# Advice Leaflet 4: Bus Priority in SCOOT

**S**PLIT

**C**YCLE and

**O**FFSET

**O**PTIMISATION

**T**ECHNIQUE

**Introduction**

This leaflet is one in a series about SCOOT and should be read in conjunction with Advice Leaflet 1. It expands some of the information provided in the general guidance on the SCOOT Urban Traffic Control System. The priority techniques discussed here are normally used by buses, but can be made available to any vehicle that is selectively detected. More information on SCOOT is available at: www.scoot-utc.com

**Priority Techniques**

SCOOT has a number of facilities that can be used to provide priority to buses. 'Passive' priority, which does not differentiate between vehicles, can be given to links or routes using split and offset weightings. As all vehicles on the weighted link receive a similar benefit, the level of priority that can be given is limited. 'Active' priority can be given to individual buses: extensions to prevent a bus being stopped at the start of red and recalls to start the bus green earlier than normal. In addition, in SCOOT MC3, intermediate stages between the current stage and the bus stage can be skipped. Differential priority allows different levels of priority to be given to certain buses, e.g. limited priority to late buses and high priority to very late buses, but no priority to those ahead of schedule. All these techniques are controlled by user set parameters to prevent the priority causing undesired extra delay to other vehicles.

## Bus detection

The SCOOT kernel software allows for buses to be detected either by selective vehicle detectors,, i.e. using bus loops and transponders on buses, or by an automatic vehicle location (AVL) system. Bus loops, or AVL systems where bus detection points can be specified, have an advantage as they can be placed in optimum positions. The best location for detection will usually be a compromise between the need for detection as far upstream as possible and the need for accurate journey time prediction. Also, bus detectors need to be located downstream of any bus stop, as SCOOT does not attempt to model the time spent at bus stops. Depending on site conditions, a location giving a bus journey time of 10 to 15 seconds to the stop line is recommended.

## Modelling

Buses are modelled by SCOOT as queuing with other vehicles. This allows buses to be given priority even though other vehicles may delay them. The effect of bus lanes can also be modelled, including those, which end before the stop line.

## Priority

The signal timings are optimised to benefit the buses, by extending a current green signal (an extension) or causing succeeding stages to occur early (a recall) or by stage skipping. Extensions can be awarded centrally, or the signal controller can be programmed to implement extensions locally on street (a local extension).

For example, for the three stage junction illustrated in Figure 1, if a bus is detected towards the end of Stage "1" (which is a green period on Link "A") it will receive an extension (i.e. Stage 1 is extended) as shown in Figure 2. If the bus is detected during a red period it will receive a recall (i.e. stage 2 and stage 3 are shortened so that stage 1 starts earlier) as shown in Figure 3. In SCOOT MC3 it may also benefit from stage skipping, when stage 3 is one that may be skipped. Figure 4 shows the result, where stage 2 has been shortened and stage 3 completely omitted from this cycle.

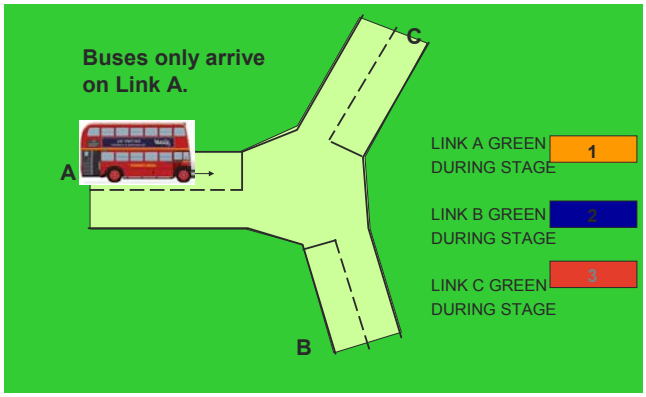


*Figure 1*

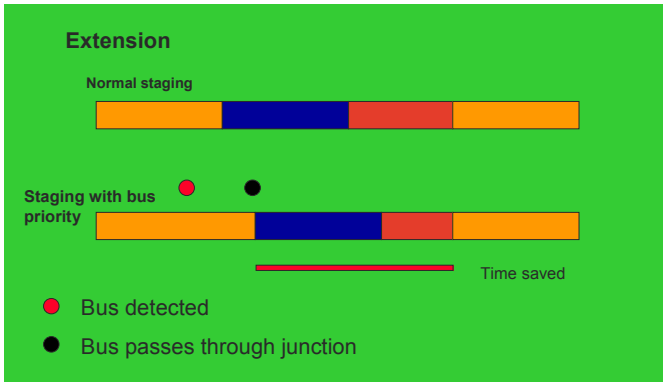


*Figure 2*

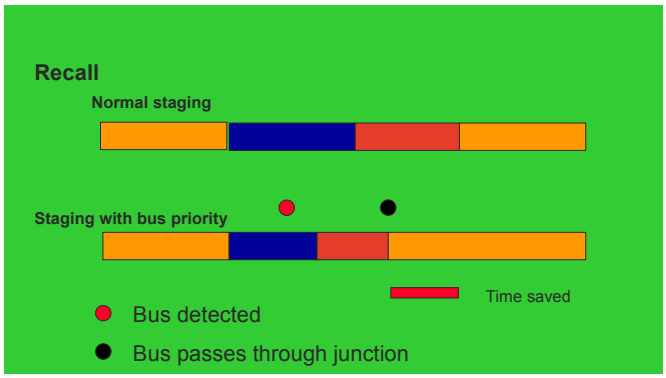


*Figure 3*

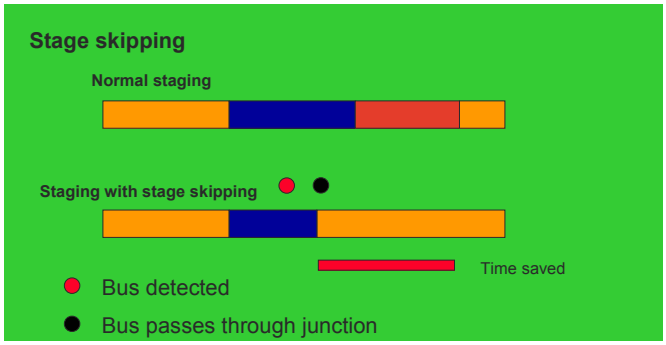


*Figure 4*

## Local extension

Extensions awarded in the controller can be advantageous, as they eliminate 3 to 4 seconds transmission delay between outstation and instation. That allows the system to grant extensions to buses that arrive in the last few seconds of green. The feature is especially important where link lengths are short, or where bus stops are located near to the stop line. SCOOT is still in control as it sends a bit each second to permit local extensions only when the saturation of the junction is sufficiently low. Techniques for programming the signal controller have been developed and implemented in London.

## Recovery

Once the bus has passed through the signals, a period of recovery occurs to bring the timings back into line with the normal SCOOT optimisation.

## Stage skipping

Guidance on stage skipping, based on the experience of on street trials and simulation testing, is provided in the SCOOT Traffic Handbook provided with all SCOOT systems and should be consulted by users. Of particular interest is the potential effect on regular users of a junction who become familiar with the normal operation, particularly when they should receive a green at the next stage change. When a stage is skipped, this normal order is interrupted. Users anticipating their green could be caught out when the bus stage, rather than their expected stage, is given green. No adverse effects were observed in the trials in London where great care was taken with the implementation. It is recommended that the principles used in the trials should be adhered to:

- Main road stages should not be skipped
- Pedestrian stages should not be skipped – a possible exception is where the pedestrian phase being skipped occurs more than once per cycle.

When stage skipping is to be introduced at a junction the stage order should be reviewed, as it may be desirable to re-order the normal stage sequence. This is especially likely at junctions where it is not permitted to skip a particular stage.

## Multiple Detection points: Cancel detection/long journey time

A number of authorities have installed bus management and information systems that make use of GPS technology to track buses through the network and are using these systems to provide bus priority in SCOOT. One big advantage of such systems is that they can provide detection of buses without the need for the installation of additional street hardware. This means that there is little cost in providing additional detection points.


SCOOT has now been enhanced to take advantage of the information that these systems can provide. In particular, the bus priority logic in SCOOT has been enhanced to allow for multiple detection points on the approaches to traffic signals, including a cancel detector when the bus passes through the junction. The maximum value for the bus journey time has also been increased. This will allow buses to be initially detected earlier, possibly before reaching the bus stop. If there is only one bus detection point then the variability in journey time and bus stop wait time would be too great to give efficient priority. However with multiple detection points the expected arrival time of the bus at the stopline will be 'corrected' as it arrives at subsequent detectors and the efficiency of the system should be maintained. The aim is to increase the level of priority that buses can be given and improve the efficiency of the control resulting in less disruption to other traffic. This development was released as part of SCOOT MC3 Service Pack 1.

## Restrictions on priority

One of the main advantages of providing priority through SCOOT is that the extent of priority given to buses can be controlled. Extensions and recalls can be restricted depending on the saturation of the junction as modelled by SCOOT. This is managed by specifying target degrees of saturation for both extensions and recalls. Non-priority stages can be run to these target saturation values, in the case of a priority extension or recall respectively. Normally the target saturation limits are set so that the junction is not allowed to become over saturated, although some degree of over saturation may be allowed to service an extension. This means that bus priority will be most effective at junctions that have spare capacity. Stage skipping has extra controls to limit the frequency of skips in addition to those that prevent skipping of a stage whose degree of saturation is over a user set level.

## Likely benefits of bus priority

The benefit to buses gained through providing SCOOT priority without stage skipping varies considerably, and is dependent on the scope for increasing or decreasing the lengths of signal stages. At junctions where the non-priority stages are already at or close to their minimum length, there is little scope for providing priority through recalls. Assuming that stages are not running close to their minimum length, the benefits of priority are then very dependent on the traffic conditions. Reductions in delay as high as 50% are achieved when the degree of saturation is low, whereas at high degrees of saturation the reduction in delay is of the order of 5 - 10%. The increase in delay to general traffic is similarly dependent on the degree of saturation. At low degrees of saturation the increase is small and insignificant, whereas at high degrees of saturation the increase in delay to general traffic can be large. The disruptive effect of providing priority by recalls is much greater than by extensions. Giving recalls to buses on a side road can be particularly detrimental as it reduces the green time as well as disrupting the coordination along the main road.

The number of buses being given priority is also an important factor, particularly at higher degrees of saturation. Benefit per bus decreases as bus flow increases, due to competing/conflicting priority calls, but total passenger benefit remains substantial at bus flows as high as 120 buses/hr/junction.

Providing priority also offers a small but significant improvement in the regularity of buses. Providing priority only to those buses that are behind schedule can increase the improvement to regularity. Providing priority to late buses only, and therefore to fewer buses, will also tend to increase the level of benefit to those late buses. However, considering all buses, the total benefit is likely to be reduced.

The benefits of stage skipping in SCOOT MC3 are in addition to those obtained through extensions and recalls. When restrictions are at their minimum level, stage skipping gives good benefits in the range 2.5 to 6 seconds per bus per junction, depending on the junction and flow conditions. Typically where the skipped roads are not too busy, the extra saving in delay, due to stage skipping, averages about 4 seconds per bus. At junctions where the links being skipped are busy, the benefit may be as low as 1 second per bus even if the skipping is uninhibited. This low benefit is due to an increase in queues of general traffic delaying buses.

On average there is a small increase of about 1 second per vehicle in the delay to general traffic when stages are skipped. The main disbenefit is to traffic on the side road being skipped. In some cases of low side road flows, there is an overall benefit to general traffic, since extra green is given to the busier main road. At junctions where the links whose green is skipped are busy, it is necessary to use the stage skipping saturation parameter to avoid large increases in delay to general traffic.

## Very high priority

Stage skipping provides the highest level of priority within SCOOT. If it is desired to provide even higher levels of priority, then it is possible to do this by overriding SCOOT. This can be done by using the controller 'hurry call' facility or by other means.

It is recommended that this is only used for emergency vehicles and other important but infrequent services, such as Light Rail Transit. Frequent uncontrolled overriding of SCOOT is likely to be very disruptive and can be counterproductive, particularly at high levels of saturation. Recovery logic introduced in SCOOT version 4.2 enables efficient recovery from an override.

## Contacts for SCOOT systems

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