Test of Traficon SafeWalk and C-Walk pedestrian detectors

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Executive summary

The Department for Transport commissioned TRL to assist in the development of vehicle and pedestrian systems for urban traffic management. One of the strands of the work is to assess the performance of new detection systems.

Puffin crossings are designed to make more time available for pedestrians to cross when they need it, but improve network efficiency by cancelling unwanted pedestrian demands so traffic is not stopped unnecessarily. Their safe and efficient operation relies on accurate detection of pedestrians.

Traficon provided two of their products to be assessed for use at Puffin crossings and junctions with Puffin facilities. The SafeWalk is a pedestrian kerbside detector, and the C-Walk provides on-crossing functionality.

The overall performance of the both the SafeWalk and the C-Walk detectors was very good. The SafeWalk was able to rapidly detect and track pedestrians entering and leaving the wait area, and stationary pedestrians within it, at ambient light levels down to 5 lux, well below the minimum level of illumination that should be present at any pedestrian crossing. The stereovision detection worked well at ignoring shadows and objects close to the ground.

The C-Walk was also able to quickly detect pedestrians stepping onto the crossing and also ensured the detection was dropped once the crossing had been completed. It remained fully operational as light levels fell below 10 lux which should be more than acceptable for any crossing in the UK. Unlike the SafeWalk, shadows from pedestrians walking nearby which project into the detection zone will trigger a detection. Shadows from nearby trees do not appear to be an issue.

On-site configuration of both products was relatively quick, with the detection zones being drawn on a camera image using a laptop. Some experience will be needed in order to ensure the angle of the camera view is accounted for when defining the zones. It isn’t quite as simple as drawing around the wait area or crossing carpet. To achieve optimum performance the torso of the pedestrian must be in the detection region rather than just the legs.

Both products are easier to setup and perform better the closer the camera is to having a plan view of the scene, i.e. the higher they are mounted the better. Mounting on an extension pole at least 0.5m above the top of the signal pole gives a noticeable difference.

It was noted that both products are unable to meet the respective specifications in terms of startup time after power failure, which demand normal operation within 5000ms. The SafeWalk was observed to take almost a minute, though Traficon state that the next firmware update will cut this to less than 10 seconds to match that of the C-Walk. Whilst still longer than specified, the output is set to permanent demand during this period, and thus this is unlikely to have any practical implications.
Abstract
The Department for Transport commissioned TRL to assist in the development of vehicle and pedestrian systems for urban traffic management. One of the strands of the work is to assess the performance of new detection systems. TRL tested the Traficon C-Walk pedestrian on-crossing detector and the SafeWalk kerbside detector to ensure they met the requirements of TR2506 and TR2507 respectively. Testing took place at TRL’s test track facility, under a variety of conditions. This report details the results of the testing.

1 Introduction
The Department for Transport commissioned TRL to assist in the development of vehicle and pedestrian systems for urban traffic management. One of the strands of the work is to assess the performance of new detection systems.

Puffin crossings are designed to make more time available for pedestrians to cross when they need it, but improve network efficiency by cancelling unwanted pedestrian demands so traffic is not stopped unnecessarily. Their safe and efficient operation relies on accurate detection of pedestrians.

Traficon provided two of their products to be assessed for use at Puffin crossings and junctions with Puffin facilities. The SafeWalk is a pedestrian kerbside detector, and the C-Walk provides on-crossing functionality.
2 Detection requirements

2.1 Pedestrian kerbside

The kerbside detector, or kerbside function of a multi-purpose detector, should detect pedestrians waiting to cross so that the controller can maintain the request for a pedestrian stage. When there are no pedestrians waiting to cross, the detector should provide an indication to the controller that it should drop the request for the pedestrian stage. The controller will not drop the request unless there are no waiting pedestrians detected in any relevant waiting area, e.g. on both sides of a simple crossing.

The requirements are defined in TR2507 and must be met. In summary, the detector must respond to a minimum size pedestrian (having a height greater than or equal to 1 metre, width 0.5 metre, depth 0.2 metres, mass of 20 Kg) in the “must detect” zone. It must also detect a person in a wheelchair. In addition, it must not respond to a maximum sized pedestrian in the “must not detect” zone. See TR2507 for definitions of the “must detect” and “must not detect” zones.

In addition to the performance specified by TR2507, the following criteria should be met in order for the product to be fit for purpose. The specific requirements are:

- The detector should operate normally during changes in illumination, both slow changes during the day and abrupt changes, such as a dark cloud passing in front of the sun.
- It should operate normally when precipitation changes the appearance of the pavement.
- It should operate in all lighting conditions that may occur on-site, including partial failure of street lighting.
- It should not detect shadows of objects that are outside the detection zone moving across the waiting area.
- It should cover the whole waiting area at an acceptable cost (requiring many expensive units each with a small detection zone to cover the whole waiting area is not an acceptable solution).
- It should not require special infrastructure for mounting. A special bracket to fit onto an existing structure, such as a signal pole is acceptable.
- It should be immune to expected vibration and movement of the chosen mounting structures.
- The detection zone should be easily set and checked on site. Drawing a detection zone on an image of the area is an example of a good method.
- The detector should not require routine maintenance, e.g. lens cleaning, more frequently than a traffic signal controller and signal aspects.

The requirement to detect in all lighting conditions is particularly important for image-based detection. It is unreasonable to expect such a detector to work in complete darkness; however, the failure of a single lamp should be anticipated. In practice, the manufacturer should specify the minimum lighting level at which the detector will operate as specified, and the Local Authority must then ensure maintenance schedules are sufficient to maintain at least that level of lighting.

2.2 Pedestrian on-crossing

The on-crossing function is used to maintain the all-red period whilst pedestrians are on the crossing. The basic specification is given in TR2506. In addition, the following criteria should also be met:
The detector should operate normally during changes in illumination, both slow changes during the day and abrupt changes, such as a dark cloud passing in front of the sun.

- It should operate normally when precipitation changes the appearance of the pavement.
- It should operate in all lighting conditions that may occur on-site, including partial failure of street lighting.
- It should not require special infrastructure for mounting. A special bracket to fit onto an existing structure, such as a signal pole is acceptable.
- It should be immune to expected vibration and movement of the chosen mounting structures.
- The detection zone should be easily and accurately set and checked on site to avoid detecting pedestrians on the footway, but to detect those stepping onto the carriageway. Drawing a detection zone on an image of the area is an example of a good method.
- The detector should not require routine maintenance, e.g. lens cleaning, more frequently than a traffic signal controller and signal aspects.

Detection of slow moving pedestrians has previously been an issue with microwave detectors which detect pedestrians stepping on to the crossing from the far side, at the limit of their range. A detector should be able to detect all pedestrians within 500ms of entering the crossing, irrespective of walking speed.

### 2.3 Image-based detection

One of the major factors influencing the performance of image-based detection systems is their performance when visibility is poor. Over the relatively short distances that pedestrian crossings cover, this essentially amounts to low light level performance.

The design of pedestrian crossings and associated lighting requirements are described in a number of documents:

- **LTN 2/95. The design of pedestrian crossings.**
- **ILE 12. Institute of Lighting Engineers Technical Report 12. Lighting of pedestrian crossings.**
- **BS EN 13201-2:2003. Road lighting – Part 2: Performance requirements.**

The lowest requirement class for pedestrian crossings (CE3) has an average maintained horizontal illuminance ($\bar{E}$) of at least 15 lux, with uniformity ($U_0$) of 0.4 (Table 2, BS EN 13201-2). In theory, this means that the darkest point should have horizontal illuminance of at least $15 \times 0.4 = 6$ lux.

BS 5489, section 11.5.1.3 states that "local lighting should have a strong vertical component". ILE 12 section 9.9 gives an example calculation of the vertical illuminance ($E_v$) required for various areas of pedestrian crossings. Using this, the calculated minimum level of illumination that should be provided is $15 \times 1.5 = 22.5$ lux.

In practice, factors such as vegetation growth and lamp maintenance may result in light levels as low as 5 to 10 lux in the wait area, with the crossing itself slightly better illuminated. Whilst this should be the exception rather than the norm, it provides a reasonable target performance criteria for image-based pedestrian detection systems.
3 Products tested

Traficon provided their two pedestrian detection products, SafeWalk and C-Walk, which together fulfil the pedestrian detection requirements for Puffin crossings. Figure 1 shows an installation of the two products.

Figure 1: Traficon C-Walk (left) and SafeWalk (right) mounted on signal pole
3.1 Traficon SafeWalk

The SafeWalk pedestrian kerbside detector uses twin CMOS sensors to produce a stereo image of the scene. This allows objects close to the ground (fallen leaves, litter, etc) and sudden changes in pavement reflectivity (due to shadows or precipitation) to be ignored when analysing the scene.

Setup of the detection zone is achieved by connecting a laptop to the SafeWalk by Ethernet cable and simply dragging the edges of the region on an overlay of the background image. The region must be drawn larger than the required detection zone to ensure a pedestrian with their feet in the required detection zone also has their torso or head in the selected region of view from the camera, remembering that anything up to approximately 0.5m from the ground is ignored. This is particularly apparent at the furthest distance from the detector, where the selected region may need to extend 2m beyond the required detection zone. The simple solution is to use a colleague to stand at each corner of the required detection zone, refresh the image from the SafeWalk and set the corresponding corner of the defined region accordingly.

In addition to the detection region, it is possible to set additional criteria for detection, such as direction of movement of the detected object or requiring an object to remain stationary for a period of time before detection is triggered. Both options allow additional flexibility to cater for site-specific issues. For example, adding a delay to ensure a pedestrian is stationary for 1 second would allow pedestrians simply walking through the zone to be ignored, whereas those waiting to cross would still be detected in a timely manner. Delays can also be configured when dropping a target which has left the zone. Overall, setup was quick and easy and should be immediately intuitive to an engineer on-street.

The SafeWalk also produced a live video stream which can be viewed on the laptop to confirm correct operation. There is a delay of about 1 second on the video stream due to the MPEG encoding. (The detection signal to the controller is not affected by this delay.) The video shows targeting traces overlayed on the image so it is easy to identify where the pedestrian was first detected. As the SafeWalk is IP addressable, remote monitoring via the video stream is possible provided that a suitable IP link is available.

3.2 Traficon C-Walk

The C-Walk is a variant of the TrafiCam vehicle detector with the software modified for use at pedestrian crossings. As with the other TrafiCam products, it uses a single CMOS image sensor. The other features generally match those of the SafeWalk; notably the image-based setup of detection area, Ethernet connectivity and live MPEG4 video streaming. It is also worth noting that Traficon claim a response rate of <500ms for detection of objects within the zone.

Further details of both products can be found on the Traficon web site at www.traficonsensors.com or www.traficon.com.
4 Test site

The testing was carried out at the pedestrian crossing on TRL’s test track facility, shown in Figure 2. The site is located within a mature pine forest, with the road running approximately in an East-West direction. This results in varied and challenging lighting conditions during daylight, with a mix of bright sunlight and shadows across the wait area and carriageway.

Figure 2: Pedestrian crossing on TRL test track

Figure 3 gives a plan view of the crossing area. The kerbside tests were done at the right hand side wait area (as drawn).
5 Test procedure and results

Testing of the detectors took place on the TRL test track facility over several sessions. Each test session consisted of a setup and initial test period during the afternoon, followed by low-light testing at sunset. The test sessions were each approximately two months apart, allowing Traficon engineers to make improvements to the products. The results presented in this report are from the final test session for each product.

The recorded light levels were measured using a CEM DT-1300 light meter. Readings were checked against a second meter brought by Traficon and confirmed to be in agreement. Formal testing commenced once light levels had fallen to approximately 200 lux, and testing continued through to complete darkness. Finally, infra-red illuminators were then activated to assess performance in these conditions.

5.1 On-crossing tests

Two C-Walk cameras were installed, one on each side of the crossing, with the output of each connected to a buzzer so that an audible notification of detector outputs could be monitored during testing. Each detector was setup to cover the full crossing area so in theory both detectors should activate for any pedestrian on the crossing.

The following tests were carried out:

1. ensure a pedestrian stepping from the kerbside wait area onto the crossing is rapidly detected
2. ensure pedestrians on the kerbside are not detected
3. ensure a continuous detection signal is present (from either or both detectors) whilst a pedestrian is on the crossing
4. all extremities of the crossing area were covered, together with examination of the effects of walking speed, size of pedestrian and reflectivity of clothing
During informal testing in daylight conditions, all pedestrians were detected across the whole crossing area, with the detection output being present prior to the first footstep landing on the carriageway. Whilst not formally measured, the response times seemed to be broadly in line with the claimed sub 500ms.

The directional sensing functionality was also tested, which successfully produced the detection output for pedestrians crossing the road and ignored those walking along the road. It was also observed that shadows falling into the detection area from pedestrians walking outside of the area also triggered detection.

5.1.1 Test results

Detection at light levels at and above 20 lux were as for daylight conditions, with pedestrians detected at all points on the crossing. As light levels fell below 20 lux, the first signs of degradation started to become apparent.

A test pedestrian walking at approximately 1 m/s entered the carriageway from various locations in the wait area. The following Figures show red arrows marking the parts of each crossing where the detector output was not on. An arrow is drawn if the pedestrian placed a foot on the carriageway prior to detection, and the length of the arrow represents the distance covered (and hence time delay) before the pedestrian was detected. The Figures should not be interpreted as areas where detection is not possible. Pedestrians travelling in the opposite direction were successfully detected at the same locations. In general, once the pedestrian was successfully detected, the detection was maintained until the opposite carriageway.

Figure 4 shows the performance at an ambient light of 10 lux. Figure 5 is at 5 lux, and Figure 6 at 3 lux. In all cases the test pedestrian was wearing dark clothing.

Figure 4: On-crossing detection at 10 lux
Figure 5: On-crossing detection at 5 lux  

Figure 6: On-crossing detection at 3 lux  

Figure 6 shows the first instance of an acquired detection being temporarily dropped before the crossing was complete.  

Pedestrians were still detected even below 3 lux, however this was much less reliable. If the pedestrian was wearing light coloured or reflective clothing, performance improved noticeably.
5.2 Kerbside tests

The SafeWalk was initially installed on a 90° mounting bracket so that the view of the wait area was not obscured by the secondary signal head (see Figure 2 and Figure 7). The wait area was drawn in the setup software to match the area covered by 8x3 tactile paving slabs, equivalent to 3.2m along the kerbside and 1.2m back. Once again, the output was connected to a buzzer for convenience during testing.

Testing was carried out by means of the following tests:

1. a stationary pedestrian is detected on each paving slab in the defined wait area
2. a moving pedestrian entering the zone along each of the boundaries is rapidly detected
3. detection is rapidly dropped when the last pedestrian leaves the zone
4. the effects of different clothing (dark/light) and different sizes of pedestrian were examined

Initial testing showed good performance overall and also revealed the areas in which the product would have the greatest difficulties. The low mounting position made it difficult to cover the full wait area with the detection zone, and the detector performance deteriorated as the angle of view became further from vertical. This was particularly apparent once light levels faded.

For the final test session, Traficon brought their own mounting bracket for the SafeWalk, raising it to approximately 4m height. Having previously identified that the portion of the wait area furthest from the detector was where any detection problems were likely to
occur, this test was to use a wait area of the maximum size that a single detector would be expected to cover: 4m wide and 3m deep. Space constraints necessitated marking out this zone on the carriageway rather than the kerbside, effectively rotating the detector $90^\circ$ from its usual orientation.

### 5.2.1 Test results

A test pedestrian entered the wait area from a number of points around the extremities of the wait area to ensure rapid detection and that detection was maintained as the pedestrian moved through the zone then stood still. A laptop connected to the SafeWalk allowed viewing of the video stream overlaid with the pedestrian traces that had been detected and tracked.

The results were impressive. Even at 2 lux, the pedestrian was detected by the first footstep entering the wait zone. Pedestrians were still successfully detected at light levels below 1 lux, although it took a little longer for the detector to identify the pedestrian.

Viewing the video output gave an interesting insight as to how the product worked and thus the criteria for successful detection. The software tracking picked up on any light coloured clothing or exposed skin very quickly. If the pedestrian's face or even just a hand was visible in the image, detection was very quick. It needed a pedestrian dressed all in black with hood up and gloves on, facing away from the detector, before the detector entirely failed to get a fix on the target. Even then, the laptop display showed that a slight change in background image had been picked up, just not enough to trigger the detection output. The ambient light level at this time was 0.5 lux.
Figure 8 shows a screenshot from a laptop connected to the SafeWalk displaying the video stream output with detection overlays. There are several things to note from the image:

- The dotted pattern on the pedestrian’s head and arm highlights the parts of the image that the image processing algorithm has identified as potentially being an object of interest.
- The “+” symbol appears when an object has been positively identified and pinpoints the current location.
- The two lines to the right of the “+” symbol show the path the identified target has moved along. In this case the pedestrian has recently moved from right to left across the image.
- The rectangular border shows the detection region that has been configured, and the light colour of the border indicates the detector is currently on. The border is drawn in a darker shade when the detector is off. Note that the detection region extends beyond the area of tactile paving at the top of the image (the crossing studs are also visible as 4 white dots in the top right). This ensures that when a pedestrian stands at the far end of the wait area, some of their torso will be in the defined region rather than just the feet.

Further testing with IR illumination showed this to give equivalent performance to that at light levels of at least 100 lux. Whilst unlikely to be necessary in practice, the option is available for any installation where there may be concerns about the local lighting conditions.

A final observation was the start-up time after power failure. After briefly removing power to the SafeWalk, it required about a minute to return to full operation following restoration of the supply. This is one point where the SafeWalk does not meet the specification in TR2507:

TR2507 paragraph 2.27 – When power is restored, the Product shall resume normal operations within 5000ms.

During the startup period, the output is set to permanent demand, and Traficon have stated that the next update to the SafeWalk will cut the startup time to below 10 seconds, to match the C-Walk. A startup time of under 10 seconds should be of little concern in practice.
6 Conclusions

The overall performance of the both the SafeWalk and the C-Walk detectors was very good. The SafeWalk was able to rapidly detect and track pedestrians entering and leaving the wait area, and stationary pedestrians within it, at ambient light levels down to 5 lux, well below the minimum level of illumination that should be present at any pedestrian crossing. The stereovision detection worked well at ignoring shadows and objects close to the ground.

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Both products are easier to setup and perform better the closer the camera is to having a plan view of the scene, i.e. the higher they are mounted the better. Mounting on an extension pole at least 0.5m above the top of the signal pole gives a noticeable difference.

It was noted that both products are unable to meet the respective specifications in terms of startup time after power failure, which demand normal operation within 5000ms. The SafeWalk was observed to take almost a minute, though Traficon state that the next firmware update will cut this to less than 10 seconds to match that of the C-Walk. Whilst still longer than specified, the output is set to permanent demand during this period, and thus this is unlikely to have any practical implications.
Acknowledgements

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References


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