

IMPROVING PEDESTRIAN CROSSING INFORMATION USING PEDESTRIAN COUNTDOWN AT TRAFFIC SIGNALS (PCaTS)

Abstract

Pedestrian Countdown at Traffic Signals (PCaTS) have been widely deployed throughout the World. Research commissioned by Transport for London (TfL) identified that around two thirds of pedestrians did not understand far sided pedestrian signals displayed to them, in particular the black-out period and notably the function of the green man as an “invitation to cross”. PCaTS presented TfL with the opportunity to provide additional information to pedestrians in the form of a digital countdown display and the ability to optimise the signal timings more efficiently. Extensive research was undertaken by TfL in developing a solution, including investigating the previous deployment of PCaTS in other world cities, consultation regarding the visual appearance of the PCaTS units along with on and off street trials. In order to deploy the units on street, TfL worked closely with the Department for Transport (DfT) and Highways Agency (HA) to secure approvals to trial this new technology. On street trials have demonstrated that:

- PCaTS has been positively received and is well liked by the public
- PCaTS has reduced pedestrian uncertainty and more informed crossing choices are being made
- With the PCaTS package there are significant benefits to traffic

As a result of the trials, the DfT has granted permanent authorisation for PCaTS to remain at the 8 trial sites, and TfL continue to work with the DfT and HA to secure approvals for a roll-out across London.



PCaTS Unit at Southwark

1. Introduction – Identifying the need for PCaTS

In 2009, The London Road Safety Unit (LRSU) of TfL commissioned the Transport Research Laboratory (TRL) to conduct research into the effects of re-timed invitation to cross periods on road users at signals with all round pedestrian stages with far side indicators. The study investigated the impact of standardising the pedestrian 'invitation to cross' (green man) to 6 seconds, in line with Department for Transport (DfT) guidance whilst maintaining the safe clearance period following the green man calculated at 1.2m/s.

The study concluded that changes to the invitation to cross period were safety neutral and found that most pedestrians exceeded the 1.2m/s walking speed. A significant finding of the study was the proportion of pedestrians who did not fully understand the signals provided to them, particularly the blackout period between the green man going out and the red man being displayed and notably the function of the green man as an invitation to cross and not the crossing time itself. Around two thirds of pedestrians did not understand the blackout period, a finding reinforced by later independent research carried out as part of the PCaTS on street trials in 2010.

The 2009 LRSU report into retimed traffic signals therefore established the potential benefit and need for PCaTS:

- Current Signalling systems provide sufficient time for pedestrians to cross the road safely.
- This is not well understood: there is confusion and uncertainty as to the purpose of the green man and black-out period.
- A countdown telling pedestrians how long they have left to cross the road when the green man goes out can reduce this uncertainty.

PCaTS provides more information than current signalling systems in the UK, reducing uncertainty and could help to improve pedestrian understanding that the green man is only an invitation to cross and is followed by a safe clearance period, the duration of which is displayed by the countdown timer. With improved pedestrian understanding of safe crossing time, the green man (invitation to cross) can be set as a true invitation based on pedestrian demand and pedestrian density and align to the DfT guidance of 6 seconds, without affecting the safe crossing time for pedestrians. Where there is scope to do so, the time saved by reducing the green man by a couple of seconds can then be re-allocated to traffic, the "package" giving benefits to both pedestrians and traffic.

The advantage created by PCaTS is that it can support delivery of the Mayor's Transport Strategy of smoothing traffic flow "... *without prejudice to the safety of pedestrians or the needs of other vulnerable road users*", as the time re-allocated to traffic is from the artificially high invitation to cross period which due to the inherent insufficient crossing information presented with current signalling systems has over time increased to account for limited pedestrian understanding of the operation of signals.

2. Developing PCaTS for London

As part of the feasibility phase of the project TfL reviewed the deployment of PCaTS worldwide, notably in other cities including Dublin, San Francisco, New York and Auckland. Broadly speaking there are two types of countdown: Countdown to green man (during the waiting phase, indicating how long before pedestrians can cross) or countdown to red man (during the crossing phase, indicating how long remains to safely clear the crossing).

For deployment in London, the countdown to red man during the crossing phase was selected as the most appropriate approach: this ensures the additional information provided to pedestrians reduces the uncertainty associated with the black-out period and helps educate the public, intuitively, as to the function of the green man – as an invitation to cross.



Members of TfL's PCaTS Project team June 2010

International research demonstrated that PCaTS (during the crossing period) has the potential to improve pedestrian comfort and safety. San Francisco reported a 50% reduction in pedestrian collisions following deployment of PCaTS, although upon further detailed investigation by TfL staff, this was determined as one element of a wider programme to improve pedestrian safety and PCaTS alone did not account for the whole improvement, however, the City wide deployment and the results were a positive indicator. New York were also undertaking trials with the subsequent decision to roll out PCaTS. PCaTS is now common in pedestrian signals throughout the United States and all new pedestrian signals must include a countdown timer, as per the Manual on Uniform Traffic Control Devices (MUTCD) issued by the US Federal Highway Administration.

As a new signal technology in the UK, any deployment (trials or otherwise) remained subject to appropriate approvals from the DfT (for the PCaTS “sign”) and the HA (for the PCaTS technical specification). Once the need for PCaTS had been identified and the feasibility of deploying the technology understood, the DfT and HA were engaged at the earliest opportunity.

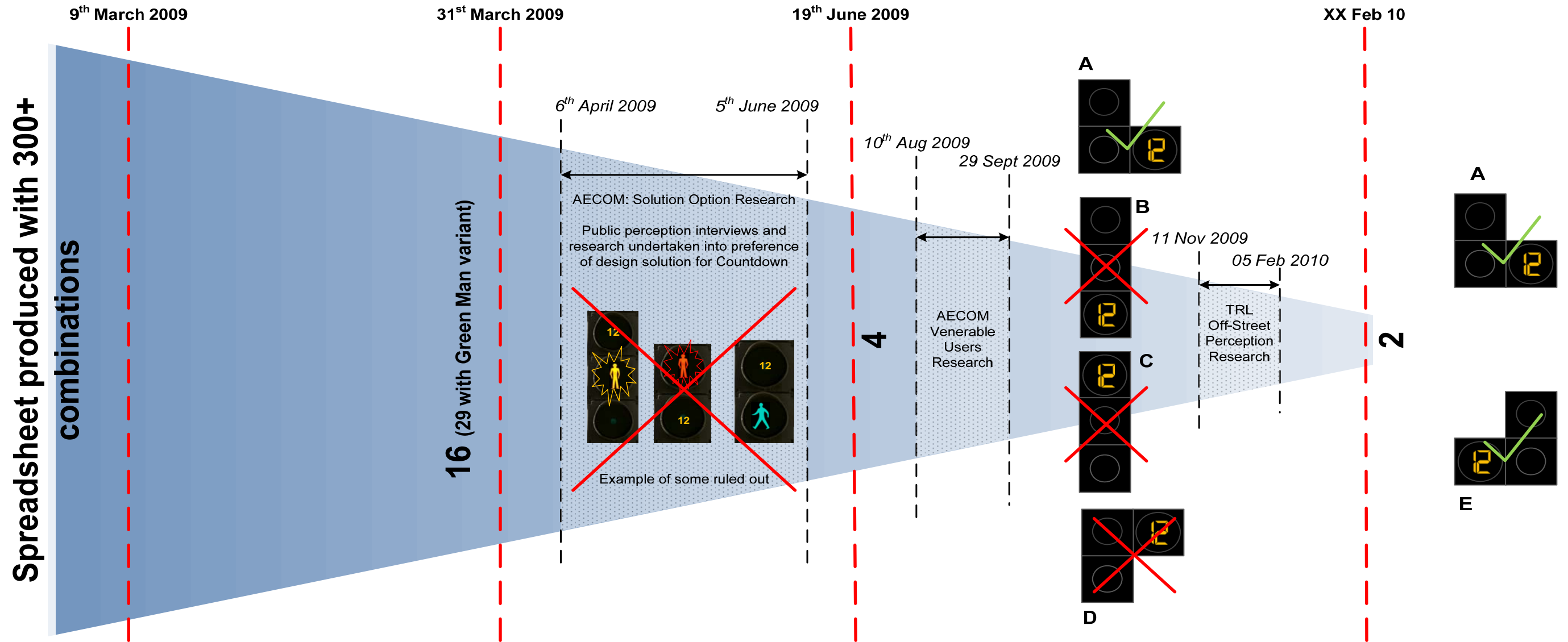
A close working relationship was developed with the representatives from both the DfT and HA, who were ultimately satisfied that the potential benefits of PCaTS warranted further investigation and trials based on the evidence presented by TfL.

Prior to any trials taking place, it was necessary to agree the visual appearance of the units, the displays and the approach to mounting PCaTS to ensure that as far as possible, the approach was practical to install and importantly, intuitive in understanding the function of PCaTS.

Following a competitive process, Aecom were commissioned to conduct extensive research and consultation regarding potential options relating to the appearance of PCaTS units.

In-depth interviews were used to develop the research methodology, define the questions to be used for the field interviews and understand the initial thoughts from the public on the PCaTS concept. The in-depth interviews were followed by a series of field interviews to gather pedestrian perceptions and feedback on the potential and optimal designs for PCaTS. Over 300 adults and 60 children who had experienced crossing at traffic signals with all red stages were involved in these interviews, which were carried out in halls at five different locations in London near to busy junction crossings. The interviews with children took place in two secondary schools in Lambeth and Tower Hamlets respectively. Throughout this process TfL consulted closely with the DfT who would ultimately be responsible for approving the sign in the event of trials or a wider deployment.

Over 300 possible display combinations were identified during the course of this consultation process. The diagram below details how these options were narrowed down to the selected design.



Discussions between DfT and TfL

- Ruled out – Countdown with a still red man during the countdown
- Ruled out – Countdown with a flashing green man during the countdown
- Ruled out – 3 aspect vertical solution with countdown numbers in the middle aspect
- Ruled out – A graphic as opposed to a digital countdown
- Ruled out – Animated walking green man during the invitation to cross period or any countdown period
- Ruled out – Separate unit displaying countdown as opposed to joined to the existing two aspect unit.
- Decision – Countdown termination point will be to the start of the still red man

Ref Doc
PCTS Sol Opt DfT Wkshp 2009-03-09_D
Minutes 9Mar09 - TfL PCTS - Solutions Workshop DTO DfT

Discussions between DfT and TfL

- Ruled out – Red and green countdown numbers
- Ruled out – Showing a green man with countdown numbers
- Decision – Investigate 3 aspect solution to bolt on side and top/bottom of unit.
- Decision – Investigate flashing amber man at the same time as countdown
- Include – Variation of counting down during the green man invitation to cross on all options

Ref Doc
Minutes 31Mar09 - TfL PCTS - Solutions Options Mtg DTO DfT

Research and DfT/TfL Discussions

- 16 options investigated through interviews and ranked in order of preference.
- Ruled out – 12 options include flashing red, amber or green man stage which interfere with current sequence specified in TSRGD2002
- Ruled out – Countdown numbers at same time of red or green man interfere with current sequence specified in TSRGD2002
- Ruled out – Flashing red man interfere with TSRGD2002
- Ruled out – Flashing amber man interferes with TSRGD2002
- L-Shaped option shown popular with pedestrians from Research

Ref Doc
Minutes 5June09 - TfL PCTS - Feedback on Solutions Options Mtg DTO DfT
Minutes 19June09 - TfL PCTS - Decisions on Solutions to take forward DTO DfT

Research and TfL Internal Discussions

- Ruled out options C & D due to proximity to Red Man
- Ruled out option B due to TfL desire for consistency of design with other traffic infrastructure
- Included option E due to mounting possibilities

3. PCaTS Trials

As part of the feasibility and approvals process TfL conducted both off street and on street trials. The off street trials were conducted at the TRL test track using mocked-up pedestrian crossings with and without PCaTS and involved over 250 pedestrians. Mobility impaired pedestrians and children were also specifically sampled during the course of the off street trials.

Questionnaires were used to establish participant's understanding of the signals (with and without PCaTS) as well as their opinions on PCaTS specifically. This reinforced the previous research that the black-out period is poorly understood – only 40% of participants thought they could continue to cross if it displayed while they were already on the crossing.

In terms of preference, participants indicated they felt safer and more relaxed with PCaTS, and many found the display to be helpful. Following the success of the off street trial and continued engagement with DfT and HA, approvals were granted to trial PCaTS on street in London.



PCaTS unit at TRL's test track

On Street Trials

The on-street trial of the PCaTS technology started with the selection of 8 sites with all red pedestrian phases with a broad range of user profiles and located in strategic areas of London that would provide relevant information on public perception of the technology. Countdown timers were installed at the signals along with changes to the signal timing which are referred to as “PCaTS package of measures”. The PCaTS package of measure includes:

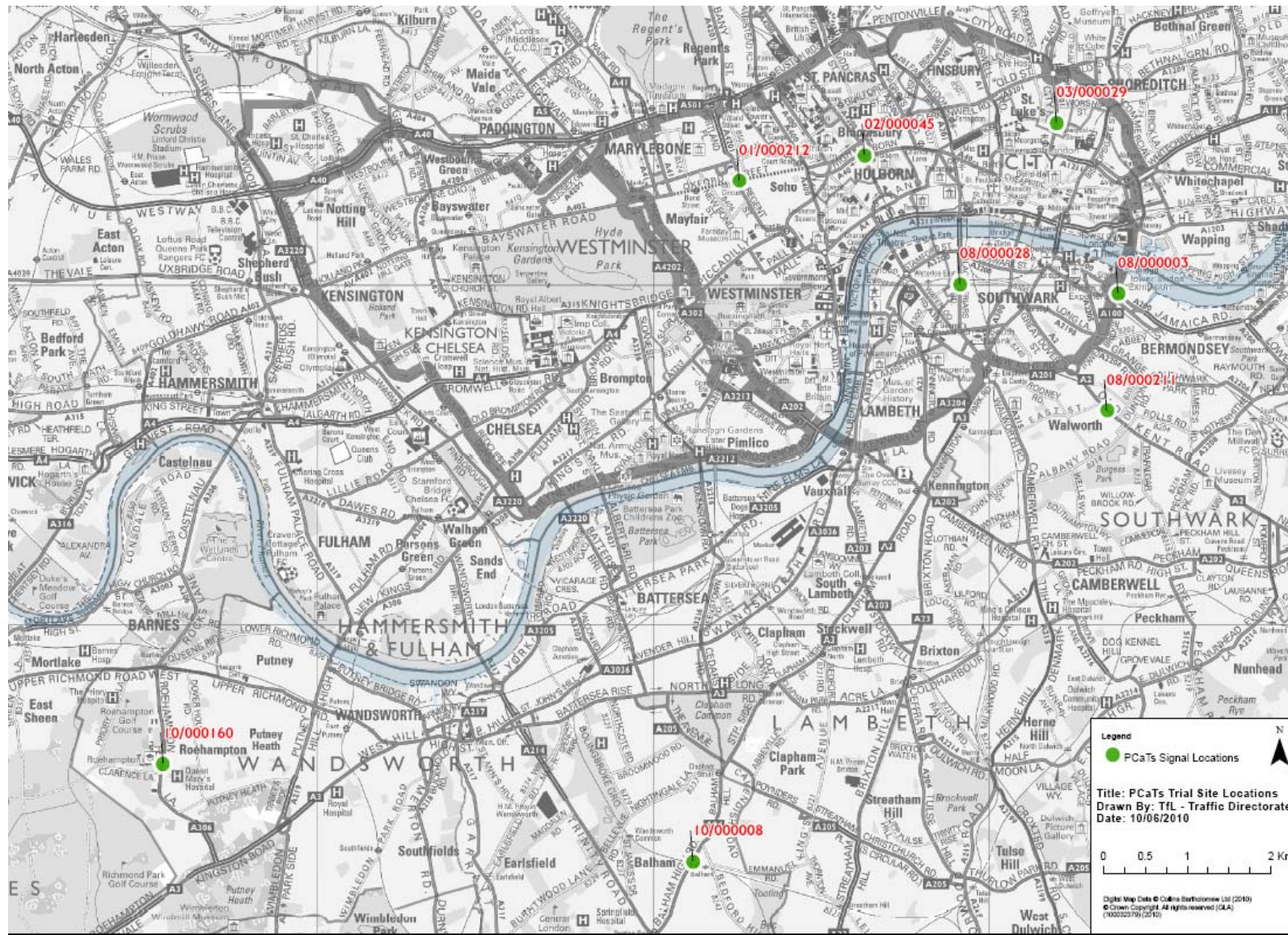
1. Reduction in Green Man time to a standard 6 seconds (aligned to DfT guidance)
2. Increase in ‘Blackout’ time (however with a countdown timer)
3. Reduction in ‘All Red’ time (to a standard 3 seconds, with a 2 second starting amber to traffic)
4. Increase in traffic green time (as a consequence of 1 above).

The trial involved conducting video-based observational surveys, as well as interviews with pedestrians, before and after the installation of the PCaTS package, to assess how it influenced both attitudes and understanding of pedestrians (Pedestrian Perception), and the behaviour of pedestrians and drivers. It also looked at the benefits to traffic (benefits to buses, cyclist, freight and general traffic) to increase network capacity and reduce delay. Specific studies were also conducted with children and mobility impaired pedestrians to ensure their views were also given consideration.

The eight geographically spread trial sites at which PCaTS units were installed are as follows:

TfL Site Number	Roads at Junction	Borough
01/000212	Oxford Street - Regent Street - Oxford Circus	Westminster
02/000045	A4200 Kingsway - A40 High Holborn - A4200 Southampton Row	Camden
03/000029	Finsbury Square - Finsbury Pavement - Chiswell Street	Islington
08/000028	A201 Blackfriars Road - B300 The Cut - B300 Union Street	Southwark
10/000008	A24 Balham High Road - Chestnut Grove - Balham Station Road	Wandsworth
08/000003	A100 Tower Bridge Road - A200 Tooley Street	Southwark
08/000211	Old Kent Road - Surrey Square - Penry Street	Southwark
10/000160	A306 Roehampton Lane - Queen Marys Hospital Main Entrance	Wandsworth

The trial sites were selected to ensure broad representation would be covered during the research – some were located near transport hubs, schools, one near a hospital, some in commercial areas and others in more residential areas. The map below indicates the geographical spread of the selected sites.



4. Trial Results

The report which details the findings of the on street trials have been published on TfL's website and is available via the link below:

<http://www.tfl.gov.uk/assets/downloads/corporate/pcats-road-trial-report.pdf>

Pedestrian Related Benefits

Sections of the research report on the results of the research have been reproduced below to show the success of the trial.

- Pedestrian Perceptions

The Countdown display provides information to pedestrians on the time remaining to cross before the Red Man appears, with the objective of overcoming the confusion that has previously been identified in pedestrians' understanding of the Blackout phase and the function of the green man invitation to cross.

The main conclusion from the attitudinal surveys is that a majority of pedestrians liked Countdown: 83% of participants in the final 'After' study, 94% of mobility impaired pedestrians and 79% of children. PCaTS was preferred over standard crossings by 69% of mobility impaired pedestrians and 56% of children, who directly experienced both types of crossing. At all sites there was an increase in the percentage of participants stating that they felt safe using the crossing in the After survey, this was statistically significant at 7 out of the 8. The average increase was from 73% Before to 91% After across all sites. Furthermore, in the separate survey of children and mobility impaired pedestrians, 83% of children and 71% of mobility impaired stated that they felt safer with PCaTS.

At all trial sites fewer pedestrians reported feeling rushed when crossing the road with PCaTS despite a reduction in green man time. The greatest change was at Balham where the proportion feeling rushed fell from 45% before to 7% in the final after survey. Furthermore, even though green man invitation time had reduced, the percentage of pedestrians feeling they had sufficient time to cross the road increased from an average of 75% in the Before surveys to 88% with PCaTS. In addition, for pedestrians still on the crossing when the Green Man phase ends, a higher percentage of pedestrians stated they were able to continue crossing with PCaTS: the average across the survey sites increased from 12% Before to 37% After. This demonstrates that PCaTS was able to reduce uncertainty about being able to cross safely.

- Pedestrian crossing behaviour

Detailed analysis of the video footage was undertaken to provide an understanding of how pedestrian behaviour changed in response to the PCaTS package, in particular the extent to which it influenced crossing decisions, waiting time, crossing speeds and how people use the crossing space.

A very interesting behavioural observation was made. Irrespective of the type of crossing (PCaTS or standard) the majority of pedestrians tended to cross as soon as possible after arrival. Over 54% crossed within 5 seconds of arrival with both crossing types, 70% within 15 seconds and approximately 85% within 30 seconds.

- Analysis of conflicts

A conflict occurs where two people attempt to use the same space at the same time. Where a conflict occurs frequently it provides an indication of a potential risk that might, over time, lead to actual collisions. Detailed observations were made of how the trial schemes affected the level of conflicting behaviour. In this study conflicts were categorised into 5 main levels of severity, ranging from 'precautionary' ones at the lowest level, where one road user has to give way to another, through more serious conflicts requiring emergency braking or steering. No actual collisions were observed during the surveys. Statistically significant changes in conflict numbers were only observed with the lowest categories of conflict levels, those at Levels 3 and 4 remained at very low levels. Large reductions in Level 2 conflicts (controlled) were observed at the two highest pedestrian flow sites (Oxford St and Kingsway), from 124 to 28 conflicts; however, they increased by a small but still statistically significant degree at two lower flow sites, from 1 to 8 at Blackfriars, and 3 to 11 at Old Kent Road.

Overall, the absence of any increase in higher level conflict types suggests that the PCaTS package does not introduce any serious risks to safety, which is consistent with the observation that there are no more pedestrians on the crossing at the time when vehicles are given priority. Site by site variations in the lower level conflicts suggest that local factors, in particular flow rates, can have an effect on the minor conflicts, which can be monitored and, if necessary, addressed on a scheme by scheme basis.

Traffic Related Benefits

In terms of traffic benefits, the TRL research demonstrated a reduction in vehicle delay following the implementation of the PCaTS package of measures at six of the 8 trials sites during the surveys. This reduction in delay ranged from 2 seconds at Balham to 8 seconds at Blackfriars. The reductions in delay for vehicles observed in the trial are consistent with research conducted by TfL, which is detailed in this section.

The implementation of Pedestrian Countdown at Traffic Signals at 8 sites incorporates changes to the signal timings. At all trial sites the green man now runs for six seconds. The pedestrian to traffic intergreen remains the same as before PCaTS was installed, with the time re-apportioned from reducing the green man reallocated to traffic phases.

These timing changes mean that there is more green time available to traffic due to the green man being reduced. Over the 8 trial sites the increase in traffic green ranges from 1 to 7 seconds, depending on the green man time before installation. These changes are summarised below:

Site	Green Man before PCaTS	Green Man with PCaTS	Change
08/028	9	6	3
10/008	8	6	2
03/029	13	6	7
08/003	8	6	2
10/160	7	6	1
08/211	8	6	2
02/045	9	6	3
01/212	8	6	2

To assess the impact of PCaTS on traffic flow, delay and junction capacity three data sources have been used. Firstly a Linsig model has been produced for each junction for the before and after situation. Both models are exactly the same with regards to flow, saturation flow, phases, stages, stage sequence etc. The saturation flow has been calculated by entering lane widths measured from the site layout drawing. The only change is the reduced green man time to reflect the installation of PCaTS in the after situation, with the additional road green allocated to the main stage. This method can show the theoretical increase in capacity at each junction as there are no changes to variables other than the signal timings.

Secondly, ASTRID data has been obtained from 7 of the 8 sites which operate under SCOOT control. 03/029 (Finsbury Square/Finsbury Pavement/Chiswell Street) is under fixed time operation so it is not possible to collect Astrid data. The graphs show trend data for total delay for a week (Monday – Friday) before and after the installation of PCaTS. The data is for a specific link, which corresponds to the arm of the junction which was surveyed by TRL.

Thirdly, classified turning counts were taken at each of the junctions before and after PCaTS was installed. Flow comparisons have been made for the peak 15 minutes within the AM, Inter peak and PM peak hours. The total PCU count for the peak 15 minutes was determined and then the percentage difference between the total before and the total after PCaTS calculated.

As expected, the Linsig model results show an increase in capacity on all of the 8 trial sites. The table below summarises the results.

Linsig Capacity Results

Site	Capacity Increase		
	AM	IP	PM
08/028	14.3%	18.8%	15.2%
10/008	5.2%	5.0%	4.6%
03/029	20.0%	23.3%	16.4%
08/003	6.1%	5.5%	6.4%
10/160	2.1%	2.5%	2.2%
08/211	3.8%	3.8%	3.8%
02/045	10.7%	11.1%	10.4%
01/212	4.6%	5.3%	4.9%

The implementation of the pedestrian countdown package creates green time for traffic where the green man time is decreased. The capacity results are based upon the maximum number of PCU's that can cross the stop line over the peak hour. This is calculated using the green time and the saturation flow. The largest increases in capacity are seen where there is the greatest increase in green time due to the addition of the PCaTS package. 03/029 had the biggest reduction in green man time of 7 seconds hence the largest increase in capacity. The average results over all eight trial sites are an 8.6% increase in capacity for the three peak hours.

A daily fluctuation in traffic flow of approximately 10% is expected on street. This factor combined with varying traffic conditions in the surrounding areas means that the number of vehicles arriving at the stopline is not consistent day after day. The theoretical increase shown in the Linsig models, where all data is identical apart from signal timings, may not translate to the same increase when looking at traffic flows owing to these changing conditions. For example, where a junction had not been at full capacity in the before survey, the percentage increase in traffic throughput measured by turning counts is greater than capacity increase generated by the PCaTS Package. Equally, in some cases analysis of turning counts (see below) show a decrease between the 'before' and 'after', as even though there is extra green time available to traffic, the demand may not be there for the time to be utilised.

Turning Counts

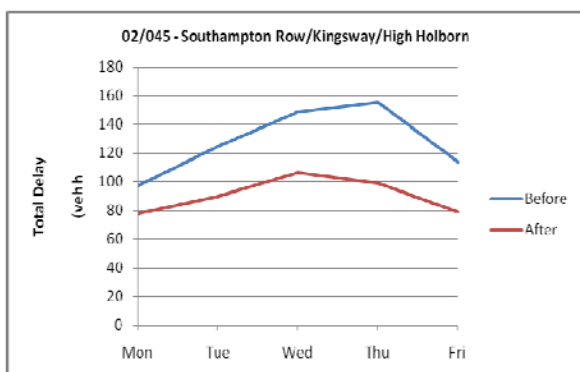
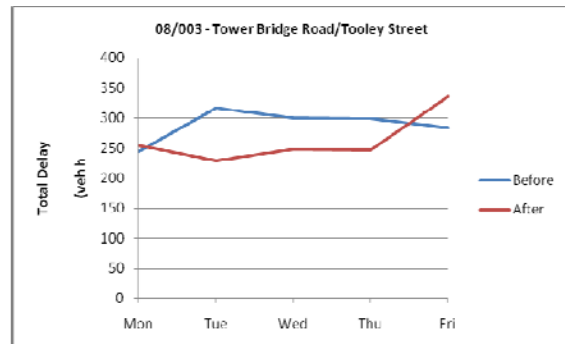
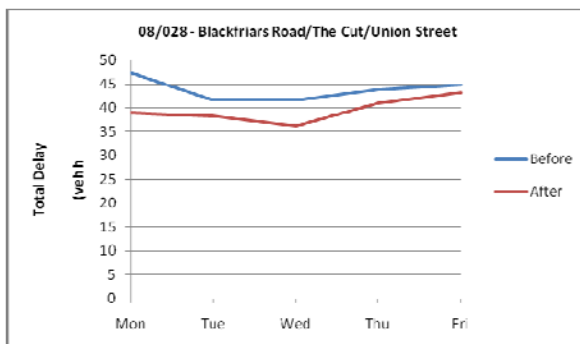
Site	% difference		
	AM	IP	PM
08/028	25.9%	25.7%	25.0%
10/008	-9.8%	-5.5%	-1.4%
03/029	1.3%	-21.9%	2.6%
08/003	4.4%	5.3%	12.4%
10/160	-3.3%	-10.2%	-20.7%
08/211	13.9%	0.1%	-4.7%
02/045	6.7%	18.0%	15.1%
01/212	1.6%	4.5%	-16.1%

The turning counts show that six out of the eight sites showed an increase in the turning counts in at least one of the peaks. The two sites that showed no increase at all were 10/160 (Roehampton Lane/Queen Mary's Hospital Access) and 01/212 (Oxford Street/Regent Street).

Three of the sites showed increases in turning counts over all three peaks. These were 08/028 (Blackfriars Road/The Cut/Union Street), 08/003 (Tower Bridge Road/Tooley Street) and 02/045 (Southampton Row/Kingsway/High Holborn). This shows that where there is a demand, more traffic is able to get through the junction.

Averaged over the eight trial sites there was an overall increase in traffic flow. The figures were 5.0% in the AM peak, 1.9% OP and 1.3% in the PM peak.

Astrid Delay Data



These three Astrid graphs show the delay before and after PCaTS, for the three sites that showed an increase in turning counts for all three peaks. The graphs clearly show a decrease in delay despite the increase in vehicles at the junction. There is a slight increase in delay on 08/003 on the Friday results but this could be due to knock on effects of Tower Bridge opening.

Overall, the average delay decrease on all sites for the week prior to PCaTS and the week after. This is summarised in the table below:

Site	Average Delay before	Average Delay after	% difference
08/028	43.86	39.52	-9.9%
10/008	44.09	40.21	-8.8%
08/003	288.86	263.22	-8.9%
10/160	48.12	25.02	-48.0%
08/211	22.4	20.26	-9.6%
02/045	128.1	90.36	-29.5%
01/212	72.9	67.18	-7.8%

Astrid Delay unit veh H/H

Using a conservative assessment (disregarding the very high outliers of 02/045 and 10/160) TfL estimate that on average an 8% delay saving to vehicle traffic can be achieved by deploying PCaTS in the manner adopted during these trials.

5. Challenges

As a pioneering technology in the UK, development and deployment on street of PCaTS has created a number of challenges. TfL has worked closely with the DfT, HA, suppliers and other key stakeholders to ensure the success of the project, and based on the very encouraging results continues to work towards a wider deployment of PCaTS in the future. Securing the appropriate approvals and development of PCaTS technology to meet the needs of London (with the potential for wider deployment) are two key areas where collaborative working has been successful in overcoming challenges.

Approvals

From the outline concept of PCaTS deployment in the UK through to securing special authorisation for the 8 trial sites (and subsequently special authorisation for these sites to retain PCaTS permanently) has required a significant investment in time to develop strong working relations with the DfT and HA.

The value of evidence based independent research including both off and on street trials should not be underestimated in terms of demonstrating the benefits and performance of new technology, although a level of resource to procure and manage this process (both the research and equipment) is critical to the outcome of such trials.

Statutory timescales and obligations for developing a new specification, including European Consultation (which has now commenced for PCaTS) should not be under-estimated, nor should the need for access to expertise for both the approvals and technical aspects associated with the product, to ensure a workable technical specification can be developed.

Technology

The PCaTS units have been specified to be independent and self learning to ensure the time displayed reflects the blackout duration. During the course of the on street trials a number of lessons were learned regarding fault monitoring and reporting.

Ensuring that the units did not mistake the dimming of the traffic signals as a fault was a further challenge that required detailed technical analysis before a solution could be specified.

The development of PCaTS aligned to the specification and lessons learned from trials means that the units could be deployed at any site with a pedestrian phase which has a fixed black-out duration – subject to the necessary approvals being granted.

6. Conclusion

The on street trials has demonstrated that

- 1) PCaTS has had a positive response from the public.
- 2) PCaTS has reduced pedestrian uncertainty and more informed crossing choices are being made.
- 3) Where the “PCaTS package” is implemented, there are significant benefits to traffic.

Based on the combined pedestrian and traffic benefits presented by PCaTS, TfL continue to work with the DfT and HA to secure approval for a wider deployment of PCaTS across London in support of delivering the Mayor’s Transport Strategy.

The DfT have indicated their support for approving this, and already granted special authorisation for the 8 trial sites to retain PCaTS on a permanent basis.



Kulveer Ranger and former MD of Surface Transport David Brown at the unveiling of the Southwark trial site

In collaboration with the HA and DfT, TfL have developed a draft TR specification which has completed consultation within the UK and is now under review in Europe.

Subject to the necessary approvals and a successful procurement process, TfL remain committed to deploying PCaTS and realising the associated benefits across London.

References

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