within the same region can be configured to become independent, each operating with their own Minimum Practical Cycle Time (MPCY)
2. Sub-Region Independence – This allows a collection of nodes (a 'sub-region') to be treated as one when considering independence from the region cycle time. All nodes within a sub-region will operate the same cycle time and will have unique region numbers and region attributes

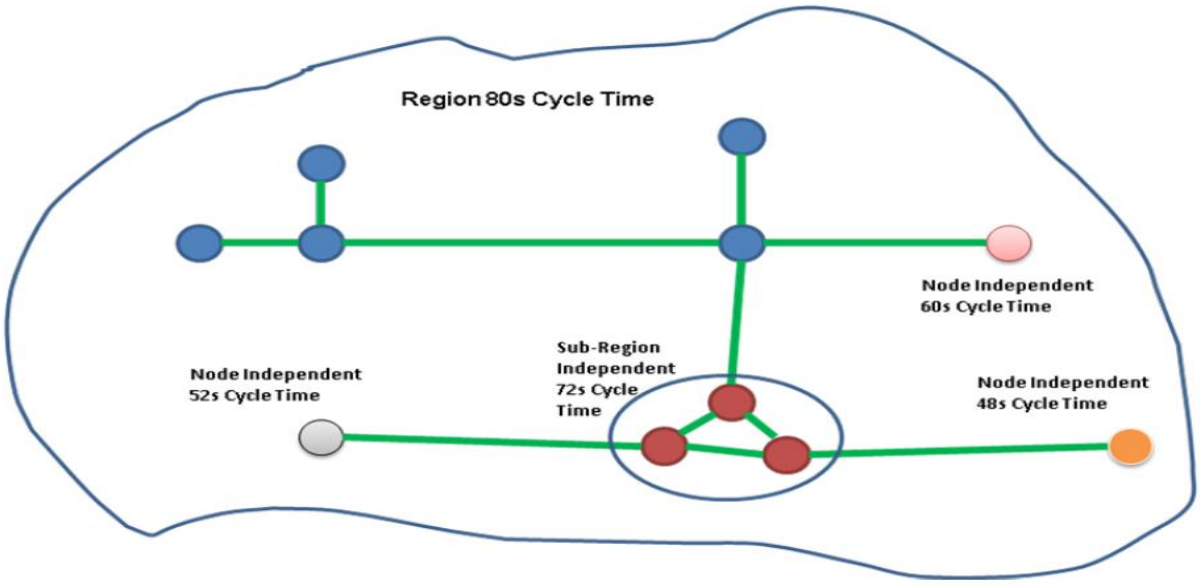

Figure 6: Example of how SCTI could be set up within a region

SCTI was a technique which was not fully appreciated or taken advantage of until this year. In February 2018 only 75 regions were configured with SCTI. Appreciating where this technique is advantageous and how it can be used to reduce delays to buses and pedestrian wait times at under-saturated nodes, has enabled Network Managers to implement the technique at a much wider scale. As of August 2019 it is now in operation at 92 regions.

A key benefit which has resulted from the increased application of SCTI is the ability to lower pedestrian wait time in line with Healthy Streets aims. Through benefits collection we know that the additional regions with SCTI applied have helped deliver over 180 pedestrian hours saved per day across London. Through this technique, SCOOT is able to identify when traffic conditions require linking between junctions (a common cycle time) and when the benefit from lowering a node (or sub-region) cycle time outweighs co-ordination. In these instances, the lower cycle time gives significant benefit to pedestrians who now have to wait less time to cross the road. Keeping an under-saturated node (or sub-region) running an unnecessarily high cycle time also impacts bus performance (often unnecessarily high wait time, especially on side roads), and therefore dropping cycle time at these particular nodes improves their operation.

4. DTx Removal

One of the important improvements to our ageing UTC system has been the transfer to fully digital 21C comms links from the old Tele 12 system. This upgrade to the system resulted in a reduction in the data transmission round trip time (the lag from our system to the controllers and back to our system) from 4 seconds to 3 seconds. Therefore we have been able to remove a 1 second delay in the system which has had noticeable improvements to the reaction time of our signals and significant benefits for buses.

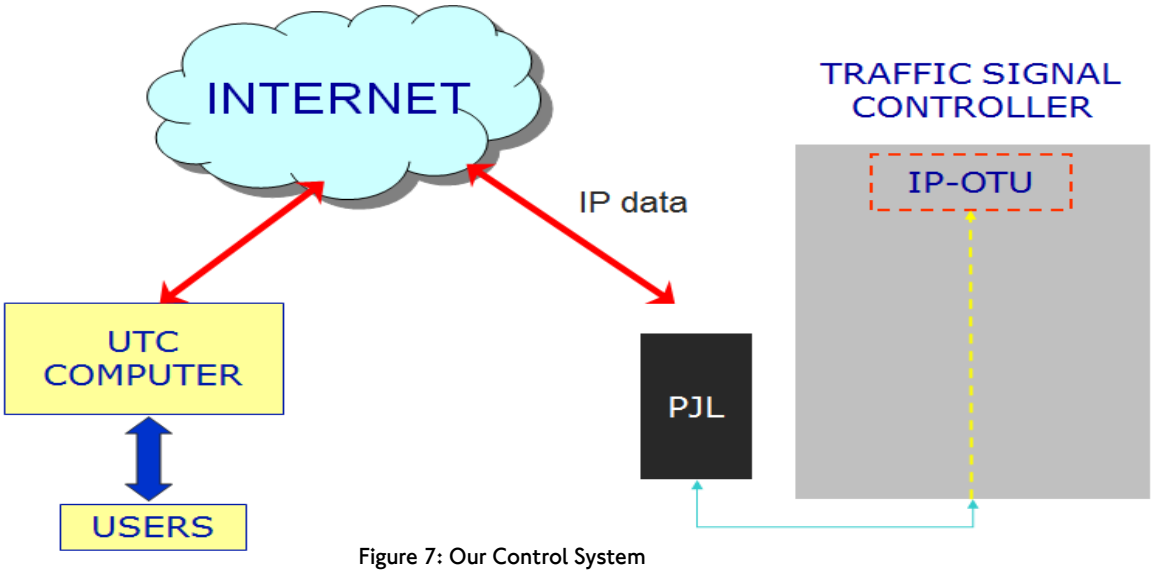

Figure 7: Our Control System

Reducing the data transmission time between our UTC system and the controllers has unsurprisingly had significant benefits to the amount of bus priority which is granted throughout London. The data on the following page shows the average buses given Bus Priority pre-1s DTx (Data Transmission) removal and post-1s DTx removal (the data was collected for all 5 cells and across 6 days before and 6 days after).

- Increase of 0.4% for Central Extensions
- Increase of 0.3% for Local Extensions
- Increase of 0.3% for Recalls

Figure 8: Pre and post 1s DTX removal (5 cells, 6 day averages)

Table 1: Average buses given Bus Priority, pre-1s DTx removal

Cell	Average buses seen by BP per day (total)	Average buses arriving during green (total)	Average buses given central extension (total)	Average buses given local extension (total)	Average buses given recall (total)	Average buses arriving during red but not receiving priority (total)
CNTR	217,736	123,829	3,116	3,792	10,863	76,136
EAST	102,721	53,773	1,757	1,510	8,845	36,836
NORT	269,399	144,424	5,282	6,620	23,623	89,451
OUTR	144,407	71,936	2,887	2,551	13,007	54,027
SOUT	303,721	175,672	4,369	5,182	17,506	100,992
Grand Total	**1,037,983**	**569,633**	**17,410**	**19,655**	**73,843**	**357,442**

Table 2: Average buses given Bus Priority, post-1s DTx removal

Cell	Average buses seen by BP per day (total)	Average buses arriving during green (total)	Average buses given central extension (total)	Average buses given local extension (total)	Average buses given recall (total)	Average buses arriving during red but not receiving priority (total)
CNTR	225,320	127,579	3,686	4,507	11,534	78,014
EAST	105,533	55,517	2,129	1,916	9,660	36,311
NORT	271,051	146,197	6,683	6,760	24,105	87,306
OUTR	146,542	73,757	3,546	3,130	14,014	52,095
SOUT	306,176	178,094	5,670	5,526	17,964	98,923
Grand Total	**1,054,622**	**581,144**	**21,714**	**21,838**	**77,277**	**352,648**

Table 3: Percentage buses given Bus Priority, pre-1s DTx removal

Cell	Average buses seen by BP per day (total)	Average buses arriving during green (%)	Average buses given central extension (%)	Average buses given local extension (%)	Average buses given recall (%)	Average buses arriving during red but not receiving priority (%)
CNTR	217,736	56.9%	1.4%	1.7%	5.0%	35.0%
EAST	102,721	52.4%	1.7%	1.5%	8.6%	35.8%
NORT	269,399	53.6%	2.0%	2.5%	8.8%	33.2%
OUTR	144,407	49.8%	2.0%	1.8%	9.0%	37.4%
SOUT	303,721	57.8%	1.4%	1.7%	5.8%	33.3%
Average	**207,597**	**54.1%**	**1.7%**	**1.8%**	**7.4%**	**34.9%**

Table 4: Percentage buses given Bus Priority, post-1s DTx removal

Cell	Average buses seen by BP per day (total)	Average buses arriving during green (%)	Average buses given central extension (%)	Average buses given local extension (%)	Average buses given recall (%)	Average buses arriving during red but not receiving priority (%)
CNTR	225,320	56.6%	1.6%	2.0%	5.1%	34.6%
EAST	105,533	52.6%	2.0%	1.8%	9.2%	34.4%
NORT	271,051	53.9%	2.5%	2.5%	8.9%	32.2%
OUTR	146,542	50.3%	2.4%	2.1%	9.6%	35.5%
SOUT	306,176	58.2%	1.9%	1.8%	5.9%	32.3%
Average	**210,924**	**54.3%**	**2.1%**	**2.1%**	**7.7%**	**33.8%**

5. Conclusion

With the desire to have 80% of all trips in London by 2041 to be made by foot, on bicycle or using public transport, it is essential that the way TfL manages the road network centres around the performance of sustainable modes. The challenge faced by Network Performance every day is to use the current UTC system to continually improve performance for buses, pedestrians and cyclists.

This Healthy Streets approach to the road network has changed how Network Managers set up, implement, optimise and analyse the system. The STUDI tool has been revolutionary in helping our Network Managers quickly and confidently analyse the ways which our signals are used and identify any potential problems or issues with their current operation. It has been crucial in helping to detect where techniques are not being maximised, such as Stage Truncation and SCOOT Cycle Time Independence. These are just two examples of techniques which are now being implemented London-wide to help improve sustainable modes. Changes to the system, such as the one second data transmission removal has also had significant impacts on the amount of priority buses now get at junctions, therefore improving their performance.

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