Technical Direction

Traffic modelling

TTD 2018/002 | RMS 18.1126 – 22 November 2018

Traffic Signals in Microsimulation Modelling

Summary:	Audience:
This Technical Direction is about traffic signals in microsimulation modelling. It provides a brief overview of the SCATS system and endorses traffic signals key requirements and identifies appropriate data sources, including: • Recommendation on key characteristics and time settings of signals to be replicated in microsimulation, • Identifies SCATS data and data sources, relevant to microsimulation modelling	• Traffic Microsimulation Modellers • Roads and Maritime Services staff

Purpose

This Technical Direction is to provide guidance on traffic signals in microsimulation modelling.

Traffic signals are an essential part of microsimulation modelling. Traffic signals in microsimulation should be configured and should operate similar to the existing traffic signals or in case of new signals should follow traffic signals practice of Roads and Maritime Services (RMS) and Transport Management Centre (TMC). Modelled traffic signals should reasonably well replicate traffic signals configuration, key operational characteristics and time settings.

Traffic signals in Sydney and NSW operate under Sydney Coordinated Adaptive Traffic System (SCATS) control. There are over 4300 traffic signal sites in Sydney and NSW connected to SCATS.

Approvals:

Owner:	Janusz Bobryk	**Review Date:**	21/11/2020
Authorised by:	David Scott	**Effective Date:**	22/11/2018

1 SCATS Brief Overview

SCATS is an intelligent transport system developed in the 1970s by the Department of Main Roads of NSW, the predecessor of Road and Maritime Services. Since then the system capability and functionality have been improved and enhanced as new technologies have become available.

The SCATS primary module is a real-time adaptive traffic control (ATC) system that operates in real-time adjusting signals timings (i.e. cycle times, phase splits and offsets) in response to variation in traffic flow. Traffic control is performed at two levels: strategic (region) and tactical (local). Tactical level control is carried out by the local computers at each intersection. It manages of allocation green times to phases, allowing phases to be extended, terminated early or skipped, in response to traffic demand. The main (stretch) phase, unlike in isolated operations, cannot be skipped nor terminated early. Strategic control is managed by the regional computers. Based on measured real-time traffic flows and lane occupancy rates, the regional computers determine the optimum cycle times, phase splits and offsets.

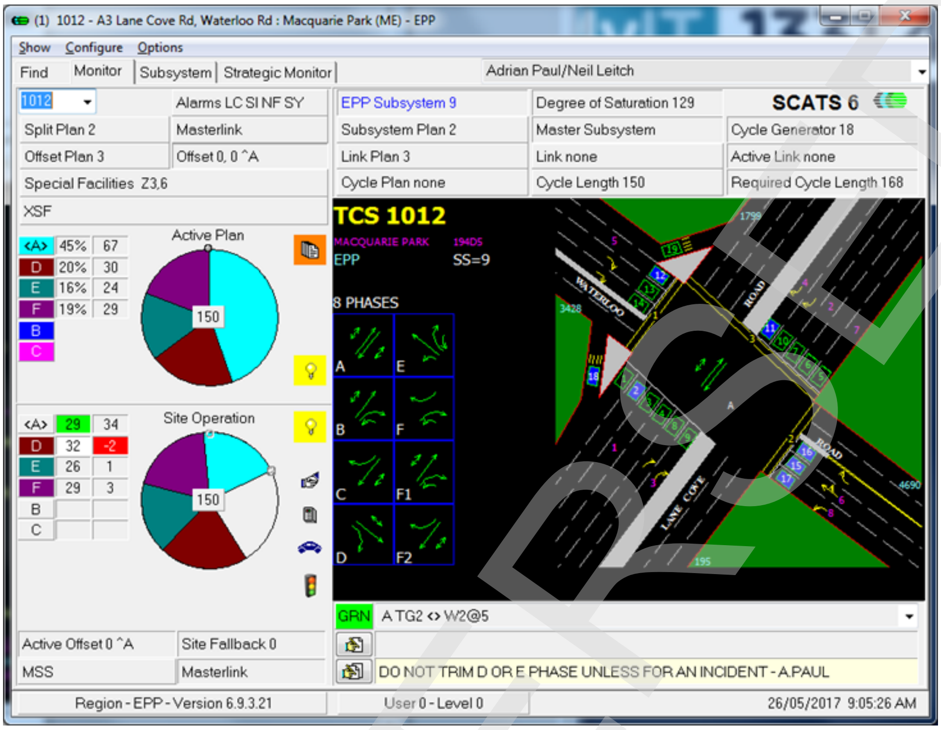

Figure 1. SCATS Access graphic user interface

The subsystem is the basic unit of the SCATS system. It contains a single critical traffic signal site and can also contain a number of non-critical signals sites. The sites in a subsystem can link (coordinate) together and share a common cycle length. Subsystems can link ‘marriage’ with other subsystems to form a larger system. The linked subsystem can unlink ‘divorce’ to suit the prevailing traffic patterns.

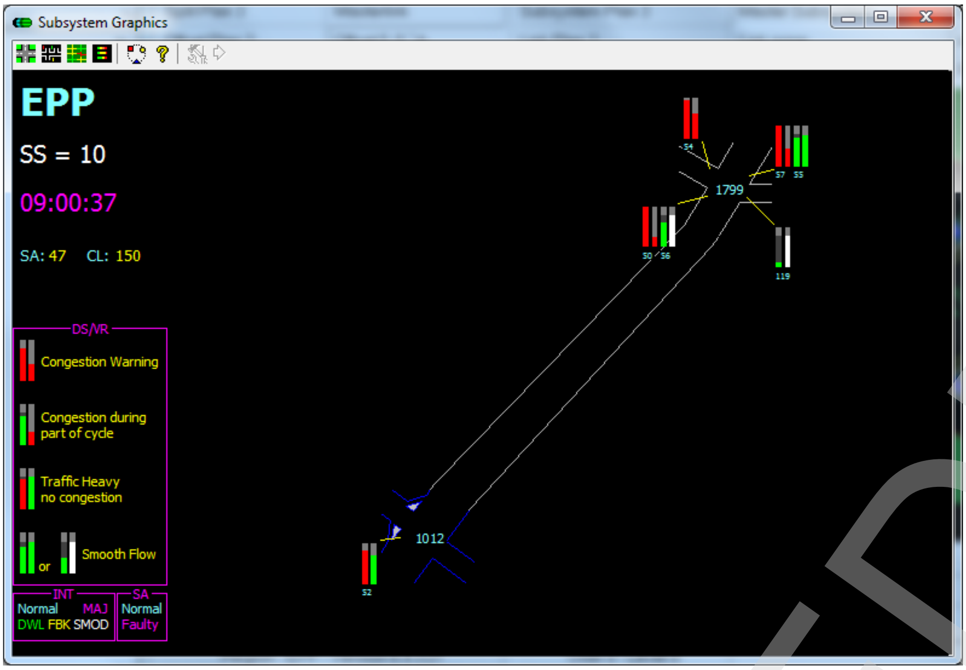

Figure 2. Subsystem graphics

SCATS' other key systems are public transport vehicle priority (using PTIPS) and ramp metering.

Regional computers are connected to the Central Computer. The Central Computer manages global data, access control, graphics data and data backup.

SCATS has automated collection of operational and performance data, including signals timings statistics and traffic volume data.

Traffic signals connected to SCATS may operate as:

- SCATS isolated
- Flexilink
- Masterlink

A SCATS isolated site operates as any other isolated site except that it can respond to SCATS special feature and can be monitored by the regional computer.

Flexilink operations are managed by the site traffic controller. Phase times are controlled by responding to inputs from vehicle detectors and pedestrian push-button detectors. The controller clock times are kept accurately by regular referencing to the times from the SCATS regional computer.

Masterlink is fully controlled by SCATS regional computer. The data from strategic detectors is used for optimising the cycle time and the phase splits for each signals site in the sub-system.

Some signals may operate as non-SCATS. Non-SCATS signals are signal sites that are not connected to a SCATS regional computer, and may operate as an isolated site, not coordinated with any other site(s) or operate in coordination with adjacent site(s) using vehicle-pedestrian link, sister link or cables link (similar to Flexilink but with no reference to SCATS time).

2 Traffic Signals in Microsimulation

Traffic signals in microsimulation can be coded to operate as:

- Fixed time
- SCATS controlled through the SCATSIM interface
- Vehicle Actuated (VA)

Fixed time signals are not recommended for microsimulation modelling of adaptive traffic signals controlled by SCATS. SCATS actuated (demand responsive) operations are unsatisfactorily represented by fixed time control, particularly when the controller's phases frequency is uneven, pedestrian volumes are low to moderate, and traffic flows and arrival patters are highly variable. Fixed time signals though, are acceptable in microsimulation if the signals are to operate as a fixed time, or analysis is for high level strategic planning.

SCATSIM is not recommended for typical microsimulation applications. It is used only for special applications on request by RMS or Transport for NSW. SCATSIM modelling requires advanced knowledge of SCATS configuration. These models are set with assistance of RMS or TMC staff familiar with SCATS.

Vehicle actuated (VA) programming is recommended for coding traffic signals in microsimulation modelling. Modelled VA signals should operate similar to SCATS controlled signals.

The VA signals should operate with variable phase green times and variable cycle times but at the same time should reasonably accurately replicate SCATS key operational features, and key configuration characteristics and timing settings.

Some signalised sites may not be controlled by SCATS. These sites may operate as the 'fully' actuate (with no stretch phase) or as the fixed time.

2.1 Signals key operational features

Modelled signals have to reasonably accurately replicate the actual traffic controller following key operational features:

- Stretch phase operation
- Phase operation
- Nominal cycle time
- Diamond phase (where applicable)
- Other features if applicable such as red arrow, PT priority
- Signals co-ordination

2.1.1 Stretch phase operation

Stretch phase is a phase that is assigned to major movements (usually concurrent through movements). This phase's key operational characteristic is its running time possible extension. If in any cycle time there is "unused" time i.e. a time from some phases that were terminated earlier (gapped out) or were not run at all (skipped), the "unused" time will prepend to the stretch phase in the next cycle. This phase may run over a whole cycle when no traffic demand is detected for other phases.

2.1.2 Phase operation

Each phase, except stretch phase, should be called only on demand, i.e. if vehicle(s) are detected by detector(s) or a push button is pressed. Otherwise the phase would not be called if traffic demand is not detected by detectors. A phase when called will display a green light for a set minimum time and then stay green until traffic demand ceases (gaps out) or until a set maximum green time is reached.

Note some phases' green time may be extended beyond a set maximum by part of 'unused' time from the preceding phase. The non-stretch phase extension will have to be included when requested by RMS.

2.1.3 Nominal cycle time

A nominal cycle is a reference cycle. It is used for setting phase initial times and setting signals co-ordination. The nominal cycle time comprises phase times: a stretch phase time and possible maximum times of other phases. Note the actual (running) cycle time is variable because phase times are variable.

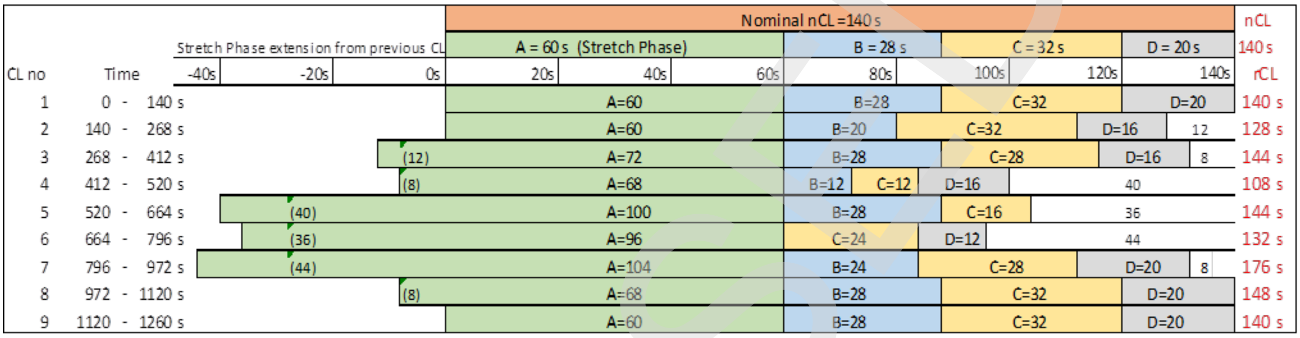

Figure 3. Example of modelled signal operation

The example in Figure 3 illustrates the relationship between nominal (nCL) and actual (rCL) cycle times, and the relationship between stretch phase (A) and other phases (B, C & D). Note Phases D and B were skipped in Cycle times number five and six respectively.

Nominal cycle time is variable (dynamically changed) in SCATS. It can also be variable in modelling as well but it has to be consistently applied to linked signals for maintaining coordination.

2.1.4 Diamond phase

Diamond phase comprises three phases: diamond (F) and two half diamonds (F2 and F3), as shown in Figure 4. Diamond phase can run five possible combinations: F or F2 or F3 or F + F1 or F + F2.

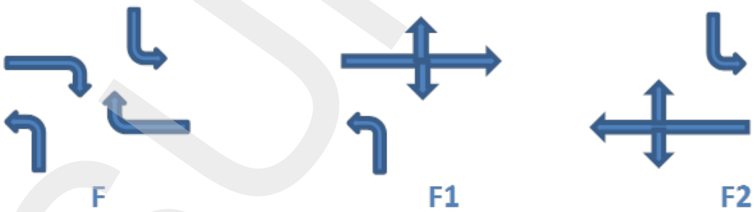

Figure 4. Diamond phasing

2.1.5 Signals co-ordination

Signals co-ordination is realised in SCATS on two levels: Offset Plans (OP) and Link Plans (LP). Offsets between signal sites belonging to the same sub-system (SS) are set by OP, whereas LP provide offsets between sub-systems, which are dynamically joint "married" by SCATS. More details on how to read and interpret SCATS signals co-ordination is given in Section 2.3.

2.2 Modelled signals settings

Modelled existing signals are to reasonably replicate the SCATS key settings, and new signals are to be set according to RMS practice – refer to RTA Traffic Signals Design [7] and RTA Traffic Signal Operation [4].

Modelled signals key characteristics and time settings are:

- Phase configuration
- Phase sequence (running order)
- Stretch phase
- Diamond phase (where applicable)
- Other time settings, including late start, bus pre-emption
- Nominal cycle time
- Minimum green and intergreen (amber + all red) time
- Pedestrian walk, and clearance time (C1+C2)
- Phase green time
- Signals co-ordination

It is recommended that SCATS Graphics, History Files, Traffic Reporter, and the LX file (or SCATS Access) to be used to identify SCATS settings relevant to modelling.

Modelled actuated signals may typically be set with a gap time of 3 to 5sec, and where applicable with a headway time of 0.8 to 1.4sec and a waste time of 3 to 10sec.

Modelled new signals are also to have the above mentioned characteristics and settings set similar to SCATS and in accordance with RTA Traffic Signals Design [7] and RTA Traffic Signal Operation [4].

If RMS does not request otherwise, the following key settings are recommended for new signals:

- Nominal cycle time of 140sec
- Cycle shorter times than 140sec may apply to off-peak traffic, to intersections along minor routes and to isolated intersections.
- Minimum green time of 5sec for vehicles.
- Minimum green time of 6sec for pedestrians and when appropriate, use longer green times to address pedestrian safety requirements.
- Gap time of 3 to 5sec.
- Signals coordination should be set to maximise the progression of major traffic flows.

2.2.1 Phase maximum green time

There is no straightforward method or standard benchmark on how to determine phase maximum green time. It is determined in an iterative process where initial green times are estimated and then adjusted further, and this usually takes up to three iterations.

Phase maximum green times are estimated in an iterative process. Firstly, initial green times are assigned according to one of the methods listed below. Secondly, the model is run and then modelling output reviewed and assessed. Traffic intersection performance (total and by movement) should be assessed against control objectives. If not otherwise requested by RMS, the objectives are to optimise the intersection delay i.e. to minimise intersection total delay but at the same time to maintain delays of secondary and minor movements in a reasonable range when compared against the major movements. In addition, for the existing intersections the modelled average green time should be compared against actual average green times. A difference between modelled and real average green times of up to 20% is acceptable, and any higher variation would need to be individually assessed. Third, based on the assessment the maximum green times should be further revised if required. Steps two and three are then repeated again, until intersection performance is found to be acceptable.

Several methods can be used to estimate phase initial maximum green time:

Method 1 (recommended for existing signals)

Use History Data Statistics and History Data Phases output (as in Figure 12 & 13) to determine phases average green times. Check whether these times meet pedestrian safety provision (green time + clearance); if not, revise the green times upwards accordingly.

Set all phases (except stretch phase) initial maximum green times around 0-20% higher than these revised averages. The stretch phase time is set as a difference between the adopted Nominal Cycle and the total time of other phases.

Method 2 (for existing signals)

Identify for each modelled peak a relevant (active) Split Plan (or Plans) as mentioned above (in Subsection 3.5. Use the relevant Split Plan to calculate phase green times. Then set initial maximum green times of all phases in the same way as in Method 1.

Method 3 (for new signals)

Assume a typical phase configuration and a cycle time of 140 sec (longer or shorter than 140 sec times may be used when accepted by RMS) and calculate phase times using traffic signals software such as SIDRA, LinSig, TRANSYT, etc. Then set initial maximum green times of all phases in the same way as in Method 1.

Method 4

Some signals initial green times may be estimated based on maximum green times from sites with similar traffic flows and patterns. Then set initial maximum green times of all phases in the same way as in Method 1.

2.3 Existing traffic signals coordination

SCATS traffic signals coordination is set on two levels: signals linking within the subsystem (Offset Plan) and subsystem linking (Link Plans). Typically, each TCS has four offset plans, and each subsystem has four link plans. Subsystems can be connected (married) or disconnected (divorced). SCATS dynamically manages signals coordination selecting appropriate offset plans to traffic conditions at any given time.

Modelled existing signals should in principle be coordinated in the same way as the SCATS existing signals.

To identify SCATS existing signals coordination for a given time period the following information for each signal site has to be identified:

1. Settings: link plans, offset plans, stretch cycle time (XCL), highest cycle time (HCL) (source: LX file)
2. Active offset plan(s) (OP), active link plan(s) (LP), nominal cycle time(s) (CT), for analysed time period (source: Traffic Reporter: Subsystem graphics).
3. Record the collected data as show in Figure 5
4. Calculate offsets (OP+LP)
5. Determine offsets for microsimulation modelling

Notes:

a. Offset plans and link plans have two values (low and high). The low applies to cycle times lower or equal to the stretch cycle time (XCL) and the high to the highest cycle time (HCL). If nominal cycle time (CT) is between XCL and HCL, the offsets need to be adjusted accordingly.

b. If Link Plans or cycle times vary over the modelling reference period, select the most prevailing or proportionally adjusted.

c. In the example shown In Figure 5, the relevant OPs and LPs are underlined.

SCATS settings					
Offset Plans (PP)	1	0, 0 A	0, 0 A	0, 0 A	9,9 A
	2	**0, 0 A**	**0, 0 A**	**0, 0 A**	**8, 16 A**
	3	0, 0 A	0, 0 A	0, 0 A	9, 9 A
	4	**0, 0 A**	**0, 0 A**	**0, 0 B**	**9, 9 A**
SubSystem (SS)		9	10	19	19
TCS		**1012** MS (Master Subsystem)	**1799**	**3161**	**3446**
Link Plan (LP)	1	Link none	-18, -18, 1012 A	-29, -29, 1799 A	-29, -29, 1799 A
	2		**12, 13, 1012 A**	**1, -7, 1799 A**	**1, -7, 1799 A**
	3		-22, -12, 1012 A	-18, -22, 1799 A	-18, -22, 1799 A
	4		**-30, -16, 1012 A**	**-9, -15, 1799 A**	**-9, -15, 1799 A**
		sec	sec	sec	sec
Cycle time	Stretch - Max (XCL - HCL)	130 -150	130 - 150	130 - 150	130 - 150
				(-16-15)	(-16-15+9)
CL =150 sec	AM	0	-16	-31	-22
				(13-7)	(13-7+16)
CL =150 sec	PM	0	13	6	22
Microsimulation offsets (SCATS equivalent)					
CL = 150	AM	0	134	119	128
CL = 150	PM	0	13	6	22

Figure 5. Example of Signals Offset

3 SCATS data for modelling

SCATS data appropriate for modelling can be extracted from SCATS system through several applications, including SCATS Access, SCATS Traffic Reporter and SCATS File Downloader. In the past SCATS data were extracted through Intersection Diagnostic Monitor (IDM) application. The IDM tool is no longer available.

3.1 TCS site graphics

TCS site graphics can be accessed through SCATS Access, a primary SCATS interface for setting, monitoring and reviewing SCATS in real time. TCS site configuration and timing settings are coded, monitored and reviewed through SCATS Access. Other key functions of SCATS Access are subsystem monitoring and strategic monitoring.

The TCS site graphics shows a typical set of phases and a pictorial representation of the intersection with detectors (in green), pedestrian crossing (in yellow), signal groups (in pink), region identifier and adjacent TCC numbers (in light blue), and subsystem (SS) number (in white).

Two 'diamond' phasing sets: D, D1, D2 and G, G1, G2 are shown in Figure 6.

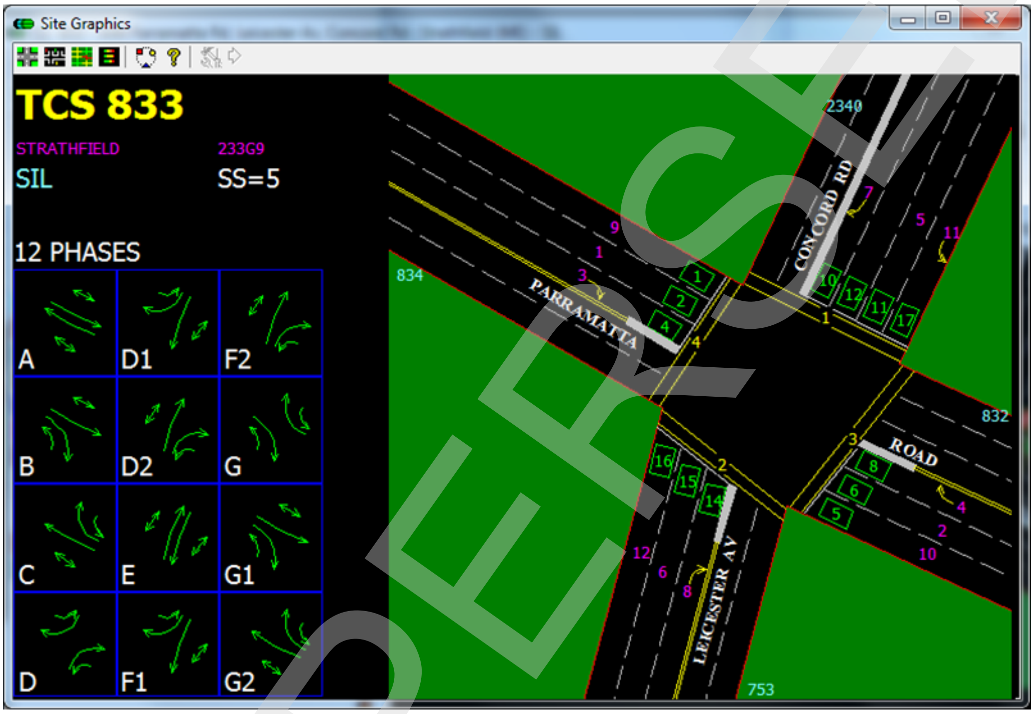

Figure 6. SCATS Site Graphic

Note that some phases shown above in Figure 6 may operate only in some signal plans or may not operate at all. For example, the phases B, C, F1 and F2 are not used in TCS 833.

More detailed information on signals configuration intersection layout can be found on TCS plans.

3.2 Split plans

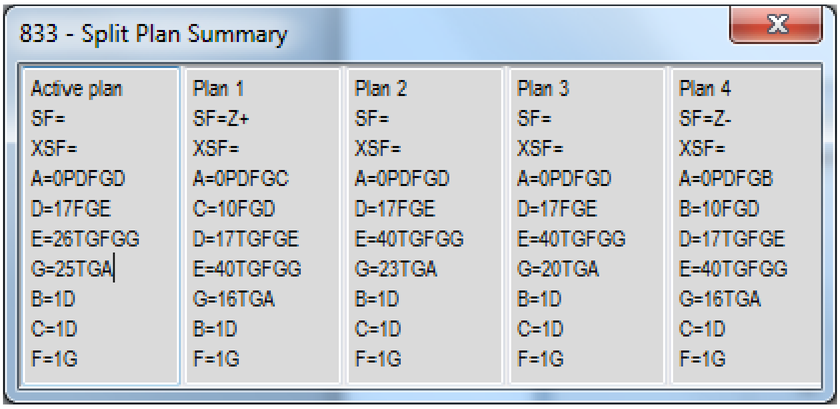

Figure 7. Split Plan Summary

Note a stretch phase coding consists “0P…” so in the given example (in Figure 7), Phase A is a stretch phase. Note also that in some plans phases are marked as “1D” or “1G”. These phases are not in use

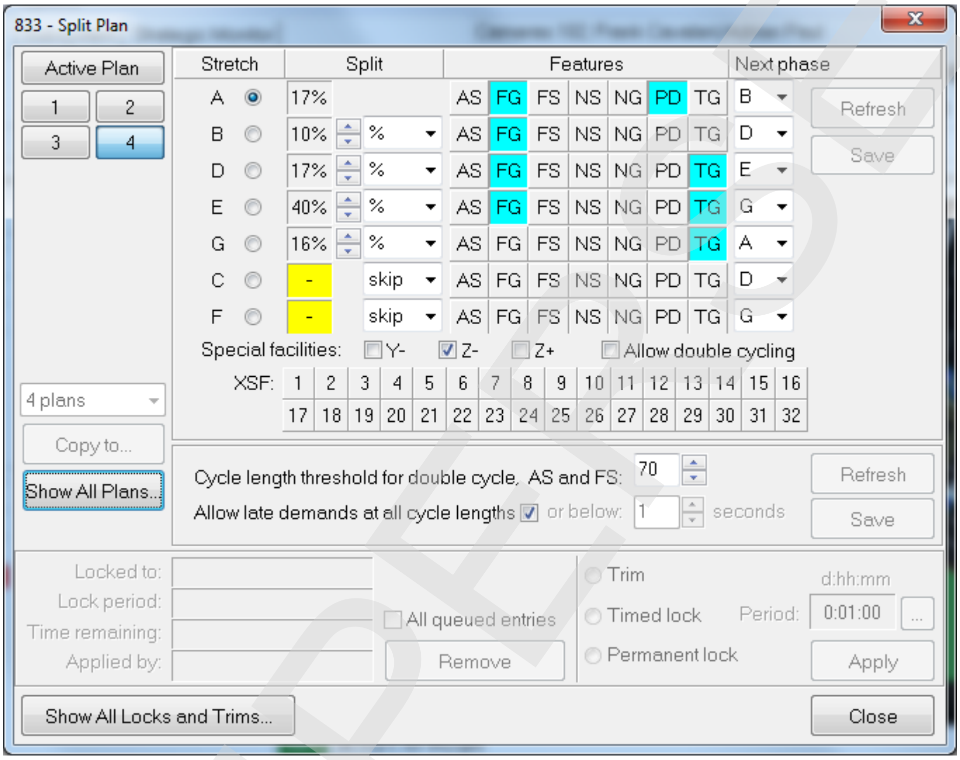

Figure 8. Split Plan

3.3 Other settings relevant to modelling

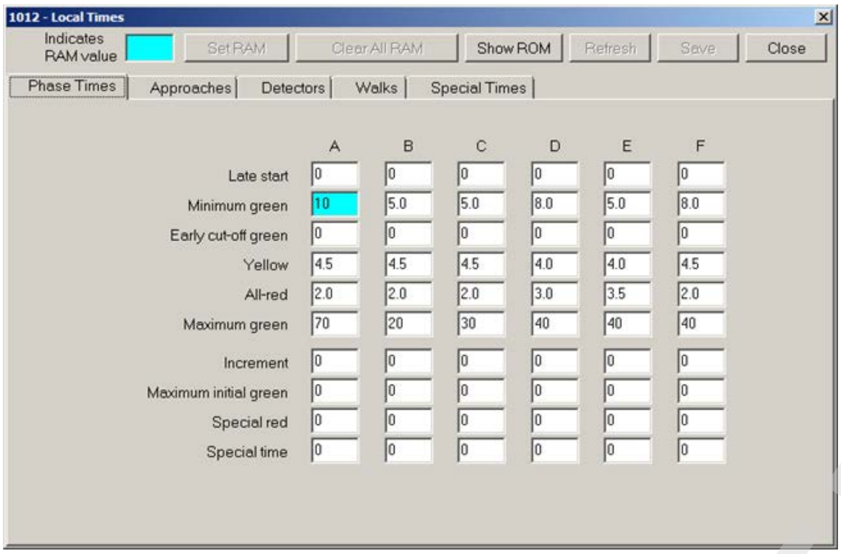

Figure 9. SCATS Configuration, Controller Local Times: Phase Times

Note: The above maximum green times are not relevant for modelling as the sum of maximum green times is higher than the SCATS maximum cycle time.

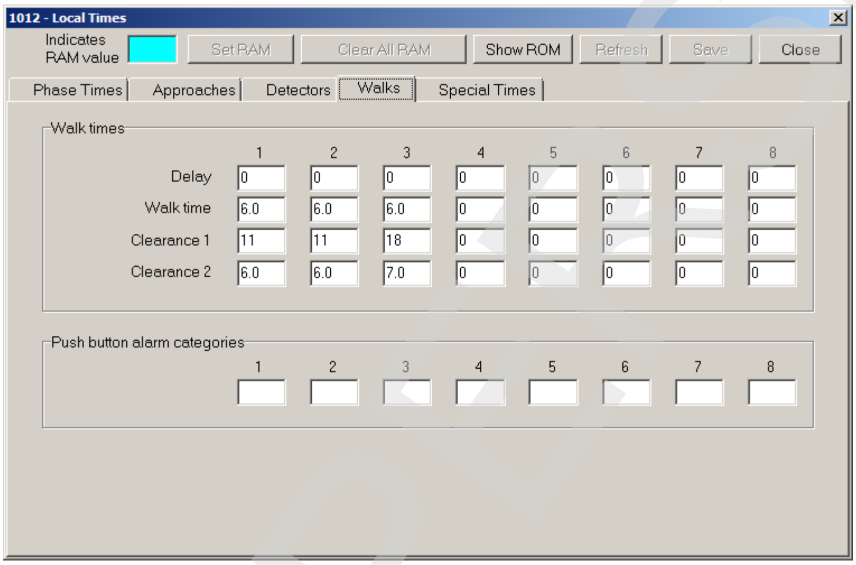

Figure 10. SCATS Configuration, Controller Local Times: Walks Pedestrian phases green and clearance times

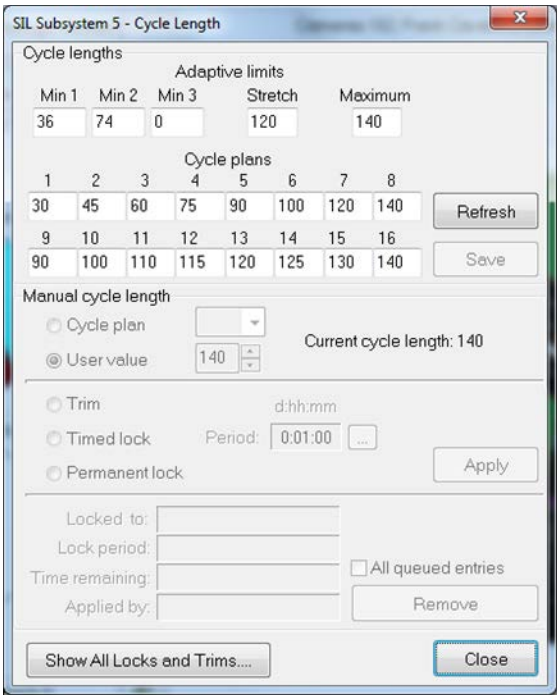

Figure 11. Subsystem – Cycle Length

4 LX file

Each SCATS Region has an LX file. The LX file is a SCATS configuration file that contains signal setting details of all sites in a SCATS region. The key timing settings relevant to modelling are cycle time (minimum, stretch and maximum), phase minimum green and intergreen times, pedestrian phase green and clearance times, split plans, link plans, offset plans, special times (e.g. late starts). Split plans show the running order of the phases and an initial time split.

The LX file information is in a SCATS command format. The file content therefore has a low legibility for non-SCATS users. To help in interpreting LX file content, a brief explanation on some LX signals settings relevant to modelling is given in Attachment A.

5 History file data

A history file contains all signals timing statistics (actual phase times and cycle times) for selected SCATS Region and selected day (24 hours). The history information can be viewed in five formats: events, phases, cycles, timeline and statistics. The phases and statistics formats are most suitable for modelling – see Figure 12 and 13. The phase information in the phase format should be collected for time periods longer than modelling time periods, extending before and after.

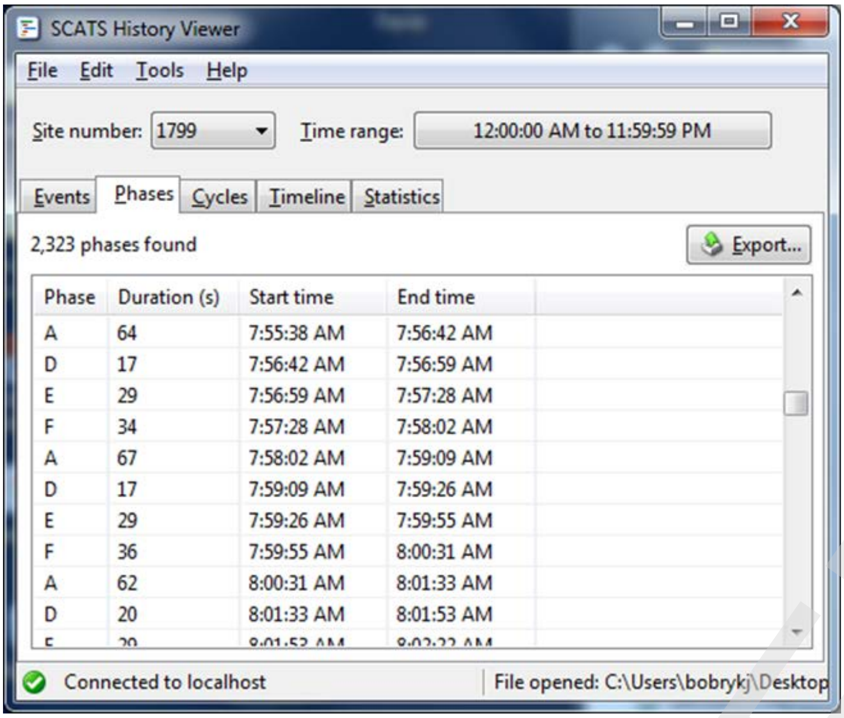

Figure 12. History File Data: Phases

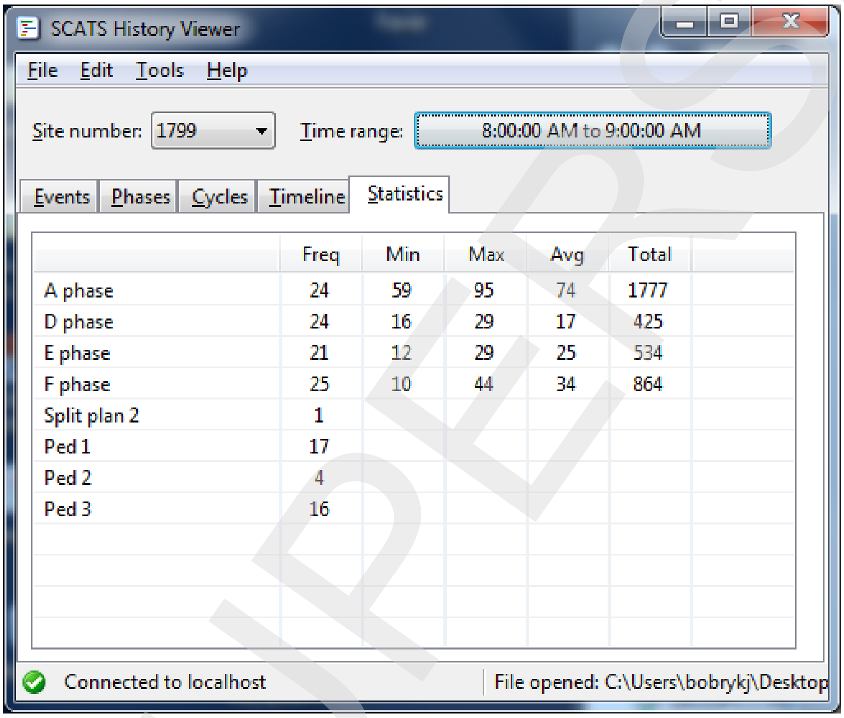

Figure 13.History File Data: Statistics

Notes:

- It is likely that the first and the last phase are going to be truncated for any given time range. Subsequently average times, some minimum times and phase frequency may not be correct
- The 15-minute time ranges are not recommended because of truncation impact on the reported statistics

- Cycle times may be produced with some selected time ranges. These times need to be checked against phase times.
- Information on a pedestrian signals frequency is given here.
- Phase F was running at both (8:00 and 9:00) ends of the selected time range. The reported phase F minimum time of 10 sec is incorrect since it is a result of truncation, and is lower than minimum of 12 sec.
- To avoid the issue of truncation mentioned above, it is recommended to use the raw “Phase Data” shown in Figure 12 rather than using the given averages in Figure 13.

6 Subsystem information

Subsystem data can be extracted through Traffic Reporter for any day in the last six months.

Assistance of TMC staff will be required to access data older than six months.

Subsystem information can be extracted on daily (24 hours) basis and it consists of split plans, link plans, cycle length, subsystems linking. The data can be in text or graphic formats. The latter appears to be more suitable for modelling. It shows a nominal cycle time, and split and link plans.

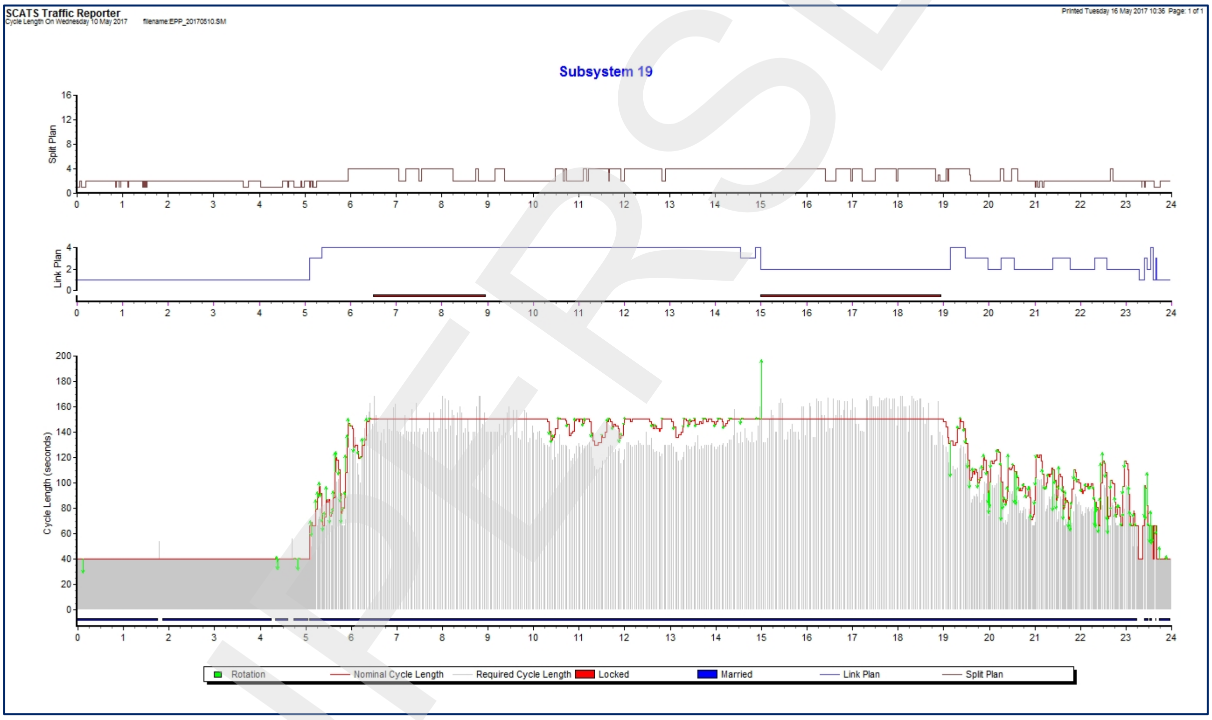

Figure 14. Traffic Reporter: Subsystem Graphics

Literature

1. Roads & Maritime Services, July 2016, Traffic Signals Design, Section 7 Phasing and Signal Group Display Sequence
2. Austroads 2014, Guide to Traffic Management Part 9: Traffic Operations, AGTM09-14
3. Roads and Traffic Authority, NSW, 2011, SCATS 6 Functional Description
4. Roads and Traffic Authority, NSW, 2010, Traffic Signal Operation, RTA-TC-106
5. Roads and Traffic Authority, NSW, 2009, Standard for Single Diamond Overlap Phasing. Guidelines for Developing, TS-TN-026
6. Roads and Traffic Authority, NSW, 2009, Standard for Double Diamond Overlap Phasing. Guidelines for Developing, TS-TN-027
7. Roads and Traffic Authority, NSW, 2008-2011, Traffic Signals Design
8. Roads and Traffic Authority, NSW, 2000, SCATS 6 Quick Reference Manual, RTA-TC-102

Attachment A

A brief overview of LX file content and settings appropriate for modelling is given below.

Each SCATS Region has the LX file. The LX contains signals configuration time settings of all TCS sites in the region. All settings are coded in SCATS programming language and are difficult to follow for someone not familiar with SCATS programming. Note signals phases minimum green times, late start times or red arrow times are not recorded in the LX file.

The LX file is a large file in text format. To identify and then extract signals time settings pertaining to any site being modelled, the signals following identifiers have to be known: traffic signals TCS number (Intersection ID), subsystem number (SS) and SCATS Region name.

SCATS commands and settings pertinent to modelling.

Symbol/Command	Description
HCL=	Highest Cycle Time
e.g. HCL=150	Highest Cycle Time of 150 sec
INT=	TCS number, Intersection number
e.g. INT=1012!	TCS 1012
LCL=	Lowest Cycle Time
e.g. LCL=40!	Lowest Cycle Time of 40 sec
LPn=	Link Plan Number “n”, subsystem offset “n”
e.g. LP4=-30,-18^A1012	Link Plan 4, subsystem offset: low=-30 sec, high=-18 sec
nT=	“n” phase clearance time
e.g. AT=7!	A phase clearance time of 7 sec
PPn=	Offset Plan “n”
e.g. PP2=16,28C	Offset Plan 2, low=16, high=28 to start of Phase C
SS=	Subsystem
e.g. SS=10	Subsystem 10
Wn=	Walk number “n” green time

e.g. W4=6!	Walk number 4: green time of 6 sec
WnT=	Walk “n” clearance time
e.g. W4T=32!	Walk 4 clearance time of 32 sec
XCL=	Stretch Cycle Time
e.g. XCL=130	Stretch Cycle Time of 130 sec

a. Intersection ID (TCS), phase intergreen time, pedestrians (walk) green times, walk clearance times and offset plans (PP)

…………………………..
SLOT12=4,4,2!**INT=807!**VC=5!CS=152!PK=/ZSL=0!
COM=NET,H!CTYPE=C18V5R20S24!
LS=ON!
IK=!
S#=11!LM=MF^!RMN=0!DCL=60!
VOLS=1-24!
AT=7!BT=7!CT=7!DT=7!
W1=6!W1T=16!W1F=!W2=6!W2T=22!W2F=!
PP1=26,26C!PP2=22,18C!
PP3=0,15C!PP4=-22,-16C!
VAR1=47!VAR1.1=2!VAR1.2=128!VAR1.3=10!VAR1.4=10!
VAR2=47*!VAR2.1=3!VAR2.2=146!VAR2.3=24!VAR2.4=29!
VAR3=11!VAR3.1=62!VAR3.2=12!VAR3.3=0!VAR3.4=18!
VAR3.5=0!
VAR4=29!VAR4.1=16!
…………………………..

Where:

Command	Description/meaning
INT=807	TCS 807
AT=7!	Phase A intergreen time of 7 sec
BT=7!	Phase B intergreen time of 7 sec
CT=7!	Phase C intergreen time of 7 sec
DT=7!	Phase D intergreen time of 7 sec
W1=6!	Walk 1 green time of 6 sec
W1T=16!	Walk 1 clearance time of 16 sec
W2=6!	Walk 2 green time of 6 sec
W2T=22!	Walk 2 clearance time of 22 sec
PP1=26,26^C!	Offset Plan 1 - 26, 26 sec to start of Phase C
PP2=22,18^C!	Offset Plan 2 - 22, 18 sec to start of Phase C
PP3=0,15^C!	Offset Plan 3 - 0, 15 sec to start of Phase C
PP4=-22,-16^C!	Offset Plan 4 - -22, -16 sec to start of Phase C

b. Split Plan Data

…………………………..
I=1799!PLAN=1!SF=!XSF=0!

A=0PDFGD!
D=18FGE!
E=13F!
F=12TGA!
B=1D!
C=1D!
…………………………..

Where:

Symbol/Command	Description
I=1799!PLAN=1!	TCS 1799, Split Plan 1
A=0PDFGD!	Stretch Phase A of 57% (=100-18-13-12)
D-18FGD!	Phase D of18%
E=13F!	Phase E of 13%
F=12TGA!	Phase F of 12 %
B=1D!	Phase B not used
C=1D!	Phase C not used

c. Link Plan Data, Low Cycle Time, High Cycle Time and Stretch Cycle Time

……………………………
SS=10!LCL=40!HCL=150!SCL=66,0!KCL=0!ZSS=0!
SK=DDNAOVIFBF!
XCL=130!SZ=88,94!SMX=/
FCL=30,40,45,50,60,70,75,80,90,100,110,115,120,125,130,140!
PS1=40^,66!PS2=76,130!PS3=76,130!PS4=76,130!
LP1=-18,-18^A1012!
LP2=12,13^A1012!
LP3=-22,-12^A1012!
LP4=-30,-16^A1012!
…………………………..

Where:

Symbol/Command	Description
SS=10!	Subsystem 10
LCL=40!	Lowest Cycle Time of 40 sec
HCL=150!	Highest Cycle Time of 150 sec
XCL=130!	Stretch Cycle Time of 130 sec
LP1=-18,-18^A1012!	Link Plan 1: -18, -18 sec from start of Phase A at TCS 1012
LP1=12,13^A1012!	Link Plan 2: 12, 13 sec from start of Phase A at TCS 1012
LP1=-22,-12^A1012!	Link Plan 3: -22, -12 sec from start of Phase A at TCS 1012
LP1=-30,-16^A1012!	Link Plan 4: -30, -16 sec from start of Phase A at TCS 1012

www.rms.nsw.gov.au/

13 22 13

Customer feedback
Roads and Maritime
Locked Bag 928,
North Sydney NSW 2059

November 2018
RMS 18.1126