COORDINATION OF TRAFFIC SIGNALS
INFORMATION FOR THE LOCAL IMPACTS COMMITTEE

WHAT IS COORDINATION?

When traffic signals are located in close proximity, the presence of the upstream traffic signals alters the arrival pattern of traffic at the downstream traffic signals from random arrivals to arrivals in platoons. This means that improved traffic flow can be achieved if the green signal at the downstream traffic signal is arranged to coincide with the arrival of the platoon.

To achieve this, traffic signals are coordinated, sometimes called "linked". This improves the level of service on a road network where the spacing of traffic signals is such that isolated operation causes excessive delays.

The following terms are used when discussing traffic signal coordination:

- Phase – a predetermined set of traffic signal movements that operate concurrently.
- Cycle time – the total time taken to run once through all phases for an intersection.
- Offset – For coordinated traffic signals the beginning or end of the green period on the coordinated approach of each intersection is set to occur a given time relative to that at the reference intersection. This time is known as the offset.

Coordination is achieved through three features:

1. Traffic signals run on a common cycle time (or in special cases, one half of the cycle time).
2. The beginning or end of the green period on the coordinated approach of each intersection is set to occur at the offset time relative to that at the reference intersection. This offset is determined by the distance between the signals, the progression speed along the road, and the queues of vehicles waiting at red signals.
3. The optimisation of offsets and phase times.

INHERENT LIMITATIONS TO COORDINATION

Coordination does not mean that there will be no delays for traffic, rather that the level of delay is minimised. This is because:

- As all traffic signals have different traffic flows, and often have different phasing, so the amount of green time available to the coordinated approaches varies along a coordinated route. Therefore, it is often inevitable that some traffic in the platoon is stopped somewhere along the coordinated route.
- It is necessary to start the green period on the coordinated route sufficiently in advance of the arrival of the platoon to allow any queues of traffic stopped at the downstream traffic signals to clear. These times accumulate for subsequent traffic signals along the route, progressively reducing the green-time available for the original platoon.
- Coordination cannot improve the capacity of an intersection above that it would have under independent operation. However, it can improve the capacity of intersections that are closely spaced and therefore have strongly interacting traffic queues.
- Outside periods of strong "tidal" traffic flow (i.e. outside peak hours) traffic along arterial roads is typically balanced, so two-directional coordination is required. It is extremely rare that intersection green times, spacing and travel time align to allow for complete two-way coordination. Normally a compromise coordination

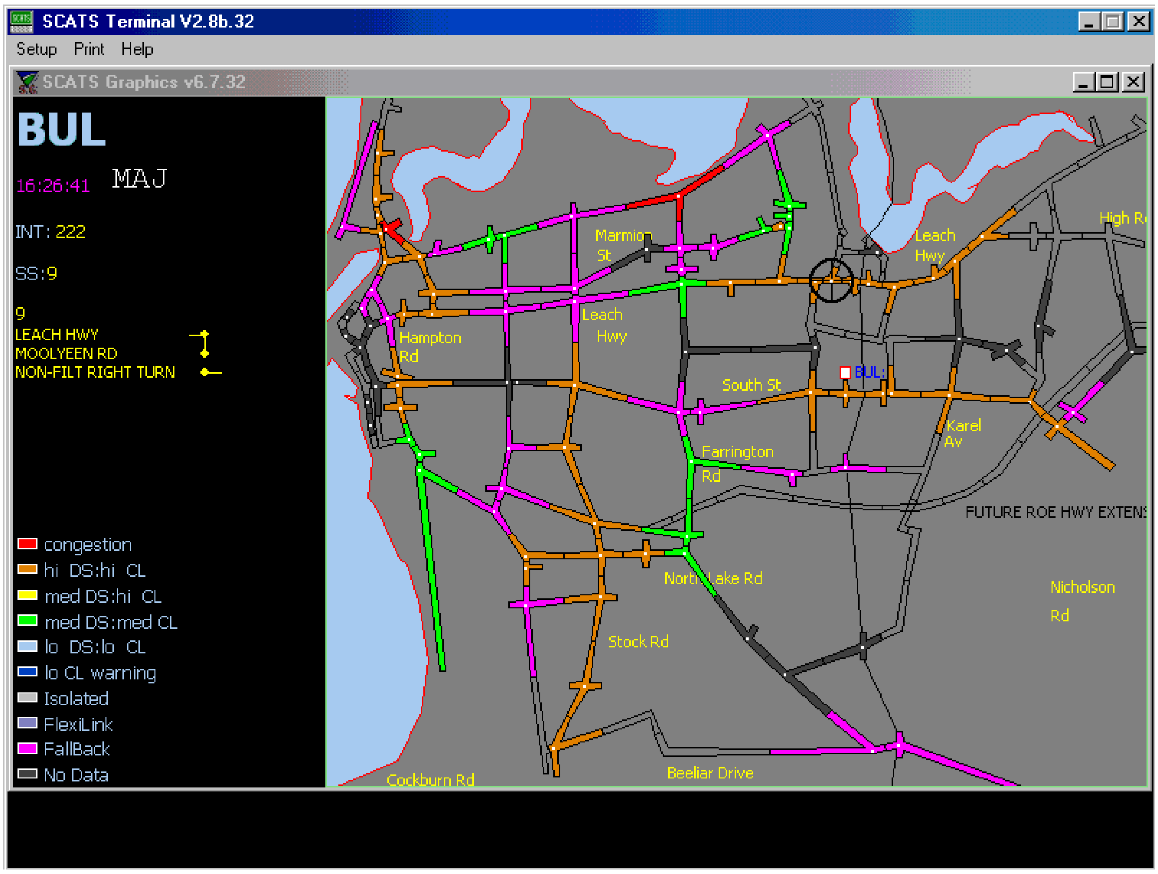
plan is required, which minimises (i.e. does not reduce to zero) stops and delays in both directions.

- The mix of traffic is also an important consideration when determining offsets. Large trucks take longer to accelerate than passenger cars, so offsets that are ideal for passenger cars may result in heavy trucks being stopped at the next set of traffic signals. Also, if the offsets were set for heavy traffic this would result in additional traffic congestion, thereby adding delay for all traffic (including heavy traffic). As a result, on major freight routes it is often necessary to have compromise offsets that are not ideal for either passenger cars or heavy trucks.
- Better coordination along an arterial road most often results in increased delays to side-street traffic. During peak hours the overall delays to all traffic (i.e. including side-streets) are lower as a result of the coordination, so this can be justified. However, as traffic flow along the arterial road reduces (i.e. at night) the justification for imposing additional delays on traffic on the side streets reduces. So in a period of low flows coordination is not justified.

THE SITUATION IN WESTERN AUSTRALIA

In Perth, as in all of Australia & New Zealand (excepting Queensland), the Sydney Coordinated Adaptive Traffic System (SCATS) is used to coordinate traffic signals. All traffic signals in this state are connected to the system. This also allows operators at Main Roads Western Australia's Traffic Operations Centre (24-hour facility) to monitor traffic flow and adjust the timing and coordination of traffic signals to cater for unusual traffic flows, incidents or emergencies. All traffic signal faults detected by local traffic controllers are recorded and monitored, helping to facilitate repairs and reduce down time.

Below is an example of an over-view screen showing traffic congestion levels that is available to an operator through SCATS.



Although all traffic signals are connected to SCATS, during peak hours only approximately half of the 700 sets of traffic signals in Perth are coordinated. Also, SCATS automatically drops intersections off coordination in response to reducing traffic flows according to preset parameters so that during the night very few intersections are coordinated.

The reason that not all intersections are coordinated even in peak periods is that there is no advantage in doing so. If intersections are widely spaced, or if there are not strong platoon flows, coordinating traffic signals would provide an overall negative benefit to road users as it would introduce additional delays for side street traffic without providing any benefit to a major traffic movement.

For example, during a typical business day, Leach Highway is coordinated between High Road and North Lake Road, South Street is coordinated between Bannister Road and Murdoch Drive and Stock Road is coordinated between South Street and Yangebup Road.

BENEFITS OF COORDINATION

Studies have shown that coordination of traffic signals can provide:

- Improved capacity of groups of closely spaced traffic signals
- Reduction in overall network travel time and delay
- Reduction in the overall network number of stops
- Reduction in intersection crashes
- Reduction in noise levels, air pollution and fuel consumption

A detailed study on the effects of SCATS on Parramatta Road in Sydney, a congested 6 lane divided road, showed a reduction in stops of almost 40% and a reduction in travel time of 12% during peak hours.

However, it is worth putting the above figures in perspective, especially for control-of-access highways and expressways. While it is obvious that coordination of traffic signals provides benefits, these are a magnitude smaller than those provided by grade separation of intersections (i.e. 100% reduction in stops on the major road, 100% reduction in intersection delay for through traffic and less delay for the crossing traffic as it no longer conflicts with the through highway traffic).

TRUCK PRIORITY

Advances in technology have made giving efficient priority for specific classes of vehicles possible. For example, the RTA NSW and Tyco are developing a system called the Public Transport Integrated Priority System (PTIPS) as an integrated module of SCATS to provide a flexible priority mechanism for public transport. However, this does not mean that buses do not have to stop when this system is working. Rather the green display on the arterial road can be held longer or introduced slightly earlier to allow a bus to pass through the intersection. A typical cost for such a system would be $3,000 per bus, plus $200,000 for the control system, plus an ongoing communications cost of $100,000 per year.

However, the practicality of providing such priority for heavy vehicles must be considered. If there are 5,000 vehicles that use a busy intersection on an arterial road during the morning peak hour, it may be practical to include some priority for 30 buses on the arterial road (i.e. 0.6% of the traffic). That is, with an average 120-second cycle time this equates to, on average, one bus on one approach every cycle that can be given some limited priority.

However, if heavy transport makes up 15% of the total traffic, this equates to 25 heavy vehicles every cycle, on average. This means that on an average cycle there will be several heavy vehicles on most approaches, and by definition it is not possible to give priority to every approach!

In such circumstances it is not necessary to install a sophisticated system for giving priority to heavy vehicles, as we could safely assume that on average they will be on all approaches during each cycle in the peak hour. Rather, an overall priority can be given to the major traffic flow, an approach that is already undertaken through SCATS. Alternatively, if there are two major roads intersecting (i.e. Leach Highway / Stock Road) delays are balanced.

It should also be noted that during the night SCATS always gives priority to the arterial road by putting in a permanent call for the arterial road. That means that during the middle of the night if a vehicle triggers the traffic signal on a side-road, the traffic signals will automatically return to green for the arterial as soon as this vehicle has gone.

TRUCK LANES

Main Roads Western Australia engaged the Australian Road Research Board (in 1997) to examine the possible options for improving the level of service for trucks using Leach Highway. One option considered in detail was the introduction of exclusive truck lanes.

The study concluded that setting aside of one existing lane in each direction for trucks would provide a large overall negative benefit to the community, as this lane would be under utilised and therefore all traffic signals would run less efficiently. Also, the ability for trucks to overtake slower moving trucks would be restricted by the higher congestion in the general traffic lanes.

This option is therefore not being considered further.

ADVANCED WARNING SIGNALS

Advanced warning signals are installed where there is a safety concern for traffic signals on a high-speed road (i.e. 80 km/h or higher), roads with a severe downgrade, or the first sets of signals when entering an urban environment.

A Main Roads Western Australia study prepared in 2002 showed that while the advanced warning signals have improved the overall safety at the above intersections through reducing right angle crashes, there is the possibility of these signals increasing other classes of crashes (i.e. severe rear end crashes). This would be a concern if these devices were installed at locations without an elevated risk of right angle crashes.

It should also be noted that these advance signals reduce overall intersection efficiency outside peak times by effectively doubling the effective intergreen period. That is, when a gap in traffic flow is detected an additional period must run before the next phase can commence, thereby reducing efficiency.