Every Second Counts

Choices in the operation of traffic lights

Irving Yass
February 2011

RAC Foundation

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About the author

Irving Yass spent thirty-six years in government service, in the Departments of Transport and Environment, ending as Director of Planning and Transport at the Government Office for London. He was Director of Transport and then Director of Policy at London First until the end of 2008, since when he has been working as an independent consultant.

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Foreword

Ever thought you were spending more and more time sitting at traffic lights? You might just be right.

In the past decade the number of sets of lights across the UK has increased by almost a third, in London it is up by almost a quarter.

To some the lights are yet another example of how something as simple as getting from A to B is highly regulated and restricted. To others they are a necessary requirement to help improve interactions between conflicting uses of the road network.

This report by Irving Yass shows the truth lies somewhere in between. Overall, traffic lights deliver benefits, but if incorrectly sited and managed then individually they can cause undesirable impediment and frustration.

The report includes a lot of data gathered from London. This is unsurprising. The Capital suffers more than its fair share of traffic hold ups and the demand for finite road space means the method by which tarmac is allocated is a contentious issue.

Traffic lights often try to be ‘all things to all people’, and they are being increasingly used to prioritise different modes of travel. The challenge for transport planners is to show this approach delivers overall benefits to people and for road safety in a way that doesn’t unnecessarily hinder vital traffic movement.

A key message coming out of this report is that the impact of lights needs to be continually and rigorously assessed. Irving Yass says technology is already enabling real-time re-phasing of lights to take into account changing circumstances: e.g. varying times of day, accidents, road works, which is a significant improvement that should be built on.

Traffic lights have been a familiar sight on our roads for almost ninety years. We have come to take them for granted. Clearly they have an important part to play in managing the way the road network is used, but as decisions about their use are largely made behind closed doors a more open public debate is now needed.

S. Glaister.

Professor Stephen Glaister,
Director, RAC Foundation

1. Background

The purpose of this study is to look at the way traffic lights are managed from the point of view of road users and to consider possible changes. It focuses to a large extent on London, which has the largest number of traffic signals – over 6,000, about a quarter of the total in Britain. London also suffers from the worst traffic congestion – Transport for London (TfL) estimates that congestion costs London some £2 billion a year (GLA, 2010). The study also looks at experience in other cities in the UK and abroad.

The need for traffic lights is clear. They were introduced in the 1920s in order to stop traffic crossing a junction from colliding with traffic going the other way. At busy junctions traffic lights improve safety and assist traffic flow. A recent study (Colin Buchanan & Partners 2009) concludes that traffic signals generally provide significant benefits to road users, though not necessarily at all times of day. And there are some places where they are counter-productive.

As traffic in urban areas has grown, leading to increased congestion, traffic lights have been managed so as to minimise delays, with timings coordinated along a route or across an area and timing plans that are varied to match the traffic flows at different times of day. Computers and new communications

technology have enabled control systems to become more and more sophisticated. A major advance was the development of SCOOT (split-cycle offset optimisation technique), which allowed the phasing of a linked set of signals to respond to changing traffic conditions in real time. In congested urban traffic conditions queues build up very quickly. Fine adjustments to the timing of traffic lights can make a huge difference to traffic flow. Literally, every second counts.

There has been a big increase in the number of traffic lights in recent years. A survey by the Department for Transport (DfT) (unpublished) shows that the number of installations increased by more than 30% between 2000 and 2008. The increase in London was 23%.

At the same time, the aim of reducing traffic congestion has been subject to other objectives: to make roads safer and more convenient for pedestrians, including those with disabilities; to give priority to buses; to promote cycling; and to reduce the number of accidents. These objectives have been reflected in standards and guidance issued by DfT and the policies of local authorities.

The DfT survey (unpublished) shows that the number of traffic signals equipped to give priority to buses more than doubled between the beginning of 2007 and the end of 2008, from 3,801 to 8,425, 3,200 of them in London. The number of junctions in London with a full pedestrian crossing stage, i.e. all the vehicle signals held at red, has increased from 481 in 2000 to 783 in 2010.

These developments raise questions about how the available technology is used and in particular:

- Are there too many traffic lights? Could some be removed? Do they all need to operate all the time?
- How can the interests of drivers be reconciled with the needs and safety of pedestrians, cyclists and bus passengers? What priority should be given to each?

2. Where are Traffic Lights Needed?

About half of all traffic lights are at junctions: the remainder are at stand-alone pedestrian crossings. It is clear that traffic lights are needed full time at the busiest junctions, where there are significant competing demands for time and space. Equally there is no need for them at the junction of quiet residential roads. But where should the line be drawn in the often grey area in between? There is no national standard to determine where traffic lights are needed. Decisions are made by local authorities on the basis of local circumstances. This allows for an element of democratic accountability. In London TfL is the traffic authority for signals; it sets criteria for their installation and ensures common standards and coordination.

At busy junctions traffic lights not only improve safety but also help traffic flow. A recent study by Colin Buchanan & Partners for GLA Economics looked at five sets of traffic lights in London, which were representative of different types of junction and location (Colin Buchanan & Partners 2009). It modelled the effect of removing the signals at different time periods, using cost–benefit analysis to test whether the signals provided traffic benefits (in normal conditions). It concluded that traffic signals generally provide significant benefits to road users, though not necessarily at all times of day – see next page.

2.1 Local examples of traffic light changes

There may be cases however where traffic lights have proved not to be needed or where circumstances have changed since they were installed. Some local authorities have recently reviewed the need to keep traffic lights in a number of locations. The following are some examples.

2.1.1 Bristol

Following the failure of traffic lights at the Cabstand junction in Portishead in June 2009, there was a trial of switching off the signals, without any introduction of alternative conventional give-way markings, allowing unregulated behaviour to be assessed. As a result traffic flow increased from 1,700 to 2,000 vehicles per hour; queues were halved; pedestrian crossing times remained unchanged; there were no more accidents; and traffic stopped using a rat run to avoid the junction. Following the success of the trial the traffic lights have remained switched off and zebra crossings and road humps have been installed at the approach to the junction.

In 2010 similar trials were carried out switching off the traffic lights for a week at the junctions of Union St/Broadmead and Broad Quay/Prince St/Marsh St in the heart of the city. Again there were time savings for all road users, yet despite no evidence of safety problems, there were concerns for pedestrian safety under the unregulated arrangements, particularly for visually impaired people. This would require measures to improve conditions for them if the changes were to be made permanent.

2.1.2 Reading

The council carried out a review of traffic signals and an initial assessment identified 27 junctions based on the number of complaints and a perception that the negative impact to road users outweighed the positives. At seven of these no change was recommended. The remaining 20 are now subject to further investigation and public consultation.

2.1.3 Westminster

At the junction of Ebury Street and Elizabeth Street traffic lights with a full pedestrian stage were replaced by give-way markings and a raised crossing table.

At Drury Lane/Great Queen Street (on the border with Camden) traffic signals and guard rails have been removed as part of public realm improvements – below.

Figure 1: Traffic light removal at Drury Lane and Great Queen Street, London.

2.1.4 Ealing

In December 2009 experimental schemes involving the removal of traffic signals and replacement with mini roundabouts and zebra crossings were implemented at two junctions: Gunnersbury Lane/Bollo Lane; and Western Road/Featherstone Road/Montague Way. 'Before and after' traffic and pedestrian data demonstrate that the new junctions operate more smoothly and efficiently for both vehicular traffic and pedestrians. In particular:

- The volume of traffic through the junctions has increased by 6–12%;
- Average queue lengths have reduced by two thirds; and
- Typical pedestrian wait times have reduced by half.

While the removal of these traffic lights does not appear to have led to an increase in accidents, three years of before and after figures are required to establish a statistically significant result.

Where traffic lights have been removed, accident data for three years before and after should be reported to DfT so that there can in due course be a full assessment of the road safety implications.

TfL's criteria for installing traffic lights includes traffic flow, accident record and, in the case of pedestrian facilities, pedestrian demand. It has identified 145 sites where traffic signals do not accord with these justification criteria and could either be causing unnecessary delays or are not achieving the expected accident reductions. These are currently being investigated. TfL will be holding discussions with local boroughs and stakeholders about whether these traffic signals could be removed or replaced with alternative measures.

These cases suggest that there is a need for a wider review by local authorities of sites where traffic lights may not be justified.

Although there will be some cost involved in carrying out these reviews and removing unnecessary installations and infrastructure, there will be ongoing savings in road-user, maintenance and electricity costs. It will be necessary to consider alternative conventional measures, such as standard give-way control, mini roundabouts and zebra crossings, or indeed more unconventional solutions without formal controls and the introduction of shared spaces. These alternative measures could be costly to introduce and will still have a maintenance burden, yet sensible planning could ensure that schemes deliver a positive cost-benefit.

2.2 Part-time signals

The Buchanan study (2009) suggests that there may be many sites where traffic lights do not need to operate all the time and that it would be beneficial, in terms of journey time and thus road-user costs, to switch off traffic signals at some junctions at particular times of day. In particular there would be a benefit at the junctions studied from switching off during the off-peak, after a full safety assessment. However this study focused on the local costs and benefits rather than the function of signals as part of a wider traffic control system.

In other situations traffic lights may not be needed at night: for example, in city business districts or junctions serving industrial estates. There is some provision for part-time signal control in DfT Local Transport Note 1/09 *Signal Controlled Roundabouts* (DfT, 2009a). Some major roundabouts have signals that are used at peak hours only: in these cases however the junctions operate as normal roundabouts when the signals are switched off and no extra measures are needed. The DfT states (ibid.) that 'there can be situations where the advantages of providing part-time signals outweigh the disadvantages', but suggests that a strong safety case needs to be made.

Whereas there are clear priority rules at roundabouts when traffic signals are not operating, this is not the case at junctions. So if signals were switched

off at junctions, alternative priority rules would need to be developed. The Buchanan study (2009) suggests that flashing amber lights should be used at times when signal control is not justified. This is common practice in some other countries: for example, France, Italy. This approach is not favoured in Britain because a flashing amber is associated with pelican crossings, so it could cause confusion if such a flashing light was used for part-time signals at junctions as well. It is also thought that the flashing amber would give no protection to pedestrians trying to cross the road. This is a particularly important issue for people with disabilities.

For drivers, a flashing amber currently means give way to pedestrians crossing the road. To use flashing amber instead of traffic lights at some times would involve changing current regulations and the Highway Code to give it a second meaning. Would this confuse drivers? Either way the message to them would be 'look out'.

Pedestrians would be unlikely to confuse a flashing amber at a junction with a pelican crossing. At pelican crossings, when drivers see a flashing amber, pedestrians see a flashing green man. Even if a pedestrian were to mistake the crossing for a pelican, it should not lead to unsafe behaviour. When there is a flashing amber light for traffic at a pelican pedestrians do not have automatic right of way to start crossing the road, but have to check whether there is any on-coming traffic.

It would in any case be possible to allow for a pedestrian crossing stage to be demanded by using the push-button and temporarily showing a red signal to all approaching traffic, thus providing for more vulnerable pedestrians, especially those with impaired sight. There would however be risks that drivers would be surprised by a switch from flashing amber to a red signal and that, if there were some delay between pedestrians pressing the button and the lights changing, they would not wait before crossing. These issues would need to be dealt with in the detailed design. In identifying locations where traffic lights could be switched off at night or replaced by flashing amber, the number of pedestrians using the road should be considered as well as the number of vehicles.

There are proposals simply to switch off traffic lights at night in Devon and in the East Riding primarily as a way to save money. A poll in East Riding found 57% of respondents in favour.This strategy is perhaps however unlikely to save a great deal of money, or energy. The signal controllers and microwave vehicle detection systems (if present) need to be powered continuously. The latest LED technology for lamps results in running costs for signals being around £40 per signal head per year, and operating for 50% of the time would perhaps typically save around £500 per year.

There are other options to avoid drivers being held at red lights at times when there is no other traffic around: for example, controls can be switched from a fixed time plan to vehicle actuation (VA). This would involve installing detectors

to sense approaching vehicles. All signals could be held at red and change to green when an approaching vehicle is detected; or signals could be held at green on a major road with VA for traffic on the side roads. In London during periods of low demand some sites do switch to VA. At some others there are demand detectors on side roads and the traffic lights do not change to green if no demand is detected. For a new version of SCOOT that will be trialled in London 2011, there is provision for 'low flow' SCOOT. This will give SCOOT the ability to calculate the optimum cycle time of each node and determine when it is most beneficial to release a junction from its normal coordinated network cycle time to operate on the optimum local cycle time. This will give similar advantages to VA operation without the need for added expensive infrastructure.

DfT has been carrying out a study of how to manage traffic lights at periods of low demand so that drivers are not detained at red lights when this is unnecessary. This study is now nearing completion.

DfT should expedite publication of guidance on how to avoid traffic being held up unnecessarily and local authorities' review of their traffic signals should take account of this. DfT should make the legislative changes necessary to enable trials to be carried out of new techniques, such as flashing amber lights.

3. Traffic Lights and Congestion

In the 1980s the UK led the way in introducing advanced traffic control systems and achieved substantial benefit in reducing congestion. In particular London was at the forefront in developing traffic control technology through its urban traffic control (UTC) system and the installation of SCOOT. Around 2,000 signals operate with SCOOT technology and TfL plans to install SCOOT at a further 1,000 sets of signals by 2015/2016. The current SCOOT programme to date is delivering in excess of 13% reduced delay, which means that the benefits exceed the investment in the first year. SCOOT has been installed in more than 200 towns and cities in the UK and across the world. Other forms of traffic-responsive control system such as the Sydney Coordinated Adaptive Traffic System (SCATS) – an adaptive control system developed in Australia – have been introduced in many other countries.

Where demand exceeds capacity, more and more traffic signals are used tactically to manage flow. The use of System Activated Strategy Selection (SASS) techniques in London acts as a network watchdog at key locations. When patterns of traffic that lead to congestion are detected, SASS is able to utilise SCOOT and other London UTC data as advanced real-time system intelligence to manage traffic effectively to prevent traffic jams from occurring.

Sophisticated urban traffic control systems were originally designed to minimise delays to motor traffic, whether through variable fixed-time plans or traffic-responsive systems such as SCOOT. Minimising overall delay to traffic does not allow for giving more favourable treatment for some classes of road user whom policy makers may wish to protect or encourage. Over the last twenty years or so advances in technology that could reduce delays to vehicles – not only cars, but also commercial vehicles and buses – have to some extent been offset by giving greater priority to other road users, particularly pedestrians.

In London the Mayor Livingstone's Transport Strategy was based on giving priority to modes of transport other than motor traffic and there was a strong presumption against increasing road capacity. The only policy that aimed to reduce road congestion was the central London congestion charge, introduced in 2003. Monitoring reports of the congestion charging zone show that, after an initial improvement, congestion has been increasing again and is back to pre-charge levels, even though the number of vehicles entering the zone has not increased. TfL's Travel in London Report 2 analyses the reasons for this increase in congestion in some depth. It notes that there has been a reduction in traffic speeds at night as well as during the day and draws the following conclusions (TfL, 2010a: paras 10 and 11):

> 'As there is no evidence of changes in night-time traffic flows, the high proportion of additional day time delay… that is also observed in the reduced average night-time speeds strongly indicates that the additional delay on the network is occurring predominantly at junctions…
> Between the 2004 and 2007/08 night-time survey, the time spent stationary or moving at less than 10 kilometres per hour broadly doubled… from around 15% to around 30% in the original central zone; and from around 13% to around 24% in the Western Extension…
> The deterioration in average night-time speeds appears to reflect an increase in time spent stationary or moving at very low speeds, again suggesting a change in the time spent queuing at junctions. It is worth noting here that there was an increase of 15% to 20% in the number of traffic signal installations in central London in the period 2004 to 2006. The potential causes of the additional delay on the two networks have been considered in TfL's Congestion Charging Annual Monitoring Reports; they have been attributed to a combination of traffic management measures to improve conditions for pedestrians and other road users and to an intensification of roadworks in connection with utilities replacement or specific land-use developments.
> … between spring 2004 and spring 2008 there was a relentless downward trend in capacity, amounting to a total estimated to be about 30% of current capacity, or 25% of previous capacity. After a small recovery in the next two periods, the capacity in autumn 2009 appears to be the same as the low point reached in spring 2008.'

The number of new signal installations in central London is probably mainly due to the replacement of existing ones by new ones incorporating more sophisticated features, including greater priority for pedestrians – most junctions in central London were already controlled by traffic lights.

Mayor Johnson has adopted a different approach in his *Transport Strategy,* based on 'smoothing traffic flow', which is defined as follows:

> "Smoothing traffic flow" is the term used for the Mayor's broad approach to managing road congestion and, in particular, improving traffic journey time reliability and predictability. The aim of the smoothing traffic flow approach to managing the road network is to improve conditions for cyclists and pedestrians as well as vehicular traffic… measures will include:
>
> a) Further investment in intelligent traffic control systems (such as the traffic control system, SCOOT) and the infrastructure to support them…

> The aim is to create a state-of-the art urban traffic signal control system for the 21st century capable of maximising the efficient use of road capacity in London.' (GLA, 2010: paras 341–342).

As part of the mayor's pledge to smooth traffic flow, TfL reviewed timings at 1,003 signals in 2009/2010 to ensure they were operating as efficiently as possible. Changes made to the signals as a result of the reviews have delivered a 6% reduction in unnecessary delays at traffic signals, without negatively impacting on pedestrians. TfL is committed to review timings of a further 1,000 traffic signals a year to ensure that London's signals are operating in the best possible way for both drivers and pedestrians. TfL also plans to install SCOOT at 1,000 more sets of signals by 2015/2016.

The main thrust of TfL's current thinking is to concentrate on making the operation of the road system more reliable rather than generally speeding traffic flow or increasing capacity. TfL has analysed the causes of delay, compared with average journey time, on 23 key road corridors and found that congestion – volume of traffic – accounts for less than 10%. The main causes are accidents, highway authority and utility roadworks, and breakdowns, which together account for nearly 75% of delays. There is therefore a strong emphasis on active management by the London Streets Traffic Control Centre, at which TfL staff and Metropolitan Police are co-located, using SCOOT and SASS to intervene when problems occur or are likely to develop.

This interventionist approach is very welcome. It means accepting however that routes where traffic congestion is endemic may not get any better, for example, the inner ring road. There may nevertheless be some scope for adjusting the balance of priorities for road use to improve traffic flow along key routes or corridors.

4. Full Pedestrian Stages

The most significant change in traffic light installations over the last decade has been a growing trend to introduce full pedestrian crossing stages at junctions i.e. all the vehicle signals held at red, with a green man sign – 'invitation to cross' – for pedestrians indicating that it is safe for them to cross without risk from turning traffic. TfL's policy has been in line with this trend. The number of junctions with a full pedestrian stage has increased from 481 in 2000 to 783 now.

The then Department of Transport issued a guidance note in 1981 on *Pedestrian Facilities at Traffic Signal Installations* (DfT, 1981), which gives numerical criteria for the provision of pedestrian facilities. It said full pedestrian stages could be justified if 'either the number of pedestrians crossing was high or the headway of vehicles turning into the section was short and there were at least a minimum number of pedestrians crossing.' Otherwise the assumption was that pedestrians would choose to cross either during an intergreen period or when vehicles were turning into the section being crossed when volumes and speeds were likely to be lower. An intergreen is 'the period between the end of the green signal giving right of way for one stage and the beginning of the green signal giving right of way for the next stage' (DfT, 2006).

This guidance was superseded by Traffic Advisory Leaflet 5/05 *Pedestrian Facilities at Signal-Controlled Junctions* (DfT, 2005). It says that 'with more sophisticated control methods, with perhaps unexpected movements, and in many cases more complex layouts and higher vehicular flows, generally' the assumption that pedestrians could cross safely when vehicles are turning 'is not now thought to be reasonable, or realistic.' It goes on to say that crossings with no pedestrian stage are the least popular with pedestrians. 'They can be intimidating, especially for the more vulnerable pedestrian, and this option should be seen very much as an exception.'

DfT (2005) goes on to discuss the advantages and disadvantages of a full pedestrian stage. 'It is simple and easily understood by pedestrians… However of all the options it has the worst effect on junction capacity, as the additional time lost to vehicle movement is made up of an intergreen plus the crossing time. Also it can produce a long cycle time and a pedestrian arriving at the end of the invitation period has a lengthy wait.' This is especially true for coordinated networks.

In some other countries, for example France and the USA, traffic lights show it is safe for a pedestrian to cross – with a green man or white hand – without stopping traffic on the other arm of the junction. Pedestrians have right of way over turning traffic. It would be possible to introduce this rule in the UK so that it would not be necessary to stop traffic on all arms of a junction to enable pedestrians to cross safely. However traffic signals with staggered pedestrian phases and all-round pedestrian stages have now become established in the UK. Pedestrians cross on a green man on the assumption that there will be no turning traffic and it might be difficult now to go back on that. It would however be possible to ensure that an all-round pedestrian stage is not called unless a pedestrian pushes the button to request it – this is already the general practice in London and elsewhere.

The extent to which full pedestrian stages reduce traffic capacity depends on the particular situation and traffic flows. DfT (2005) sets out guidance on timing.

There is a period when a green man is shown – 'invitation to cross' – followed by a blank – 'the pedestrian safety clearance period' – when it is still safe to cross, and then a few seconds, depending on the width of the road, after the pedestrian sign is shown red and before the traffic lights turn to green, to enable pedestrians who have started to cross to complete their crossing safely. In total the length of time for which traffic is stopped for pedestrians may vary between 10 and 20 seconds, or even longer on wide roads, taking up 10–20% of the available time and much more in some locations. The effect on road capacity may be greater however if not all the traffic waiting at the lights gets through when they change to green and a queue develops. In some places, where pedestrian demand is heavy, two pedestrian stages are introduced in each cycle (double-cycling), which reduces traffic capacity even more severely.

4.1 Pedestrian safety

It is difficult to draw any conclusions about the effectiveness of light controlled junctions with pedestrian phases and stages in reducing accidents (See Table 1).

Table 1: Pedestrian casualties in Great Britain on pedestrian crossings

	2001	2009	% reduction
with pedestrian phase	1225	1202	2.0
zebra and pelican	2689	2100	22.0
other crossings	4004	2445	39.0
Total pedestrian casualties	40577	26887	34.0

Source: [for 2001: Reported Road Casualties GB 2001 Tables 1j and 32.] Bhagat et al., 2010: Tables 6c and 33

These figures are however difficult to interpret as there are no statistics for the numbers of crossings with and without pedestrian stages: the greater casualty reduction for 'other crossings' is likely to be at least in part attributable to the number without pedestrian stages being reduced.

For London, *Collisions and Casualties on London's Roads* provides figures for pedestrian casualties at or within 50 metres of a pedestrian crossing (See Table 2).

Table 2: Pedestrian casualties in London at or within 50 metres of a pedestrian crossing

	2004	2008	% reduction
zebra and pelican	1196	958	12.0
other crossings	1291	1039	19.5
Total pedestrian casualties	6376	5127	19.6

Sources: Transport for London, 2005; Cobbing, 2009, Table 5.1

Here again it is difficult to draw any firm conclusions. The category 'other crossings' includes traffic lights both with and without pedestrian stages. However changes to traffic signals over this period do not appear to have achieved a greater reduction in casualties than for pedestrians generally.

The introduction of full pedestrian crossing stages at traffic lights represents a major policy shift which has taken place without any analysis of the benefits in terms of accident reduction and time savings for pedestrians or the costs in terms of delay to traffic.

There should be a review of effectiveness of full pedestrian crossing stages and whether the benefits outweigh costs, either through before and after studies – for example, by carrying out trials like the 'green man' trials referred to below – or by comparing sites with full pedestrian stages with others without them.

4.2 Major pedestrian schemes

In London major signal projects are authorised at a senior level on the basis of a scheme design and impact analysis. In the case of the diagonal crossing that was installed at Oxford Circus in 2009, there was a cost–benefit analysis that showed a very high rate of return, principally from time savings for pedestrians, which greatly outweighed delays to cars – with surprisingly no disadvantage to buses.

Another recent major scheme was the installation of an all-round pedestrian stage at the junction of High Holborn, Kingsway and Southampton Row. The analysis concluded that without mitigating measures this would lead to the junction becoming overloaded, with queues on all arms creating congestion at neighbouring junctions. TfL therefore looked at a 'queue relocation strategy' i.e. holding traffic back before it reaches the junction. One option would have led to westbound queues on High Holborn of 650 metres, with knock-on effects at other junctions. Instead TfL opted for a strategy that involved holding back

traffic on the parallel Theobalds Road, with a 'bus gate' which would prevent buses from incurring additional delay i.e. allowing buses to go while holding other traffic at red. This would leave only 28 seconds of green time for other traffic in a 88 second cycle, while still leaving queues of 250 metres on High Holborn. It was noted that 'there is a slight concern that as people are forced to wait at these lights with very slight conflicting traffic (i.e. buses) they may not comply with the red signal.'

The scheme was approved without any cost–benefit appraisal. This junction was the most serious accident black spot in Camden. There was therefore a strong imperative to find a technically acceptable solution. It may well be that the value of likely accident savings and other benefits to pedestrians outweighed the cost in terms of additional delays, but this analysis does not appear to have been carried out.

In Manchester the impact of any major proposals is modelled as a basis for developing a cost-benefit appraisal.

Major pedestrian schemes that are likely to cause significant traffic delays should be subject to cost–benefit analysis and should be approved only if the benefits to pedestrians clearly outweigh the costs to others.

4.3 How pedestrian stages are managed

Given the need to maintain and enhance safety for pedestrians and to avoid long waiting times to cross the road, could these objectives be achieved with less delay to traffic? In October 2009 TfL commissioned trials at a number of crossings of reducing the green man – 'invitation to cross' – stage from ten to six seconds in accordance with DfT guidelines, while maintaining the blank – pedestrian safety clearance – period. Vehicle throughput on the priority arm observed increased by 6.5%, with no significant impact on safety (TfL, 2010b).

Six seconds could be set as the national standard if it were more widely understood that the full length of time that pedestrians have to cross is not just the green man period but also includes the time when the pedestrian sign is blank. The study (ibid.) notes that this is not well understood. Only 36% of pedestrians interviewed noticed the blackout period: when asked 'What do you think this blackout period means?' 40% of pedestrians answered correctly and 60% either answered incorrectly or did not know. There are other forms of pedestrian signals – Pedestrian User-Friendly Intelligent (puffin) and countdown, currently being trialled at eight sites in London – that avoid this problem:

In the light of these findings, authorities should consider standardising the green man invitation to cross period at six seconds supported by puffin or pedestrian countdown where appropriate.

Figure 2: Blank Pedestrian Signal

Puffin crossings were introduced in the 1990s as an alternative to pelicans as stand-alone signal-controlled – mid-block – crossings between junctions. The main differences between puffins and pelicans are:

- At pelicans the red light for traffic is followed by a flashing amber before it turns green; at the same time the pedestrian green man flashes before turning red. During this period traffic may proceed, but must give way to pedestrians. At puffins traffic lights follow the same red-amber-green sequence as at junctions and the pedestrian signal shows either green or red. Puffins therefore remove any uncertainty for both traffic and pedestrians about whether it is safe to proceed;
- At pelicans and standard signals at junctions, the pedestrian signal is located at the far side of the crossing. Pedestrians have to look across the road to see whether it is safe to cross. At puffins the pedestrian signal is located on the nearside post, on the side facing the oncoming traffic. Pedestrians are therefore able to see whether there is any traffic approaching the crossing at the same time as they look at the pedestrian signal; and
- Pelicans operate on a fixed time sequence, so the traffic signal remains at red even if all pedestrians have crossed. Puffins can have detectors which register whether pedestrians are waiting and end the pedestrian stage if there are none. If a pedestrian presses the button but then crosses in a gap in the traffic the pedestrian stage is cancelled if no one else is waiting to cross. Conversely it is possible to programme the control system to extend the pedestrian stage if people are still crossing.

Figure 3: Puffin Crossing with nearside sign showing red or green

Puffins have both safety and traffic benefits. A study for the DfT due to be published shortly shows that pedestrian accidents at puffins (mainly at mid-block crossings) were 27% lower than at pelicans.

The estimated additional cost of installing a new puffin crossing compared with a new pelican crossing is approximately £2,500, while the average net benefit of reduced vehicle delays is estimated at approximately £10,000 per site per annum, though there is significantly more equipment to maintain – see *Puffin Crossings Good Practice Guide*, issued jointly by DfT and the County Surveyors' Society (Routledge et al., 2006).

The principles of puffin control can also be used at junctions (though the cost of installation is higher). DfT first issued guidance on this in 2002 (Traffic Advice Leaflet 1/02). At junctions with a pedestrian stage, puffin control has the added advantage that it eliminates the period between the green and red walking man when the pedestrian signal is blank, which causes uncertainty about whether it is safe to cross.

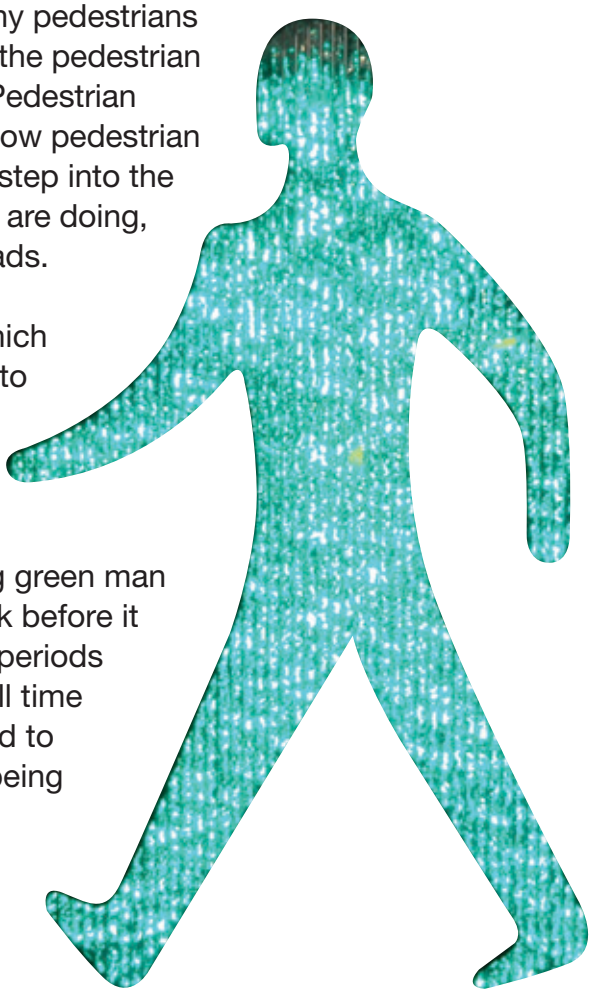
Puffin crossings also have traffic benefits. The *Puffin Crossing Good Practice Guide* (Routledge et al., 2006) says:

> 'DfT research in the UK (UG336) has shown that when junction traffic signals with an all red pedestrian stage are converted from farside to puffin pedestrian facilities, the average lost time can

be reduced significantly. This is a result of the reduced average clearance time and the shorter pedestrian green signal. Cancelling of unnecessary demands when pedestrians cross in gaps can also significantly reduce cycle times and thus further reduce delay for all road users' (ibid.: 11)… 'Work in 2005 at junction traffic signals converted to puffin facilities showed an average annual rate of return of 325% (ibid: Appendix C).

DfT has therefore been actively promoting the use of puffin control, both at stand-alone, mid-block sites and at junctions. Following research by TRL, the most recent version of SCOOT, MC3, models the variability of the pedestrian stage when puffin control is installed so as to maximise the benefit to traffic of shorter pedestrian periods. DfT has issued advice on *Integration of Pedestrian Traffic Signal Control within SCOOT-UTC Systems* (DfT, 2009b). Puffin installations have been incorporated into SCOOT control systems in a number of cities, for example, Manchester and York.

In London puffins are being installed to replace pelicans at mid-block crossings, and have been installed at some junctions, within a SCOOT environment. But TfL has reservations about the overall network effect if all junctions were to be converted to puffin control in a dense urban environment, where there is both high traffic and pedestrian demand and a large number of linked traffic signals. It is concerned that the variance in clearance periods for pedestrians at each site will have very detrimental effects for progression. TfL fears that this could lead to serious loss of capacity in peak hours if the control system is programmed to extend the crossing time as long as any pedestrians are waiting to cross. It is however also possible to set the pedestrian stage so that it is no longer than with farside signals. Pedestrian periods will be shorter only where there is low to very low pedestrian demand. TfL is also concerned that once pedestrians step into the road they have no indication of what the traffic signals are doing, which may cause some anxiety, especially on wide roads.



TfL is trialling pedestrian 'countdown' at junctions, which shows pedestrians how many seconds they have left to complete their crossing before the lights change. This system is now being adopted across the USA as standard. New York has just made the decision to install it at 1,500 signal sites. It gives pedestrians a much clearer message than the existing green man followed by a period when the pedestrian sign is blank before it turns red. By combining the green man and blackout periods of conventional pedestrian control, it allows the overall time allocated to pedestrians to be reduced and reallocated to traffic. The current version of pedestrian countdown being trialled at eight sites is however incompatible with the variability of puffin control.

Figure 4: Pedestrian countdown signal

Puffin and countdown both have advantages over conventional pedestrian signals. There is however a difference of professional opinion about their respective merits. The choice between them depends on a number of factors:

- With puffin the length of the pedestrian stage varies with demand, whereas with countdown it is fixed. Puffin therefore allows more time for traffic when pedestrian demand is light, but TfL is concerned that this variability is difficult to manage within an overall control strategy.
- With countdown it is clear to pedestrians starting to cross how long they have to complete their crossing; with puffin they have no indication how long they have left once they start to cross.
- The countdown sign can be seen by all pedestrians waiting to cross. With puffin the nearside panel may be obscured at very crowded crossings; some additional indicator would be needed if puffin were used at such locations: for example, a high-level repeater panel.
- The kerbside detectors required for puffin involve higher capital and maintenance costs.

It is difficult for the non-specialist to judge between differing expert views. Puffin has been shown to have traffic benefits in the locations where the DfT/CSS study (Routledge et al., 2006) was carried out, but these did not include any junctions within a UTC system. Further trials are needed to establish

whether it would be compatible with a finely tuned control strategy. Countdown also has traffic benefits in allowing an overall reduction in time allocated to pedestrians at sites where the green man exceeds six seconds compared with the conventional green man/blank signal sequence and is likely to be more suitable where there are very large numbers of pedestrians, for example, in central London, but may still hold up traffic unnecessarily when there are few pedestrians crossing.

TfL's evaluation of the current trial of countdown should help to clarify these issues. DfT should promote a trial of puffin control in a congested city centre to test whether it is able to achieve traffic benefits in such a location within a sophisticated UTC system. There should also be street trials to test public perception of countdown, with farside indicators, against puffin, with nearside indicators.

5. Buses

Many authorities have introduced ways of speeding buses through traffic lights. Buses can carry transponders that signal their approach to the junction or their approach can be signalled through global positioning system (GPS). The signal can cause a green light to be held until the bus has passed or a change from red to green to be brought forward. Bus control systems make it possible for priority to be limited to buses that are running late. In London 3,200 junctions are equipped for bus priority. With SCOOT control bus priority need involve only minimal delay to other traffic: the signals can be set so that bus priority will be given only if subsequent signal stages can adjust automatically to give reasonable compensation to other traffic. DfT has issued detailed guidance on how to incorporate bus priority into SCOOT (DfT, 2000).

Similar measures are taken for trams: in Croydon, Manchester, Sheffield and Nottingham there are junctions where there are conflicting movements of trams, other traffic and pedestrians.

The report of stage 1 of a detailed review of bus priority systems in 29 cities around the world was published in April 2009 (Gardner et al., 2009). The work was commissioned by TfL for the international association of public transport (UITP) and carried out by TRL and the Transportation Research Group at the University of Southampton. All cities undertaking an economic appraisal of their bus priority systems reported very good economic returns, with systems typically paying for themselves in 3–16 months, from the passenger and operator benefits gained.

A more radical form of bus priority is to install separate stages for bus lanes and other traffic, allowing buses to go while holding other traffic on red. This is particularly helpful to buses where they need to turn right, enabling them to move into the right-hand lane without being blocked by other traffic moving forward. These measures are often part of a strategy that includes bus lanes and other bus priority measures and are not subject to cost–benefit analysis. However this form of priority can impose significant delays to other traffic.

Figure 5: Buses and taxis go ahead while other traffic is held at the lights

Selective phasing to give priority to bus lanes at traffic lights should not be introduced unless the benefit to bus passengers is greater than the cost to other road users.

6. Cycles

There are well-established policies to promote cycling at both national and local level. At traffic signals advanced stop lines for cyclists were first trialled in Britain in 1984 and their use has since become widespread. A study by the TRL into the capacity implications found that a majority of cyclists thought them to be safer and easier to use as cyclists were allocated more road space. They also made cyclists more visible to drivers and enabled them to turn right much more easily. They do not appear to have a significant effect on road capacity in themselves, but are often associated with cycle lanes that restrict road space at the approach to the junction for other traffic: these can substantially reduce junction capacity (Wall et al., 2003).

There are a number of special arrangements for cyclists at traffic signals, including both cycle crossings and toucans – combined cycle and pedestrian crossings. In cities with large numbers of cyclists, such as Cambridge and York, there is also cycle priority at some signals: for example, a separately signalled cycle lane is given a green ahead of the rest of the traffic. In London the mayor is planning 12 cycle superhighways, the first two of which were inaugurated in August 2010. These include marked cycle paths that continue through junctions and new cycle crossings.

Figure 6: Cycle Path across junction

Barclays Cycle Superhighways © Transport for London

The Mayor's Cycle Safety Action Plan analyses the causes of serious cycling accidents. Collisions with heavy lorries account for more than half of cycling fatalities each year, many of them due to lorries turning left at traffic lights whose drivers are unaware of cyclists alongside them. This problem should not occur where there are advanced cycle stop lines that allow cyclists to wait ahead of lorries. Allowing cyclists to turn left through red traffic lights might help to prevent some of these accidents – though not in cases where the cyclist is going straight ahead.

There are however concerns that there would be risks for both cyclists and pedestrians. Cyclists could be turning left into the path of traffic going through a green light, which would be particularly dangerous on high speed roads or where there are parked vehicles. And it is a fixed principle in the UK that no other traffic movements are allowed during a pedestrian stage. TfL says that recent trials of an equivalent measure in Bordeaux and Strasbourg are reported not to have created any problems however. DfT is planning a study of how junctions can be made safer and more convenient for cyclists, which will take account of overseas experience. Whatever the outcome however current traffic regulations would not permit a trial of allowing cyclists to turn left on red in the UK.

DfT should amend the current regulations to allow highway authorities to trial innovative measures of this kind.

7. Conclusions

The need for traffic lights at busy road junctions is clear, but the way that they are used has been changing. It is now time to take stock of the cumulative effect of these changes.

The number of installations increased by more than 30% between 2000 and 2008. The study carried out by Colin Buchanan & Partners for GLA Economics suggests that most traffic lights at junctions produce an overall economic benefit compared with the likely situation if there were no signal control, but not everywhere and not all the time. In some locations where traffic lights have been switched off traffic flow has improved. These cases suggest that there is a need for a wider review by local authorities of sites where traffic lights may not be justified. However it will be necessary to consider alternative conventional measures, such as zebra crossings or mini roundabouts, or indeed less conventional solutions such as unregulated, shared space.

The benefit of traffic lights in some places is more doubtful at times when there is less traffic The Buchanan study suggests that normal operation could be replaced by a flashing amber light at such times, as is the practice elsewhere. DfT is currently opposed to this measure on safety grounds however. It has been carrying out a study of how to manage traffic lights at periods of low demand so that drivers are not detained at red lights when this is unnecessary. This study is now nearing completion.

Urban traffic control has become increasingly sophisticated with the development of traffic responsive systems such as SCOOT. In London traffic signals are being upgraded through timing reviews and extending the areas covered by SCOOT. The benefits of SCOOT are well proven in a large number of cities. In London the benefits exceed the costs in the first year.

There is significant benefit to traffic through the regular review of signals timings as shown by the TfL programme of 1,000 sites per year. Urban authorities should regularly review their signal timings to ensure they are efficiently managing traffic and pedestrian flow.

TfL's analysis shows that the main causes of congestion are accidents, highway authority and utility roadworks, and breakdowns rather than just the volume of traffic. There is therefore a strong emphasis on active management to intervene when problems occur or are likely to develop. SASS has been developed to detect traffic conditions that lead to congestion and use UTC and SCOOT to manage traffic to prevent traffic jams from occurring. This interventionist approach means accepting that routes where traffic congestion is endemic may not get any better, for example, the inner ring road. There may however be some scope for adjusting the balance of priorities for road use to improve traffic flow.

The most significant change in priorities over the last decade has been to improve convenience and safety for pedestrians. DfT advice issued in 2005 creates a presumption in favour of a full all-round pedestrian stage at junctions

i.e. all the vehicle signals held at red, while accepting that this significantly reduces traffic capacity (DfT, 2005). However it is difficult to draw any conclusions from analysis of accident statistics about the effectiveness of light controlled junctions with full pedestrian stages in reducing accidents. There has been no evaluation of either benefits to pedestrians or the increased traffic congestion resulting from full all-round pedestrian stages at signals.

An appraisal of the diagonal pedestrian crossing at Oxford Circus (unpublished) shows that it would produce a high cost–benefit return, mainly through time savings for the very large number of pedestrians. However another major scheme, which caused significant traffic delays, was approved without such an appraisal.

Delay to traffic could be reduced without significant disadvantage to pedestrians by better management of the pedestrian stage. Trials at a number of crossings in London of reducing the green man – 'invitation to cross' – stage from ten to six seconds increased vehicle throughput by 6.5%, with no significant impact on safety.

Puffin crossings have safety and traffic benefits. A major advantage of puffin control is that it uses detectors to identify when pedestrians are waiting to cross and adjusts the length of the pedestrian stage accordingly. Puffin control at junctions has the added advantages that it eliminates the 'blackout' period between the green and red walking man when the pedestrian signal is blank, which causes uncertainty about whether it is safe to cross, and by combining the green man and 'blackout' periods of conventional pedestrian control, it allows the overall time allocated to pedestrians to be reduced and reallocated to traffic.

In London puffins are being installed to replace pelicans at mid-block crossings, and have been installed at some junctions, within a SCOOT environment. But TfL has reservations about the overall network effect if all junctions were to be converted to puffin control in a dense urban environment, where there is both high traffic and pedestrian demand and a large number of linked traffic signals.

TfL is trialling pedestrian 'countdown' at junctions, which shows pedestrians how many seconds they have left to complete their crossing before the lights change. It has similar advantages to puffin.

Further trials are needed to establish whether puffin control would be compatible with a finely tuned control strategy. Countdown is likely to be more suitable where there are very large numbers of pedestrians, for example, in central London, but may still hold up traffic unnecessarily when there are few pedestrians crossing. TfL's evaluation of the current trial of countdown should help to clarify these issues.

Many authorities have introduced ways of speeding buses through traffic lights. In London 3,200 junctions are equipped for bus priority. With SCOOT control bus priority need involve only minimal delay to other traffic. A more radical form of bus priority is to install separate stages for bus lanes and other traffic, allowing buses to go while holding other traffic on red. However this form of priority can impose significant delays to other traffic.

Advanced stop lines for cyclists do not appear to have a significant effect on road capacity in themselves, but are often associated with cycle lanes that restrict road space for other traffic at the approach to the junction. These can substantially reduce junction capacity.

Collisions with heavy lorries account for more than half of cycling fatalities in London each year, many of them when lorries are turning left at traffic lights. Allowing cyclists to turn left through red traffic lights might help to prevent some of these accidents. Current traffic regulations do not however allow this measure to be tried in the UK.

Although decisions about traffic lights affect millions of drivers every day, they are taken by a few transport specialists, usually without any public consultation unless there are visible changes to the system, for example, installing a new set of signals, when there is formal consultation with stakeholders. There has been some research into pedestrians' experience of using signal-controlled crossings, but there does not appear to have been any research into the views of drivers. While it may be difficult to justify the cost of any new survey given current constraints on expenditure the DfT should take any available opportunity to research the views of road users, for example by arranging for relevant questions to be included in regular opinion surveys.

8. Recommendations

This report makes the following recommendations:

- **Traffic light signals review:** There is a need for a wider review by local authorities of sites where traffic lights may not be justified
- **Accident data reporting:** Where traffic lights have been removed, accident data for three years before and after should be reported to DfT so that there can in due course be a full assessment of the road safety implications
- **National guidance and legislation:** DfT should expedite publication of guidance on how to avoid traffic being held up unnecessarily and local authorities' review of their traffic signals should take account of this. DfT should make the legislative changes necessary to enable trials to be carried out of new techniques, such as flashing amber lights
- **SCOOT deployment:** Urban authorities should consider wide deployment of SCOOT

- **Pedestrian stage and scheme reviews:** There should be a review of effectiveness of full pedestrian stages and whether the benefits outweigh costs, either through before and after studies or by comparing sites with full pedestrian stages with others without them. Major pedestrian schemes that are likely to cause significant traffic delays should be subject to cost–benefit analysis and should be approved only if the benefits to pedestrians clearly outweigh the costs to others. Urban authorities should regularly review their signal timings to ensure they are efficiently managing traffic and pedestrian flow

- **Green man invitation to cross:** Authorities should consider standardising the green man invitation to cross period at six seconds supported by puffin or pedestrian countdown where appropriate

- **Puffin control trials:** DfT should promote a trial of puffin control in a congested city centre to test whether it is able to achieve traffic benefits in such a location within a sophisticated UTC system. There should also be street trials to test public perception of countdown, with farside indicators, against puffin, with nearside indicators

- **Establishing the level for bus and other mode priority:** Selective phasing to give priority to bus lanes at traffic lights should not be introduced unless the benefit to bus passengers is greater than the cost to other road users. Authorities should look to adjust the balance of priorities and calls on road space to improve traffic flow

- **Consultation and research:** The DfT should take the opportunity to research the views of road users on signal controlled crossings, to ensure the right measures are being implemented

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