ADEQUACY OF OPERATION AND DELAYS AT SIGNAL CONTROLLED CROSSINGS WITH AND WITHOUT PEDESTRIAN DETECTION

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ABSTRACT

Vehicle and pedestrian detection offered by 'Puffin' type control at signal controlled mid-block crossings is recommended by the UK Department for Transport for new installations and refurbishments of existing signal controlled crossings. Puffin type control uses on-crossing detection to vary the green time and uses waiting area detection to cancel demand if pedestrians move away after calling a pedestrian stage. A survey of delays over fifty cycles caused to pedestrians and vehicles at three Puffin and three Pelican crossings (without pedestrian detection) with matched attributes has been conducted. Pedestrian arrival times, time of demand request, pedestrian crossing times and vehicle delays were recorded. Observations have been collected on pedestrians' behaviour relating the time when they called for a pedestrian stage, the time of the invitation to cross and the time at which they actually crossed.

Analysis of the data shows that there is an increase in delay to pedestrians and vehicles at Puffin crossings when compared with equivalent Pelican crossings. The increase in vehicle delay results from the generally longer time to return to a green signal aspect for motor traffic after a pedestrian green aspect. The data show that this additional time is not required for pedestrians to clear the crossing. The suggestion is that the flashing amber period of a Pelican, which occurs after the green period for pedestrians, performs this function adequately. Even under the high vehicle flow conditions which obtained during the survey periods, significant non-compliance in pressing the button to create a demand was observed at Puffins (maximum 28%), and this was more than at Pelicans (maximum 23%). Observations also suggest that the tuning of pedestrian detection equipment remains a significant issue. No conflicts were observed during the Pelican flashing amber period, but five red light violations were observed in the red period after the pedestrian period at Puffin crossings.

Keywords: Pedestrians, signal control

INTRODUCTION: THE NEED FOR PEDESTRIAN CROSSINGS

The majority of collisions involving pedestrians and vehicles occur whilst the pedestrian is crossing the carriageway and the vulnerability of pedestrians is highlighted by the high proportion of collisions involving pedestrians that result in death or injury compared with other road users (IHT, 1997). In order to minimise the number of such collisions, pedestrian mid-block crossing facilities are considered at locations where significant numbers of pedestrians cross. Signal control has been shown to reduce the probability of fatalities to crossing pedestrians (for example, Kim et al. (2008).

The UK government established as early as 1998 an aim to increase the use of walking as a mode of transport (DETR, 1998), which identified benefits linked with health, congestion and the emission of greenhouse gases. More and better pedestrian crossings with less delay, including signal controlled crossings, have been identified as potentially encouraging walking (DETR, 2000). Latest policy (DfT, 2008) states that the UK transport system must support economic growth whilst tackling climate change and improving safety and health by promoting travel modes that are beneficial to health. Policies similarly designed to promote walking feature in the strategies of many other countries.

Pedestrian crossings ease the difficulty in crossing a carriageway and are provided based on assessment criteria including: vehicle flows, pedestrian flows, width of carriageway, speed of traffic, accident statistics and local representations (DoT, 1995a). Pedestrian crossing facilities may be provided above or beneath a carriageway (subways or bridges), but these frequently require additional distance to be travelled by a pedestrian. Facilities may be provided level with the carriageway and without signal control and these include a simple pedestrian refuge island in the centre of the carriageway and so called ‘Zebra’ crossings, where pedestrians have priority over vehicles.

There are four main types of signal controlled crossing in use in the UK: Pelican, Puffin, Toucan and Pegasus crossings. ‘Toucan’ and ‘Pegasus’ crossings as currently being installed have similar control to Puffin crossings, but include parallel or combined facilities for cyclists and horses respectively. Puffin control is replacing Pelican control for new installations and refurbishments and includes pedestrian detection. The control regimes for these two types of controller are described in detail in the next section. There remains concern amongst some traffic engineers that Puffin control may not be performing in the way anticipated and not to the levels of efficiency currently obtained from Pelicans.

The research presented in this paper compares operations and delays experienced by pedestrians and motorists at min-block Pelican and Puffin crossings installed on urban roads in Preston, a Northern UK city, on roads with a 30mph (48kph) speed limit. The data demonstrate a range of interesting insights about pedestrian behaviour and response to the two types of control regime. After the following section, which describes the different control regimes, a section is presented on previous research into controlled crossings. Methodology and site selection is then described, followed by the results and discussion. The final section presents conclusions.

PELICAN AND PUFFIN CONTROL REGIMES

Pelican type control (without pedestrian detection)

Still the most common type of pedestrian control in the UK is the Pelican crossing, introduced in 1969. The pedestrian raises a demand request by pressing a button which initiates the cycle and the pedestrian controller illuminates an indication to 'WAIT' above the request button. The signal to the pedestrian is by a far side pedestrian signal head which displays either a 'Red Figure' (wait), a 'Green Figure' (cross with care) or, at the end of the display of the Green Figure, a flashing 'Green Figure' (do not start to cross). Signals to vehicles are by standard traffic signal heads which display either a steady Green Aspect (vehicles may proceed), a steady Amber Aspect (vehicles must stop if safe to do so), a steady Red Aspect (vehicles must stop), or a Flashing Amber Aspect (give way to pedestrians who are still crossing the carriageway). The sequence is presented in Table 1 (DoT, 1995b).

Table 1 Pelican Crossing aspects and timings

		Signals shown			
Period	**Use**	**To Pedestrians**	**To Vehicles**	**Timings (seconds)**	**Variations for**
A	Vehicle running time	Red Standing Figure	Steady Green (proceed if way is clear)	20-60 seconds (fixed) 6-60 seconds (vehicle actuated)	Traffic volume
B	Standard stop warning to vehicles	Red Standing Figure	Steady Amber (stop unless not safe to do so)	3 (mandatory)	None
C	Vehicle clearance time	Red Standing Figure	Steady Red (Stop, wait behind stop line on carriageway)	1 to 3	Vehicle actuation
D	Pedestrian invitation to cross	Green Walking Figure with audible signal if provided (cross with care)	Steady Red	4 to 7 seconds (in some circumstances plus 2)	Road width, disabled pedestrians, crossings with central refuge
E	Warning to pedestrians to clear the crossing and not to cross. Vehicles remain stopped. For use with divided crossing.	Flashing Green Figure (do not start to cross)	Steady Red	0 or 2	Site conditions
F	As Period E above but with vehicles allowed to proceed provided the crossing is clear of pedestrians ahead of them	Flashing Green Figure	Flashing Amber (give way to pedestrians on crossing, they have priority)	6 to 18	Road width
G	Additional pedestrian clearance time before vehicle running time	Red Standing Figure	Flashing Amber	1 or 2	Road width

The operation of the cycle may be controlled by pre-determined timings for pedestrian and vehicle phases, or more commonly, by pre-determined times for pedestrians and variable timings for vehicles determined by the detection of vehicles, called vehicle actuation (VA). Vehicle actuation is normally achieved by induction loops in the carriageway or microwave detectors mounted above the traffic signal heads. If no vehicles are detected when a pedestrian demand is raised, the signals change once the minimum extension period has elapsed (normally seven seconds from the start of the vehicle green signal). If vehicles are detected, the vehicle phase is extended by a series of fixed periods until a gap in the flow is detected resulting in a ‘gap change’, or the maximum vehicle extension period (usually between twenty and sixty seconds) is reached causing a ‘forced change’.

Once the pedestrian phase begins, vehicles are stopped by an Amber Aspect (three seconds) followed by Red Aspect and the steady Green Figure is shown on the pedestrian head for a pre-determined time based on the width of the crossing. A further period follows when the Green Figure flashes, indicating that pedestrians should no longer start to cross, but those on the crossing should continue to complete their crossing. During this period, a flashing Amber Aspect is displayed to vehicles, indicating that they may proceed if the crossing is clear, but pedestrians retain priority. Following the pre-set flashing amber period the Red Figure is again displayed to pedestrians and, following a short delay, a steady green aspect is displayed to vehicles.

Puffin type control (with pedestrian detection)

The Puffin crossing came out of developments in the 1990s to tackle complaints about Pelican crossings: vehicles often have to stop unnecessarily because a pedestrian demand cannot be cancelled[1]; and insufficient time to cross is offered to pedestrians, particularly those with mobility impairments (DfT, 2006).

The pedestrian raises a demand by pressing a button and a red ‘Call Confirmation’ light is illuminated on the pedestrian control unit. The continuous presence of the pedestrian within the waiting area is then monitored by infra-red detectors. If the pedestrian moves out of the waiting area, because he or she crosses before the signals change, or decides not to cross, the demand is cancelled and the ‘Call Confirmation’ light is extinguished.

[1] A circumstance which may arise either because a pedestrian abandons a decision to cross, or crosses in a gap before the Green Figure is displayed.

Figure 1 Puffin Type Control showing overhead detectors and nearside pedestrian signal

(Source: DfT, 2006)

The Red and Green Figure aspects are signalled to pedestrians by a nearside signal head, located such that pedestrians can also watch approaching traffic. The reasons given for near side signal heads are that: they encourage waiting pedestrians to look towards the traffic approaching the crossing; it can be easier for the visually impaired to see; and also it reduces pedestrian confusion when pedestrian signals change whilst they are on the crossing (DfT, 2006).

The nearside signals displayed to pedestrians are similar to those on the Pelican crossing with a Red Figure indicating that pedestrians should not cross and a Green Figure indicating that they may cross (and which is normally accompanied by an audible bleep). There is no flashing Green Figure, because, once the pedestrian is on the crossing, he or she should continue to cross and is unable to see the nearside pedestrian signal head. The sequence is shown in Table 2 (DfT, 1995).

Table 2 Puffin Crossing aspects and timings

		Signals shown			
Period	**Use**	**To Pedestrians**	**To Vehicles**	**Timings (seconds)**	**Variations for**
1	Vehicle running time	Red Standing Figure	Steady Green (proceed if way is clear)	20-60 seconds (fixed) 60 seconds (vehicle actuated)	Traffic volume
2	Standard amber to vehicles	Red Standing Figure	Steady Amber (stop unless not safe to do so)	3 (mandatory)	None
3	Vehicle clearance time	Red Standing Figure	Steady Red (Stop, wait behind stop line on carriageway)	1 to 3	Vehicle actuation
4	Pedestrian invitation to cross	Green Walking Figure with audible signal if provided (cross with care)	Steady Red	4 to 9 seconds	Road width, disabled pedestrians, crossings with central refuge
5	Pedestrians must not start to cross	Red Standing Figure	Steady Red	1 to 5	Site conditions
6	Completion of pedestrian crossing time	Red Standing Figure	Steady Red	0 to 22 (pedestrian extendable period)	Road width
7	Additional pedestrian clearance time	Red Standing Figure	Steady Red	0 to 3 (only appears on a maximum change if pedestrians are still detected)	Pedestrian detection
8	Additional pedestrian clearance time	Red Standing Figure	Steady Red	0 to 3 (only appears at a pedestrian gap change)	Pedestrian gap change
9	Standard red/amber to vehicles	Red Standing Figure	Red with Amber (stop)	2	None

The signal aspects displayed to vehicles are the same as those used at a signal controlled junction: steady green (vehicles proceed); steady amber (vehicles must stop if safe to do so); steady red (vehicles must stop); and simultaneous red and amber (stop phase is coming to an end). The flashing amber phase used in the Pelican crossing is not used.

The cycle of the puffin crossing is determined by variable timings for both vehicle and pedestrian phases within pre-prescribed limits. Vehicle timings operate in the same way as for the Pelican crossing with vehicle actuation determining the green time within the minimum and maximum limits. The duration of the pedestrian crossing phase is determined using a combination of minimum times and extension periods based on data received from infra-red detectors monitoring the crossing area within the carriageway. There is an initial fixed time Green Figure displayed during which time pedestrians may begin to cross, this is followed by a short fixed time Red Figure period, during which pedestrians continue to cross but should not start to cross. Following this, there is a Red Figure extension period during which pedestrians on the crossing may continue to cross safely, as the detectors will detect their presence and extend the period until no pedestrians remain on the crossing. Once the crossing is clear of pedestrians, a simultaneous red and amber aspect followed by a green aspect is displayed to vehicles.

The Department for Transport has a preference for all signal controlled pedestrian crossings to migrate to Puffin control and has published guidance to local authorities accordingly (DfT, 2006). So far as the setting of maximum extension greens is concerned, the practice is variable across the country, but with a few proponents suggesting that only proven requirements because of higher flows at particular times of the day should lead to maximum extension greens in excess of 20 seconds (Lingwood, 2008).

PREVIOUS RESEARCH AND DEVELOPMENT STUDIES

The Department of Transport began investigating methods of overcoming the complaints about Pelican Crossings by trials to incorporate detectors into crossings. These took place in West Sussex and London in 1991 at two signal controlled junctions (Davies, 1992). This was swiftly followed by PUSSYCATS (Pedestrian Urban SafetY and Comfort At Traffic Signals), a European research project which trialled methods of detection of pedestrians at the waiting area and on the crossing including pressure mats and infra-red detectors (Levelt, 1992).

Davies (1992) reported significant non-compliance with the intended method of use of a signal controlled crossing, with 51% not pushing the button to call a demand in a small town and 73% not doing so in London. Levelt (1992) found the proportion not pushing the button to be 82% in Toulouse. Such high non-compliance calls into question the value being placed on the assistance offered by signal controlled crossings.

Carsten et al. (1996) undertook a study to trial different levels and regimes of pedestrian detection at mid-block crossings in three European cities to determine the effects on pedestrian waiting times, safety and comfort and the effects on vehicle delay. The trials included replacing the push-button with active detection, reducing the pedestrian waiting time, extending the green time for late arrivals and providing longer stages for larger numbers of pedestrians. They concluded that detection can assist pedestrians but that more experimentation should be encouraged with signal timings.

As part of the widespread introduction of Puffin type control, Walker et al. (2005) undertook ‘before’ and ‘after’ studies and found that delays to vehicles increased when five sites were converted from Pelican to Puffin control. The study, however, concluded that this was the result of conservative timings being set under Puffin control, specifically for Periods 5, 7 and 8 in the cycle (See Table 2). The current recommended settings (DfT, 2006) for Periods 7 and 8 are zero seconds, because it is acknowledged that any variable extension should be included in Period 6. Walker et al. also studied the effects of changed control on pedestrian delays, and they demonstrated longer delay for some sites, particularly where urban traffic control (i.e. additional external control on crossing timings) was in operation, with shorter delay at other sites. McLeod et al. (2004) discussed reductions in pedestrian delay at signal controlled crossings by shortening the vehicle detection zone where vehicle actuation is installed, and extending the Green Figure period for as long as a pedestrian demand is present, which also assists in increasing pedestrian compliance.

Recognising the increased occurrence of pedestrian red light violations with an increased interval between green aspects, Zou et al. (2009) developed an algorithm to minimise average vehicle delay using the period of green for the pedestrian phase as a variable. They illustrated a scenario with extended green pedestrian phase and reduced average vehicle delay. Also taking a modelling approach, Feng (2008) used a weighted sum of pedestrian and vehicle delay to optimize pedestrian signal control. On the premise that the balance in delay between different modes is ultimately a political decision, Schmöcker et al. (2008) developed a signal control approach using fuzzy logic where the acceptability and unacceptability thresholds may easily be programmed by the traffic engineer.

The development of pedestrian detection has a history spanning nearly two decades. The relatively recent work of Walker and revised recommendations for signal timings from the Department for Transport, coupled with the more recent work on modelling to optimise signal control for signal controlled crossings, indicates that this area of work remains an active field. This paper contributes to the research by providing comparisons in operations and delay between paired crossings with and without pedestrian detection.

METHODOLOGY AND SITE SELECTION

Three pairs of Puffin and Pelican crossings have been studied with similar pedestrian and vehicle flow and control attributes. Surveys of fifty cycles at each crossing were carried out in dry weather when traffic and pedestrian flows were at high levels. Preliminary observations indicated that when traffic flows were low, pedestrians were less likely to approach and use the crossing, but would cross in gaps in the traffic. This lack of use of the crossing facilities under lower flow conditions brings in to question the appropriateness of the settings adopted in controllers for such conditions.

The time that the pedestrian demand button was pressed was recorded and the time subsequent pedestrians arrived was also recorded. The time that the waiting pedestrians crossed the road was recorded as the time the Green Figure signal was displayed, unless the pedestrian crossed before it was displayed, or abandoned the decision to cross. In these cases, the time at which this actually happened was recorded.

The time the last pedestrian cleared the crossing was also recorded during most surveys, and this allows for the determination of the period of time between the crossing becoming clear and the green aspect to vehicles being displayed. In addition, the number of pedestrians that used the crossing between cycles without pressing the request button was also recorded.

The number of vehicles that were delayed was recorded, together with vehicle occupancy. Preliminary trials attempted to record the time that each vehicle stopped but this proved to be difficult to determine from a practical point of view. The recorded times were the time the traffic signal changed to red for vehicles and the time the vehicles started to move, or, for Puffin crossings, the time the traffic signal changed to green.

The study used a process of elimination to select from the forty-one Pelican crossings, six Puffin crossings and three Toucan crossings with Puffin type control within the urban area of the City of Preston in Lancashire, UK. Sites were eliminated if they were on roads with a 40 mph speed limit, on dual carriageways with separate cycles for each side of the carriageway, where bus lanes were present, and where timings were controlled by the Urban Traffic Control Computer. Only three Puffin crossings remained on the list, and so consideration was given to including the remaining Toucan crossing.

As the crossing width provides the basis for the Green Figure period and is proportional to crossing time, the width of crossings was used as the basis for matching pairs of crossings remaining on the list. Site specific factors, signal timings and local knowledge were then used to complete the match. Site specific factors considered included: proximity of residential homes (where there may be high proportion of users with reduced mobility); the nature of the business of road users including both drivers and pedestrians (commuter, through traffic, social); flows of traffic and pedestrians; and proximity and links to public transport. The paired sites selected for survey are shown in Table 3.

Table 3 Selected paired sites

Crossing Number	Location	Type	Width (metres)	Maximum green extension (Seconds)
F5054	Moor Lane, North of Victoria Street	Puffin	7.30	30
F5043	Deepdale Road, South of Victoria Street	Pelican	7.30	30
F5030	Fylde Road, South of Kirkham Street	Puffin	9.80	30
F5008	Tag Lane, South of Dovedale Road	Pelican	10.30	30
F5053	Fylde Road, opposite Greenbank Place	Toucan	8.00	25
F5027	Avenham Lane, East of Syke Street	Pelican	7.60	40

It should be noted that the last pair have dissimilar vehicle actuated maximum extension green periods which may result in an increase in pedestrian waiting times at the Pelican site if a gap change does not occur. The pre-set timings of each of the crossings are shown in Table 4.

Table 4 Pre-set timings for the crossing pairs

Pelicans

Period	A	B	C	D	E	F	G
Vehicle Signal	Green	Steady Amber	Red			Flashing Amber	
Pedestrian Signal	Red			Green	Flashing Green		Red
Deepdale Road (Pair 1)	Max 30 Min 7	3	1 or 3	5	2	6	1
Tag Lane (Pair 2)	Max 30 Min 7	3	1 or 3	7	0	12	2
Avenham Lane (Pair 3)	Max 40 Min 7	3	1 or 3	7	0.2	8	2

Puffins

Period	1	2	3	4	5	6	9
Vehicle Signal	Green	Steady amber	Red				Red amber
Pedestrian Signal	Red			Green	Red	Red extension	Red
Moor Lane (Pair 1)	Max 30 Min 7	3	1 or 3	3	3	10	2
Fylde Road (Pair 2)	Max 30 Min 7	3	1 or 3	5	3	10	2
Fylde Road Toucan (Pair 3)	Max 5 Min 7	3	1 or 3	6	3	10	2

Notes

1 Periods 7 and 8 for the Puffins are set to zero seconds.

The vehicle actuation maximum setting runs from the point that the call for demand is raised in all cases. The length of the all red phase (Period C at Pelicans and Period 3 at Puffins) is determined by the type of change that occurs. If the change occurs during a gap in the flow of traffic detected by the vehicle actuation sensor (a gap change), the all red phase is one second. If the change occurs at the end of the vehicle maximum extension period because the flow of traffic never contained gaps, the all red phase is three seconds.

RESULTS AND DISCUSSION

This section presents the results of the site observations of delay together with observations about the operation of the two types of control; that is with and without pedestrian detection. It goes on to discuss some of the implications of the results and observations.

Pedestrian Delay

Table 5 shows the pedestrian flow and delay for each crossing.

Table 5 Pedestrian flow and delay

Location	Type	Total number crossing	Number (%) crossing who did not raise a demand	Mean number crossing per cycle	Mean delay per pedestrian per cycle (seconds)	Standard deviation (seconds)
Moor Lane	Puffin	211	58 (27.5%)	3.06	17.8	12.5
Deepdale Road	Pelican	105	14 (13.3%)	1.82	14.3	9.2
Fylde Road	Puffin	121	12 (9.9%)	2.18	18.9	11.7
Tag Lane	Pelican	93	3 (3.2%)	1.80	15.4	10.7
Fylde Road	Toucan	111	31 (27.9%)	1.60	13.8	12.6
Avenham Lane	Pelican	89	20 (22.5%)	1.38	6.9	5.1

Note:
1 Delay is estimated only for pedestrians crossing on the Green Figure

A significant proportion of pedestrians (up to nearly 28% at some crossings), even at the busy times selected for survey, did not raise a demand. Presumably, this is because experience has suggested to pedestrians that there will be a gap in the traffic in which they will be able to cross before the controller responds to their demand. It is also noticeable that non-compliance at Puffins is always greater than at the paired Pelican. These findings are surprising and in themselves immediately begin to point to a different approach to use by pedestrians.

The mean delay to pedestrians ranges from just under 7 seconds to nearly 20 seconds. The standard deviation, and hence the variability in delay is, however, relatively large and the sample sizes have not allowed for a full investigation of the shape of the distribution of mean delay. There is a consistent difference in the mean individual pedestrian delay per cycle between paired crossings. In each case, the mean delay is greater at the Puffin crossing compared with the equivalent paired Pelican crossing, but the only difference which is significant is for the Fylde Road/Avenham Lane pair (p=0.01).

Two factors affect the mean delay per pedestrian per cycle relative to the length of the period of the Red Figure. Firstly, the mean will reduce with increasing non-compliance (i.e. crossing before the Green Figure). Secondly, with longer Red Figure periods, the probability of additional pedestrians arriving during the Red Figure period increases. These later arrivals will have a lesser period of time to wait before the change to a Green Figure. To overcome these two effects, Table 6 shows the mean maximum pedestrian delay for each cycle which is defined as the difference between the time that the initial demand is raised and the time that the Green Figure is displayed to waiting pedestrians.

Table 6 Mean maximum pedestrian delay

Location	Type	Mean maximum pedestrian delay per cycle (secs)	Standard deviation (secs)	Mean number of pedestrians crossing before Green Figure per cycle	Proportion of pedestrians crossing against a Red Figure after demand raised
Moor Lane	Puffin	37.5	0.9	1.6	58%
Deepdale Road	Pelican	17.9	10.4	0.3	20%
Fylde Road	Puffin	23.5	12.2	0.1	8%
Tag Lane	Pelican	17.7	10.7	0.1	8%
Fylde Road	Toucan	14.7	7.0	0.3	20%
Avenham Lane	Pelican	9.5	8.5	0.2	14%

The difference between the mean maximum pedestrian delay per cycle is significant for every pair of crossings ($p<0.001$, $p=0.02$, $p=0.003$ for the pairs reading down the table).

Moor Lane/Deepdale Road

Traffic flow is greater at Deepdale Road Pelican crossing than at Moor Lane Puffin crossing (see Table 7 for the flows), so it could be expected that pedestrian delays would be longer at Deepdale Road because more cycles are likely to run to the maximum vehicle extension. However, the data show that Deepdale Road only ran to maximum on seven occasions out of the fifty surveyed, whereas Moor Lane ran to maximum on every cycle. It is possible that the flow was more consistent along Moor Lane resulting in fewer or no gap changes. The very high proportion of pedestrians crossing against a red signal (58%) indicates, however, that gaps in the traffic flow did exist. These gaps were insufficiently long to trigger the controller to make a gap change.

A higher proportion (28%) of pedestrians crossed at the Moor Lane Puffin crossing without raising a demand as compared with the Deepdale Road Pelican crossing (13%). It is possible that regular pedestrians have learnt that there is long and unnecessary delay at the Moor Lane site before the signal will change and this may be the reason that they are not raising a demand.

Observations noted during the survey at the Moor Lane Puffin crossing indicate that, of the fifty cycles surveyed, the controller could have cancelled the pedestrian demand on twenty-nine occasions but did not do so, indicating a lack of tuning in the pedestrian detection equipment. In some of these instances, further pedestrians arrived and utilised the crossing period, but on many occasions the cycle unnecessarily ran through to maximum.

Fylde Road/Tag Lane

Traffic flow is greater at the Fylde Road Puffin crossing than the Tag Lane Pelican crossing and this is consistent with the greater pedestrian delay at the Fylde Road crossing. There were three occasions when a pedestrian demand should have been, but was not, abandoned by the controller.

The proportion of pedestrians who crossed against the traffic flow having requested a demand was the same at both the Fylde Road Puffin and the Tag Lane Pelican crossings. The proportion crossing without attempting to raise a pedestrian demand was again greater at the site with the higher mean maximum pedestrian delay.

Fylde Road/Avenham Lane

The two main variables which affect pedestrian delay, vehicle actuation maximum extension settings and the vehicle flow rate, would suggest there ought to be less pedestrian delay at the Fylde Road Toucan crossing than the Avenham Lane Pelican crossing. However, this was not found to be the case[2]. There are no indications, such as proximity to other signal controlled junctions, that traffic flow is more platooned at one site compared with the other. The data does not indicate that there were any issues with the tuning of the vehicle detection equipment, as appears to the case at the Moor Lane site: both crossings performed gap changes and forced changes.

The Fylde Road Toucan crossing was the only crossing out of the three surveyed where the controller cancelled any abandoned pedestrian requests. Of the five occasions during the survey that the pedestrian crossed before the signals changed, the request was cancelled by the controller on three occasions. On one occasion the controller cancelled the pedestrian request whilst the pedestrian remained waiting. The pedestrian was not aware that the controller had cancelled the request and subsequently waited 86 seconds before crossing against the Red Figure during a gap in the traffic.

Vehicle delay

Total vehicle delay per cycle was estimated assuming an average delay per vehicle of half of the vehicle red time, plus a two second headway between vehicles on commencement of the vehicle green. This approach provides a reasonable basis for comparison between sites. Table 7 shows the vehicle flow, delay and the time after the last pedestrian had crossed before the traffic stream once again began to proceed.

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[2] Although the Fylde Road site was actually a Toucan crossing, all of the collected data refers to pedestrians as no cyclists were observed using the crossing during the survey.

Table 7 Vehicle flow and delay

Location	Type	Vehicle flow (vehicles per hour)	Mean vehicle delay per cycle (secs)	Standard deviation (sec)	Mean number of vehicles delayed per cycle (secs)	Mean vehicle occupancy	Mean time stopped after last pedestrian had crossed (secs)
Moor Lane	Puffin	719	15.5	3.2	5.2	1.3	20.9
Deepdale Road	Pelican	1231	6.1	3.1	3.3	1.7	4.0
Fylde Road	Puffin	1662	10.3	3.5	3.5	1.9	-
Tag Lane	Pelican	1057	6.3	2.4	2.4	1.6	2.0
Fylde Road	Toucan	713	9.5	3.9	3.9	1.8	-
Avenham Lane	Pelican	1182	7.4	2.2	2.2	1.3	5.0

Mean vehicle delay is generally shorter than mean pedestrian delay and ranges from 6 seconds to 16 seconds. The standard deviation of delay is also less. Most ‘excess’ vehicle red aspect periods after the last pedestrian had completed a crossing are significantly longer at the Moor Lane Puffin than the Deepdale Road Pelican crossing ($p<0.001$)[3]. This finding is contrary to evidence from work undertaken on behalf of the DfT (undated) which indicates that conversion to Puffin control reduces vehicle delay.

Walker et al. (2005) recommended that periods 5, 7 and 8 should be 1.8 seconds, zero seconds and zero seconds respectively. At the three Puffin sites surveyed these periods are three seconds, zero seconds and zero seconds. The difference in mean vehicle delay between paired sites is always greater than the difference of 1.2 seconds between the Walker recommendation and the installations surveyed.

In addition to considering mean vehicle delay per cycle the period of time from the point that a red signal was shown to traffic to the point that a green signal was shown was determined as shown in Table 8.

[3] Data on ‘excess’ red times for the two other puffin crossings was not collected.

Table 8 Vehicle red times

Location	Type	Mean vehicle red to vehicle green time (secs)	Theoretical minimum period (secs)	Theoretical maximum period (secs)	Mean time period vehicles compelled to stop (Standard deviation) (seconds)	Mean time vehicles remained stopped after crossing was clear (seconds)
Moor Lane	Puffin	26.0 (0.7)	9	21	26.0 (0.7)	20.9
Deepdale Road	Pelican	15.3 (0.7)	15	17	11.8 (1.8)	3.6
Fylde Road	Puffin	14.9 (2.7)	11	23	14.9 (2.7)	6.2[1]
Tag Lane	Pelican	22.3 (0.7)	22	24	11.3 (1.8)	2.4
Fylde Road	Toucan	17.2 (5.5)	12	24	17.2 (5.5)	10.8[1]
Avenham Lane	Pelican	18.2 (0.0)	18.2	20.2	12.2 (1.4)	5.1

Note

1 *The time that the 'last pedestrian cleared the crossing' was not available from the data collected for the Puffin and Toucan sites on Fylde Road. An approximation was calculated from crossing time data at the paired site with an adjustment for width.*

The mean vehicle red to vehicle green signal time is longer at the Pelican crossings than the Puffin crossings at the second two pairs, but not at the first pair (and it should be noted that there was no cycle length variation at the Moor Lane Puffin crossing). The difference at the second two pairs of sites is to be expected as the Puffin crossing reduces the red period once the crossing is clear of pedestrians, whilst the vehicle red to vehicle green time includes the flashing amber phase at Pelican crossings. At the pelican sites, vehicles start to move during the flashing amber phase on the majority of observed cycles so inducing less delay than at Puffin crossings. The ability to proceed on flashing amber provides valuable reduced delay at Pelican sites as compared with Puffin sites.

The efficiency of the timings at the end of the Puffin cycle, once on crossing detectors determine that the crossing is clear, is, however, less than optimal as compared with Pelicans. There is a requirement for the Puffin cycle to include safety periods to ensure that the crossing is clear before a green signal is given to motorists. This will result in unnecessary extension of Period 6 during many cycles. In addition to this, Period 9 in the Puffin cycle is a mandatory 2 second Red and Amber phase which entails a further delay.

During the surveys, vehicles were recorded proceeding against a vehicle red signal on five occasions. Each of these occurrences was at a Puffin site and each appears to have been a deliberate contravention of the signal because each vehicle had stopped at the crossing initially and then proceeded once pedestrians had cleared the crossing. No observations of vehicles running red lights were made at Pelican sites. There were no incidents of conflict between pedestrians and vehicles during the 300 observed crossing cycles. Vehicles gave way to pedestrians at all times whilst they were on the crossing during the crossing cycle.

Moor Lane/Deepdale Road

The mean vehicle red time at the Moor Lane Puffin crossing is the same length as the maximum allowed by the controller and indicates that the pedestrian detection equipment was not well tuned and supports the evidence discussed above concerning pedestrian delay. This highlights the importance of ensuring that Puffin crossings are suitably tuned and maintained.

It can be seen that, although vehicle flow rates are substantially lower at the Moor Lane Puffin crossing, the mean number of vehicles delayed per cycle is higher. There are two likely contributory factors: firstly, the longer vehicle red periods due to the pedestrian detection equipment not detecting when the crossing was clear. Secondly, the initiation of the cycle is not happening on a gap change because the vehicle detection equipment is not well tuned, and so it will always occur on a forced change. There is therefore a higher probability of vehicles being present at the start of the pedestrian green. In contrast, the vehicle actuation at the Deepdale Road Pelican site will most probably have initiated the cycles during periods when no vehicles are approaching, thus reducing the overall number of vehicles affected. It can be seen that there is a significant difference in the mean delay experienced by vehicles at the two sites. The total vehicle red to vehicle green time is of little significance at Pelican crossings when related to vehicle delay as vehicles may proceed well in advance of a clear green signal.

Fylde Road/Tag Lane

The traffic flow at the Fylde Road site was substantially greater than at the Tag Lane site. This is most likely to affect the overall vehicle delay at the site as increased traffic flow is likely to result in more vehicles being delayed. The effect on mean vehicle delay will be far less, but the higher flow rate could lead to increased mean vehicle delays as the probability of a forced change, as opposed to a gap change, is increased. Overall it is unlikely that the higher flow rate is the cause of such a significant difference in mean vehicle delay between the two sites. It is most likely that the increase in delay is due to the different crossing type.

Fylde Road/Avenham Lane

It was found that mean vehicle delay was greater at the Fylde Road Toucan (Puffin type control) compared with the Avenham Lane Pelican. This is despite the traffic flow being significantly higher at the Pelican site. This corroborates the conclusion reached in the comparison of Fylde Road Puffin crossing with the Tag Lane Pelican crossing that the main determining factor in vehicle delay time is the crossing type not the flow rate of traffic.

CONCLUSIONS

The study has compared pedestrian and vehicle delay at signal controlled crossings with and without pedestrian detection. All Puffin sites (with pedestrian detection) showed a higher mean pedestrian delay than Pelican sites (without pedestrian detection). At busy sites, mean pedestrian delay is limited, because an increase in time to the Green Figure increases the probability of further pedestrians arriving, and these pedestrians will wait for a shorter period of time. This observation is supported by the high standard deviation of the mean pedestrian delay.

Surveys were only undertaken at busy times, and even at these times, it was found that a higher proportion of pedestrians failed to raise a demand at Puffin sites (maximum 28%) compared with Pelican sites (maximum 23%). That is to say, pedestrians crossed between crossing cycles without pressing the button to call a demand. It can reasonably be concluded that there is a relationship between the proportion of pedestrians not raising a demand and the mean maximum waiting period: many people will be regular users and will base the decision on whether or not to raise a demand on their previous experience.

It was expected that the preset maximum vehicle green extension would be one of the larger contributory factors in determining the duration of pedestrian delay. This was not found to be the case as vehicle flow patterns rarely created a situation where a forced change occurred at the end of the maximum extension green.

Greater vehicle delay at Puffin crossings was observed as compared to Pelican crossings. The mean individual vehicle delay and the total time period that vehicles were compelled to stop were both examined and found to be significantly greater at Puffin sites. As the analysis shows that the Puffin crossings were operating correctly in adjusting the time allowed for pedestrians to cross, it must be concluded that the difference in delay is as a result of the time that it takes for the on-crossing detector to release vehicles once the crossing is clear of pedestrians. At Pelican crossings this system is not automated and the vehicle driver effectively operates in the same manner as the Puffin ‘on-crossing detector’. It is concluded, therefore, that the flashing amber arrangement of the Pelican is more efficient than the pedestrian detection system used in the Puffin crossing.

There is more potential for conflict between pedestrians and motor vehicles during the flashing amber period at Pelican crossings than the mandatory red signal at Puffin crossings. This survey did not identify any conflict incidents. Contrariwise, five motor vehicles did run red lights after the pedestrian period at Puffin crossings. A lack of proper tuning of pedestrian detection equipment can cause significant additional delays. Pedestrian detection is the feature cited as one of the major advantages of the Puffin crossing, but it appears to be one of the least reliable.

Consideration should be given to a hybrid system that uses pedestrian detection along with the signal features of the Pelican crossing. Such a system could work on the basis of existing Puffin settings for periods 1 through to 6 followed by a flashing amber phase beginning the moment that on-crossing detectors register that the last pedestrian has cleared the crossing. This would provide the safety period currently built into the crossing extension period and the red with amber phase without additionally delaying vehicles.

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