SCATS

# *SCATS 6*

## Functional Description

# Contents

# An Introduction – SCATS 6

## What is SCATS?

In 1970's, the Department of Main Roads developed a facility that was initially called the SCAT system (2) – now SCATS (3)– to deliver sophisticated adaptive traffic control functionality to key roads within Sydney. SCATS was abbreviated from "Sydney Coordinated Adaptive Traffic System".

SCATS is an area traffic management system consisting of hardware, software, and a unique control philosophy that operates in real-time, adjusting signal timings in response to variations in traffic demand and system capacity *as they occur*.

SCATS has grown and strengthened through organisational changes of the owning organisations: Department of Main Roads, the Roads and Traffic Authority of New South Wales, and now, the Roads and Maritime Services (4). These organisations have developed SCATS to deliver on their responsibility to dynamically manage the road network that spans the metropolis of Sydney and the regional cities, towns and roads within the Australian state of New South Wales (NSW).

SCATS was implemented by the appropriate Australian and New Zealand Government Departments as the preferred system of choice and to date all major and minor cities in Australia and New Zealand use SCATS.

The development of SCATS by the Roads and Maritime Services is primarily aimed to deliver worlds best practice service to the people of NSW. Other vibrant cities around the world have also chosen to adopt and share in the SCATS capability and indirectly influence its development including: Hong Kong, Shanghai, Singapore, Kuala Lumpur, and Auckland – to name a few.

## Who are the Roads and Maritime Services?

Roads and Maritime Services (RMS) (previously known as Roads and Traffic Authority of New South Wales (RTA) and before that Department of Main Roads (DMR)) is a NSW statutory authority established on 1 November 2011 under the Transport Legislation Amendment Act 2011. It works to deliver customer focused services in a cost effective manner to achieve transport outcomes.

RMS is a multi-modal transport agency within the broader transport cluster that has Transport for NSW (TfNSW) at its centre. TfNSW has responsibility for transport policy, planning and coordination functions, and the oversight of infrastructure delivery and asset management.

In this framework, RMS implements initiatives that improve the movement of people by various transport modes, including public transport (bus and ferry), cycling and walking, as well as motor vehicles. RMS also delivers initiatives to improve the movement of goods through the freight network, including the implementation of reliability, productivity and safety initiatives.

### RMS' responsibilities

RMS' primary responsibilities are to:

Manage the road network and travel times.

Provide capacity and maintenance solutions for road and maritime infrastructure.

Test and licence drivers and vessel operators, and register and inspect vehicles and

vessels.

Improve road and maritime safety.

**RMS manages a network that includes:**

18,031 km of RMS-managed State roads, including 4323 km of national road network, for which the Australian Government provides a funding contribution, and 147 km of privately-funded toll roads.

2970 km of regional and local roads in the unincorporated area of NSW.

5190 bridges and major culverts, and 23 tunnels, 3867 traffic signals and more than 12,000 other road traffic facilities, systems and corridor assets.

2137 km of coastline and 32,424 km2 of navigable waterways comprising, 5000 km2 enclosed waters, and 27,691 km2 of coastal waters to 12 nautical miles.

49 commuter wharves.

3418 aids to navigation, including 191 courtesy moorings, on NSW waterways.

**RMS delivers its services through a range of facilities:**

126 motor registries, seven Government Access Centres, 29 maritime service centres, 34 agencies (including 29 online council agencies), and 44 itinerant sites which provide face-to-face customer service across NSW.

Purpose-built facilities including the RMS Crashlab at Huntingwood, the Document Management Centre in Auburn and three contact centres (call centres).

Other facilities include work depots, motorcycle rider training centres, fleet workshops, mobile service units, laboratories and inspection stations.

**Licensing and registration**

In 2011–12 in NSW, RMS provided:

Registration and licensing services for around 4.98 million motor vehicle licence holders and 480,000 boat drivers licence holders.

Registration for 5.72 million motor vehicles and 230,000 vessels.

Services for hire and drive, aquatic, mooring and commercial boating licences.

Management of around 22.3 million motor vehicle, and 670,000 maritime, licensing and registration related transactions over the year.

**Employees**

RMS currently employs around 7195 full-time equivalent (FTE) staff across NSW. This includes wages and salaried staff, school crossing supervisors, participants in targeted employment programs and 649 FTE staff currently assigned to Transport for NSW. About 47 per cent are employed in regional locations and, of these, 30 per cent are wages staff and school crossing supervisors and 70 per cent salaried staff. RMS also delivers through its industry partners and contractors across a range of services.

## SCATS enduring principles are its strength

The initial SCATS development created break-through technologies with what would now be considered humble: electronics, microprocessors and communication networks. The early generations laid the foundation principles of what would become SCATS characteristic, demand-responsive, traffic control decision-making.

SCATS operation is known for its effective feedback control that continuously and autonomously self-calibrates efficient traffic conditions and measures road utilisation at each detector. Calibration

and measurements are used to estimate the balance of: the traffic signal and road capacity supply, and the traffic demand–in each vehicular lane, and optimise and allocate scarce road resources, accordingly.

SCATS is being continually refined and updated to respond to the increasing and varying modern traffic management needs, and to leverage the advantages of new technologies. However, in this face of continuous change, the originating SCATS principles (1,5,6) have proven enduring because of the demonstrated ability of SCATS to produce effective and robust traffic outcomes.

The modern improvements to SCATS have stood on the shoulders of the originating SCATS principles. These SCATS principles are its strength.

## SCATS is a Hierarchical Platform

SCATS tracks critical traffic demand to adjust the effective road capacity with cycle time changes and optimises phase (or stage) times to fit the varying demands of competing movements. SCATS dynamically balances the local site optimisation and inter-site coordination to capture the efficiency benefits of platoon progression.

- SCATS manages three main parameters to achieve traffic signal coordination:

  1. Cycle time: The total time of all signal sequences in a cycle

  2. Phase split: The proportion of the cycle time allocated to each phase

  3. Offset: The time relationship between the starting or finishing of the green phases of successive sets of signals within a coordinated system.

In SCATS parlance, SCATS decision-making occurs at two levels: strategic and tactical (6).

At the strategic level: SCATS dynamically balances the needs of a coordinated network such as achieving offsets to aid platoon progression, with the needs of the local site such as the appropriate phase sequence and the balance of phase (stage) allocation given demand.

- Strategic control is managed by the regional computers. Using flow and occupancy data collected from vehicle detectors the regional computer determines on an area basis the optimum cycle length, phase splits, and offsets to suit the prevailing traffic conditions.

  Strategic control bases its adjustments on a traffic demand measurement known as 'Degree of Saturation' (DS). However, in this context, DS represents how effectively the road is being used. Using the in-ground loop detectors at the critical intersections, the local controller collects flow and occupancy data during the green phase. The data is sent to the regional computer which calculates the degree of saturation. Values of DS greater than unity (insufficient green time to satisfy demand) will occur in congested conditions, and SCATS will quickly respond to such an over-saturated situation.

At the tactical level: SCATS responds in real-time to significant changes in the traffic state to reduce inefficiencies through terminating under-utilised movements and to capture efficiencies by re-allocating time to competing movements.

SCATS strategic decision-making considers the interrelatedness of the traffic controllers that are networked by the characteristics of the road network.

- Rather than changing individual intersections in isolation, SCATS manages groups of intersections that are called 'subsystems', the basic unit of the system. Each subsystem will often consist of between one and ten sets of traffic signal sites.

  SCATS adapts and coordinates the signals within each subsystem, and is able to coordinate a subsystem with adjacent subsystems. This coordination aims to allow just enough time for

each platoon of vehicles to enjoy a smooth journey while allowing the needed green time for competing flows. This maximises the network capacity for the benefit of all.

To give coordination over larger groups of sites, subsystems can link with other subsystems to form larger systems. These links may be permanent, or may link and unlink adaptively to suit the prevailing traffic patterns. A SCATS 6 region has 250 subsystems.

SCATS tactical decision-making is predominantly made at the road side controller level; SCATS strategic decision-making is made at a higher level within supervisory, SCATS region computers.

- Tactical control is undertaken by the local controllers, and meets the cyclic variation in demand at each intersection. Tactical control primarily allows for green phases to be terminated early when the demand is low, and for phases to be omitted entirely from the sequence if there is no demand. The local controller bases its tactical decisions on information from vehicle detectors at the intersection. It should be emphasised, however, that the degree to which tactical control is able to modify the signal operation always remains entirely under the control of the regional computer.

There is a tight integration between the SCATS controllers, SCATS region computers and SCATS communication network. The result is a 'SCATS platform' that provides the catalyst for hierarchical control to function effectively and robustly.

### SCATS is Network Scalable

The SCATS platform characteristic makes SCATS readily scalable to different sized road networks. It is for this reason that SCATS is used across the scales of: countries, states, municipalities (counties), towns, corridors and local areas. It also means that the deployed scale of a SCATS installation can evolve and grow organically with the changing needs of the road network and respond to road infrastructure improvement opportunities.

- The SCATS regional traffic control software has a maximum capacity of 250 intersections per region. With a maximum of 64 regions, the total capacity is 16,000 intersections. All SCATS software comes with the Central Management Computer (CMS) software that allows a number of other software packages that are part of the SCATS family to be used as part of the traffic management package.

### SCATS is Sophisticated

The modern traffic problem is not only about private vehicles.

SCATS responds to pedestrian push button calls and dynamic pedestrian measurements with appropriately responding pedestrian traffic signals. SCATS also implicitly tracks pedestrians calls over time and attempts to consider the significant effect that those movements have on the road network within the traffic signal optimisation process.

SCATS interfaces with public transport priority systems that include the more traditional forms such as bus lane or dedicated tram detection, and the more sophisticated tracking of public transport vehicles. For example, in Sydney, thousands of buses (7) are tracked through the road network using GPS and SCATS reschedules appropriate traffic signals in real-time to provide higher levels of service to individual tracked buses.

SCATS adjusts in real-time both the introduction and termination of traffic signals in response to priority requests; this process ensures the perturbation to general traffic is minimised while prioritised service is achieved (8).

SCATS is often used with loop detectors located in each lane at the stop-line. SCATS principles motivate this usage, together with the obvious benefits that close measurement of the valuable

conflict area provides. However, SCATS can also operate with detectors upstream of conflict areas to measure queues and/or overflows of turn-bays, to measure traffic arriving mid-block within the link, and to use measurements at upstream sites to influence control at downstream sites, and visa-versa.

Inductive loop detectors are often used with SCATS because of the high measurement accuracy and reliability that technology provides. However, SCATS can also be used with other measurement technologies to access particular advantages, for example, video detection, and radar. Often the technological choice depends on the constraints and characteristics of the detection problem.

The modern traffic management problem concerns the effective, integrated usage of different traffic control applications including, traffic signal controlled: intersections, roundabouts, and ramps. The SCATS platform delivers all these applications, which ensure solutions can be deployed seamlessly across the road network, across motorways and arterials, and across different and interfacing traffic control applications (9).

SCATS traffic application solutions can help control platoons of traffic as often used at intersections and roundabouts, and can operate metering applications as often used on motorway ramps and also roundabouts and merges. SCATS can provide 'opportunistic' traffic signals that 'turn on' only when required to mitigate unacceptable delays, and 'turn off' to capture the efficiencies of only interrupting traffic with traffic signals when necessary.

SCATS provides principled techniques that can be deployed to respond to congestion in the manner deemed appropriate. Policy may require that inefficiencies due to congestion are deemed unacceptable and that road resources should be re-allocated to efficient, competing movements; or the reverse, that road resources should be re-allocated to alleviate the cause and/or mitigate the effects of congestion.

- When congestion occurs SCATS estimates the full extent of the unmet demand using a parameter known as reconstituted volume. Reconstituted volume is estimated using the calibrated and measured conditions at each detector. SCATS records the duration of congestion for traffic performance purposes and can be configured to respond adaptively to a measured congested state.

The economic, 'best practice' SCATS arterial usage is with stop-line detectors in each lane at all approaches of each intersection, and the re-use of those same detectors at adjacent upstream and downstream intersections to further influence control at each intersection. This provides SCATS with significant demand-responsive capability that considers road network effects. This is the practice adopted within the central business district of Sydney.

SCATS 'best practice' can be enhanced with midblock and end-of-turn bay detection. This is often used in a needs-only-basis where particular effects must be managed, such as managing the overflow of turn bays.

SCATS can measure and control traffic at the signal group or movement level. Traffic signals can overlap, re-introduce or skip in the cycle, operate for only part of the phase or conditionally operate based on the measured traffic state. Importantly, the SCATS optimisation explicitly considers signal group characteristics to ensure accurate scheduling. This ensures SCATS precisely and efficiently allocates road capacity to the differing traffic demands.

## SCATS is Flexible and Customisable

SCATS can also operate with less demand-responsive capability if the situation requires it. In practice this means more fixed time operation that is based on more configured assumptions and less measurement.

Fixed time control may be used because: the local traffic characteristics do not lend itself to demand-responsive control, that measurement capability is not possible, or that a technical issue such as a communications or detector fault has caused the system to 'fall back' to an inferior mode of operation.

The SCATS platform allows for the integration of different sites employing different levels of demand-responsive traffic control. The levels of control can be dynamic–and often are, in particular with the changing status of a real world system that incurs faults, modifications and enhancements.

### SCATS is a Lifecycle Solution

SCATS allows for significant configuration changes and updates 'on the fly'–by remote operators or automatically. This minimises the need for significant down time of the system and the significant costs that otherwise would be imposed on communities.

A SCATS installation can be authentically operated within an accommodating traffic microsimulation application and model (10,11,12). This facility allows SCATS configuration and deployment choices to be rigorously and defensibly assessed and optimised within a controlled environment (10,11,12). The ongoing development of SCATS is underpinned by this facility to ensure continuous improvement.

### SCATS is Rigorously Performance Tested

Recent analyses that credibly demonstrated the traffic performance of SCATS installations (13,14,15,16) have built on the rich history of SCATS investigations (17,18,19,20). This type of applied analysis is the foundation that supports the ongoing development of SCATS by ensuring that SCATS delivers proven and practical outcomes.

One of those papers provided an indication of the "value offered by (SCATS) more sophisticated adaptive and optimising traffic control operation." (15, p.3) The study analysed SCATS operation in Sydney on a key arterial corridor of 21 intersections over 24 weekday hours.

The results from the study indicated comparative reductions of physical costs for vehicles of 28% travel time, 25% stops, 15% $CO_2$, 13% $NO_x$ and 15% PM10-emissions were determined. This amounted to reductions in physical terms of 5,266 hours travel time, 157,581 stops, 34,240 kg $CO_2$, 109 kg $NO_x$ and 2,418 g PM10-emissions. The cost reductions were interpreted as a total opportunity cost savings of AUD $142,051 or 28% of the total cost at 2009 values for 24 hours for all vehicles across the corridor. (15, p.6)

The final result of the study demonstrates that SCATS as a sophisticated adaptive and optimising traffic management system delivers significant value to road network stakeholders. (15, p.6)

The corridor results from (15) were extrapolated across the 2814 intersections in the Sydney metropolitan area (21) to provide an indication of SCATS value offered at the metropolis level. For detail of the general extrapolation methodology that was used refer (16).

The extrapolation to the Sydney metropolis level indicated comparative reductions of physical costs for vehicles of 30% travel time, 18% stops, 14% $CO_2$, 12% $NO_x$ and 12% PM10-emissions were determined. This amounted to reductions in physical terms of 886,464 hours travel time, 24,579,527 stops, 6,044,692 kg $CO_2$, 21,545 kg $NO_x$ and 444,222 g PM10-emissions. The cost reductions were interpreted as a total opportunity cost savings of AUD $24,020,102 or 28% of the total cost at 2009 values for 24 hours for all vehicles across the Sydney metropolis. (21, p.9)

SCATS

## Adaptive SCATS — Superior to ‘Fixed Time’ Systems

Many traffic control systems manage the signals on a ‘fixed-time’ basis, where a series of signal timing plans are scheduled by day of week and time of day. The time relationship between signals is pre-calculated; based on previously surveyed traffic conditions. Such fixed-time systems cannot be expected to cope with traffic conditions that differ from those prevailing when the intersection was surveyed.

Furthermore, as traffic patterns change with the passage of time, fixed time plans become outdated. This requires the area to be resurveyed, and new signal timing plans calculated every few years. Experience has shown this procedure to be expensive, and to require resources which are not always readily available. As a result, the development of new plans is either deferred beyond the useful life of the old plans, or improvised changes are made to the plans and timetables; either case results in sub-optimum performance.

The problems of most fixed-time systems make it clear that a more responsive approach to changing traffic conditions is needed. One cost-effective answer is the SCATS 6 Fixed Time Plan system. This is a great improvement on other ‘fixed time’ systems because it has the benefit of improved decision making capabilities built-in.

The full answer is the adaptive SCATS 6. Unlike most fixed-time or semi-responsive systems, it requires no costly pre-calculation of signal timing plans. Additionally, SCATS is self calibrating, automatically adjusting to changing traffic patterns over time. The SCATS 6 controllers and traffic control computer analyse real-time traffic data from vehicle detectors, and produce signal timings which are suitable for the traffic conditions *as they really are*. It offers a variable sequence of signal phases, and the option to omit phases or movements from the sequence on a cycle-by-cycle basis when there is no demand.

The implementation of a fully responsive system does not, however, mean that the careful design of each intersection can be avoided. The present state of technology only allows for the real-time variation of signal timings at intersections which have known or anticipated traffic requirements.

# Operation of Scats 6

In this section various aspects of the operation of SCATS 6 will be described. The description is not comprehensive,

## The Principal Signal Timing Parameters

SCATS manages three main parameters to achieve traffic signal coordination:

1. Cycle time: The total time of all signal sequences in a cycle
2. Phase split: The proportion of the cycle time allocated to each phase
3. Offset: The time relationship between the starting or finishing of the green phases of successive sets of signals within a coordinated system.

## Strategic and Tactical Control

Traffic control is affected at two levels, *strategic* and *tactical*.

Strategic control is managed by the regional computers. Using flow and occupancy data collected from loop detectors in the road by the local controllers, the computers determine, on an area basis, the optimum cycle length, phase splits, and offsets to suit the prevailing traffic conditions.

Tactical control is undertaken by the local controllers, and meets the cyclic variation in demand at each intersection. Tactical control primarily allows for green phases to be terminated early when the demand is low, and for phases to be omitted entirely from the sequence if there is no demand. The local controller bases its tactical decisions on information from vehicle detector loops at the intersection, some of which may also be strategic detectors.

It should be emphasised, however, that the degree to which tactical control is able to modify the signal operation always remains entirely under the control of the regional computer.

The tactical level of control operates in a similar way to Isolated operation (described further on in this document). A basic difference from Isolated operation is that one phase, usually the main road phase, cannot skip nor terminate early as a result of lack of demand. This is because all controllers in a linked group must share a common cycle time to achieve coordination. Any time saved during the cycle as a result of other phases terminating early or being skipped may be used by subsequent phases, or is added on to the main phase to maintain each local controller at the system cycle length.

## Subsystems

The subsystem is the basic unit of the SCATS 6 system. Each contains a single *critical* traffic signal site that is often an intersection but may be a junction or motorway ramp. The critical site is one which demands accurate and variable phase splits. A subsystem may be configured with only one site.

The sites in a subsystem form a discrete group which–for intersection control–are always coordinated together, and they share a common cycle length, with an inter-related phase split and offset. Phase splits for all the other intersection sites in the subsystem are non-critical, and are therefore either non-variable, or are allocated phase splits which are compatible with the splits in operation at the critical intersection.

To give coordination over larger groups of signals, subsystems can link with other subsystems to form larger systems, all operating on a common cycle length. These links may be permanent, or may link and unlink adaptively to suit the prevailing traffic patterns. A SCATS 6 region has 250 subsystems.

## Degree of Saturation

Adaptive SCATS 6 bases its adjustments on a traffic demand measurement known as 'Degree of Saturation' (DS). However, in this context, DS represents how effectively the road is being used. Using the in-ground loop detectors at the critical intersections, the local controller collects flow and occupancy data during the green phase. The data is sent to the regional computer which calculates the degree of saturation. Values of DS greater than unity (insufficient green time to satisfy demand) will occur in congested conditions, and SCATS will quickly respond to such an over-saturated situation.

## Phase Sequencing

The signal cycle is divided into phases. These phases are labelled A, B, C, etc, and they can be introduced in any defined sequence. Any phase, except for that on the most important road, can be skipped if no vehicle is waiting for a green on that phase (e.g. if no vehicle is waiting for B phase the sequence would be A–C–A). In Isolated and Flexilink modes, the sequence is as defined in the local controller settings. In Masterlink mode, the regional computer determines the sequence.

## Cycle Length is Used to Maintain an Ideal Degree of Saturation

Cycle length is increased or decreased to maintain the DS at around 0.9 on the lane with the greatest saturation. Cycle time can range between 20 seconds and 240 seconds, but a lower limit for cycle time (usually 30 to 40 seconds), and an upper limit (usually 100 to 150 seconds), are specified by the user. Cycle time can vary by up to 21 seconds, but this upper limit is resisted unless a strong trend is recognised.

## Phase Split Adjustment

Phase splits are specified as a percentage of the cycle time and are varied by a small amount each cycle in such a way as to maintain equal degrees of saturation on competing approaches. The minimum split which can be allocated to a phase is either a user definable minimum or, more usually, a value determined from the local controller's minimum phase length. The current cycle length and the minimum requirements of the other phases limit the maximum split that can be allocated to a particular phase. Fixed time phases can have their phase time specified in seconds.

## Offsets

Offsets are selected for the signals within each subsystem, and also between the subsystems which can link. Subsystems carrying lower flows may not receive good coordination if the cycle time is inappropriate. However, when traffic conditions permit the use of a cycle time that can provide good offsets over a number of subsystems, the system tends to maintain this cycle time even though a smaller cycle time would provide sufficient capacity. SCATS does this because optimal offsets on the heavy flow links minimise the *total number of stops* in the system, reducing fuel consumption and increasing the capacity of the network.

# Available Operating Modes

SCATS local controllers can operate in any of several modes. These modes can be invoked manually or automatically by the regional computer or at the local controller:

## Masterlink

This is the real-time adaptive mode. In Masterlink mode the regional computer determines the phase sequence, the maximum phase duration, and the duration of the walk displays. The local controller may terminate any phase under the control of the local vehicle actuation timers or skip an undemanded phase, unless prohibited by instructions from the regional computer.

The regional computer controls the phase transition points in the local controller, but subject to the local controller safety interval times being satisfied (e.g. minimum green, pedestrian clearance). On completion of the transition to a new phase, the local controller times the minimum green and minimum walk intervals, and then waits for a phase termination command from the regional computer. On receipt of the command to move to the next phase, the local controller then independently times the necessary clearance intervals (e.g. yellow, all red) for the phase termination.

These safety settings prevent communications errors or regional computer faults from causing the local controller to produce dangerous signal displays, such as short greens or all-red periods.

The termination of pedestrian walk signals is also under the control of the regional computer so as to allow the walk timing to be varied to match prevailing traffic conditions. As for the other settings, however, the duration of the walk signal cannot be less than the minimum time programmed into the local controller.

## Flexilink

In the event of failure of a regional computer or loss of communications, the local controllers can revert to a form of time-based coordination known as Flexilink. In this mode, adjacent signals are synchronised by the power mains frequency or an accurate crystal controlled clock. The phase sequence and duration of each, and the duration of walk displays are determined by the current plan according to the time of day. Local vehicle actuation facilities are still operational in this mode.

The local controller may terminate any phase under the control of the local vehicle actuation timers or skip an undemanded phase, unless prohibited by instruction within the plan. Flexilink is the usual fallback mode of operation.

## Isolated

Signals may also operate in Isolated mode, with local vehicle actuation (by detector loops) being the sole operating strategy. In Isolated mode the sequence and the maximum duration of each phase is as specified in the local controller time settings. The local controller may terminate any phase under the control of the local vehicle actuation timers or skip an undemanded phase, unless prohibited by the local controller settings. Isolated mode may be specified as the fallback mode of operation.

## Hurry Call

The local controller invokes a pre-programmed mode usually associated with an emergency phase or local pre-emption such as a train or tram phase.

### Police Off (optional)

The lamp state at the local controller has been turned off using a facility key to actuate a special switch provided on the controller housing.

### Police Red (optional)

All lamps at the intersection have been turned to red using a facility key to actuate a special switch provided on the controller housing.

### Police Manual (optional)

The phases at the local controller are being manually introduced using a facility key to actuate a special switch provided on the controller housing.

### Maintenance Mode

A technician is on-site service the controller.

### Flashing Yellow

The normal signal display is replaced by flashing yellow displays on all approaches, or flashing yellow and flashing red to competing approaches. Provided communications are functional, signal operation can still be centrally monitored in Flexilink, Isolated and Flashing modes. Any of the Masterlink, Flexilink, Isolated and Flashing Yellow modes may be applied by an operator using a SCATS workstation, or be programmed by time of day. Flashing Yellow is also the fall back mode if the controller has a fault.

# Control

## Operator Control

SCATS provides the operator with a range of manual functions to override the normal automatic operation. These functions allow manual control of:

- Signal lamps to *on*, *flash*, or *off*;
- selection between Masterlink, Flexilink or Isolated mode;
- alteration of phase split, cycle time or offset, either at an individual intersection or for a whole subsystem;
- a dwell facility which allows any signal to be held on a nominated green phase for as long as required.

## Variation by Timetable and Special Routines

SCATS also allows for system operation to be scheduled. Almost any function which can be executed manually can also be set up to occur at specified times on specified days. For example, in a central business district, pedestrian walks may be automatically introduced on business days, late shopping nights and other periods of high pedestrian activity.

A range of special routines is also available in SCATS which allows the user to vary operations to suit special conditions. These routines can be used to detect events and address requirements not covered by the general operation of SCATS. It is features of this type that enable every detail of signal operation to be tailored to meet the operational needs of each individual intersection.

# Fallback Operation

## Default Fallback

In the event of regional computer failure, loss of communications between the computer and any local controller, failure of all strategic detectors, or certain other local malfunctions, the affected intersection(s) will revert to a user-specified mode of operation. This may be either Flexilink (coordinated) or Isolated (uncoordinated) operation.

## Coordination Maintained During Fallback

If specified by the user, fallback at one intersection will also cause other intersections in the subsystem to fall back and, optionally, intersections in adjacent linked subsystems. In this way, if Flexilink is specified as the fallback mode, a degree of coordination can be maintained between intersections affected by the failure.

Alternate local signal timings, as well as plans and schedules for Flexilink operation are stored in RAM at the local controller. The master copy of this data is held in the regional computer, so that it may be downloaded from the regional computer to the local controller in the event of it being lost. The clocks in the local controllers are regularly checked by the regional computer and adjusted as necessary.

# Computer System Requirements

## Distributed, Hierarchical System

SCATS has been designed in a modular configuration to suit the varying needs of small, medium, and large cities. In its simplest form, a single regional computer can control signals at up to 250 intersections. Expansion of the system is achieved by installing additional regional computers. All systems have a Central Management Computer to manage global data, access control, graphics data as well as data backup. A typical SCATS system is shown in the Figure 1 below.

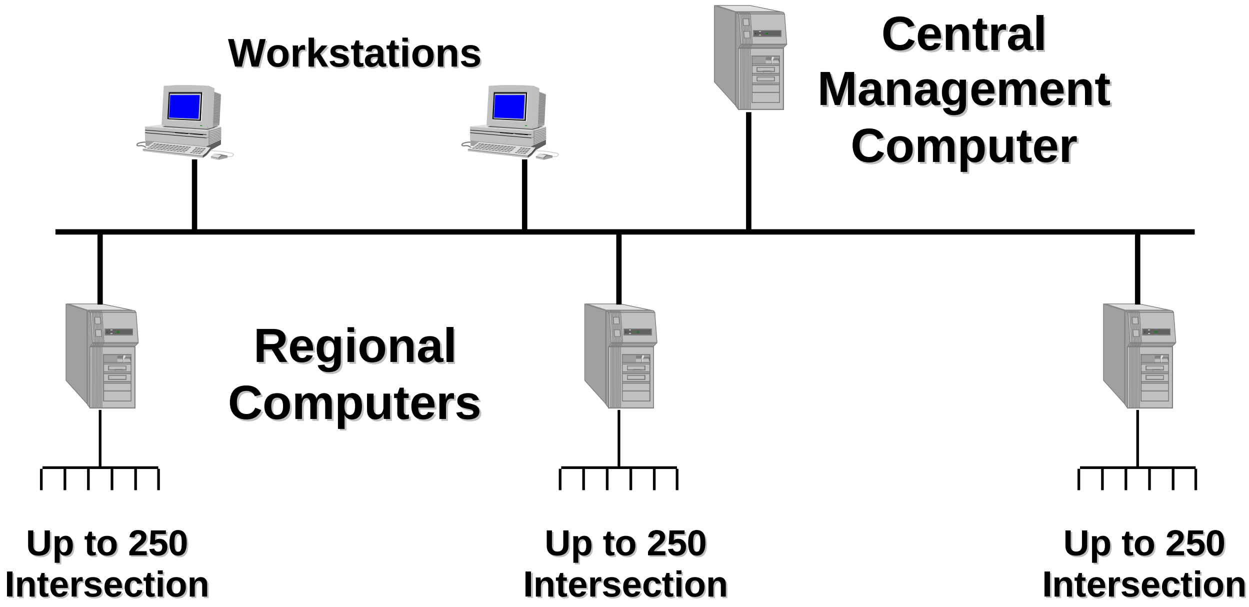


**Figure 1: Typical SCATS system**

## Regional Computers

The regional traffic control function utilises standard personal computers operating under the Windows operating system. A range of intersection communication methods are provided and include network (TCP/IP), serial, dial-out and dial-in.

## Central Management Computer

The Central Management computer is also a personal computer operating under the Windows operating system. Communications with regional computers and workstations is via TCP/IP.

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# Monitoring and Control Facilities

## User Interfaces

A graphical user interface provides the full range of operator commands and monitoring functions. Up to 200 users are catered for with full access control. The data displayed includes:

| **For Intersections** | **For Subsystems** |
|---|---|
| Lamps ON/OFF/Flashing | Current splits |
| Current phase demands | Current offset plan |
| Detectors occupied | System cycle length |
| Cycle length | System detector data |
| Operational mode | |
| Alarms | |
| Phase running | |
| Time in phase | |

The intersection-monitoring window is illustrated in Figure 2. Data entry is by forms, an example of which is shown in Figure 3. All alarms are logged, and can be viewed with the alarm management window as seen in Figure 4. Monitoring the performance of a SCATS controller built to the TSC/4 specification and type approved by RMS is shown in Fig 5. A host of control features for the operation of intersections using Variation Routines to take into account the SCATS configuration and special requirements for intersection performance is shown in Fig 6.

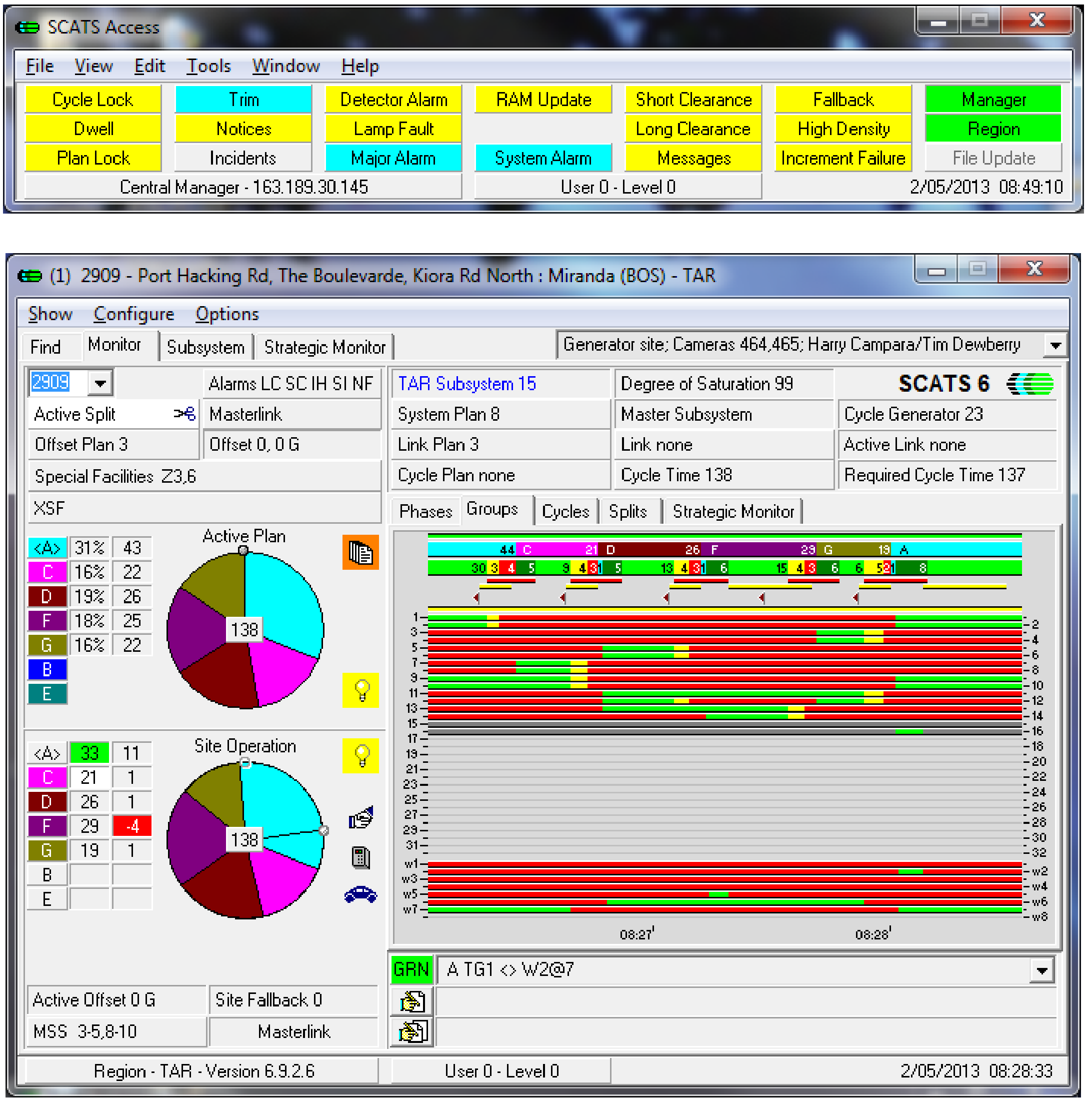


**Figure 2: Monitoring window**

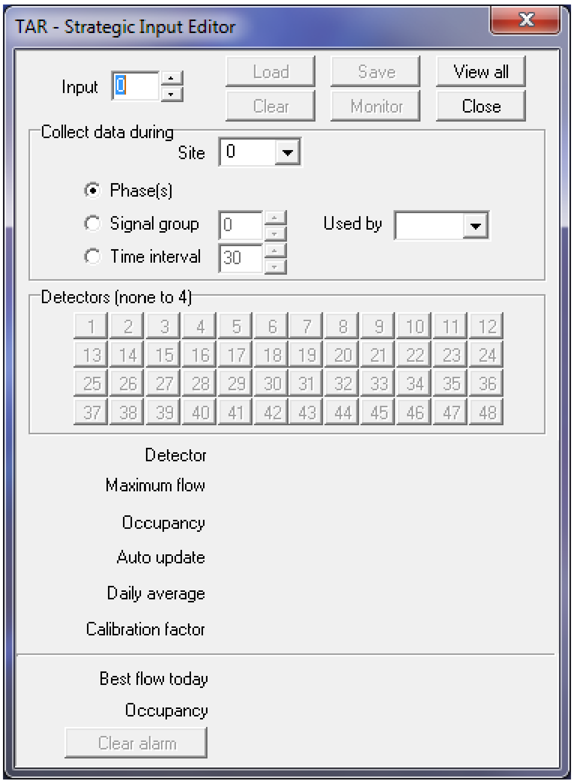


**Figure 3: Data entry form**

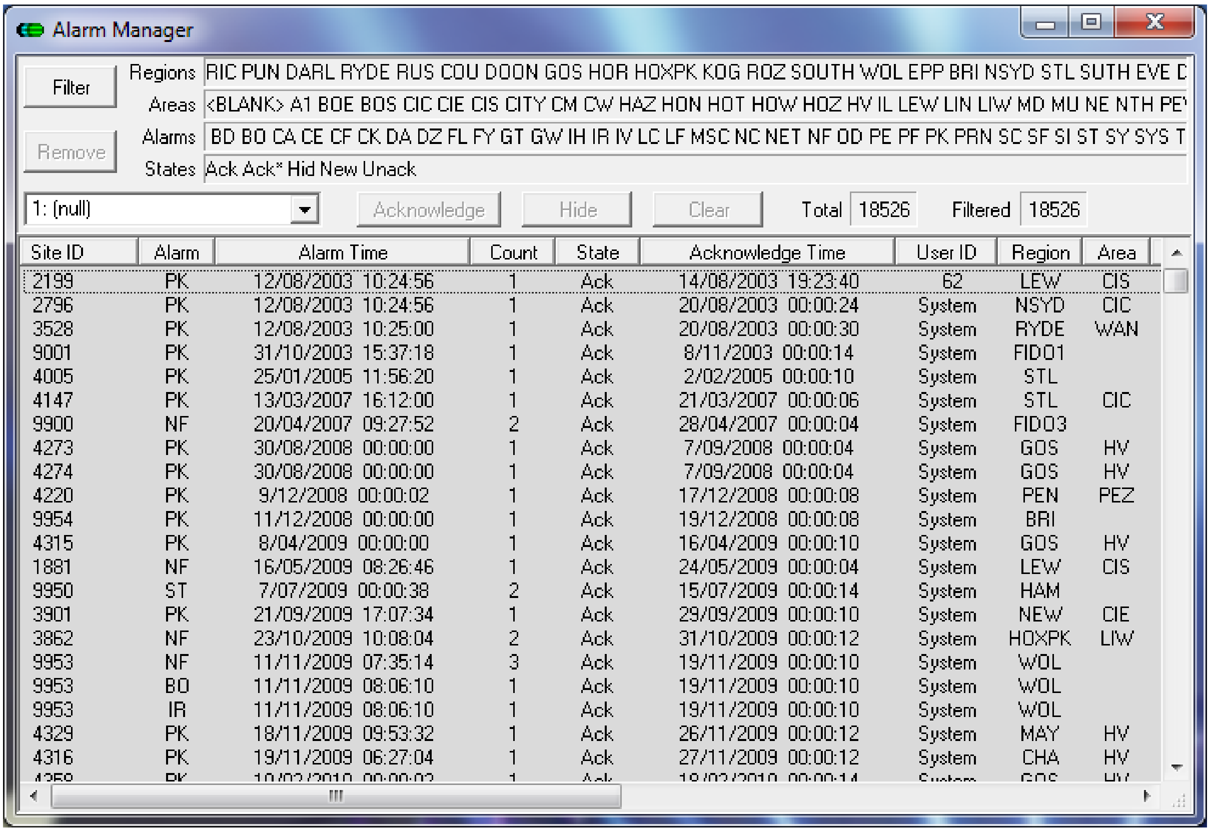


**Figure 4: Alarm Manager**

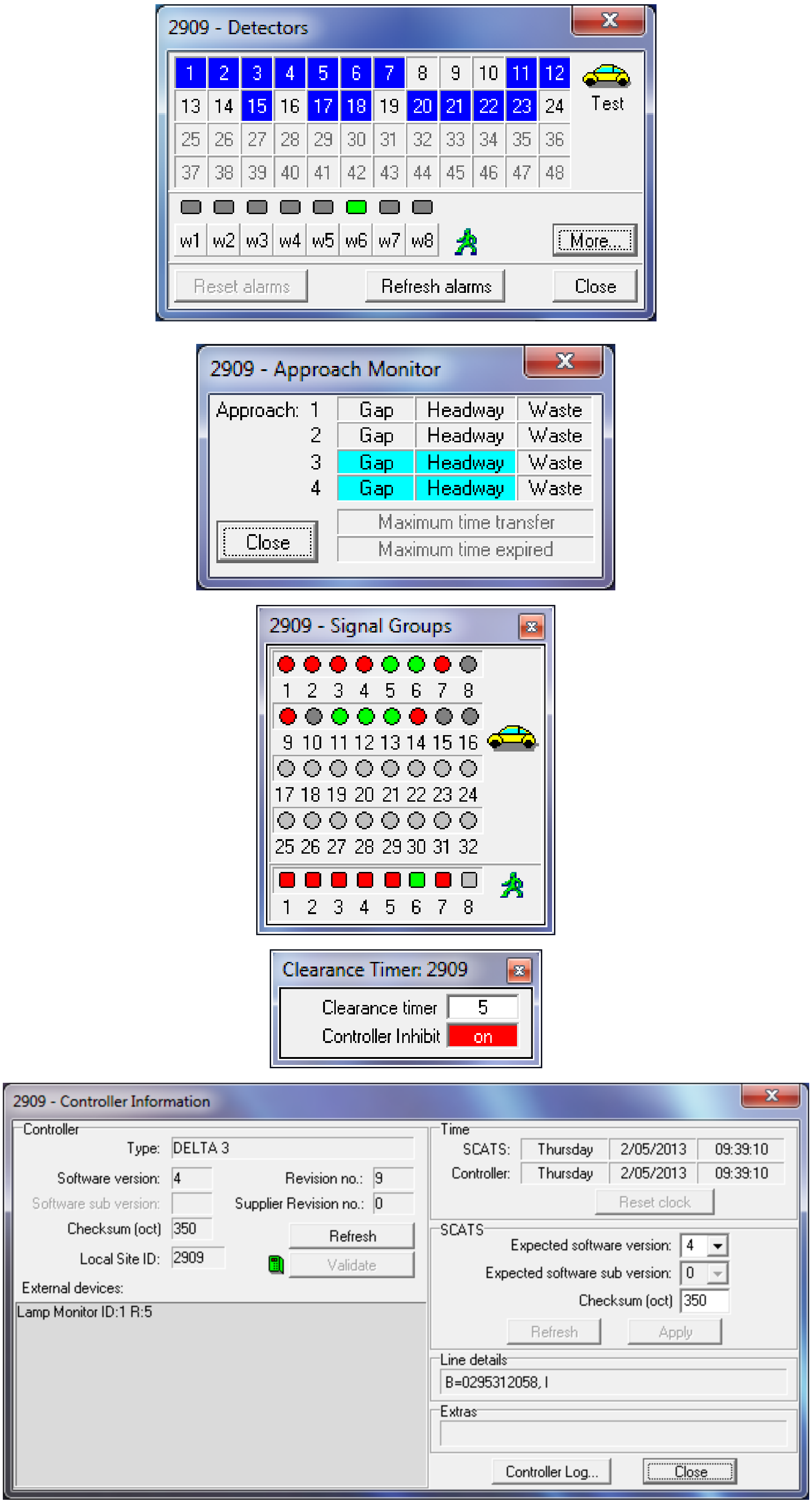


**Figure 5: An Example of some Controller Monitoring Windows**

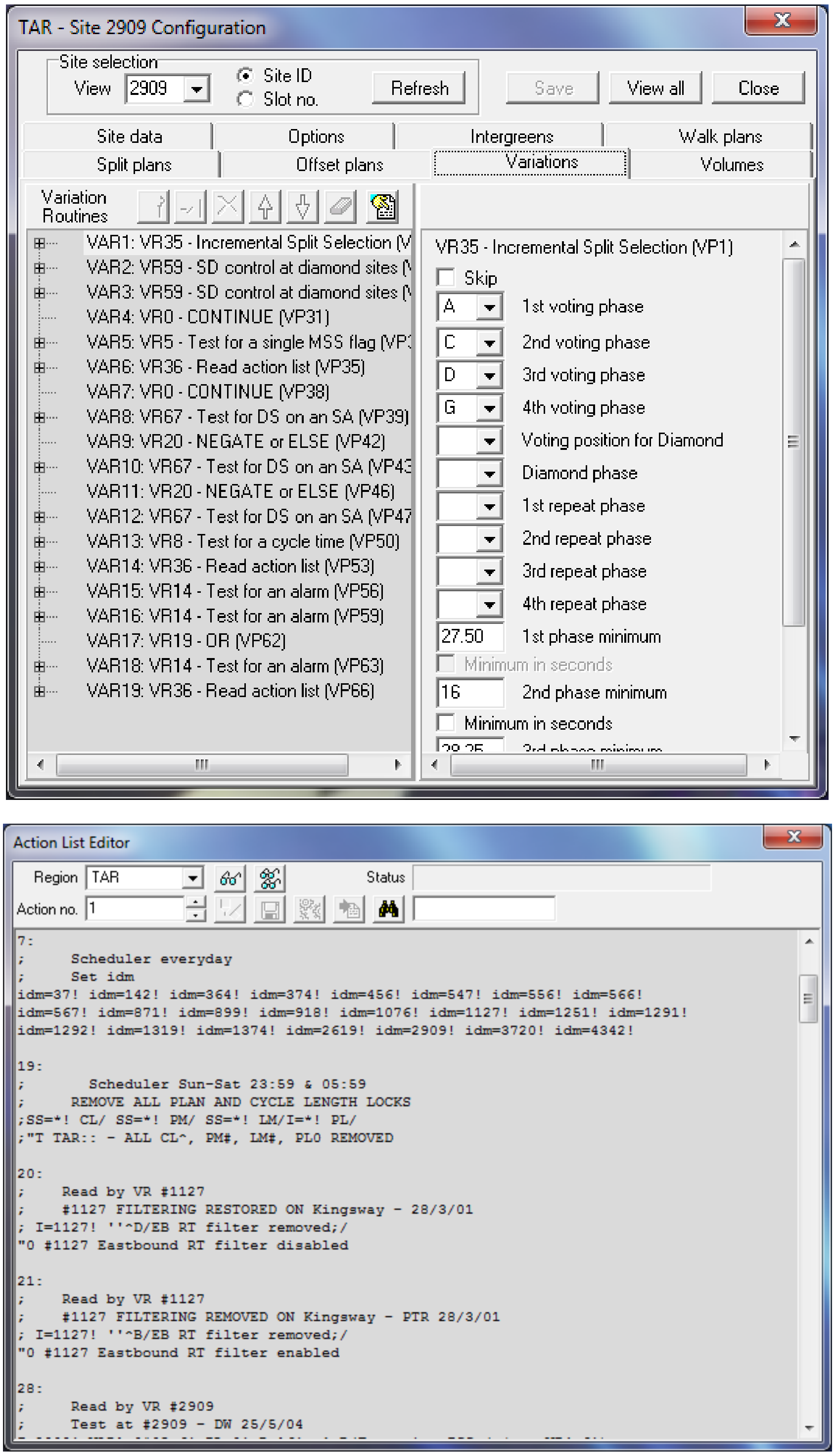


**Figure 6: Variation routines display and action list**

## Graphics

The workstations support full colour graphics. The user may choose to view the system as a whole, a region, a subsystem or just a single intersection.

The graphics windows *subsystem* display: Figure 5 shows the selected subsystem layout together with an on-line graphical bar chart representation of traffic flow and density, as measured by the strategic detectors in the subsystem. The subsystem number is displayed below the region name.

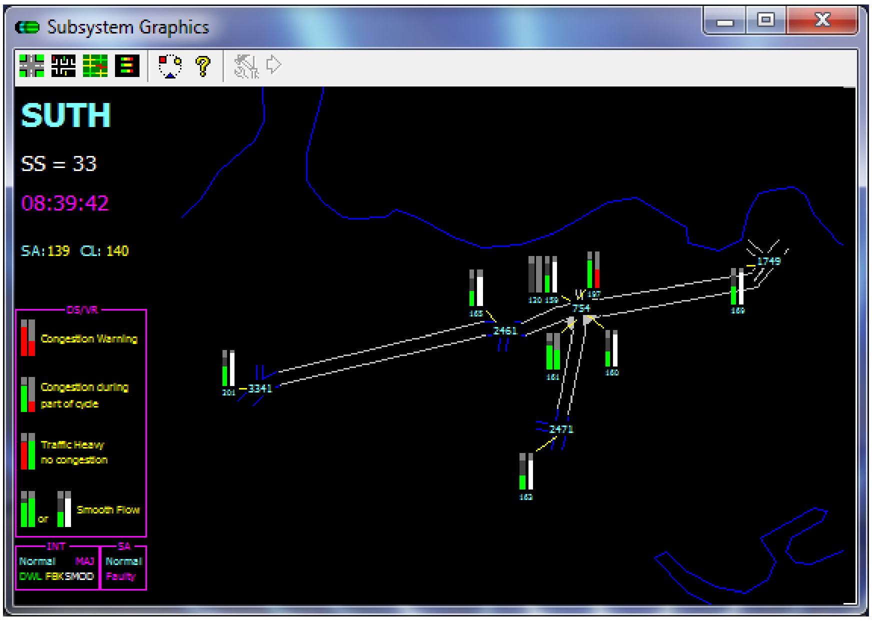


**Figure 5: Subsystem display**

The graphics window *intersection* display: Figure 6 shows the selected intersection layout and phasing design, with real time display of detector operation and phase greens.


**Figure 6: Intersection display**

## Time / Distance Diagram

The time distance diagram shows the relationship of the phase splits and the offsets in real time.

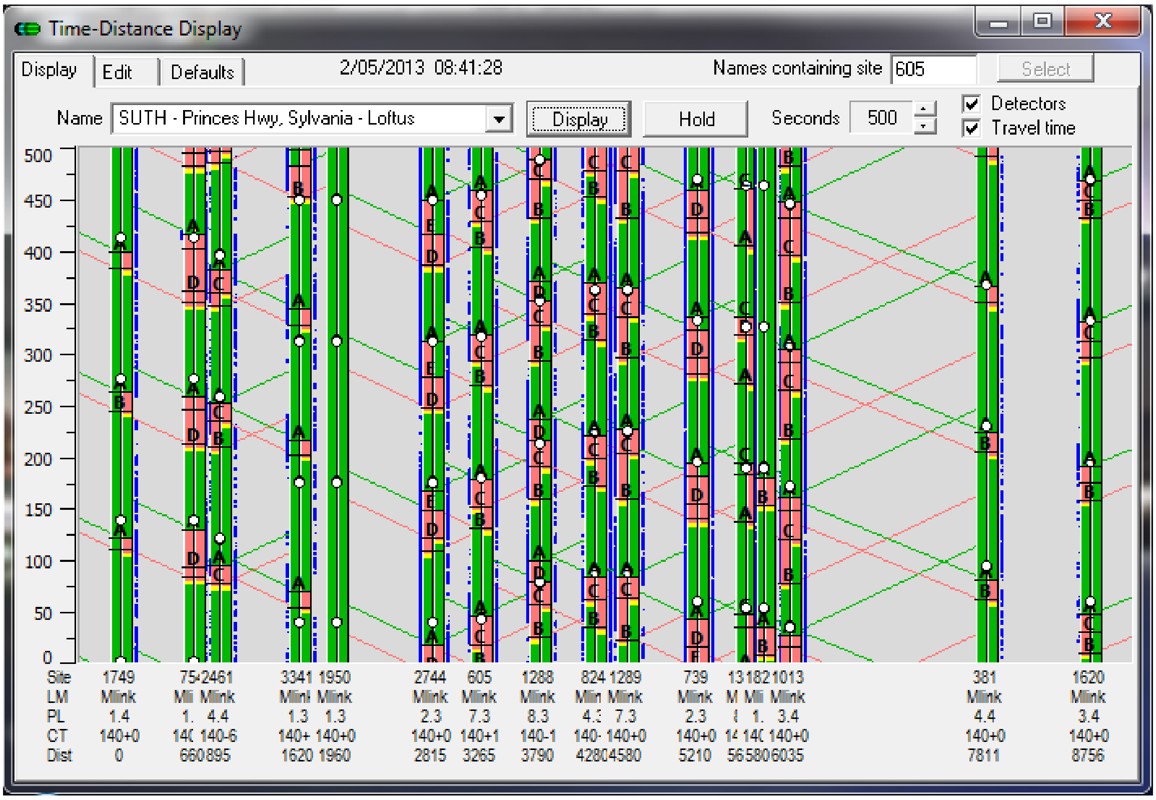


Figure 9: Time / Distance Diagram

## Route Pre-emption

Route pre-emption allows a user to manage the sequential introduction of a green window through a set of intersections and is typically used for emergency vehicles.

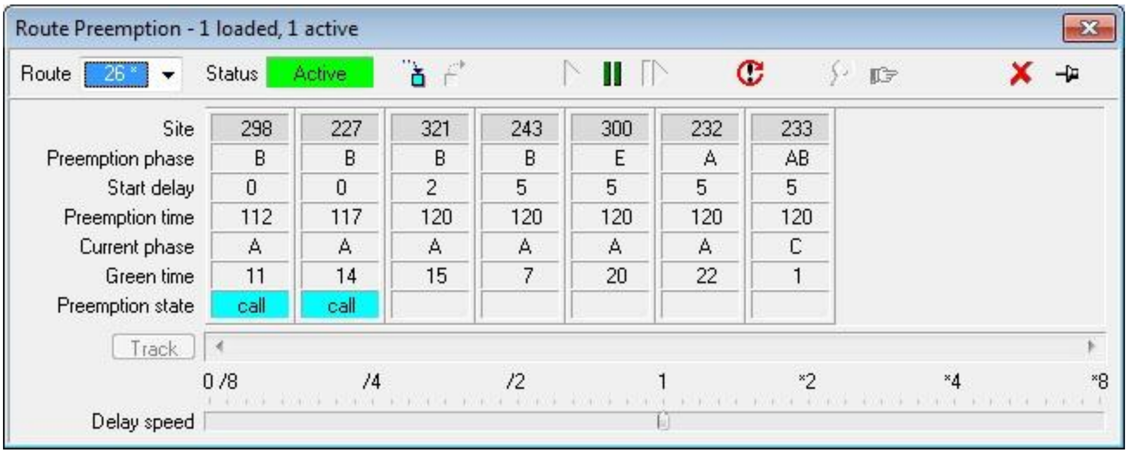


Figure 10: Route Pre-emption Control

## On-Line Control

It is possible to display and/or change all adaptive control parameters from any workstation while the regional computer is on-line. This can be achieved either by operator command or automatically by time of day. There is no need to take the regional computer off-line when altering data. Manual control of any intersection is also possible from any workstation.

## Alarm Conditions

The system provides a comprehensive set of alarm conditions to warn the operator of all unusual or fault conditions. These alarms are logged automatically on occurrence and clearance, and can be queried at any time. Alarms are also provided for congested traffic conditions in each subsystem.

# Detection

## Detection Location

The preferred primary location for SCATS detectors is at the stop line in each lane. This preference is to:

- Accurately measure the absence of any stopped vehicles waiting at the stop line for an accommodating signal to inform SCATS to skip the respective phase where appropriate (i.e., if configured to do so), and to
- Accurately measure the utilisation of the conflict area to inform SCATS of the:
  - traffic characteristics during the phase, and the
  - demanded green time.

Detectors located at the stop line enable differentiation between the left turn, straight ahead and right turn movements at the intersection, both by knowledge of the lane usage in lanes of exclusive use, and by speed differential in a lane shared by two or more movements. If the detectors were remote from the stop line, it is often not possible to identify with confidence the intended movement (direction) of detected vehicles due to subsequent lane changing.

SCATS can also use other detection locations including, for example:

- Downstream of the stop line within the conflict area for presence detection with filtered turns,
- End-of-turn bays to measure overflows, and
- Upstream/mid-block to provide advanced measure of arriving traffic.

The traffic control of a particular SCATS site can also be configured to use detectors from upstream sites and downstream sites (generically, any site connected to SCATS). This usage allows SCATS to consider network effects and leverages existing measurement assets without incurring additional infrastructure and maintenance costs.

## Detection Length

The detection length is crucial for accurate calculation of the SCATS DS measure. If they are too short they may register large values of space under conditions of slow moving, closely spaced traffic (which would appear to a detector to be the same as light traffic widely spaced). On the other hand, if they were too long they would not measure any spaces when traffic moves freely.

Research has shown the optimum length of the detection zone for DS calculation to be approximately 4.5 metres.

SCATS automatically and continually calibrates each detector and implicitly accounts for variations of detection area length between different detectors.

Where detectors are used for purposes other than calculating DS, e.g. a SCATS ramp metering application, a different detection length may be more preferred than that stated above. (Refer to the appropriate SCATS manual for guidance.)

## Detector measures

SCATS requires accurate and consistent occupancy and non-occupancy measurement of a detection area to provide accurate traffic control operation. This accuracy is critical to provide traffic

engineers with confidence that the traffic management policy they define in SCATS configuration will produce the intended traffic outcomes.

For example of a critical issue, assume the traffic engineer requires a traffic policy where undemanded phases are skipped to achieve efficiency. To enable this policy the traffic engineer requires confidence that the measurement of the absence of any waiting vehicles is appropriately accurate.  A failure to detect, i.e. ‘false negative’, may risk unreasonably skipping a phase and stranding a waiting vehicle. (Note: The option to enable the skipping of a particular phase is a configuration choice by the SCATS engineer.)

Inductive loop detectors have proved to provide sufficient accuracy for SCATS operation across environmental conditions and across vehicle speed conditions. In cases, often traffic engineers require SCATS to use of alternative detection technologies.

Often, alternative detection technologies have different measurement characteristics to inductive loop detectors including measurement accuracy and consistency particularly across differing environmental conditions and potentially different vehicle speed conditions*.

(*NB An example of an issue with different speed conditions is reduced accuracy when a vehicle is stopped on or within the detection area. This degradation could be due to the measurement technique used and/or the communication method between the detector and controller.)

SCATS is able to use alternative measurement technology but this usage must be taken with an understanding by the responsible traffic engineer of the measurement characteristics of that technology.

For example, where the measurement technology cannot provide a level of confidence appropriate to the responsible traffic engineer that a stopped, waiting vehicle will be detected then the policy of a skipping of the phase may not be appropriate. SCATS could then be used with that measurement technology and configured to provide the policy deemed appropriate in the circumstance.

# Communications

SCATS 6 supports the following communication methods between a region and an intersection:

- Serial – e.g. leased line
- Network – e.g. dial IP or ADSL using TCP/IP
- Dial out
- Dial in

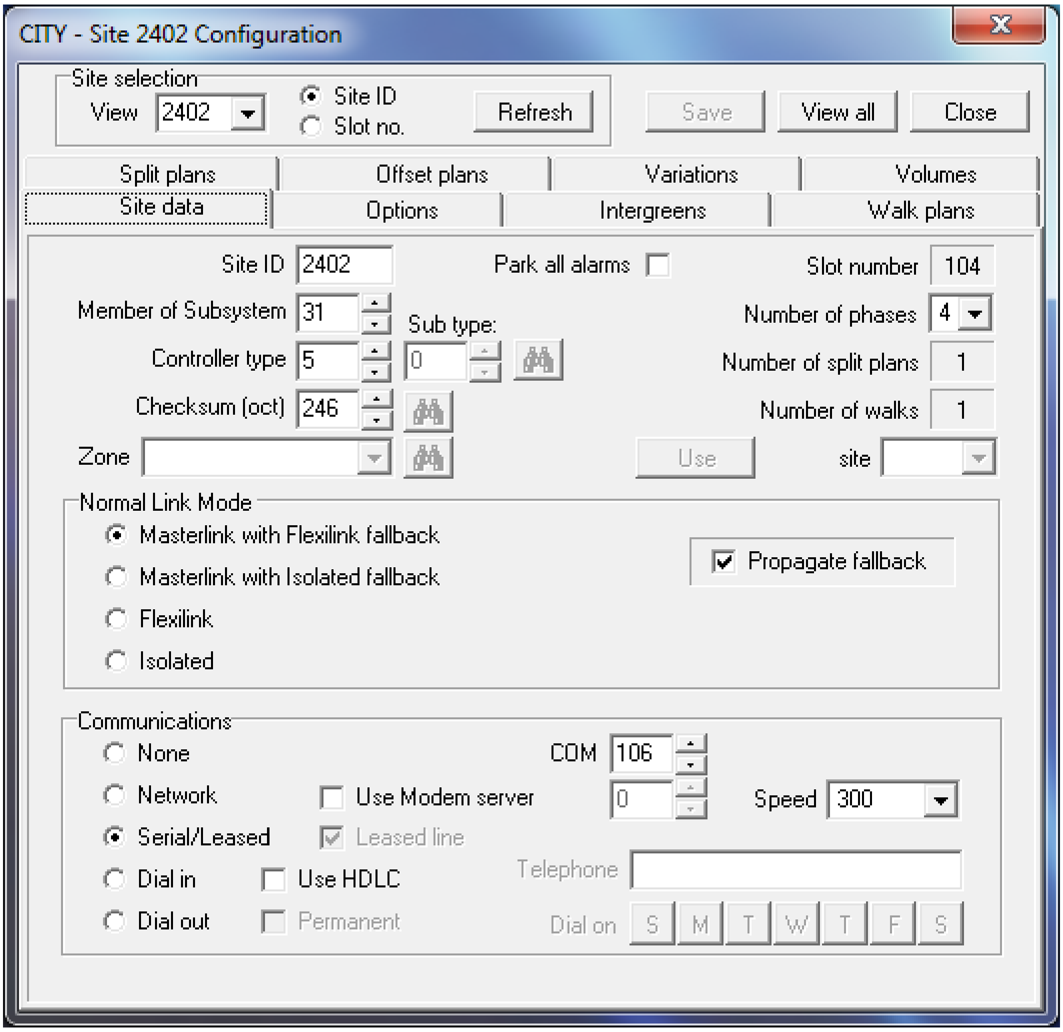


**Figure 11: Communication options**

There are messages to and from each intersection controller every second. The minimum requirement is 300 bits per second. The low speed rate required for SCATS communications allows for a high degree of tolerance in the reliability of the communications network.

# Software

## Scats Core Software

SCATS core client software includes the following:

- SCATS Access, incl. Graphics
- Picture
- SCATS Log

SCATS core server software includes the following:

- Central Manager, incl. Configuration
- Region, incl. Configuration

SCATS is an area wide traffic management system that operates under the Windows environment. It controls the cycle time, green splits and offsets for traffic control intersections and mid-block pedestrian crossings. With the inclusion of vehicle detectors, it can adaptively modify these values to optimise the operation to suit the prevailing traffic. Alternatively, it can manage intersections in fixed-time mode where it can change plans by time of day, day of week. It is designed to coordinate traffic signals for networks or for arterial roads.

Intersection connections to a regional traffic control computer can be permanent or may be on-demand using dial-in or dial-out facilities. Each regional computer can manage up to 250 intersections. A SCATS system can have up to 64 regional computers.

Monitoring is provided by a graphical user interface. Up to 100 users can connect to a SCATS system at the same time. Up to 30 users can connect to a single regional computer simultaneously. Performance monitoring, alarm condition notification and data configuration facilities are included. SCATS automatically collects alarm and event information, operational and performance data and historical data. SCATS operates automatically but operation intervention is provided for use in emergencies.

The software includes utilities supporting configuration of SCATS computers, creation of SCATS graphics, production of traffic performance reports and alarm/event/incident reports.

## Optional Scats Software

### SCATS client software option suite

- Traffic Reporter

This utility provides reports for detector volumes and traffic performance in graphical or tabular form.

- SCATS Alert

This program allows a user to be alerted when a nominated event is detected for a user definable period.

- SCATS Alarm Analyser

Alarm analyser can report on a specific fault over an extended period. It produces a detailed tabulated summary that includes alarms by duration, occurrences per site and occurrences by generation time.

- SCATS Communication monitor

Communications monitor is used to evaluate the communications between intersections and their SCATS regions with particular emphasis on loss of communications and loss of adaptive control due to fallback. Similar to Alarm Analyser, a detailed summary is produced that includes communications uptime and adaptive uptime.

- SCATS History reader

History reader allows a user to view the phase sequence and phase time at any intersection after the event.

**SCATS Server Software option suite**

- Event Generator

Allows alarms to be raised from non-SCATS devices

- SMS Server

Component to send SMS alerts

**SCATS Congestion Server c/w Unusual Congestion Monitor**

Server component to report Unusual Congestion

**ITS port activation**

SCATS has an ITS port that allows operational data to be exchanged with other Intelligent Transport Systems. Enabling of the port to third party applications is subject to an additional licence fee.

## Scats Value Added Software

**WinTRAFF software suite**:

**WinTRAFFsingle**

WinTraff Single is a Windows application that allows the simulation of a single RTA standard controller. An RTA standard controller is one that operates using the RTA traffic software (TRAFF) and standard configuration data.

WinTraff can operate in isolation or communicate with a SCATS region

**WinTRAFFsimulation**

WinTraffsimulation is a Windows application that allows the simulation of multiple RTA standard controllers. An RTA standard controller is one that operates using the RTA traffic software (TRAFF) and standard configuration data.

The application was developed for the purposes of enabling traffic modelling and the visualisation of RTA standard controllers operating in a SCATS environment.

**WinTRAFFtest**

WinTraff Test is a Windows application that allows the simulation of multiple RTA standard controllers. An RTA standard controller is one that operates using the RTA traffic software (TRAFF) and standard configuration data.

The application was developed to allow load testing of the SCATS environment. WinTraff Test establishes socket connections with a SCATS Region and a test application using TCP/IP. The test application is used to setup/alter the detector simulation operation in the WinTraff Test controllers.

WinTraff Test can be configured to operate connected to SCATS alone.

**SCATSIM**

A suite of software that allows SCATS to be linked to a traffic micro simulation. This provides a faithful simulation of a network of SCATS controlled intersections or motorways with entry ramps controlled by SCATS Ramp Metering System (SRMS). The suite includes WinTRAFFsimulation.

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