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Puffin pedestrian crossing accident study

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Transport Research Laboratory

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Executive summary

This is the project report for the Department for Transport (DfT) project *Puffin Pedestrian Crossing Accident Study*. It describes the outcome of a study by TRL and Ian Routledge Consultancy comparing accident frequency at pedestrian crossings using the Puffin facility and pedestrian crossings using farside facilities (i.e. Pelican crossings and farside pedestrian signalling at traffic signal junctions).

Puffin facilities were devised to replace Pelican crossings and farside pedestrian signalling at junctions. The main differences between Puffin facilities and existing farside facilities are that Puffins have:

- Nearside pedestrian signals.
- No flashing pedestrian green period as at Pelican crossings or pedestrian signal blackout period at junctions.
- On-crossing pedestrian detectors which provide an extension to the pedestrian clearance period whilst pedestrians are still on the crossing.
- No flashing amber traffic period as at Pelican crossings.
- Pedestrian kerbside detectors to cancel the pedestrian demand if there are no pedestrians in the wait area.

These changes were designed to increase pedestrian convenience and safety, reduce the number of unnecessary stops for drivers, and provide clearer and consistent signals to road-users by eliminating the flashing sequence at mid-block crossings and the pedestrian signal blackout at junctions.

Previous research has shown that correctly installed and operated Puffin facilities can reduce both driver and pedestrian delay at signal controlled junctions (Davis, 1992) and improve pedestrian 'comfort' at mid-block crossings compared with Pelican crossings (Davis, 1992), (Transport for London, 2005). It was expected that Puffin facilities should improve road safety, and previous research has indicated safety benefits. The aim of this study is to quantify the safety benefits with a view to clarifying the business case for Puffin facilities.

This project reviewed accident data at 40 mid-block crossings and 10 traffic signal junctions that had been converted to Puffin facilities from Pelican crossings and farside facilities at junctions, with no other significant changes in layout, operation, or traffic flow.

The results show statistically significant safety benefits after conversion to Puffin facilities. Personal injury accident frequencies were shown to be:

- 17% lower at the mid-block sites (statistically significant at the 5% level),
- 19% lower over all the sites (statistically significant at the 5% level),
- 24% lower for all pedestrian accidents (statistically significant at the 10% level),
- 16% lower for all vehicle accidents (statistically significant at the 10% level).

Junction accidents, pedestrian accidents at mid-block crossings, and accident severity also indicated notable reductions, but the results were not statistically significant for the sample size assessed.

A shortlist of 72 sites potentially fulfilling the study criteria were inspected on-street. The sites were graded (A to E) on the basis of conformance to current guidance, installation standard, and operation. The 40 mid-block crossings and 10 junction sites with the highest grades formed the sample set for the accident analysis. The 50 sites used in the accident analysis, except one junction, were installed and operating in general conformance to current DfT Puffin guidance.

The majority of the 72 sites inspected generally conformed to current DfT guidance. A notable finding from the survey was that the cancel facility was not operating at a large number of the sites, even though in most cases the kerbside detection appeared to be functional. It is likely that some authorities or their maintenance contractors may have purposely disabled the cancel facility to avoid perceived problems. Mid-block crossing control tends to be relatively responsive to pedestrian demand and there are often few opportunities to cancel. Current guidance recognises that kerbside detection is optional and may be omitted at some sites depending on local factors. While the benefit of the cancel facility at many mid-block crossings is limited, there can be substantial efficency gains at junctions. As such the full potential benefits of Puffin facilities are not being realised.

A literature review was undertaken. The flashing green figure at Pelican crossings and blackout period at junctions are often misunderstood by pedestrians and have a relatively poor compliance rate. The flashing sequence is associated with a high proportion of pedestrian accidents on Pelican crossings and appears to present a higher accident risk than the equivalent all-red shown at Puffin crossings. All-red extensions cater for people with impaired mobility and lower the potential for conflicts, but at high pedestrian flows they may facilitate some pedestrian non-compliance compared with the flashing sequence at Pelican crossings. Improved observation of on-coming vehicles with nearside pedestrian signals, which should improve safety, is indicated but not fully proven. The cancel facility has shown significant improvements to junction operation.

STATS19 accident data shows that that pedestrian compliance with the signals and pedestrians failing to look properly are the most common factors in pedestrian accidents on signalised pedestrian crossings. Pedestrian accidents caused by driver non-compliance are notably greater at mid-block crossings than junction signals.

Junction accidents results in this study indicated a large decrease in injury accident frequency of 26% for all accidents and 39% for pedestrian accidents. The results were not statistically significant, but were very similar to a previous study in Manchester (Greater Manchester Transport Unit, 2007) at twenty-four junction sites which showed a 24% reduction in all junction accidents and 38% in pedestrian accidents. The Manchester study results were statistically significant, but unlike this study, did not specifically identify sites where no other significant changes were made except the crossing facility. The focus of the accident analysis was primarily on mid-block crossings. A further junction accident study would be worthwhile as more converted junctions become available conforming to the recent Puffin guidance.

In conclusion, Puffin crossings, when installed and operating in general conformance to the current guidelines, have been shown provide significant safety benefits over Pelican crossings. After conversion to Puffin from Pelican crossings, injury accident frequency for the sample assessed reduced by an average of 17%, and the combined accident data for mid-block crossing and junction conversions showed a 19% reduction, both results are statistically significant at the 5% level.

1 Introduction

This is the project report for the Department for Transport (DfT) project *Puffin Pedestrian Crossing Accident Study*. It describes the outcome of a study by TRL and Ian Routledge Consultancy comparing accident frequency at pedestrian crossings using the Puffin facility and pedestrian crossings using farside facilities (i.e. Pelican crossings and farside pedestrian signalling at traffic signal junctions).

2 Background

Puffin facilities were devised to replace existing farside facilities. Figure 2.1 shows a typical Puffin crossing. The main differences between Puffin facilities and existing farside facilities are:

- Puffins have the pedestrian signal on the nearside as opposed to the farside. They are located so that waiting pedestrians looking at the pedestrian signals also have approaching nearside traffic in their line of sight.
- Puffins do not have a flashing pedestrian green period as at Pelican crossings or a pedestrian signal blackout period at junctions.
- No flashing amber traffic period as at Pelican crossings.
- On-crossing pedestrian detection is used to extend the pedestrian clearance period whilst pedestrians are still on the crossing. Thus catering for pedestrians with slower walking speeds and those starting to cross towards the end of the pedestrian green, while allowing the onset of vehicle green as soon as the crossing is clear.
- Pedestrian kerbside detection is used to cancel pedestrian demand if there are no pedestrians in the wait area, e.g. because they have crossed in vehicle green, or have chosen not to cross and left the wait area.

These changes were designed to increase pedestrian convenience and safety, reduce the number of unnecessary stops for drivers, and provide clearer and consistent signals to road-users by eliminating the flashing sequence at mid-block crossings and the pedestrian signal blackout at junctions.

Figure 2.1: Example of a mid-block Puffin crossing

Puffin facilities were initially developed in the late 1980's/ early 1990's. Trials of the first experimental sites were reported by TRL in 1992 (Davies, 1992). The results of initial studies were sufficiently successful for the DfT to pursue the Puffin facilities as the standard for mid-block crossings and junctions (*LTN 2/95*, DfT (1995)).

However, there has been resistance by some highway authorities to the introduction of Puffin facilities. Due in part to the use of nearside displays, kerbside detection problems, and additional installation and maintenance expense compared with conventional facilities. Most highway authorities are now using Puffin facilities, and anecdotal evidence indicates that generally the design and operation of Puffins facilities has improved noticeably in recent years. Possible reasons for this include:

- Improved guidance, including the *Puffin Crossings - Good Practice Guide* (DfT and County Surveyors' Society, 2006).
- Refined timings - *TAL 5/05: Pedestrian Facilities at Signal Controlled Junctions, (Part 4 of 4).*
- Increased expertise in the installation and maintenance organisations as well as in local authorities.
- Improved equipment including enhanced pedestrian detection and pedestrian demand units.
- High level repeater signals for use at crossings with high pedestrian flows.
- Promotional videos, leaflet, and posters covering crossing safely with Puffin crossings to support training, particularly for school children.

Puffin crossings form about 30% of the 10,500 plus mid-block Pelican and Puffin crossings in Great Britain (source *Traffic Signal Group Signals Interim Signals Inventory 2008*). The number of Puffin crossings has been increasing by about 7.5% per year over the last few years, while the total number of Pelicans has not changed.

Previous research has shown that correctly installed and operated Puffin facilities can reduce both driver and pedestrian delay at signal controlled junctions (Davis, 1992) and improve pedestrian 'comfort' at mid-block crossings compared with Pelican crossings (Davis, 1992), (Transport for London, 2005). It was expected that Puffin facilities should improve road safety, and previous research has indicated safety benefits. The aim of this study is to quantify the safety benefits with a view to clarifying the business case for Puffin facilities.

3 Objectives

The overall project objective is to assess the road safety benefits, in terms of accident frequency, for correctly installed and operated Puffin facilities compared with existing farside pedestrian facilities for:

- Mid-block crossings, and
- Signal controlled junctions.

4 Methodology

This section gives an overview of the project methodology. Further details are given in the relevant results sections.

In order to assess the safety benefits of correctly installed and operated Puffin facilities, sites needed to be identified that had been converted from farside pedestrian facilities to nearside, that complied at least largely with DfT's current guidelines (Department for Transport and County Surveyors' Society, 2006) and that had been maintained to a reasonably high standard. In addition there needed to be no other significant changes to the infrastructure, layout, method of signal control, or vehicle and pedestrian flows. There also needed to be sufficient 'after' accident data – ideally at least three years of data after conversion. The sites also should have a good geographical spread and be representative of the different layouts and control strategies used in the UK.

By assessing converted sites the study could directly assess the safety benefit of Puffin facilities, without imposing accident frequency variations due to site differences. This facilitates robust statistical assessment using paired 'before' and 'after' data.

A scoping study was undertaken. Information on Puffin installations was supplied by the Traffic Signals Group, and highway authorities with potentially suitable sites were contacted. Site information was supplied by a range of highway authorities and inspected (See Section 6). It was found that it would not be possible to limit the choice of sites to those strictly adhering to the *Puffin Crossings - Good Practice Guide*. This was primarily owing to the fact that this guidance was issued in 2006 and sites were needed with three years of data after implementation. Given the low accident frequency at mid-block crossings there would have been insufficient sites to obtain statistically robust results if all the sites needed to fully conform to the guidance.

The information received in the scoping study indicated that it was probable that sufficient mid-block crossings would be identified for statistical analysis, while the number of suitable junction conversions would be limited. It was agreed with DfT that a mixture of mid-block crossings and junctions be pursued. The study would comprise mainly mid-block Puffin crossings, supplemented with a smaller number of junctions with Puffin facilities. This would allow the findings to provide information on both mid-block crossings and junctions, while concentrating effort on mid-block crossings as this was more likely to be able to provide statistically robust results.

A list of sites for inspection was created. The inspection was undertaken by the project team, and sites graded to standard (Section 6). The sites with the highest grades for the required sample size were included in the accident analysis (Section 7).

A literature review on Puffin safety was undertaken (Section 5) to summarise previous Puffin accident analysis and ascertain behavioural and perception factors that could affect safety.

5 Summary of previous Puffin safety research

5.1 Introduction

Pedestrian accident statistics at signalised crossing facilities are reviewed in Section 5.2. Section 5.3 reviews factors which affect pedestrian compliance at signalised crossing facilities. There have been two studies that have looked at changes in accident frequency after conversion to Puffin facilities (Section 5.5). A number of studies have looked at behavioural and attitudinal aspects (Section 5.4). The final section in this chapter discusses the likely safety implications of Puffin facilities.

5.2 Pedestrian accidents at signalised crossing facilities

Kennedy *at al* (2009) investigated pedestrian safety at traffic signals. The pedestrian casualty frequency nationally within 50 metres of a signalised mid-block pedestrian crossing was 0.29 casualties per year and on the crossing 0.14 casualties per year (STATS19 data 2000-2004). The respective figures for signalised junctions (with or without pedestrian phases) were 0.27 and 0.11 casualties per year. Younger pedestrians (less than 16 years old) appeared over-represented in mid-block crossing accidents (34% of pedestrian casualties), but not at signalised junctions. Around a third of all pedestrian casualties at signals occurred at night. Reduced pedestrian conspicuity, higher vehicle speed, and a higher proportion of pedestrians who had been drinking were cited as possible reasons.

In 2009 TRL reviewed pedestrian killed or seriously injured (KSI) accidents (STATS19 data 2005-2007) on behalf of the Department for Transport. Fourteen percent of all pedestrian KSI occurred within 50 metres of a signal controlled mid-block crossing (52% of these on the crossing) and 11% within 50 metres of a signal controlled junction with pedestrian phases (57% of these on the crossing). The STATS19 form requires 'contributory factors' to the accident. Up to six factors can be specified. Pedestrian-only factors were the main causes of pedestrian accidents 'on the crossings' (see Table 5.1). The predominant pedestrian factors were 'failed to look properly', 'wrong use of the pedestrian crossing facility' (defined as starting to cross when the pedestrian signals indicated they should wait), and 'careless, reckless or in a hurry' (see Table 5.2). All these factors are greater at junctions.

Pedestrian 'failed to look properly' is defined as 'Pedestrian either failed to check road for traffic when entering the carriageway, or looked but misinterpreted what they saw'.

Pedestrian impairment by alcohol is also a notable accident factor (Table 5.2). Alcohol consumption is a relatively frequent occurrence in pedestrian accidents (e.g. Keigan and Tunbridge (2003), Clayton and Colgan (2001)) and at higher levels significantly increases accident risk (e.g. Clayton *et al*, 2000).

Table 5.1: Contributory factors to pedestrian KSI accidents on the crossing (STATS19 2005-2007)

Crossing facility	Pedestrian only factors	Vehicle only factors	Vehicle and pedestrian factors
Signalised mid-block	47%	31%	21%
Ped phase at junction	57%	19%	23%

Pedestrian non-compliance with the pedestrian signal was assigned as a contributory factor in 33% of pedestrian accidents on mid-block crossings and 40% of pedestrian accidents on junction crossing facilities (Table 5.2).

Note that, Tables 5.2 and 5.3 show that in around half the cases the Reporting Officer did not assign any contributory blame to either party in terms of signal violations. It is expected that in most cases one of the parties would have disobeyed the lights to cause the accident, i.e. code 804 plus 301 for junctions or 304 for crossings would equal nearly 100% if all knowledge of the accident could be gained.

Table 5.2: Pedestrian contributory factors on pedestrian crossings (Pedestrian KSI accidents, STATS19 2005-2007)

		Crossing on	
Code	**Factor**	**Pedestrian crossing**	**Pedestrian phase**
802	Pedestrian failed to look properly	48%	59%
804	Wrong use of pedestrian crossing facility	33%	40%
808	Careless, reckless or in a hurry	19%	27%
803	Failed to judge vehicle’s path or speed	13%	18%
801	Crossing road masked by stationary or parked vehicles	8%	10%
806	Impaired by alcohol	8%	9%
809	Pedestrian wearing dark clothing at night	3%	2%
810	Disability or illness, mental or physical	3%	2%
805	Dangerous action in carriageway	1%	1%
807	Impaired by drugs	1%	0%

Table 5.3: Vehicle factors on pedestrian crossings (Pedestrian KSI accidents, STATS19 2005-2007)

		Crossing on	
Code	**Factor**	**Pedestrian crossing**	**Pedestrian phase**
405	Driver failed to look properly	22%	17%
304	Disobeyed pedestrian crossing facility	18%	6%
602	Careless, reckless or in a hurry	11%	8%
307	Travelling too fast for conditions	5%	5%
301	Disobeyed automatic traffic signal	8%	8%
601	Aggressive driving	4%	4%
406	Failed to judge other’s path or speed	4%	3%
706	Vision affected by dazzling sun	3%	2%
701	Vision affected by stationary or parked vehicles	3%	2%
306	Exceeding speed limit	4%	2%
103	Slippery road (due to weather)	2%	2%
403	Poor turn or manoeuvre	1%	2%
710	Vision affected by vehicle blind spot	1%	1%

Table 5.1 shows that vehicle-only factors were higher at mid-block crossings, 31% compared with 19%. This would appear to be largely due to a greater vehicle signal violation rate than at junctions, see Table 5.3. It is important to note that Table 5.3 shows errors in the completion of the STATS19 form by the Police Officer. Code 304 applies only to mid-block crossings while Code 301 applies only to traffic signal junctions. Thus 304 should be zero for pedestrian phases, and 301 zero for pedestrian crossings. As such the totals should be regarded with care. However, the indication is that vehicle signal violations causing pedestrian accidents are greater at mid-block crossings than signal junctions.

Nicholls (1997) investigated a sample of serious injury pedestrian accidents at signalised junctions. Of the 24 accidents on signalised pedestrian facilities, 50% were recorded as occurring when the pedestrian started to cross with the red man, 8% with the green man and 42% unknown. These figures are very similar to the results for junctions in Tables 5.2. and 5.3 (Codes 804 and 301).

Davies and Winnett (1993) studied pedestrian accidents in six large UK urban areas for the period 1991-1992. At Pelican crossings the number of accidents which were assigned to non-compliance was similar for drivers and pedestrians, around 25% for both – this differs from Table 5.1, which indicates pedestrian non-compliance to be a greater cause of pedestrian accidents at signalised mid-block crossings. Pedestrian error was cited as a notable contributory factor in pedestrian accidents, especially pedestrian inability to judge vehicle speed.

Preston (1989) studied Pelican pedestrian casualties' reports in Greater Manchester for the period 1986-87. The signal to the pedestrian was recorded for 171 accidents on the Pelican crossing. It was recorded that 61% of pedestrian started crossing in the steady green man period (NB significantly higher for women (77%) than men (34%)). This suggests a high proportion of Pelican pedestrian casualties involving vehicle violations of the red or flashing amber signals, and higher than indicated by the tables above for all types of signalised mid-block crossings. In fact the accident risk was found to be lower for females who crossed without the pedestrian phase.

A study conducted by Halcrow into the causation of accidents at Pelican crossings on behalf of the Department of Transport (referred to in Austin and White, 1997) found that a disproportionate number of pedestrians are injured in the flashing sequence. Preston (1989) reviewed when pedestrians started to cross. The advised steady green man period at Pelican crossings is sufficient for pedestrians to establish themselves on the crossing but not to complete the crossing. The Halcrow study reviewed when the accident occurred. Fifty one percent of pedestrians involved in accidents stated that the accident occurred in the flashing green figure period (and 14% in red figure, and 6% in the steady green figure). It should be noted that the drivers often disputed the pedestrian's claim.

In summary, the studies show that that pedestrian compliance with the signals and pedestrians failing to look properly are the most common factors in pedestrian accidents on signalised pedestrian crossings. Driver violations and driver observation are also common factors at mid-block crossings, but less so at junctions. The flashing sequence is associated with a high proportion of pedestrian accidents on Pelican crossings.

5.3 Pedestrian compliance factors at signalised crossing facilities

A literature review undertaken by Kennedy *et al* (2009) showed that there is a significant propensity for pedestrians in the UK to not comply with pedestrian signals, and cross in gaps in the traffic if the opportunity presents itself. Pedestrians are more likely to comply if they are female, older, mobility impaired, have been waiting for less than 30 seconds, where the traffic is heavy, or there are other pedestrians waiting. Out of these factors, only the waiting time is dependent upon the traffic signals. The report suggested signal control methods for reducing delay to pedestrians including increasing the responsiveness to pedestrian demand, keeping cycle time as short as possible, and increasing the proportion of the cycle time available to pedestrians.

There are some factors, which are discussed in more detail below, which could marginally affect overall compliance rates between Puffin and farside facilities. For instance the flashing pedestrian green and blackout periods have been shown to have significantly lower compliance rates compared with the equivalent all-red at Puffins, except at very high pedestrian flows. Also the pedestrian demand cancel facility can substantially reduce junction cycle time. However, there have been some operational and technical problems with the cancel facility, particularly in earlier installations, which may have reduced its effectiveness at some sites and usage at others.

5.4 Behavioural, operational, and attitudinal studies

5.4.1 Introduction

As mentioned earlier, the main differences between Puffin facilities and conventional pedestrian signal facilities is that Puffins have:

- Nearside pedestrian signals.
- No flashing pedestrian green period as at Pelican crossings or pedestrian signal 'blackout' period at junctions.
- On-crossing pedestrian detectors which provide an extension to the pedestrian clearance period whilst pedestrians are still on the crossing.
- No flashing amber traffic period as at Pelican crossings.
- Pedestrian kerbside detectors to cancel the pedestrian demand if there are no pedestrians in the wait area.

This section reviews these features with regards to the findings of previous studies.

5.4.2 Nearside pedestrian signals

Nearside pedestrian signals should increase pedestrian awareness of on-coming traffic. Pedestrian 'failed to look properly' is the largest single factor in pedestrian accidents at signal crossings (Table 5.2). Nearside signals are located so that waiting pedestrians looking at the pedestrian signals also have approaching traffic in their line of sight (Figure 5.1). Pedestrian observation of traffic while on the crossing should also increase due to no visible pedestrian signals once on the crossing.

It also should be easier for pedestrians with certain visual impairments to see the nearside signal.

Figure 5.1: Pedestrian view of nearside signals, showing on-coming traffic in line of sight

The nearside arrangement also avoids potentially misleading signals while on the crossing:

- The green figure is an invitation to start to cross. However, it is often misinterpreted as the safe crossing period, leading to pedestrian complaints about its length and pressure on authorities to set green times based on carriageway width, rather than pedestrian volume, with associated control inefficiencies.
- The red figure indicates that you should not be using the crossing, and thus the use of an intermediate signal (i.e. the flashing green figure or the 'blackout') at farside signals to denote the clearance period for those still crossing. However, these signals can be misunderstood and have a poor compliance record (see Section 5.4.3).

There is little robust evidence to show that pedestrians watch approaching traffic more closely because of the position of the pedestrian signals. This may be a result of the difficulty in capturing this behaviour. Davies (1992) used head movements for eye positions, stating that it is only a rough guide. At the two junction conversions studied, there was judged to be an increase in pedestrian observation of on-coming (nearside) traffic at one of the sites, however there was no clear change in pedestrian behaviour at the other. A high proportion of pedestrians, before and after conversion at both junctions, were judged not to have looked at the traffic before crossing.

Ian Routledge Consultancy and the University of Southampton (2006) asked pedestrians at two converted junctions (both crossroads) whether the nearside signal helped them watch the pedestrian signal and traffic at the same time. At one site there was a 48% agreement, but at the other site only 14% agreed.

Without farside pedestrian signals pedestrians have no indication of whether their priority is coming to an end. This could affect pedestrian anxiety over not reaching the footway in time.

Reading *et al* (1995a) found the average time taken to cross by pedestrians at a Puffin crossing converted from a Pelican was slightly longer after it was converted. This was particularly the case amongst older people and people with impaired mobility, leading to the authors to suggest that crossing was less stressful at a Puffin. It was considered that this may be explained by the removal of the flashing amber reducing harassment by drivers, and the removal of the flashing pedestrian green reducing the pressure to 'hurry'.

Ian Routledge Consultancy and the University of Southampton (2006) in a study of two converted Puffin crossings found no difference in crossing time after conversion from Pelican crossings.

A Transport for London pedestrian perception study (Transport for London, 2005) also indicates a less stressful experience using a Puffin compared with Pelicans, with more pedestrians believing that they have sufficient time to cross (Section 5.4.4) and that the crossing is safer (see Section 5.4.6).

However, a number of studies, while showing that generally pedestrians feel safer at Puffin facilities (Section 5.4.6), have shown some pedestrians expressing safety concerns over the lack of farside signals. Eight percent of pedestrians questioned at one Puffin crossing (York and Gutteridge, 2006) thought the lack of farside signals led to the crossing being unsafe. A number of pedestrians in the Davies (1992) study also expressed this. Around a third of pedestrians questioned at two converted junctions (Ian Routledge Consultancy and the University of Southampton, 2006) thought that the 'lack of farside signal head and/or audible sound made it more confusing and unsafe' (note that, the response includes audible signals, and as such cannot specifically isolate perception of nearside signals, however does indicate a pedestrian concern).

Davies (1992) in a survey of the first two Puffin junction sites asked pedestrians whether they preferred the original farside or the new nearside signals. The results were not conclusive, but tended to indicate a preference for farside signals. At one of the junctions interviewees showed no real preference (Woolwich), while at the other (Rustington) interviewees were highly in favour of farside, 47% preferring farside, and 16% preferring nearside. Many people at this site commented that the nearside pedestrian signals could be obscured by other pedestrians (counter-intuitively this site had notability fewer pedestrians than Woolwich). There were a higher proportion of pedestrians over 60 years old surveyed at Rustington (around 45% compared with about 15% at Woolwich) which may indicate a difference in preference by age, perhaps influenced by nearside signals being a new arrangement.

TfL's perception study (Transport for London, 2005) found that less than half (46%) of pedestrians using Puffin crossings 'strongly agreed' that the pedestrian signals were 'very easy to see', this compares with around a two-thirds (68%) of pedestrians at Pelican crossings. There appears to be an element of learning though, with 50% of frequent Puffin users 'strongly agreeing' that they were 'very easy to see', compared with 36% non-frequent users. Overall 82% of pedestrians at Puffins 'agreed' that the pedestrian signals were 'very easy to see', with a slightly higher figure for Pelicans, 88%. Obscuration of the Puffin signals was cited as a particular issue, with 29% of those surveyed stating that they sometimes cannot see the signals due to other pedestrians.

It has been suggested anecdotally that the perceived lower visibility of nearside signals can lead to a higher propensity for pedestrians to start to cross on the basis of other pedestrians using the crossing without reference to the signal indication.

Mott MacDonald and Imperial College London (2008) reviewed pedestrian behaviour at Puffin and farside pedestrian facilities. They found no difference between mid-block Puffin crossings and Pelican crossings regarding pedestrians stating that they noticed the pedestrian signal status when they crossed. However, significantly fewer stated they noticed the pedestrian signal status when they crossed at Puffin junction facilities compared with farside junction facilities. The results for pedestrians crossing without requesting the pedestrian stage were similar, which could indicate site specific effects (the study was not a conversion study, but compared different sites) that made it easier to cross at the Puffin facility junctions without regard to the pedestrian phase.

TRL (Walker *et al*, 2005) compared five Puffin and five Pelican crossings in London. They found no notable difference in pedestrian behaviour between the crossing types, except compliance with the clearance period which was notably better at Puffin crossings (Section 5.4.3). General pedestrian compliance was poorer at sites on Urban Traffic Control. Otherwise pedestrian behaviour was judged site specific and pedestrians apparently following others on to the crossing ('pedestrian platooning') when in potential conflict with traffic was shown at both Puffin and Pelican sites.

Ian Routledge Consultancy and the University of Southampton (2006) postulated that masking of the pedestrian signal indication could lead to pedestrian vehicle conflicts. 'Late crossers' could see that the vehicle signals were red and decide to cross without reference to the red man. 'Early crossers', without a potential nearside conflict, could lead to a pedestrian on the other side of the road incorrectly believing that the green man is displayed and starting to cross when they could be in conflict.

The Davis (1992) study of two converted Puffin junctions showed an increase in pedestrians starting to cross in the clearance period at the junction with high pedestrian flow (more than 2000 crossing per hour). Note that, this was not the junction (Rustington) where some pedestrians commented about obscuration of the pedestrian signals. These junctions had a maximum clearance period far in excess of that later recommended. This will have had a significant effect on the non-compliance shown (Section 5.4.4), and thus it is not possible to draw conclusions from this result in terms of the position of the pedestrian signal.

Pedestrian non-compliance with the clearance period was also show by Ian Routledge Consultancy and the University of Southampton (2006) in an Oxford High Street Puffin survey. Whether obscuration was an issue was not identified. It was suggested that the comparative safety of the variable all-red period may facilitate non-compliance at high pedestrian flows (Section 5.4.4).

Note that, neither of these two high pedestrian flow sites used high-level pedestrian signal repeaters. Current Department for Transport guidance (Department of Transport and County Surveyors' Society, 2006) recommends high-level repeaters when pedestrian flows are high to avoid masking of the pedestrian signal.

In summary, there is limited evidence to show that pedestrians watch approaching traffic more closely because of the position of the pedestrian signals. There is a lack of detailed study in this area. Nearside pedestrian signals negate the need for an intermediate pedestrian signal in the clearance period, which can be misunderstood and has a relatively poor compliance record (Section 5.4.3). The perceived visibility of nearside signals is lower than farside signals, but appears to improve with familiarity. Nearside signals can on occasion be obscured by other pedestrians and this could in theory contribute to some pedestrian non-compliance. High-level repeaters are recommended at high pedestrian flow sites.

5.4.3 Omission of the flashing pedestrian green and 'blackout'

TfL's pedestrian perception study (Transport for London, 2005) found that there was some confusion as to the meaning of the flashing pedestrian green figure. One-third of Pelican users were unaware that you should not start crossing when the flashing green figure is showing, and pedestrians stated they were more likely to start to cross on the flashing green figure than when the red figure showed. Observed behaviour showed 6% of all interviewed pedestrians starting to cross in the flashing pedestrian green period. This implies a high non-conformance rate given its relatively short length. Similarly, Mott MacDonald and Imperial College London (2008) reported 8% of all observed pedestrians starting to cross in the vehicle flashing amber period.

A recent large survey by TRL for Transport for London (Sterling *et al*, 2009) found significant confusion over the meaning of the blackout period, with 60% of pedestrians either not knowing or giving an incorrect answer. Results of a large video survey over a number of junctions indicated that virtually all pedestrians arriving in the blackout period choose to cross, 10% of all pedestrians started to cross in this period and the blackout period averaged 10% of the cycle-time. Figure 5.2 shows the farside pedestrian signal 'blackout' at a junction.

Figure 5.2: 'Blackout' at a farside pedestrian signal

Hao *et al* (2008) undertook stated preference surveys at a number of signalised crossings. The results indicated that pedestrians were around twice as likely to start to cross against a flashing green figure or blackout period as a red figure.

The incorrect use of the flashing pedestrian green period was also found in Walker et al (2005). At five Puffin and five Pelican sites there was a statistically significant higher proportion of pedestrians starting to cross with the flashing green figure compared with the equivalent all-red period at Puffins, 1% and 0.1% of total pedestrians respectively.

A recent study in Wellington, New Zealand (Murrey and Walton, 2009) specifically looked at compliance at a trial Puffin mid-block crossing. It also found a statistically significant improvement in compliance when compared with farside signals (in New Zealand a flashing red figure is shown in the clearance period). The study was a 'before and after' conversion. In order to purely assess the benefit of the nearside signals and absence of the flashing pedestrian signal, no other changes were made (including the pedestrian green and clearance times), and the cancel and on-crossing Puffin detection was not utilised. Compliant crossing (which is a legal requirement in New Zealand) increased from 80.0% to 86.6%, and clearance period violations decreased from 2.9% to 0.2%, both results statistically significant. Crossing against the red figure also decreased. Overall the study found that a compliant crossing was 1.61 times more likely when compared with the existing farside pedestrian signal crossing.

Reading *et al* (1995a) reviewed pedestrian compliance rates at a mid-block Puffin converted from a Pelican crossing and said that there was evidence that compliance with the pedestrian signals increased with the Puffin (5% non-compliant compared with 10% when it was a Pelican). Although how comparable these results are is questionable, as the Pelican was operating on a 'fixed cycle' while the Puffin green to traffic was 'variable'.

Hodgeson (2009) looked at understanding of pedestrian crossings by learning disabled pedestrians. The study concluded that Puffin facilities are by far the easiest to understand, as there is only a steady red or green figure, and the pedestrian signals are in the same field of vision as the approaching traffic. Education on the function of on-crossing detectors was strongly recommended given the absence of signals on view whilst crossing. The flashing green figure at Pelican crossings was found confusing, particularly as vehicles can move in this period. The blackout was deemed the least understood.

These conclusions were also found by Mott MacDonald and Imperial College London (2008) who showed pedestrians the three pedestrian signal sequences on 'show-cards'. The sequence with blackout was thought confusing by 54% of pedestrians, flashing green figure by 39%, and the Puffin sequence by 20%.

In contrast to the markedly improved compliance shown above, Ian Routledge Consultancy and the University of Southampton (2006) found no difference in pedestrian compliance with the pedestrian clearance period in four before-and-after conversion studies (two junctions and two mid-block crossings).

Pedestrian non-compliance with the Puffin clearance period has been shown at high pedestrian flows sites (see Section 5.4.4). This is likely to be due to all-red extension factors, and possibly the visibility of nearside pedestrian signals in the absence of high-level repeaters (Section 5.4.2) rather than the signal indication shown.

In summary, there is some pedestrian misunderstanding over the meaning of the flashing green figure and the blackout, and they have a poor compliance rate. The red and green sequence at nearside signals is much more clearly understood, and studies shown pedestrian compliance to be significantly greater in the clearance period except at very high pedestrian flows.

5.4.4 On-crossing detectors and omission of the flashing amber

The advised pedestrian clearance time (flashing amber period at Pelicans, or end of pedestrian green to beginning of starting amber at junctions) is based upon a 1.2 m/s walking speed. On-crossing detectors can vary the clearance period given:

- from a minimum of zero seconds if there are no pedestrians on the crossing,

- up to a predefined maximum, allowing pedestrians with a slower walking speed time to complete their crossing before precedence is given to vehicles.

Walker *et al* (2005) measured crossing speeds at ten signalised crossings. Average speed for adults under 60 years old was 1.1 to 1.5 m/s depending upon the site, while for those over 60 years old the average was between 1.0 and 1.2 m/s. Pedestrians with impaired mobility (including e.g. pushing prams or carrying an awkward object) averaged between 0.8 and 1.2 m/s.

Studies in the USA have also highlighted that older pedestrian walking speeds are often less than the 1.2 m/s design speed, also used in the US. All the results below are based upon 15th percentile speeds for pedestrians using a signalised crossing. Fitzpatrick et al (2005) found a statistically significant difference between walking speeds for pedestrians aged 60 years and over (0.92 m/s) and under 60 (1.15 m/s). Gates et al (2006) also observed a 15th percentile speed of 0.92 m/s for older pedestrians, whilst Knoblauch *et al* (1995) found a 15th percentile speed of 0.94 m/s.

Various authors (e.g. Gates *et al* (2006), Fitzpatrick *et al* (2005), Baass (1989), and Wall (2000)) have pointed out that the ageing population will ideally require signal timings to be based on a slower walking speed than the 1.2m/sec currently used. On-crossing detectors allow the clearance period to be increased as required, thus potentially bringing safety benefits and catering for pedestrians with impaired mobility without a wholesale increase in clearance periods, leading to increases in road-user delay and cycle-time. Figure 5.3 shows an on-crossing detection unit.

Figure 5.3: On-crossing detection unit

Transport for London (2005) found that significantly more pedestrians at Puffin crossings perceived that they had enough time to cross before the traffic started to move compared with Pelican crossings, 88% compared with 69%. This difference in opinion was more polarised amongst pedestrians over 60 years old, 60% feeling they had sufficient time at Pelican crossings and 90% at Puffin crossings.

Mott MacDonald and Imperial College London (2008) also found that more pedestrians perceived that they had sufficient time to cross at Puffin crossings compared with Pelicans (71% compared with 63%). The report also concludes that most pedestrians are not aware of the on-crossing detection feature and recommends further public education on Puffin facilities. Public awareness of the on-crossing detection feature was also shown to be low in the Ian Routledge Consultancy and University of Southampton (2006) study.

Walking speed on crossings has also been found to reduce with pedestrian volume. Goh *et al* (2004) in a study in Hong Kong found that with high pedestrian flows average crossing speed dropped to around 1.0 - 1.1 m/s, and at very high flows average speed was found to be around 0.8 m/s. On-crossing detection can cater for the reduced crossing speeds, however there is some evidence (see below) that at high pedestrian flow sites pedestrians use the extended clearance period to continue to start to cross.

The combination of on-crossing detector and absence of flashing amber should lead to a reduction in potential conflicts. Austin and White (1997) surveyed two Pelicans and one Puffin mid-block. One of the Pelicans changed directly to the flashing amber after the steady green figure, whilst the other provided two seconds of flashing green figure before showing the flashing amber to vehicles. The percentage of pedestrians who started to cross on the steady green figure still on the crossing after the end of vehicle red was 94% at the Pelican crossing without an overlap period, 59% at the Pelican with an overlap period and 9% at the Puffin crossing. This difference was even greater for older people and people with impaired mobility. Potential conflicts and associated accident risks were expected to be significantly lower at Puffin crossings compared with Pelican crossings. The review of pedestrian accidents at signalled crossings (Section 5.2) indicates that the flashing sequence is associated with a high proportion of pedestrian accidents on Pelican crossings.

Ian Routledge Consultancy and University of Southampton (2006) showed a very slight reduction in pedestrian clearance period time at the two converted junctions from the fixed 8 seconds with blackout to an average of 7 seconds with on-crossing detection. The results showed a wide range of pedestrian clearance period times run. Highlighting the benefit of longer clearance periods when required, e.g. for older pedestrians, while average pedestrian clearance periods can actually reduce.

At the first two Puffin trial sites, Davis (1992) showed increases in the average pedestrian clearance period at both junctions when converted to Puffin facilities. At one of the junctions (Woolwich) the increase in average clearance time was significant, averaging between 6 and 10 seconds more than with the original 7 second blackout period. Also pedestrians starting to cross in the clearance period increased sustainably after conversion, from 2% with blackout (7 seconds) to 12% when converted to Puffin facilities (24 seconds maximum extension period). The site had a high pedestrian flow, over 2000 per hour for much of the day. Thus it was likely that pedestrians would arrive in the clearance period and observe pedestrians still on the crossing. A significant proportion of these pedestrians then started to cross thus further extending the pedestrian clearance period. It is important to note that the maximum clearance period times configured at these junctions were considerably longer than later recommended and will have significantly contributed to the high level of non-compliance shown.

Pedestrian non-compliance with the clearance period was also show by Ian Routledge Consultancy and the University of Southampton (2006) in the Oxford High Street Puffin survey. A comparable Pelican crossing in Southampton (Portland Terrace) with about twice the pedestrian flow (around 2000 pedestrians/ hour) of the Oxford High Street Puffin had far fewer occasions where a pedestrian was still on the crossing at the start of vehicle green, around 4% of cycles, compared with 18% at the Puffin crossing. It was noted that there may be a higher propensity to continue to start to cross at Puffins as pedestrians may be led by the red signal for vehicles during the clearance period. The flashing amber at Pelican crossings may be a greater deterrent to starting to cross.

In summary, on-crossing detectors provide the required clearance times for individual pedestrians, thus catering for slower pedestrians while minimising vehicle delay. Pelican crossings provide a variable clearance period to allow early vehicle precedence by the use of flashing amber. The flashing sequence has been identified with a potentially higher accident risk than the equivalent all-red shown at Puffins.

At high pedestrian flow the variable all-red period has been shown to increase the number of pedestrians who do not comply with the signals when excessive maximum timings are used. Where pedestrian flows are high the flashing amber may deter more pedestrians from starting to cross than the all-red at puffin crossings.

5.4.5 Kerbside pedestrian detectors

Kerbside detectors can cancel demands for the pedestrian phase when there are no pedestrians waiting to cross i.e. when the pedestrian crossed in a gap in the traffic, or decided not to cross at all. Thus unnecessary vehicle stops are negated. Such a difference can reduce vehicle delay and the potential for shunt accidents, and should reduce driver frustration and potentially driver non-compliance.

The first trial sites, both junctions (Davies, 1992), showed good potential for cancelling pedestrian demands, typically around 10% of pedestrian demands were cancelled, rising to above 33% in some periods. This led to large savings in vehicle delay. Pedestrian delay, although not observed, was also calculated to have decreased.

Ian Routledge Consultancy and the University of Southampton (2006) found approximately one-third of pedestrian demands were cancelled at the two studied junctions. At these sites pedestrians often crossed in the inter-green and vehicle gaps. The cancel facility assisted in reducing the average cycle time, which led to a significant reduction in vehicle delay.

There have been reported problems with kerbside detection equipment, particularly in early studies. Kennedy *et al* (2009) states that failed pedestrian demands can increase pedestrian non-compliance. At a trial site in Edinburgh, Reading *et al* (1995b) found that nearly 10% of all pedestrian requests were not confirmed. Both the push button and the kerbside detection were used to confirm the pedestrian demand. This has since been clarified in the *Puffin Crossings - Good Practice Guide* so that the kerbside detector is not required to be active (or showing a fault) to confirm a demand.

Reading *et al* (1995b) also found that approximately 5% of requests were incorrectly cancelled. The majority were reportedly due to 'erroneous equipment problems'. However, some cancellations were due to installation issues. It was reported that pedestrians waiting close to the signal pole could be masked by a signal hood, and some pedestrians waited further back than the detector coverage. The recommended installation practice (Department for Transport and County Surveyors' Society, 2006) highlights the importance of setting-up and checking detection covers the effective waiting area.

Catchpole (2003) reports on a Puffin crossing pilot study in Australia. This research found some pedestrian phases to be incorrectly cancelled due to the pedestrian wandering outside of the detection zone. A decision was made to disable the detection on the basis that it had little effect on traffic delays, as only 4% of cycles had no pedestrians waiting to cross under the previous fixed-time operation.

More recently, at five mid-block Puffin crossings in London (Walker *et al*, 2005) over 500 pedestrian phase demands were observed, but the cancel facility was activated only once. Tests indicated there were probably problems with the cancel facility at each of the sites studied including faults, and activation by non-crossing pedestrians on the footway. Pedestrian flows at these crossings were reasonably high (generally 300 to 500 pedestrians per hour crossing) so the opportunities for cancellation were limited. Analysis indicated only eight cancellations should have occurred.

Ian Routledge Consultancy and University of Southampton (2006) also found the pedestrian demand cancel facility was not often activated at the two studied mid-block sites. This was prominently due to the use of pre-timed vehicle maximums at the sites, combined with low pedestrian flows. These resulted in pedestrian demands usually being exercised almost immediately.

Current advice recognises that there can be limited scope for the cancel facility at mid-block crossings, and they may be omitted where there will be few opportunities to cancel demand – e.g. where the control strategy quickly responds to pedestrian demand, or where there are very high pedestrian or vehicle flows. Similarly the pedestrian cancel facility is not required at junction pedestrian phases where they run in parallel with vehicle movements.

The benefit of the cancel facility has not perhaps been as wide as envisaged when the Puffin was developed. Pedestrian priority at mid-block crossings has led to pedestrian phase demands being satisfied quickly and thus few opportunities for the cancel to operate. The cancel facility should provide benefit where less responsive mid-block control strategies are used. Large efficiency benefits from the cancel facility have been shown at junctions, potentially with associated safety benefits.

5.4.6 Comparative perception of safety

Perception studies imply that pedestrians generally feel safer at Puffin mid-block crossings than Pelicans.

Transport for London (2005) found that 91% of pedestrians at Puffin crossings compared with 81% at Pelican crossings felt safe. This difference in opinion on crossing safety increased with age, 98% for over 60's at Puffin crossings and 75% for Pelican crossings.

Where Puffin crossings had replaced Pelican crossings, 48% of those pedestrians who used both felt safer using the Puffin crossing compared with 23% who felt the Pelican crossing was safer.

Davies (1992) also found that pedestrians felt safer using Puffin facilities compared with farside facilities. At the two converted junction sites, 40% and 70% of pedestrians interviewed believed the new crossing to be safer. The percentages for 'no difference' and 'less safe' were not given, but it was summarised in the report that there was a greater feeling of safety.

The majority of pedestrians at the Puffin facility junctions in the Ian Routledge Consultancy and the University of Southampton (2006) study also thought the conversion was safer, once the on-crossing detection system was explained to them.

5.5 Puffin accident rate comparisons

In 2006 the London Road Safety Unit (part of Transport for London) reported on an accident study of 23 mid-block Puffin crossings (Webster, 2006), six of which had been converted from Pelican crossings. Accidents were included 50 metres either side of the crossing. A Tanner test was used, using control accident data from the associated boroughs. At the six converted crossings total injury accident rates (accidents/ month) reduced by 39% and pedestrian injury accidents reduced by 30%. The results were not statistically significant at the 95% confidence level, although the total injury accident rate was significant at the 90% level. Five of the six sites showed reductions in accidents, and a Chi-squared test indicated no significant variation in accident rate changes between the six sites indicating the change was due to the change in crossing type.

A larger accident study was conducted in Manchester using three years of before and after data (Greater Manchester Transport Unit, 2007). This considered fifty-eight mid-block Pelican to Puffin crossing conversions and twenty-four junctions where farside pedestrian facilities were replaced by nearside. A Tanner test was performed using control data from the county to remove underlying trends. Replacing mid-block Pelican with Puffin crossings resulted in a small (3%) increase in injury accidents, and a 16% increase in pedestrian injury accidents. The results were not statistically significant. The number of junction injury accidents decreased by 24%, and the number of junction pedestrian injury accidents decreased by 38%. These changes were statistically significant, but a chi-squared test found notable variations in the overall injury accident rates, implying there was no systematic reduction across the sites. Note that, the study did not examine whether any changes other than just the pedestrian facility were made.

Anecdotal evidence suggests that the many of the mid-block Puffin crossings did not conform to current best practice guidelines.

5.6 Summary of potential effects on accidents

Accident data shows that that pedestrian compliance with the signals and pedestrians failing to look properly are the most common factors in pedestrian accidents on signalised pedestrian crossings. Pedestrian accidents caused by driver non-compliance are notably greater at mid-block crossings than junction signals, and there appears to be a higher accident risk associated with the flashing periods at Pelicans than the equivalent all-red shown at Puffins.

Pedestrian observation of approaching vehicles should be increased by nearside signals. However, there is limited evidence to show that this occurs, although this may be due to a lack of detailed study in this area.

Nearside pedestrian signals negate the need for an intermediate pedestrian signal (i.e. the flashing green figure and the blackout), which are often misunderstood and have a poor compliance rate compared with the equivalent all-red at Puffins. However, nearside signals can on occasion be obscured by other pedestrians and this could in theory lead to some pedestrian non-compliance.

On-crossing detection varies the clearance period, catering for slower and mobility impaired pedestrians while minimising vehicle delay. Removing the flashing amber at mid-block crossings and using all-red extensions reduces potential conflicts and increases perceived safety, especially for older pedestrians. However, at high pedestrian flows the all-red extension period can facilitate pedestrians to continue to start to cross after the end of the pedestrian green.

There have been some operational and technical problems with the cancel facility, particularly with earlier installations. The potential to provide operational benefits at mid-blocks is often low, and in these cases detection can be omitted. Where a less responsive mid-block control strategy is used the cancel facility should reduce the potential for shunt accidents, and may reduce driver frustration and non-compliance. Substantial operational benefits have been shown at traffic signal junctions, and this may have associated safety benefits.

It is envisaged that the clear and consistent signalling provided by Puffin facilities, and catering for pedestrians of differing walking speeds, should reduce potential conflicts and thus accidents. It is anticipated that nearside signals should improve pedestrian observation of on-coming traffic. The operational benefits of the cancel facility at junctions may well also provide safety benefits.

Results of previous accident rate comparison studies have indicated benefits but have not been conclusive. Accident reductions at junctions have been found, while studies of mid-block crossings have shown mixed results. One study indicating no change and the other a notable reduction in accidents under Puffin control. Some questions have been raised over installation standards in the survey which showed no change in accidents, and installation in all the studies was prior to the practical advice and collated experience provided by *Puffin Crossings - Good Practice Guide*.

6 Site analysis

6.1 Site requirements

To assess the change in accident frequencies at mid-block and junction signals, sites were required where farside pedestrian facilities had been changed to Puffin facilities, with no other significant changes in layout, operation, or traffic flow. To ensure a realistic assessment of the safety benefits of Puffin facilities only sites that substantially complied with DfT's current advice as set out in the *Puffin Crossings - Good Practice Guide* (Department for Transport and County Surveyors' Society, 2006) would be considered. Also there needed to be sufficient 'after' accident data – ideally at least three years. The sites were also desired to:

- Have a good geographical spread,
- Include examples of 3- and 4-arm junctions and differing mid-block crossing arrangements,
- Include examples of different types of pedestrian provision (e.g. all-red phase, whether crossing is staggered and different control strategies).

Site selection favoured sites with higher vehicle and pedestrian flows. Such sites were more likely to have a greater number of accidents occurring, and therefore any safety improvements could have a large enough effect to identify.

6.2 Identification of possible sites

The Traffic Signals Group (TSG) undertook a survey of highway authorities on traffic signal installations towards the end of 2007. The results of the survey were made available to TRL for use within this project. Out of those authorities completing the survey, nearly 3000 Puffin mid-block crossings were identified and around 11,500 junctions. No information is given on the pedestrian facilities provided at junctions or on conversion to Puffin facilities. However, it was noted that most authorities stated that all new pedestrian facilities would use Puffin technology. Authorities that were actively installing Puffins were identified as the primary potential source of sites. They were contacted by e-mail and asked to list:

- Puffin mid-block crossings that have been converted from Pelican crossings without any other significant infrastructure changes. Ideally those that operated as Pelicans for at least 3 years and have now operated as Puffins for at least 3 years.
- Junctions that have been converted to nearside pedestrian signals from farside without any other significant infrastructure changes, i.e. a simple refurbishment. Again, ideally they should have operated under each method for at least 3 years.

The following information was required:

- Type of installation (mid-block or junction),
- Location reference,
- Date of initial installation,
- Date of conversion to Puffin, or Puffin type facility,
- Confirmation that there have been no other significant changes that would affect the collision rate in the analysis period, including control strategy, and vehicle/ pedestrian flows,
- Indicative vehicle and pedestrian flow.

Thirty-five Highway Authorities were approached and eight responded with the information requested: Cheshire, Devon, East Sussex, Essex, Greater Manchester, Hampshire, Transport for London, and York.

Further information was then obtained from the above authorities including:

- Type of signal control strategy (e.g. SCOOT, VA, MOVA or fixed time),
- Data to confirm Puffin operation e.g. signal configuration and timings and whether these have been the same since implementation,
- A plan showing geometric layout.

A shortlist of sites to be visited was prepared based on an assessment of the information provided. This included conformance to the recommended timings given in the *Puffin Crossings - Good Practice Guide*, or if not, Traffic Advisory Leaflet TAL 1/02 '*The installation of Puffin Pedestrian Crossings'.*

6.3 Site visits

An inspection procedure based upon the advice given in *The Puffin Crossings - Good Practice Guide*, was developed and tested on-street by the project team. The finalised proforma used in the inspections is given in Appendices A and B. Particular areas for attention during the site investigations included:

- Setup and performance of on-crossing detection,
- Setup and performance of kerbside detection,
- Signal timings used.

Figure 6.1 shows a site inspection in progress. Sites were classified according to the data collected on site. The following categories were used:

A	= Very good	Compliant with current guidance and no operational issues.
B	= Good	Largely compliant with current guidance/ some minor operational issues
C	= Adequate	Generally compliant with current guidance/ some operational issues.
D	= Poor	Deviates from current guidance/ several issues.
E	= Very poor	Significant deviation from current guidance/ significant issues.
F	= N/A	Site has been modified since facilities converted.

In all, 72 sites were visited and assessed. Their locations are indicated in Figures 6.2 and 6.3 (note that icons may denote multiple sites).

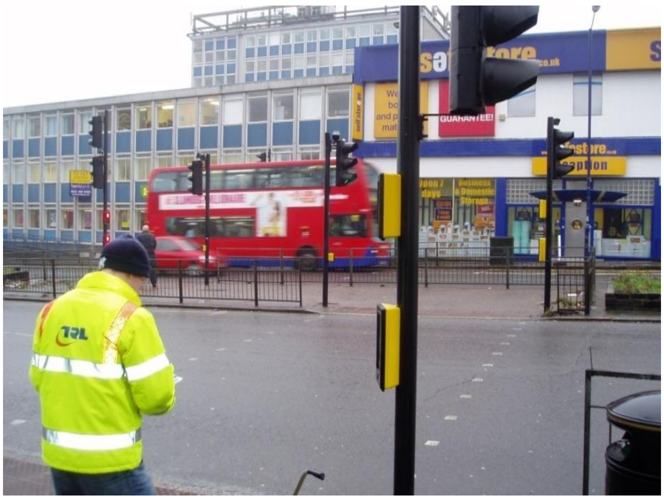

Figure 6.1: Site inspection

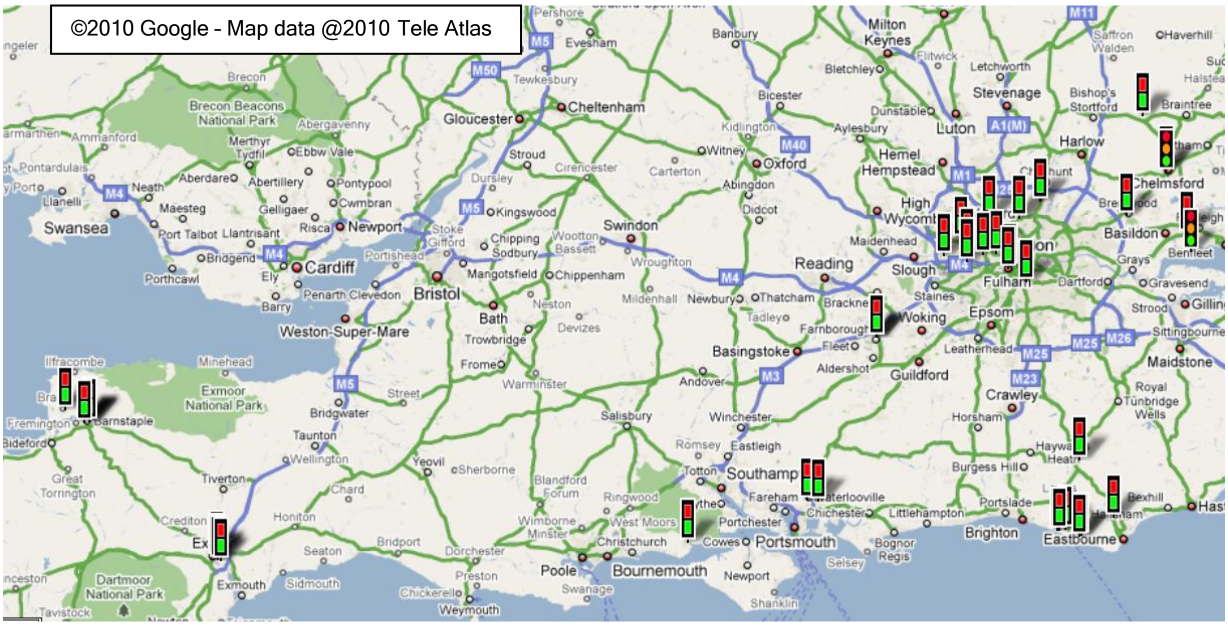

Figure 6.2: Sites inspected in Southern England

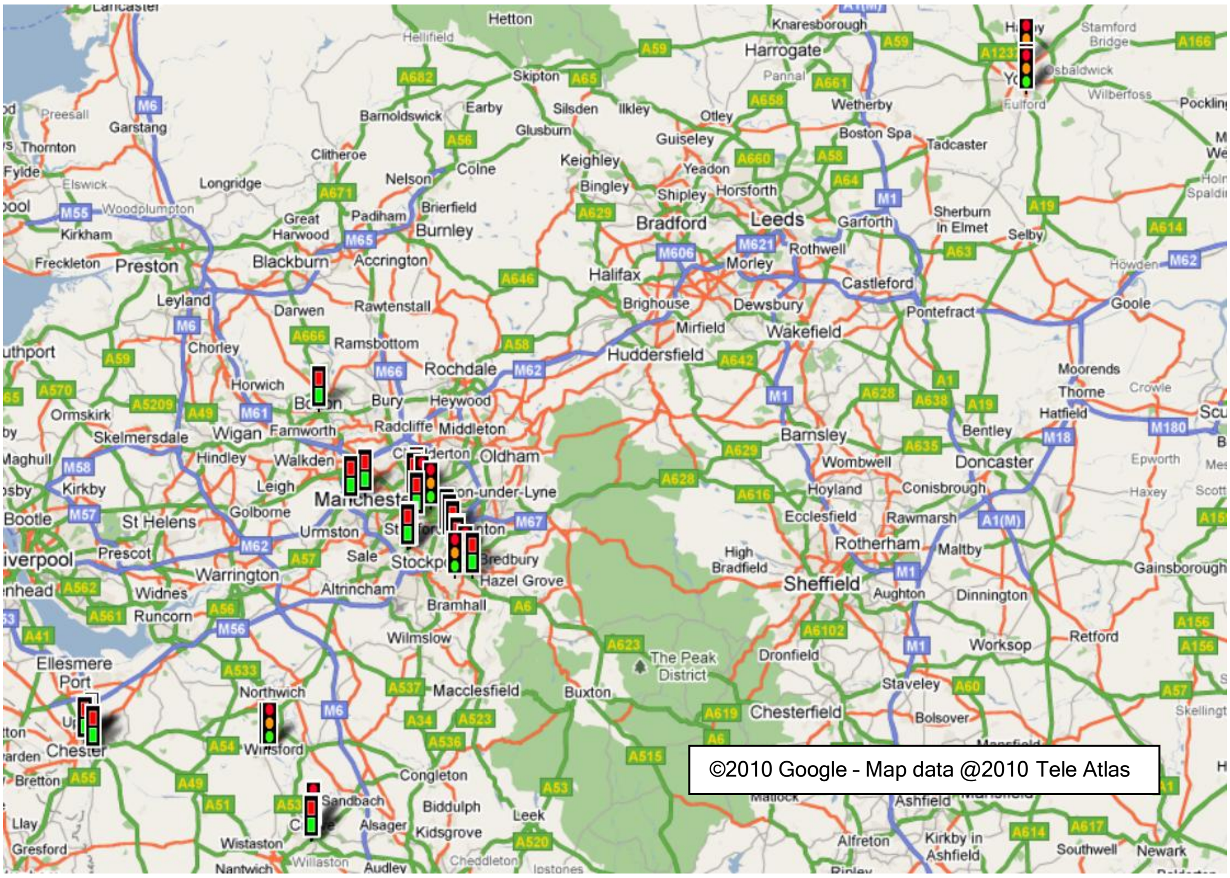

Figure 6.3: Sites inspected in Northern England

6.4 Inspection results (all sites)

Table 6.1 gives an overview of the numbers of sites in each category. In total 72 sites were inspected, two of these sites were later found to have had significant changes other than conversion to Puffin facilities and were excluded from possible accident analysis (shown as N/A in the below table).

Table 6.1: Number of sites in each classification

Classification	Junctions	Mid-block	Total
A	0	3	3
B	3	27	30
C	6	20	26
D	3	7	10
E	1	0	1
N/A	1	1	2
Total	14	58	72

In total 84% of all sites inspected were judged adequate or better, with most in the 'good' category. Only a very few were graded in the very good category. A notable finding from the survey was that the cancel facility was not operating at a large number of the sites, even though in most cases the kerbside detectors appeared to be functional.

Mid-block crossing control tends to be relatively responsive to pedestrian demand (unless on linked control) and there are often few opportunities to cancel. Current guidance recognises that kerbside detection is optional and may be omitted at some sites depending on local factors. Many mid-block sites that did not have operating cancel facilities were still judged in the good or adequate category. Depending on the site, junctions can gain significant operational benefit from the cancel facility (Section 5.4.5). The cancel facilities not operating in these cases led to a larger reduction in the grade given.

Whilst undertaking the individual site visits, a number of fields of data were recorded to indicate the operational performance of the site. Details of the inspection results are given in Appendix C and are summarised below:

- At 79% of sites, all installed pedestrian detection was functioning as shown by the operation on the LED on the detector unit. Where there was non-functional detection this was largely associated with the kerbside detection, either apparently switched off, or a few sites with 'permanent demand' on the kerbside detector. At three sites a push button unit was recorded as not working.

- The variable all-red was operating at all mid-block crossings except one site running a fixed all-red period. On-crossing detection was used less at junctions than mid-blocks, with three sites having no detection and two having detection but running fixed pedestrian clearance periods. Two of these five sites did not require a variable clearance period as the pedestrian phase finished well before a concurrent traffic phase.

- Generally there was complete on-crossing detector coverage of the crossing, as shown by the operation of the LED on the detector. Where there were gaps it tended to be at the extremes of the crossing. In all cases the system coverage provided by detection extensions and the fixed all-red period after the pedestrian green where operating correctly, and appropriate pedestrian clearance periods were being provided. Overall the on-crossing detection was found to work well and reliably.

- Only 11 of the 72 sites were shown to have an operating cancel facility, although the majority of the detectors were apparently functional. Inspection of the controller specification showed a number of sites where the demands for the pedestrian stage where configured as 'latched'. It is also likely that some authorities or their maintenance contractors may have purposely disabled the cancel facility to avoid perceived problems.

- There were two junction sites without kerbside detectors. They always ran the pedestrian phases in conjunction with main road phases and as such the cancel facility was not needed.

- A number of the mid-block sites ran pre-timed max, and as such present very few opportunities to cancel demand. The vast majority of the other mid-blocks ran Vehicle Actuation which also should present limited cancel opportunities, although there were a few reports of overhead vehicle detectors being aligned quite far downstream, thus failing to detect reasonable gaps in the traffic.

- One site with an operating cancel facility failed to detect pedestrians waiting close to the kerb and incorrect cancelation of the demand was shown. Some of the other sites with an operating cancel facility showed incomplete coverage as specified by the *Puffin Crossings - Good Practice Guide*, although this tended to be small patches at the extremes.

- Inspection of the coverage at sites where the cancel facility was not operating showed around 60% of sites having one or more kerbside detectors not covering the full recommended area. This again tended to be small patches at the edges. Problems of coverage could explain why some kerbside detection was not set to operate.

- Site layout generally conformed to the *Puffin Crossings - Good Practice Guide*. The most common deviation was the angle to the Pedestrian Display Unit. Deviation tended to be authority based, with one typically using 45 degrees and two others typically zero degrees, rather than the recommended 25 to 30 degrees to the kerb face. A few sites had on-crossing detectors that were directly opposite each other, rather than diagonally which provides better on-crossing coverage. At a couple of sites the inspectors commented that a high-level repeater could have been beneficial due to high pedestrian demand. Other deviations included poles being located too close to the carriageway or too far from the edge of the tactile paving, and Push Button Unit heights. It should be noted that in most cases the recorded deviations in layout were minor and few.

Informal feedback was sought from some senior local authority traffic signal engineers on why many sites did not have operating cancel facilities. Comments included:

- Kerbside detection can be problematic, while it is expensive to install and maintain, leading to Authorities not using them.
- Often when problems are reported by members of the public there is 'no fault found', this may be due intermittent problems such performance in poor lighting conditions, or pedestrians standing outside the normal detection zone in rainy conditions.
- Maintenance contractors often turn off the facility to avoid fault reports, and if Local Authorities pursued all kerbside detectors to be operational it would become a significant maintenance issue and increase costs.

- It was recognised that kerbside detectors are not needed in certain situations such as high pedestrian flows. It was commented that a new detector by a major manufacturer appears to work well and consistently.

The high proportion of sites operating without the cancel facility may be indicative of perceived reliability and operational issues associated with experience of early kerbside detection (Section 5.4.5.). Technological advances by detection manufacturers have made substantial improvements to this situation. The study sites used detection from a variety of different manufacturers and ages.

6.5 The 50 sites for accident analysis

The 10 junctions and 40 mid-block crossings with the highest grades (Table 6.1) formed the sample set for the accident analysis. In order to achieve the target sample size, one junction from the D category (poor) and ten mid-block crossings in the C category (adequate) were included. Inspection results for the 50 sites in the accident sample are included in Appendix C.

The mid-block sites included in the accident analysis were in general conformance to the current guidance, most were graded as 'good' or better. A notable number did not have an operating cancel facility but this was judged to have little impact on operation at these sites due to the use of responsive pedestrian control strategies. All sites in the sample had correctly operating variable clearance periods for pedestrians.

Some junction sites included in the accident analysis did not have the cancel facility operating where it would have been likely to be used regularly, and some of the sites used fixed pedestrian clearance periods when on-crossing detection could have been utilised. Both of these factors may have reduced the potential safety benefits seen. Ideally a larger and higher graded set of junctions would have been preferred for the accident analysis.

7 Accident analysis

7.1 Accident data

Accident data was obtained for the 14 year period from 1st January 1994 to 31st December 2007 for the 50 sites (10 junctions and 40 mid-block crossings) identified by the site inspections (Section 6). Appendix D lists the sites.

Injury accident data was collected for the 50 sites, intended to include accidents on the crossing(s) and within 100m approach to the crossing(s). Plain language descriptions were obtained with the intention of eliminating irrelevant accidents (e.g. those on a nearby side road). However the locations were mostly not given in these terms. Also, these accidents are present in both the 'before' and 'after' data and therefore, if there were any, should not bias the results.

Table 7.1 summarises the number of accidents and site years by type of site (junction or mid-block crossing) for each accident group. 'Pedestrian accidents' refers to a road traffic accident involving injury to one or more pedestrians. 'Vehicle accidents' refers to all other road traffic injury accidents. The terms 'junction accidents' and 'accidents at mid-block crossings' refer to all accidents within the 100m boundary.

The pedestrian accident frequencies (accidents/ year/ site) 'on mid-block crossing', 'on mid-block zigzag' and 'within 50 metres' are taken from the STATS19 accident descriptions.

Table 7.1: Number of accidents by accident group

Accident group (within 100m box unless stated)	Site years	Number of accidents	Mean accident frequency (accidents / year)
All accidents	700	1149	1.64
All pedestrian accidents	700	312	0.45
All junction accidents	140	214	1.53
All mid-block crossing accidents	560	935	1.67
All vehicle accidents	700	837	1.20
Pedestrian accidents at junctions	140	47	0.34
Pedestrian accidents at mid-block crossings	560	265	0.47
Pedestrian accidents on mid-block crossing	560	49	0.09
Pedestrian accidents on mid-block zigzags	560	10	0.02
Pedestrian accidents within 50m of mid-block crossing (including accidents on the crossing or zigzags)	560	91	0.16

Table 7.2 shows the number of accidents by severity. Compared with Hall (1986) for accidents at 4-arm junctions on 30 mph roads, the results here had the same severity of 24% for pedestrian accidents but a much lower severity for total accidents (12% compared with 20%) probably because of improvements to in-car safety over the past 20 years.

Table 7.2: Number of accidents by severity

Accident group	Number of accidents				Severity
	Fatal	Serious	Slight	Total	(% serious & fatal)
All accidents	14	119	1016	1149	12%
All junction accidents	2	22	190	214	11%
All accidents at mid-block crossings	12	97	826	935	12%
All pedestrian accidents	10	64	238	312	24%

For all sites, there were three years of 'before' data. Authorities had not been asked to confirm the method of control for more than three years before conversion. Earlier data is not included in Tables 7.3, 7.4, E1 and E2 which compare Puffin with farside facilities, but is included in Tables 7.1 and 7.2. Only two sites had less than three years of 'after' data, most having several extra years. Appendix E shows the accident data by site.

Table 7.3 gives accident frequency by form of pedestrian facility (farside or Puffin) for all 50 sites. The results indicate reductions in accident frequency and severity after conversion to Puffin facilities. In order to undertake robust statistical analysis of the data, paired comparison regression analysis is used to take account of potential biases such as site and time factors (see Section 7.2). The percentage of fatal and serious accidents appears to have decreased after conversion to Puffin facilities from 12.0% of all accidents to 8.7%. However there were too few of these accidents to undertake a robust statistical assessment.

Table 7.3: Accident frequency by form of pedestrian facility (50 sites)

	Farside	Puffin
Site years	150	227
All accidents	266	358
Serious and fatal	27 and 5	27 and 4
Slight	234	327
Severity (% fatal or serious)	12.0%	8.7%
Mean accident frequency	1.77	1.58
Mean serious and fatal accident frequency	0.21	0.14
Mean slight accident frequency	1.56	1.444
Site yrs (junctions)	30	34
Junction accidents	56	51
Mean junction accident frequency	1.87	1.50
Site yrs (mid-block crossings)	120	193
Accidents at mid-block crossings	210	307
Mean accident frequency at mid-block crossings	1.75	1.59
All pedestrian accidents	77	93
Mean pedestrian accident frequency	0.51	0.41

7.2 Model form

Analysis was undertaken by fitting generalised linear models using the GENSTAT program (Alvey *et al*, 1977). Control sites were not required because 'regression towards the mean' was unlikely, as the conversion from Pelican and farside facilities to Puffin facilities has largely been undertaken as part of general refurbishment, rather than a treatment for particularly high accident sites. 'Regression towards the mean' can occur when sites with relatively high accident counts (above what is the long term mean for that site) are selected for treatment. The after period accident count will usually be closer to the long term average, and as such accident reductions can be incorrectly inferred. Avoiding regression towards the mean was achieved by selecting authorities known to be undertaking a general refurbishment programme using Puffin facilities. Hence they were not converting to Puffin facilities for site specific safety reasons.

The model form adopted was as follows:

$$A_{ijm} = k.\ T_m^{\alpha} \exp\{\ \beta S_i + \gamma M + \delta Q_j\ \} \qquad \text{Equation 1}$$

where

A_{ijm}	is the number of accidents at site i (i = 1…50) in quarter j (j=1…4) and quarter year m (m=1…56)
k, α, β, γ, δ	are constants to be determined by the regression
S_i	is the site factor (i = 1…50)
M	is the type of pedestrian facility 1=Pelican/ farside facility 2=mixed (facility during quarter when conversion occurred) 3=Puffin 4=unknown (more than 3 years before conversion)
T_m	is the time in quarter years from the start of the data (m=1…56)
Q_j	is the quarter factor in the year (j=1…4)

The site factor S takes account of vehicle and pedestrian flow and other site specific variables at individual sites. The time factor T allows for any general time trends over the 14 year period. The quarter factor Q takes account of any seasonality in the data.

The type of pedestrian facility is given by the factor M as one of four levels, Pelican (or equivalent at signal-controlled junctions), mixed (pedestrian facility during quarter with conversion to Puffin), Puffin, and unknown (more than 3 years prior to conversion). The exponential value corresponding to the third level of M gives the multiplicative effect of Puffins relative to Pelicans. Because local authorities were only asked to check that the signals were in operation three years before conversion to Puffins, data from earlier years was not used. Each site therefore has a full three years 'before' data and most had a minimum of three years 'after' data.

In a regression analysis (see e.g. Maher and Summersgill, 1996), the effect of additional site factors (such as whether the junction or crossing is on a single or dual carriageway) can be taken into account explicitly. However, in the model above, the site factor S implicitly includes this type of effect, since it automatically pairs the 'before' and 'after' data for the same site, and no additional factors were used. The effect of vehicle flow was not included in the analysis for two reasons. Firstly, it was assumed that any changes in flow would be taken into account by including the site and time factors (S and T) in the model. Secondly, Local Authorities would be unlikely to have flow records for the full 14-year accident period.

The 95 per cent confidence intervals for the effect of Puffins compared with Pelicans can be calculated from the estimated value and its corresponding standard error:

Lower limit exp{L} where L = estimate – 1.96 × standard error

Upper limit exp{U} where U = estimate + 1.96 × standard error

7.3 Results of modelling

Table 7.4 gives the estimated effect of Puffins compared with Pelicans (the third level of the pedestrian facility factor M) for each of the accident groups. Within each group, the value of exp {estimate} gives the multiplicative effect of Puffins relative to Pelicans. A positive estimate therefore indicates a higher accident frequency under Puffins than Pelicans, whereas a negative value indicates a lower accident frequency. The confidence interval for the estimated multiplicative effect is also shown. If the interval contains the value 1, then the results are not statistically significant at the 5% level. Results which are significant at the 5% level are marked with an asterisk, and those at the 10% level marked with a cross.

The time trend T_m was not statistically significant in any of the models and has therefore been omitted from the results. For simplicity, the results include the effects of Q_j whether or not this parameter was significant, as it had little effect on the model parameters.

Table 7.4: Model parameters for Puffins compared with Pelicans by site type

Accident group	Estimate[1]	Standard error[2]	Ratio of effect of Puffins to effect of Pelicans[3]	Lower confidence limit for ratio	Upper confidence limit for ratio
All accidents	-0.209	0.0821	0.812*	0.69	0.95
Junction accidents	-0.308	0.194	0.735	0.50	1.07
Mid-block accidents	-0.187	0.0907	0.829*	0.69	0.99
All pedestrian accidents	-0.281	0.156	0.755†	0.56	1.03
Pedestrian accidents at junctions	-0.499	0.451	0.607	0.25	1.47
Pedestrian accidents at mid-blocks	-0.250	0.166	0.779	0.56	1.08
All vehicle accidents	-0.181	0.097	0.835†	0.69	1.01

1 Estimate of effect of Puffins (i.e. third level of parameter M in equation 1)
2 Standard error of estimate
3 Exponential value of Puffin estimate (i.e. third level of parameter M)
4 * indicates result was statistically significant at the 5% level
5 † indicates results was statistically significant at the 10% level

Table 7.5 summarises the above results in terms of percent reduction in accident frequency.

Table 7.5: Percent reduction in accident frequency with Puffin facilities

Accident Group	Reduction in accident frequency	Statistical significance
All accidents	**19%**	**5% level**
Junction accidents	26%	N/S
Mid-block crossing accidents	**17%**	**5% level**
All pedestrian accidents	**24%**	**10% level**
Pedestrian accidents at junctions	39%	N/S
Pedestrian accidents at mid-blocks	22%	N/S
All vehicle accidents	**16%**	**10% level**

8 Discussion

The results show that conversion from farside pedestrian facilities to Puffin facilities has significantly reduced injury accident frequency at the studied sites. All accidents reduced by 19% (statistically significant at the 5% level), pedestrian accidents by 24%, and vehicle accidents by 16% (both statistically significant at the 10% level).

All accidents at mid-block crossings reduced by 17% (statistically significant at the 5% level), with accidents at mid-block crossings involving pedestrians reduced by 22%. The latter result was not statistically significant, given the relatively low frequency of pedestrian accidents found and sample size assessed.

Junction accidents showed a large decrease in injury accident frequency of 26% for all accidents and 39% for pedestrian accidents. These results were very similar to a previous study in Manchester at converted junction facilities (Section 5.5) which showed a 24% reduction in all junction accidents and 38% in pedestrian junction accidents, but unlike this study, did not specifically identify sites where no other significant changes were made except the crossing facility. The junction results for this study were not statistically significant, as expected due to the sample size, but do again indicate safety benefits for Puffin facilities over traditional farside facilities. A further study of junction safety would be worthwhile in the future.

In addition to reduced accident frequency the results also indicate a reduction in accident severity, although there were too few serious and fatal accidents to assess statistically.

The site inspection highlighted a high proportion of sites where the pedestrian demand cancelling function was not operating. At mid-block crossings the cancel facility can often be omitted. However, junction performance can be significantly improved with the cancel facility under low and moderate pedestrian flows. As such the full benefit of Puffin facilities is not being realised. Recent improvements to kerbside detection technology and advice should improve the situation, and Highway Authorities and maintenance contractors should be encouraged to check existing installations and bring them up to current advice.

A literature review was undertaken to summarise previous Puffin accident analysis and ascertain behavioural and perception factors that could affect safety. The flashing green figure at Pelicans and blackout period at junctions are often misunderstood by pedestrians and have a relatively poor compliance rate. The flashing sequence is associated with a high proportion of pedestrian accidents on Pelican crossings and appears to present a higher accident risk than the equivalent all-red shown at Puffin crossings. All-red extensions cater for people with impaired mobility and lower the potential for conflicts, but at high pedestrian flows they may facilitate some pedestrian non-compliance compared with the flashing sequence at Pelican crossings. Improved observation of on-coming vehicles with nearside pedestrian signals, which should improve safety, is indicated but not fully proven. The cancel facility has shown significant improvements to junction operation.

Lack of pedestrian awareness of the safety provision provided by on-crossing detection was highlighted in the literature. Increased awareness of this facility through further education and publicity may reduce the concern of some pedestrian regarding not being able to see the pedestrian signal indication while crossing.

The literature review highlighted two high pedestrian flow Puffin sites where non-compliance in the clearance period was greater than the compared farside facility. One study compared a city centre Pelican crossing with an equivalent Puffin crossing. The flashing amber was suggested to be a greater deterrent not to start to cross when pedestrian flow can dominate. The other studied site was an existing farside facility junction converted to Puffin facilities. The Puffin maximum clearance periods were far in-excess of later recommendations. The use of a high-level repeater signals and current guidelines on signal timings seeks to address these issues. However, a wider study on Puffin operation at high pedestrian flow sites may be worthwhile in order to more fully assess Puffin facilities under these conditions and provide additional guidance if required.

This study shows that injury accident frequency is significantly lower with Puffin facilities compared with traditional farside facilities. This result should be disseminated widely to the transport planning and engineering community to support the implementation of Puffin facilities.

9 Conclusions

The aim of this research was to assess the road safety benefits, in terms of accident frequency, for correctly installed and operated Puffin facilities compared with farside pedestrian signals at junctions and Pelican crossings.

This project reviewed accident data at 40 mid-block crossings and 10 junctions that had been converted to Puffin facilities from Pelican crossings and farside facilities at junctions, with no other significant changes in layout, operation, or traffic flow. The mid-block crossings were in general conformance to current DfT Puffin guidance, as were all but one of the junctions.

The results show statistically significant safety benefits after conversion to Puffin facilities. Personal injury accident frequencies where shown to be:

- 17% lower at mid-block crossings (statistically significant at the 5% level),
- 19% lower over all the sites (statistically significant at the 5% level),
- 24% lower for all pedestrian accidents (statistically significant at the 10% level),
- 16% lower for all vehicle accidents (statistically significant at the 10% level).

Puffin crossings, in general conformance to current guidance, have been shown to provide significant safety benefits over Pelican crossings. The combined sample of mid-block crossings and junctions also showed a significant reduction in accident frequency after conversion to Puffin facilities.

Junction accidents, pedestrian accidents at mid-block crossings, and accident severity also indicated notable reductions but the results were not statistically significant for the sample size assessed.

10 Recommendations

The results of this study should be widely disseminated to highlight the safety benefits of Puffin facilities.

The focus of this study was primarily on mid-block crossings. A further study would be worthwhile concentrating on junction safety benefits when more converted junctions become available conforming to the recent Puffin guidance.

The study has demonstrated the safety benefits of Puffin facilities when in general conformance to current guidance. Highway authorities should be encouraged to review and update as necessary existing Puffin crossings and nearside facilities at junctions, and review associated maintenance procedures.

A study may be worthwhile concentrating on the operation of sites with very high pedestrian flows to assess Puffin performance and develop further guidance for such situations if needed.

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Appendix A Mid-block site assessment method

Puffin Mid-block crossing assessment –method statement

General conditions of work

All the work by TRL staff shall be undertaken in accordance with the TRL policy on working on or near the highway, sub-contractors must provide satisfactory, compatible working procedures checked by TRL before work starts. If at any time the observer identifies potential hazards that are not addressed in the risk assessment, then work should be ceased until further guidance is sought. There are several specific factors that need to be observed in this work.

Local Authority

Try to obtain a site plan and signal timings from the local authority as part of the sifting process to decide which sites to visit.

Before visiting any site, contact the local authority to inform them of the work to be done and request permission to open the controller to consult the documentation stored there and if necessary to interface to the controller as detailed in the risk assessment.

Access to the controller

Access to the controller will normally be required to consult the documentation stored there. If the information is available in advance from the LA then it should be examined before the visit. If the documentation is not in the controller, then the LA should be approached for the information. The information to be extracted from the documentation is:

- Signal timings
- Historical record of changes to signal timings
- Significant events in the paper log that could have affected the collision record at the site

The controller must only be opened by a competent person with the permission of the local authority and in dry conditions. If the timings cannot be obtained from the documentation, it will be desired to interface to the controller to obtain them. However, such interfacing must have the explicit authorisation of the local authority and be undertaken by a competent person who meets all the local authority qualification requirements. Suitable terminal equipment should be used and the timings extracted in accordance with the manufacturer’s instructions, without changing the timings or any other aspect of the controller operation. Again, timings may be available in advance from the LA, in which case it will not be necessary to obtain them from the controller.

Checking of the detector operation will also be simplified by use of a handset interfaced to the controller. The LED indicators on the kerbside detectors can be difficult to see from parts of the waiting area. It may not be possible to tell whether the LED is off, or cannot be seen because of obscuration by other internal parts of the detector. Also the coverage of the crossing by the on-crossing detectors is most easily checked with a handset, which will show whether either detector is on without needing observers watching both detectors and communicating with each other. Even with a handset, two people will be needed to monitor detection operation.

Installation and operation

Check that the installation is in accordance with the Puffin Good Practice Guide. A measuring wheel is the easiest way of measuring the width and length of the crossing.

Pedestrian Demand Units and Pushbuttons

Pedestrian Demand Units, PDU, (push button *and* nearside pedestrian signals) should be installed not more than 500mm from the line of the crossing, aligned so that waiting pedestrians looking at the display will be facing oncoming traffic, but angled at 25 to 30 degrees away from the crossing and at least 500mm back from the kerb. PDUs can be mounted at the back of the crossing where it is necessary: on narrow footways or where there are problems with utilities' services. Nearside and farside indicators should not be mixed at the same site (we will have rejected the site without a visit if mixed indicators were shown on the supplied site plan) and, preferably not mixed at sites that are close together.

Audible devices should not be used where there is a possibility of confusing pedestrians as to which pedestrian stage is running, e.g. at staggered mid-block crossings. Again the site would be rejected where such problems show on diagrams supplied before visiting the site.

Check for see-through, particularly at staggered crossings and straight across crossings with a central reserve. Assess whether Narrow Field of View (NFV) PDUs would avoid any problems observed. If uncertain whether NFV have been used, it will be necessary to check with the LA.

Check that high-level repeater pedestrian signals are installed at busy, wide crossings where otherwise not all pedestrians would be able to see an indicator

Method of control

The method of control should be ascertained: VA, VA + SA, VA + SD, MOVA, SCOOT or Fixed-Time UTC.

Kerbside detectors

Kerbside detectors may not be used at mid-block Puffin crossings. If installed, check the operation of the kerbside detectors by operating the pedestrian demand button and then standing in relevant areas of the waiting area to check that the demand is held. It will be necessary to undertake this test when there are no other pedestrians in the waiting area, or where there is a single pedestrian, the observer should remain outside the waiting area and observe the operation of the pedestrian phase and of the detector. The operation of the detector can be observed by the LED indicator, when visible, or via a handset plugged into the controller. If there are no other pedestrians on the same side of the road, but pedestrians wishing to cross from the other side, the test of detector function can be undertaken by observing the detector LED, or handset. However, a test must be made with no pedestrians on the farside to check that operation of the kerbside detector does hold the pedestrian demand in the controller and the pedestrian stage runs as expected. To avoid frustration to motorists it will be advisable to cross the road during the pedestrian stage when no other pedestrians use the crossing or a colleague observing the controller handset.

Check that the detection area covers all the expected pedestrian waiting area, at least up to 1.2m from the kerb, but greater where pedestrians stand back because of high speed vehicles, danger of being splashed etc. Also check that the detector operates over the full width of the crossing, from the base of the pole to the furthest extent of the pedestrian waiting area. This is particularly important at wide crossings. The extent of the detection zone can be checked by standing in the waiting area and observing the LED on the detector.

On-crossing detectors

On-crossing detectors should be used at mid-block crossings, but may be omitted at junctions for parallel pedestrian phases, or where the crossings are very short (the guidance states, "say less than six mitres wide"). Checking the operation of the on-crossing detectors, when used, requires an observer to cross the road in person, or observe the operation when others cross, and do not complete crossing before the end of the fixed all red period. When a member of TRL staff crosses the road, the second observer must watch for potential vehicle hazards as well as observe the operation of the detector and signals. If the all red ends whilst a pedestrian is still on the crossing there is a potentially dangerous situation. The pedestrian will have no warning of the danger unless he or she can see a secondary vehicle signal and looks at it.

The initial check will be to observe the LED indicators in the on-crossing detectors, or the controller handset, whilst the observer crosses or observes others crossing. If the indicators fail to light, or the handset indicates no detection, as pedestrians cross, then the observer should contact the local authority to report the fault and cease work at the crossing. Figure 1 shows the idealised detection zones, in practice the zones are lobes rather than triangles with straight lines. For wide crossings, check that the on-crossing detectors cover the full width of the crossing.

The second check is that controller correctly acts on the "on" indication from the on-crossing detectors. This check is most easily, and safely for the observer, undertaken when others cross. With normal timings, the vehicle starting amber will occur 2 or 3 seconds (the length of the fixed all red period) after the end of the invitation to cross if no pedestrians are detected on the crossing. The operation of the crossing should be observed until the observer is satisfied that the controller is responding correctly to the on-crossing detectors. N.B. both on-crossing detectors can be activated at the same time. The correct operation can only be verified when each detector has been observed working on its own. It will probably require an observer to cross on their own starting in an area covered by only one detector. The extensions should cease very soon after the pedestrian reaches the footway and leaves the carriageway.

Ideally, we need also to check the safety critical aspect that pedestrians entering the crossing at the end of the fixed all red period are detected. However, it is only possible to check this operation safely when there is no traffic approaching or waiting at the stopline and no interference from other pedestrians. If conditions allow the test, first determine the length of the fixed all red period, 2 or 3 seconds, then a pedestrian should step slowly on to the crossing just before the end of the fixed all red period. The on-crossing detectors are working properly if the all red period is extended until the pedestrian completes the crossing. The test should be repeated from the other kerb.

Factors affecting the timings

Period 3: All red following traffic

The all red period following traffic should normally be one second after a gap change, or one, two or three seconds after a maximum change. On "high-speed" (85^{th} percentile approach speed greater than 35 mph) the all red period may vary with a high value (normally three seconds) after a maximum change when a speed extension is still running and a lower value at other times. Record high-speed approaches.

Period 4: Invitation to cross

There are several factors that require the invitation to cross period to be longer than 4 seconds:

- Heavy pedestrian flows
- Length of the crossing greater than 11 metres
- A central refuge is provided
- Space in the pedestrian waiting area is limited
- Crossing on high-speed road
- A high proportion of disabled, elderly or slower moving pedestrians or schools nearby

Checking the timings

If the timings cannot be obtained from documentation or by interfacing with the controller, they should be measured manually. If manual timing is required:

- Period 1 can be timed during periods of heavy traffic when no gap changes occur by timing from push button press to start of vehicle amber
- Periods 2 to 4 can be checked on any cycle:
    - 2 = length of vehicle leaving amber
    - 3= start vehicle red to start pedestrian green
    - 4 = length of pedestrian green
- Period 5 can be measured when no-one crosses. It is the length of all-red when the on-crossing detectors are not activated.
- Period 6 may be measured at quiet times when there are no vehicles approaching. It requires an assistant to walk slowly across the crossing, activating the on-crossing detectors, until the start of vehicle red and amber. The test must be abandoned if any vehicle approaches such that it would be in the vicinity of the crossing by the end of the test walk. Period 6 = time from end of pedestrian green to start of vehicle red and amber minus period 5.
- Periods 7 and 8 can be assumed to be 0 (or will have been measured as part of periods 5 and 6).
- Period 9 = standard vehicle red and amber

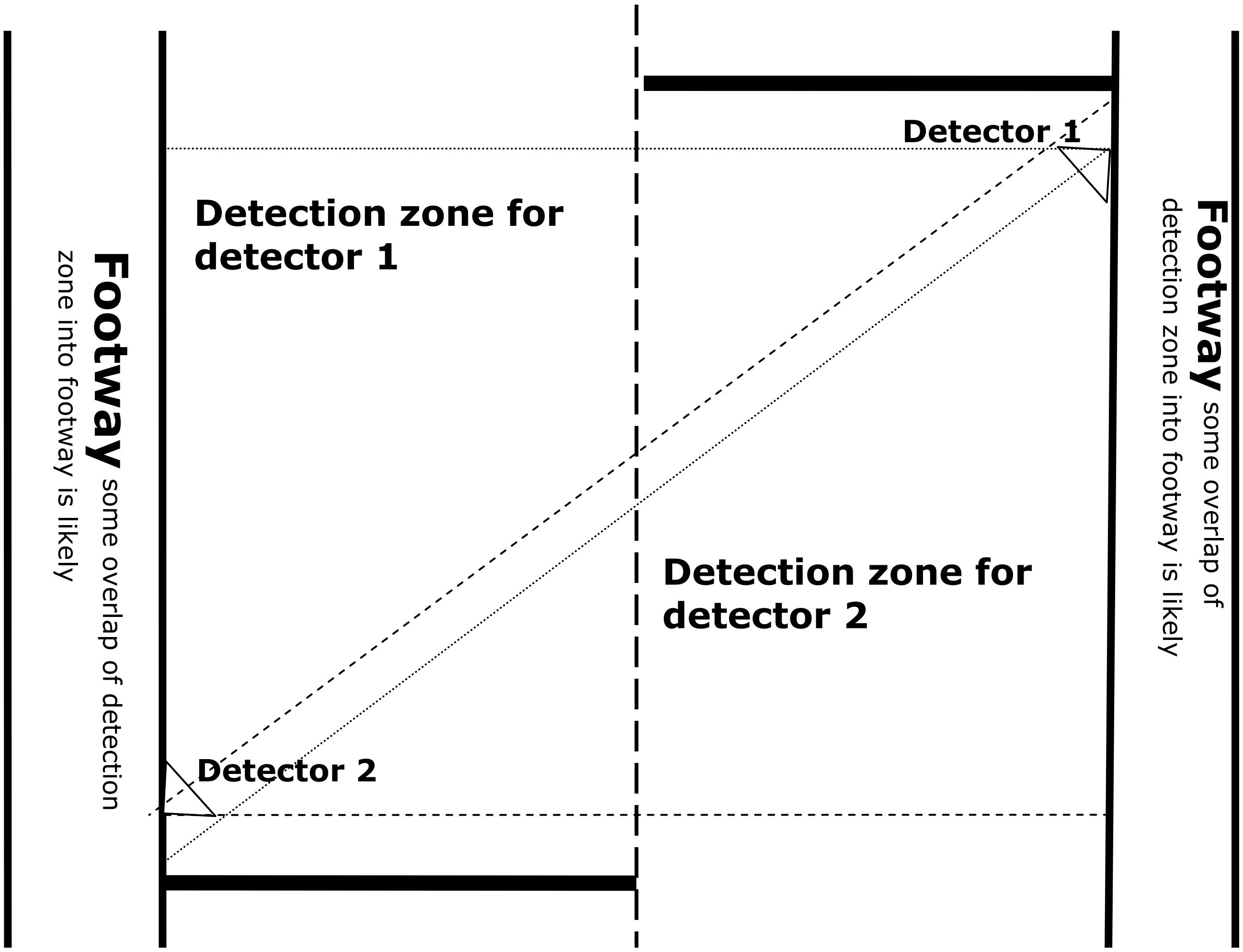

Figure 1: Idealised on-crossing detection zones

Puffin crossing inspection checklist

Site:..Speed limit...........

Observer..................................Date...................Start time..............End time..................

1. PDU alignment:

   a. Within 500 mm of the line of the crossing for all PDUs and PBs?

      ☐

   b. Distance from Kerb edge to base of poles:

pole 1	..............m	pole 5	.................m
pole 2	..............m	pole 6	.................m
pole 3	..............m	pole 7	.................m
pole 4	..............m	pole 8	.................m

   c. All PDUs and PBs at least 500mm from kerb

      ☐

   d. Angled 25^o to 30^0 away from the crossing, except on islands or when

      ☐

      see- through is a problem?

      if not angled at 25^o to 30^0, estimate of angle .... ^{o}

   e. narrow field of view ☐ or ‘standard’ PDUs?

      ☐

   f. High level repeaters or separate push buttons and high level indicators installed where required? ☐ Not required

      ☐

2. Only near-side indicators used?

   ☐

3. Audible devices (if used) are unambiguous?

   ☐

4. No problems with “see-through”?

   ☐

5. Method of control?

VA system D ☐ VA + SA ☐ VA + SD ☐ MOVA ☐ SCOOT ☐ Fixed time UTC ☐

VA + MVDs ☐

6. Kerbside detectors installed? ☐ not installed? ☐

   a. Detect 1.2m from kerb? ☐ or to back of normal pedestrian waiting area if >1.2m? ☐

   b. Detect over full width of waiting area (full width of tactile paving)? ☐

   c. Hold pedestrian demand? ☐

7. On-crossing detectors installed? ☐ not installed? ☐

   a. Cover full width of crossing, including close to the kerb? ☐

   b. Extend the all-red (each detector independently)? ☐

   c. Is there a working fixed all red period? ☐

8. Crossing width …………….……m Crossing length …………………..m

   Crossing width …………….……m Crossing length …………………..m

9. Are any approaches "high-speed"? ☐

10. Are there any factors that require an increase in the invitation to cross period?

    a. Heavy pedestrian flows ☐

b. Crossing longer than 11m

☐

c. Central refuge installed

☐

d. Space in the pedestrian waiting area is limited

☐

e. High proportion of disabled, elderly or slower moving pedestrians

☐

f. Schools nearby

☐

11. Signal timings from: documentation ☐ interfacing the controller ☐ measurement ☐

12. List timings

Period in Puffin sequence	1	2	3	4	5	6	7	8	9
Duration (s)									
Recommended in Good Practice Guide (complete in office)									
Recommended timings according to LTN 2/95									
Difference if considered significant									

13. Record any documented changes in timings

14. Record any significant entries from the log, faults and other significant changes

15. Other comments

Appendix B Junction site assessment method

Assessment of signal controlled junctions with Puffin type pedestrians crossing facility– method statement

General conditions of work

All the work by TRL staff shall be undertaken in accordance with the TRL policy on working on or near the highway, sub-contractors must provide satisfactory, compatible working procedures checked by TRL before work starts. If at any time the observer identifies potential hazards that are not addressed in the risk assessment, then work should be ceased until further guidance is sought. There are several specific factors that need to be observed in this work.

Local Authority

Try to obtain a site plan and signal timings from the local authority as part of the sifting process to decide which sites to visit.
Before visiting any site, contact the local authority to inform them of the work to be done and request permission to open the controller to consult the documentation stored there and if necessary to interface to the controller as detailed below.

Access to the controller

Access to the controller will normally be required to consult the documentation stored there. If the information is available in advance from the LA then it should be examined before the visit. If the documentation is not in the controller, then the LA should be approached for the information. The information to be extracted from the documentation is:

- Signal timings
- Historical record of changes to signal timings
- Significant events in the paper log that could have affected the collision record at the site

The controller must only be opened by a competent person with the permission of the local authority and in dry conditions. If the timings cannot be obtained from the documentation, it will be desired to interface to the controller to obtain them. However, such interfacing must have the explicit authorisation of the local authority and be undertaken by a competent person who meets all the local authority qualification requirements. Suitable terminal equipment should be used and the timings extracted in accordance with the manufacturer's instructions, without changing the timings or any other aspect of the controller operation. Again, timings may be available in advance from the LA, in which case it will not be necessary to obtain them from the controller.
Checking of the detector operation will also be simplified by use of a handset interfaced to the controller. The LED indicators on the kerbside detectors can be difficult to see from parts of the waiting area. It may not be possible to tell whether the LED is off, or cannot be seen because of obscuration by other internal parts of the detector. Also the coverage of the crossing by the on-crossing detectors is most easily checked with a handset, which will show whether either detector is on without needing observers watching both detectors and communicating with each other. Even with a handset, two people will be needed to monitor detection operation.

Installation and operation

Check that the installation of the pedestrian facilities is in accordance with the Puffin Good Practice Guide. A measuring wheel is the easiest way of measuring the width and length of the crossing.

Pedestrian Demand Units and Pushbuttons

Pedestrian Demand Units, PDU, (push button *and* nearside pedestrian signals) should be installed not more than 500mm from the line of the crossing, aligned so that waiting pedestrians looking at the display will be facing oncoming traffic, but angled at 25 to 30 degrees away from the crossing and at least 500mm back from the kerb. PDUs can be mounted at the back of the crossing where it is necessary: on narrow footways or where there are problems with utilities' services. Nearside and farside indicators should not be mixed at the same site (we will have rejected the site without a visit if mixed indicators were shown on the supplied site plan) and, preferably not mixed at sites that are close together.

Audible devices should not be used where there is a possibility of confusing pedestrians as to which pedestrian stage is running, e.g. at staggered mid-block crossings. Again the site would be rejected where such problems show on diagrams supplied before visiting the site.

Check for see-through, particularly at islands at junctions, staggered crossings and straight across crossings with a central reserve. Assess whether Narrow Field of View (NFV) PDUs would avoid any problems observed. If uncertain whether NFV have been used, it will be necessary to check with the LA.

Check that high-level repeater pedestrian signals are installed at busy, wide crossings where otherwise not all pedestrians would be able to see an indicator.

Method of control

The method of control should be ascertained: VA, VA + SA, VA + SD, MOVA, SCOOT or Fixed-Time UTC.

Kerbside detectors

Kerbside detectors are normally used at junction traffic signals with Puffin facilities, but may be omitted if pedestrian flows are very high, or all pedestrian phases run in parallel with a major traffic movement.

If installed, check the operation of the kerbside detectors by operating the pedestrian demand button and then standing in relevant areas of the waiting area to check that the demand is held. It will be necessary to undertake this test when there are no other pedestrians in the waiting area, or where there is a single pedestrian, the observer should remain outside the waiting area and observe the operation of the pedestrian phase and of the detector. The operation of the detector can be observed by the LED indicator, when visible, or via a handset plugged into the controller. If there are no other pedestrians on the same side of the road, but pedestrians wishing to cross from the other side, the test of detector function can be undertaken by observing the detector LED, or handset. However, a test must be made with no pedestrians on the far side to check that operation of the kerbside detector does hold the pedestrian demand in the controller and the pedestrian stage runs as expected. To avoid frustration to motorists it will be advisable to cross the road during the pedestrian stage when no other pedestrians use the crossing.

Check that the detection area covers all the expected pedestrian waiting area, at least up to 1.2m from the kerb, but greater where pedestrians stand back because of high speed vehicles, danger of being splashed etc. Also check that the detector operates over the full width of the crossing, particularly at wide crossings. The extent of the detection zone can be checked by standing in the waiting area and observing the LED on the detector or a colleague observing the controller handset.

On-crossing detectors

On-crossing detectors may be omitted at junctions for parallel pedestrian phases, or where the crossings are very short (the guidance states, "say less than six metres wide"). Checking the operation of the on-crossing detectors, when used, requires an observer to cross the road in person, or observe the operation when others cross, and do not complete crossing before the end of the fixed all red period. When a member of TRL staff crosses the road, the second observer must watch for potential vehicle hazards as well as observe the operation of the detector and signals. If the all red period ends whilst a pedestrian is still on the crossing there is a potentially dangerous situation. The pedestrian will have no warning of the danger unless he or she can see a secondary vehicle signal and looks at it.

The initial check will be to observe the LED indicators in the on-crossing detectors, or the controller handset, whilst the observer crosses or observes others crossing. If the indicators fail to light, or the handset indicates no detection, as pedestrians cross, then the observer should contact the local authority to report the fault and cease work at the crossing. Figure 1 shows the idealised detection zones, in practice the zones are lobes rather than triangles with straight lines. For wide crossings, check that the on-crossing detectors cover the full width of the crossing.

The second check is that controller correctly acts on the "on" indication from the on-crossing detectors. This check is most easily and safely for the observer, undertaken when others cross. With normal timings, the vehicle starting amber will occur 2 or 3 seconds (the length of the fixed all red period) after the end of the invitation to cross if no pedestrians are detected on the crossing. The operation of the crossing should be observed until the observer is satisfied that the controller is responding correctly to the on-crossing detectors. N.B. both on-crossing detectors can be activated at the same time. The correct operation can only be verified when each detector has been observed working on its own. It will probably require an observer to cross on their own starting in an area covered by only one detector. The extensions should cease very soon after the pedestrian reaches the footway and leaves the carriageway.

Ideally, we need also to check the safety critical aspect that pedestrians entering the crossing at the end of the fixed all red period are detected. However, it is only possible to check this operation safely when there is no traffic approaching or waiting at the stopline and no interference from other pedestrians. If conditions allow the test, first determine the length of the fixed all red period, 2 or 3 seconds, then a pedestrian should step slowly on to the crossing just before the end of the fixed all red period. The on-crossing detectors are working properly if the all red period is extended until the pedestrian completes the crossing. The test should be repeated from the other kerb.

Factors affecting the timings

Period 3: All red following traffic

The all red period following traffic should normally be one second after a gap change, or one, two or three seconds after a maximum change. On "high-speed" (85^{th} percentile approach speed greater than 35 mph) the all red period may vary with a high value (normally three seconds) after a maximum change when a speed extension is still running and a lower value at other times. Record high-speed approaches.

Period 4: Invitation to cross

There are several factors that require the invitation to cross period to be longer than 4 seconds:

- Heavy pedestrian flows
- Length of the crossing greater than 11 metres
- A central refuge is provided
- Space in the pedestrian waiting area is limited
- Crossing on high-speed road
- A high proportion of disabled, elderly or slower moving pedestrians or schools nearby

Checking the timings

If the timings cannot be obtained from documentation or by interfacing with the controller, they should be measured manually. If manual timing is required:

- Period 1 can be timed during periods of heavy traffic when no gap changes occur by timing from push button press to start of vehicle amber
- Periods 2 to 4 can be checked on any cycle:
  - 2 = length of vehicle leaving amber
  - 3= start vehicle red to start pedestrian green
  - 4 = length of pedestrian green
- Period 5 can be measured when no-one crosses. It is the length of all-red when the on-crossing detectors are not activated.
- Period 6, only relevant when on-crossing detectors are installed, may be measured at quiet times when there are no vehicles approaching. It requires an assistant to walk slowly across the crossing, activating the on-crossing detectors, until the start of vehicle red and amber. The test must be abandoned if any vehicle approaches such that it would be in the vicinity of the crossing by the end of the test walk. Period 6 = time from end of pedestrian green to start of vehicle red and amber minus period 5.
- Periods 7 and 8 can be assumed to be 0 (or will have been measured as part of periods 5 and 6).
- Period 9 = standard vehicle red and amber

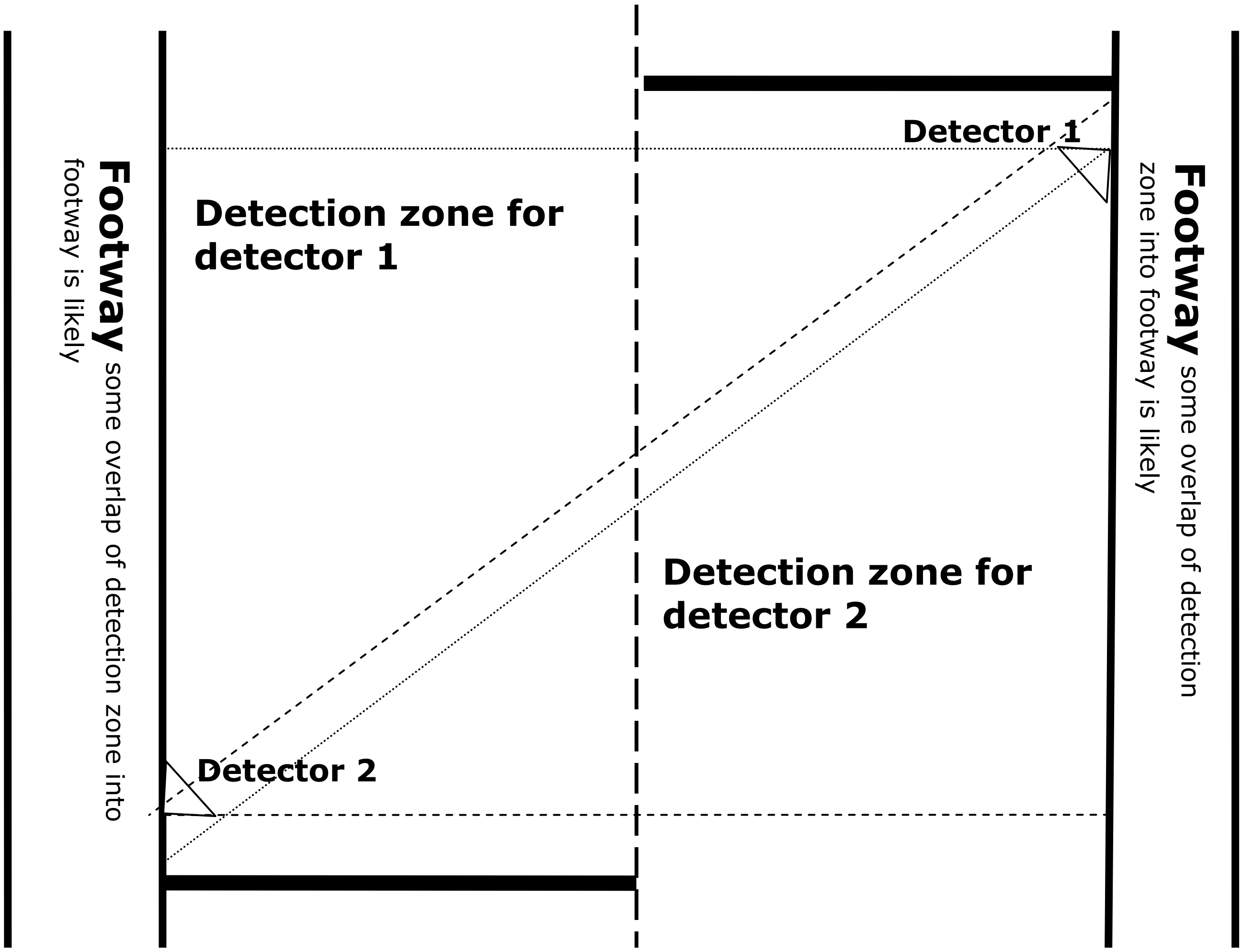

Figure 2: Idealised on-crossing detection zones

Junction (Puffin) crossing inspection checklist

Site:...Speed limit............

Observer..................................Date...................Start time..............End time..................

Crossing identification ....

16. PDU alignment:

    a. Within 500 mm of the line of the crossing for all PDUs and PBs?

       ☐

    b. Distance from Kerb edge to base of poles:

       pole …. ....m pole …. ....m
       pole ….. ....m pole …. ....m

    c. All PDUs and PBs at least 500mm from kerb

       ☐

    d. Angled 25° to 30° away from the crossing, except on islands or when

       ☐

       see- through is a problem?

       (if not angled at 25° to 30°, estimate of angle .... °)

    e. Narrow field of view ☐ or 'standard' PDUs?

       ☐

    f. High level repeaters or separate push buttons and high level indicators installed where required? ☐ Not required

       ☐

17. Only near-side indicators used?

    ☐

18. Audible devices (if used) are unambiguous?

    ☐

19. No problems with "see-through"?

    ☐

20. Method of control?

VA system D ☐ VA + SA ☐ VA + SD ☐ MOVA ☐ SCOOT ☐ Fixed time UTC ☐

VA + MVD ☐

21. Kerbside detectors installed? ☐ not installed? ☐

    a. Detect 1.2m from kerb? ☐ or to back of normal pedestrian waiting area if >1.2m? ☐

    b. Detect over full width of waiting area (full width of tactile paving)? ☐

    c. Hold pedestrian demand? ☐

22. On-crossing detectors installed? ☐ not installed? ☐

    a. Cover full width of crossing, including close to the kerb? ☐

    b. Extend the all-red (each detector independently)? ☐

    c. Is there a working fixed all red period? ☐

23. Crossing width ………………m Crossing length …………………..m

24. Are any approaches “high-speed”? ☐

25. Are there any factors that require an increase in the invitation to cross period?

    a. Heavy pedestrian flows ☐

b. Crossing longer than 11m

☐

c. Central refuge installed

☐

d. Space in the pedestrian waiting area is limited

☐

e. High proportion of disabled, elderly or slower moving pedestrians

☐

f. Schools nearby

☐

26. Signal timings from: documentation ☐ interfacing the controller ☐ measurement ☐

27. List timings

Period in Puffin sequence	1	2	3	4	5	6	7	8	9
Duration (s)									
Recommended in Good Practice Guide (complete in office)									
Recommended timings according to LTN 2/95									
Difference, if considered significant									

28. Record any documented changes in timings

29. Record any significant entries from the log, faults and other significant changes

30. Other comments

Appendix C Detailed results from the site inspections

The tables below summarise the main results from the site inspections for all sites and sites included in the accident analysis.

Table C.1 shows the sites visited that had all installed pedestrian detection functioning. This was undertaken by observation of the overhead detector LED indicator for and the operation of the push button unit. For this investigation only the operation was noted, the accuracy of the setup and performance of the detection are shown in further tables below.

Table C.1: Functioning pedestrian detectors

Mid-blocks	Accident analysis sites (40)	All inspected sites (58)
All installed detectors functional	32	47
Sites with one or more detectors switched off or not functional	8	11
Junctions	**Accident analysis sites (10)**	**All inspected sites (14)**
All installed detectors functional	6	10
Sites with one or more detectors switched off or not functional	4	4

The results show that the majority of sites had all pedestrian detectors functioning. Where there was non-functional detection this was usually associated with the kerbside detection, either apparently switched off, or a few sites with a permanent demand on one kerbside detector. At three sites a push button unit was recorded as not working.

The detection was tested to ensure setup and function were correct. A detailed explanation of the tests carried out can be found in the onsite methodology in Appendix A and B.

Table C.2 shows the mid-block sites where on-crossing detectors were recorded as working correctly and covering the full width and length of the crossing area as shown by the operation of the detector LED. It is important to note that in addition to the detector coverage, the extension provided by the detector (typically 0.5 seconds) and the controller (typically 1 second) provides coverage for those leaving the crossing, and the fixed all-red period after the green man (typically 3 seconds) provides coverage for those entering the crossing. Table C.3 shows the same information for junction on-crossing detection.

Table C.2: On-crossing detector coverage of mid-block crossings (excluding system coverage provided by extensions and fixed all-red)

Mid-blocks	Accident analysis sites (40)	All inspected sites (58)
Sites where on-crossing detectors covered full width of crossing and variable all-red operating	30	41
Sites where on-crossing detectors did not cover full width of crossing and variable all-red operating	10	16
Sites with on-crossing detection but fixed pedestrian clearance period	0	1
Sites with no on-crossing detection; fixed pedestrian clearance period	0	0

As can be seen on-crossing detection was used and operating at all but one of the mid-block sites surveyed. Where coverage was not complete the loss of coverage tended to be minimal and at the extremes of the crossing. In all cases the extension and fixed all-red period were operating and provided appropriate pedestrian clearance periods.

Installation standards tend to be authority specific, with some authorities obtaining complete detector coverage, as shown by the operation of the LED, at all sites. It was noted that on two sites without full detector coverage the on-crossing detectors were installed on the signal poles on either the upstream or downstream sides of the pedestrian crossing, rather than diagonally from one another as recommended.

The one site not using a variable all-red was under linked control to a neighbouring traffic signal junction. The all-red period was deemed short for the crossing width and reported to the highway authority. This site was not included in the accident analysis.

Table C.3: On-crossing detector coverage of junction crossings (excluding system coverage provided by extensions and fixed all-red)

Junctions	Accident analysis sites (10)	All inspected sites (14)
Sites where on-crossing detectors covered full width of crossing with variable all-red operating	4	6
Sites where on-crossing detectors did not cover full width of crossing with variable all-red operating	3	3
Sites with on-crossing detection but fixed pedestrian clearance period	1	2
Sites with no on-crossing detection; fixed pedestrian clearance period	2	3

On-crossing detection was used less at junctions than mid-blocks. In a number of cases this was because the variable all-red would not be utilised as the pedestrian phase finished well before a concurrent traffic phase. However, two of the three sites without on-crossing detection installed could have potentially benefited from the facility - both had all-round pedestrian stages. Also one of sites where the variable all-red was not operating could have benefited from the facility. It was not ascertained if this was due to a fault.

All three of the sites where on-crossing detection did not cover the full width of all the crossings was due to a poorly aligned detector. Each crossing uses pairs of detectors to achieve full coverage. All three junctions were four-armed with all-round pedestrian stages, which meant that reduced coverage on one detector of eight would usually not be shown by on-street operation.

Some of the six junctions with complete coverage did not have on-crossing detection on crossings that were very short or ran parallel with traffic phases.

Overall on-crossing detection appeared to operate well and reliably.

Table C.4 shows the operation of the cancel facility, and the kerbside detector coverage with respect to the recommendations in the *Puffin Crossings – Good Practice Guide*.

Table C.4: Kerbside detection coverage and operation of the cancel facility

Mid-block	Accident analysis sites (40)	All inspected sites (58)
Sites where kerbside detectors covered full width of waiting areas and cancel operating	3	3
Sites where kerbside detectors did not cover full width of waiting areas, and cancel operating	4	6
Sites with kerbside detection but cancel not operating	28	40
Sites with no kerbside detectors	5	9
Junction	**Accident analysis sites (10)**	**All inspected sites (14)**
Sites where kerbside detectors covered full width of waiting areas and cancel operating	1	1
Sites where kerbside detectors did not cover full width of waiting areas, and cancel operating	1	1
Sites with kerbside detection but cancel not operating	8	10
Sites with no kerbside detectors	0	2

A large number of sites did not have an operating cancel facility, although the vast majority of the detectors were apparently functional (Table C.1). Inspection of the controller specification showed a number of sites where the demands for the pedestrian stage where configured as 'latched' – i.e. the cancel facility was set not to operate in the original configuration. It is also likely that some authorities or their maintenance contractors may have purposely disabled the cancel facility to avoid perceived problems.

The two junction sites without kerbside detectors always ran the pedestrian phases in conjunction with main road phases and as such the cancel facility was not needed. A number of the mid-block sites ran pre-timed max, and as such should present very few opportunities to cancel demand. The vast majority of the other mid-blocks ran Vehicle Actuation which also should present limited opportunity to cancel, although it should be noted that a few site reports alluded to vehicle overhead detection being aligned too far downstream, thus failing to detect reasonable gaps in the traffic.

The sites with operating cancel facilities where recommended kerbside detection coverage was not achieved did tend to cover the greater majority of the area with small patches at the extremes lacking coverage. However, one site failed to detect pedestrians waiting close to the kerb, and incorrect cancelation of the demand was shown. Inspection of the coverage where the cancel facility was not operating showed around 60% of sites not covering the recommended area in the *Good Practice Guide*. Again this tended to be small patches at the edges. Problems of coverage could explain why some kerbside detection was not set to operate.

The large number of sites operating without the cancel facility could also be indicative of perceived reliability and operational issues associated with experience of early kerbside detection (Section 5.4.5.). Technological advances by detection manufacturers have made substantial improvements to this situation. The study sites used detection from a variety of different manufacturers and ages.

Table C.5 records the numbers of sites where the layout of the site deviated from the *Puffin Crossings - Good Practice Guide* - separated by deviations from the recommended angle of Pedestrian Demand Unit (PDU), which was by far the most common deviation.

Table C.5: Layout in accordance with DfT Puffin guidance

Mid-blocks	Accident analysis sites (40)	All inspected sites (58)
Sites where layout did not deviate from DfT Puffin Guidance	23	30
Sites where layout did not deviate except angle of PDU	11	18
Sites with other layout deviations from guidance	6	10
Junctions	**Accident analysis sites (10)**	**All inspected sites (14)**
Sites where layout did not deviate from DfT Puffin Guidance	6	6
Sites where layout did not deviate except angle of PDU	3	3
Sites with other layout deviations from guidance	1	5

The recommended angle for the PDU is 25 to 30 degrees to the kerb face pointing into the footway except on islands or where poles are mounted at the back of the footway due to narrow pavements. This angle aligns pedestrians view with on-coming traffic, facilitates pedestrians in the waiting area to see the indication, and reduces potential glare to off-side vehicles from the PDU. Alignments approximate to the recommended where judged within the guidance. Deviations away from the guidance tended to be Authority based. Two Authorities tended to use zero degrees and one Authority forty-five degrees.

Six sites had on-crossing detectors opposite each other, rather than diagonally which provides better on-crossing coverage. Two of these sites did not provide full detection coverage of the crossing (as described below Table C.3).

At two sites the inspectors commented that a high-level repeater could have been beneficial due to high pedestrian demand.

Other deviations included poles being located too close to the carriageway or too far from the edge of the tactile paving, and Push Button Unit heights. A few sites had Push Button Units height less or greater than recommended. It should be noted that in most cases the recorded deviations of layout were minor.

Appendix D Sites included in the accident analysis

Site address	Local Authority	Site type
A13 London Road (West of High Street) - South Benfleet	Essex County Council	Mid-Block
A130 Long Road - Canvey Road - Haven Road - Canvey Island	Essex County Council	Junction
A23 Streatham Hill by Wavertree Road	London (Transport for London)	Mid-Block
A259 Clinton Place - Seaford	East Sussex County Council	Mid-Block
A259 Elm Court - Newhaven	East Sussex County Council	Mid-Block
A259 Warwick Road - Seaford	East Sussex County Council	Mid-Block
A3005 Norwood Road by Harewood Terrace - Ealing	London (Transport for London)	Mid-Block
A304 Fulham Road by Holmead Road – Hammersmith	London (Transport for London)	Mid-Block
A325 Union Street - Farnborough Road - Farnborough	Hampshire County Council	Mid-Block
A5 Edgeware Road by Spring Villa Road - Barnet	London (Transport for London)	Mid-Block
Adswood Rd/Garners Ln (ex 7/141)	Greater Manchester	Junction
B1007 Writtle Road - New London Road - Elm Road - Chelmsford	Essex County Council	Junction
B184 High Street - Great Dunmow	Essex County Council	Mid-Block
B186 Kings Road (outside Station) - Brentwood	Essex County Council	Mid-Block
B550 Colney Hatch Lane by Poplar Grove	London (Transport for London)	Mid-Block
Bickington Road by Old Torrington Road – Barnstaple	Devon County Council	Mid-Block
Buxton Rd N of Cherry Tree Lane - Stockport	Greater Manchester	Mid-Block
Buxton Rd/Nangreave Rd	Greater Manchester	Junction
Exeter Rd - Braunton	Devon County Council	Mid-Block
Fulford Road by Broadway	York City Council	Junction
Fulford Road by Hospital Fields Road	York City Council	Junction
Haleys terrace by Huntington Road by Fossway	York City Council	Junction
High Street - Gilda Crescent. Polegate	East Sussex County Council	Mid-Block
High Street - Lymington	Hampshire County Council	Mid-Block
High Street / Dene Drive - Winsford	Cheshire County Council	Junction
High Street / Dingle Lane - Winsford	Cheshire County Council	Junction
Hoole Road near Faulkner Street - Chester	Cheshire County Council	Mid-Block
Hoole Road near Lightfoot Street - Chester	Cheshire County Council	Mid-Block

Site address	Local Authority	Site type
Hoole Road near Newton Lane - Chester	Cheshire County Council	Mid-Block
Hoole Road near Park Drive - Chester	Cheshire County Council	Mid-Block
Howell Croft South N of Ashburner Street - Bolton	Greater Manchester	Mid-Block
King St west of Gradwell Street - Stockport	Greater Manchester	Mid-Block
Lady Margaret Road by Cornwall Avenue - Ealing	London (Transport for London)	Mid-Block
Liverpool Rd E of Mather Road - Salford	Greater Manchester	Mid-Block
Liverpool Rd E of Thorp Street - Salford	Greater Manchester	Mid-Block
London Road (Hooke Hall). Uckfield	East Sussex County Council	Mid-Block
Magdalen Street, Near Southernhay East – Exeter	Devon County Council	Mid-Block
Nantwich Road near Bedford Street - Crewe	Cheshire County Council	Mid-Block
Nantwich Road near Ernest Street - Crewe	Cheshire County Council	Mid-Block
Parsons Green lane by Novello Street - Hammersmith	London (Transport for London)	Mid-Block
Princess Rd, North of Raby Street – Manchester	Greater Manchester	Mid-Block
Princess Rd, South of Darley Ave - Manchester	Greater Manchester	Mid-Block
Queen Street - near multi-storey - Barnstaple	Devon County Council	Mid-Block
Station Road by Swan Road	London (Transport for London)	Mid-Block
Uxbridge Road by Longfield Avenue - Ealing	London (Transport for London)	Mid-Block
Vernon Way / Badger Avenue - Crewe	Cheshire County Council	Junction
Wellington Rd North, North of Brackley Rd – Stockport	Greater Manchester	Mid-Block
Wellington Rd North, South of Milwain Dr – Stockport	Greater Manchester	Mid-Block
West End Road by Edwards Avenue - Hillingdon	London (Transport for London)	Mid-Block
Western Way, Near Paris Street - Exeter	Devon County Council	Mid-Block

Appendix E Detailed accident data

Table E.1: Accidents by site and type of control

Site	Site type	Pelican		Puffin	
		Site years	Accidents	Site years	Accidents
1	Junction	3	5	4.50	6
2	Junction	3	3	2.75	3
3	Junction	3	1	2.50	2
4	Junction	3	1	1.50	2
5	Mid-block	3	1	3.75	0
6	Mid-block	3	7	3.75	3
7	Mid-block	3	1	3.00	4
8	Mid-block	3	9	3.50	4
9	Mid-block	3	2	3.25	3
10	Mid-block	3	2	3.25	3
11	Junction	3	4	4.75	1
12	Junction	3	6	3.75	9
13	Junction	3	8	4.00	9
14	Junction	3	13	4.25	11
15	Mid-block	3	15	4.50	11
16	Mid-block	3	2	4.25	3
17	Mid-block	3	2	7.50	10
18	Mid-block	3	12	7.50	7
19	Mid-block	3	6	5.75	16
20	Mid-block	3	4	3.50	1
21	Mid-block	3	1	4.25	1
22	Mid-block	3	2	3.25	1
23	Mid-block	3	3	4.50	2
24	Mid-block	3	0	3.25	0
25	Mid-block	3	0	4.25	4
26	Mid-block	3	4	4.25	4
27	Mid-block	3	1	4.25	1
28	Mid-block	3	21	4.25	20
29	Mid-block	3	7	4.25	5
30	Mid-block	3	11	4.00	7
31	Mid-block	3	6	4.50	8
32	Mid-block	3	3	4.25	5
33	Mid-block	3	14	4.25	17
34	Mid-block	3	3	4.25	2
35	Mid-block	3	4	4.75	2
36	Mid-block	3	2	3.00	1
37	Mid-block	3	2	4.00	6
38	Junction	3	9	3.25	4
39	Junction	3	6	2.75	4
40	Mid-block	3	0	6.75	7
41	Mid-block	3	8	7.50	10
42	Mid-block	3	2	7.50	9
43	Mid-block	3	6	10.00	23
44	Mid-block	3	3	6.50	9
45	Mid-block	3	10	4.25	17
46	Mid-block	3	5	2.75	3
47	Mid-block	3	2	4.75	9
48	Mid-block	3	3	5.00	4
49	Mid-block	3	8	7.50	32
50	Mid-block	3	16	7.50	33
All mid-block crossings		120	210	193	307
All junctions		30	56	34	51
Total		150	266	227	358
Accident frequency			1.77		1.58

Table E.2: Pedestrian accidents by site and type of control

Site	Site type	Pelican		Puffin	
		Site years	Accidents	Site years	Accidents
1	Junction	3	1	4.50	0
2	Junction	3	0	2.75	0
3	Junction	3	0	2.50	1
4	Junction	3	0	1.50	0
5	Mid-block	3	0	3.75	0
6	Mid-block	3	2	3.75	0
7	Mid-block	3	1	3.00	2
8	Mid-block	3	4	3.50	1
9	Mid-block	3	1	3.25	0
10	Mid-block	3	0	3.25	0
11	Junction	3	0	4.75	0
12	Junction	3	0	3.75	1
13	Junction	3	4	4.00	3
14	Junction	3	5	4.25	3
15	Mid-block	3	4	4.50	3
16	Mid-block	3	0	4.25	0
17	Mid-block	3	0	7.50	3
18	Mid-block	3	6	7.50	2
19	Mid-block	3	3	5.75	10
20	Mid-block	3	1	3.50	0
21	Mid-block	3	0	4.25	0
22	Mid-block	3	1	3.25	1
23	Mid-block	3	2	4.50	2
24	Mid-block	3	0	3.25	0
25	Mid-block	3	0	4.25	4
26	Mid-block	3	2	4.25	0
27	Mid-block	3	1	4.25	0
28	Mid-block	3	8	4.25	6
29	Mid-block	3	2	4.25	1
30	Mid-block	3	2	4.00	2
31	Mid-block	3	1	4.50	2
32	Mid-block	3	1	4.25	2
33	Mid-block	3	6	4.25	4
34	Mid-block	3	1	4.25	0
35	Mid-block	3	0	4.75	0
36	Mid-block	3	1	3.00	1
37	Mid-block	3	0	4.00	2
38	Junction	3	1	3.25	0
39	Junction	3	0	2.75	1
40	Mid-block	3	0	6.75	3
41	Mid-block	3	2	7.50	2
42	Mid-block	3	1	7.50	3
43	Mid-block	3	0	10.00	2
44	Mid-block	3	0	6.50	2
45	Mid-block	3	5	4.25	7
46	Mid-block	3	3	2.75	2
47	Mid-block	3	1	4.75	6
48	Mid-block	3	1	5.00	2
49	Mid-block	3	1	7.50	4
50	Mid-block	3	2	7.50	3
All mid-block crossings		120	66	193	74
All junctions		30	11	34	9
Total		150	77	227	93
Accident frequency			0.50		0.38

Puffin pedestrian crossing accident study

Puffin facilities were developed to replace Pelican crossings at mid-block sites and farside pedestrian signals at junctions. Research has shown that compared to existing pedestrian signal facilities, Puffin facilities can reduce both driver and pedestrian delay at junctions, and improve pedestrian comfort (particularly for older pedestrians and those with impaired mobility). Previous research has also indicated safety benefits. The aim of this study was to quantify the safety benefit. Accident data was analysed from 50 sites (40 mid-block crossings and ten junctions) that had been converted to Puffin facilities from Pelican crossings and farside pedestrian signals at junctions. The sites had no other significant changes in layout or operation, and were in general conformance with current DfT Puffin guidance. The results of the on-street inspection are reported. Statistical analysis was undertaken by using a generalised linear model which included time trends and seasonal factors. "Before" and "after" conversion accident data was paired together for each site, negating any biases for particular site factors. Mid-block Puffin crossings were shown to be safer than Pelican crossings with a mean reduction in personal injury accident frequency of 17%, statistically significant at the 5% level. The accident frequency reduction for the combined sample including junctions was 19%, statistically significant at the 5% level.

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