FEET-FIRST: USING SCATS TO IMPROVE PEDESTRIAN PROVISION IN DUBLIN

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ABSTRACT

This paper looks at the various ways in which SCATS is used by Dublin City Council to deliver pedestrian priority at signalised junctions. The measures considered include (1) reducing waiting times, (2) increasing the opportunity to cross, and (3) enhancing the coordination between adjacent crossings. The paper begins with an assessment of pedestrian needs followed by a brief overview of the SCATS traffic system, with a particular focus on the operation of pedestrian facilities. This is followed by an explanation of how Dublin City Council have adapted junction operations to benefit pedestrians using SCATS. Finally, conclusions are presented and recommendations considered.

INTRODUCTION

The Sydney Coordinated Adaptive Traffic System (SCATS) is an adaptive urban traffic management tool that synchronises traffic signals to optimise traffic flow across a network. It operates in real-time, communicating with local traffic signal controllers every second, and automatically calculates the appropriate signal timings in response to variations in traffic demand and system capacity. Originally installed in Dublin in 1989, the initial project was for 32 intersections within the city centre. Since then, SCATS in Dublin has been continually upgraded and the area of operation has been expanded up to and beyond the city boundary. Currently, there are over 750 intersections connected in the Greater Dublin Area (GDA) and the SCATS network has even been extended to a number of nearby towns and cities by means of a hosting service.

At a time when more sustainable approaches are being embraced, the importance of assigning higher priority to pedestrians and cyclists is widely recognised. New strategies and policies propose a re-designing of the urban environment to redress the imbalance between movement and place functions. A paradigm shift is articulated in these plans where public transport services are expanded and private car use reduced; in addition, the numbers cycling and walking will increase, facilitated by changes to street and junction layouts and traffic signals operation.

The aim of this paper is to present some of the techniques currently being used in Dublin city to favour pedestrians, through the use of SCATS. Where necessary, for the purpose of clarity, the underlying controller operation will be discussed but, in general, the role of the controller will be kept to a minimum as it is beyond the scope of this review. As will be seen, SCATS provides a variety of techniques and tools which can be utilised in order to improve pedestrian level of service at signalised junctions. In addition, the results and effects of these techniques will be discussed and areas for further development will also be highlighted.

BACKGROUND

The vision for Dublin, as laid out in the recent development plan[1] is for a compact, vibrant city of "urban neighbourhoods, all connected by an exemplary public transport, cycling and walking system". This transition to a sustainable transport city is supported by guidance such as the Design Manual for Urban Roads and Streets (DMURS) and the National Transport Authority's (NTA) Cycle Manual which establish new pedestrian and cycling design requirements. However, little attention has been given to how traffic signal operation will need to change in order to provide for a modal share target that has public transport at 55%, walking at 10%, and private car use at only 20%[2] . What traffic signal strategies will be necessary in order to meet the competing demands of a more pedestrian-friendly city?

Over the years, Dublin has delivered many improvements for pedestrians at traffic signals both in terms of safety and delay reduction. The number of pedestrian crossings has increased, pedestrian fatalities in the city have reduced hugely, and the public realm has been improved for walking and cycling. Much progress has been made, as evidenced by Dublin being recognised for achieving the best reduction in Europe of road fatalities during 1997 – 2007[3]. Pedestrian improvements at traffic signals include the use of countdown timers, radar detection and pedestrian detection. In addition, cycle times have been lowered at many sites to reduce wait-times for pedestrians.

Dublin does not have an underground metro system. A significant challenge of having all transport at surface level is striking the appropriate balance so that an acceptable level of service is provided for all modes. The priority at traffic signals is given to Public Transport. Buses and Trams carry large numbers of commuters into the city each day and their role as transport providers is set to expand in the coming years. Bus services are increasing, a Bus Rapid Transit (BRT) is planned, and track is currently being laid for a new LUAS tram route running through the city centre. Catering for pedestrians in this environment will require that traffic signals become more responsive and intelligent. SCATS techniques will need to be more innovative in order to deliver efficiencies.

Traffic management systems that coordinate traffic junctions are at risk of having some sites running less than optimal signal operation. Cycle times and linking parameters need careful monitoring. In SCATS, the use of Master Isolated mode to unlink sites during off-peak hours and the capability of user-defined Action Lists and Variation Routines support pedestrian-friendly operations. Research shows that after about 20-30 seconds of delay, pedestrians' level of frustration grows disproportionately to the delay itself[4]. Clearly, the needs of pedestrian are different to that of other modes and this presents a challenge. If we are to achieve our targets, signals will need to adapt their operation and become more intelligent. The following sections of this paper examine the facilities and features within SCATS which can be used to create more intelligent signal operation to improve pedestrian provision.

[1] Dublin City Development Plan (2011 – 2017) (p. 10)
[2] Dublin City Centre Transport Study – Executive Summary (p.1)
[3] European Transport Safety Council 3rd Road Safety PIN Report (p. 66)
[4] Reducing Pedestrian Delay at Traffic Lights (p. 89)

PEDESTRIAN OPERATION IN SCATS

Pedestrian movements in SCATS are known as Walks and are made up of a number of time intervals as shown below. The upper bar shows the vehicle time intervals starting with Late Start (optional), Minimum Green, Extension Green, Early Cut-Off Green (optional), Yellow and Red.

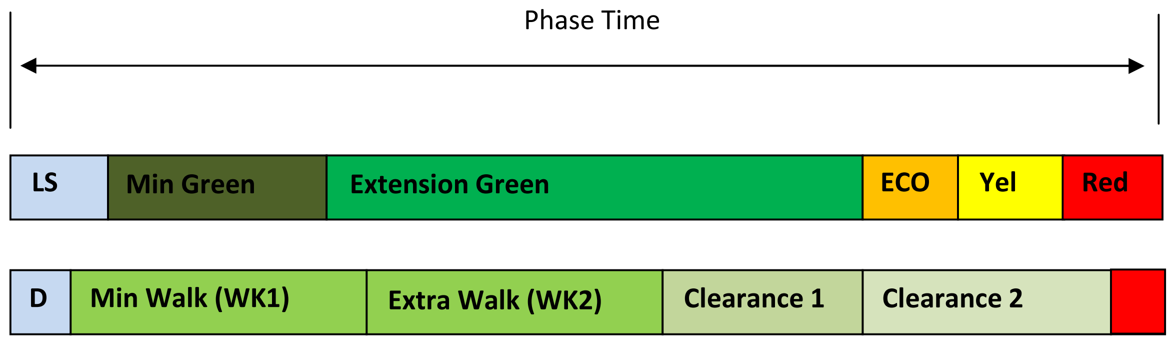

Figure 1: Time intervals used by a SCATS Phase

The first interval in the pedestrian band is the optional delay time, D, then followed by WK1, a safety minimum green time. An optional second walk time, WK2, is provided but not generally used in Dublin. Following the walk time, the first clearance interval begins. The second clearance interval follows and generally coincides with the end of the green in the corresponding vehicle phase. In Dublin, pedestrian signals show a green man during the Walk interval and an amber man during the Clearance intervals. All standard pedestrian crossings have a fully-protected operation – that is, left-turning vehicles are not permitted during the crossing.

Modifications of the standard timed operation above are available depending on the site personality but options provided by SCATS include the following:

- **Walk For Green**
  When a 'Walk for Green' operation is specified in SCATS, the walk interval is extended beyond its defined minimum and runs for the maximum time permitted. That is, the green man is displayed until the clearance intervals must begin in order to fit within the phase.

- **Walk & Clearance Overlaps**
  An overlap operation in SCATS allows either the walk or clearance interval to extend from one phase into another. The overlap function must also be defined in the personality.

- **Double Cycling**
  This SCATS facility permits a sequence to run twice in one cycle. It is often used at two-phase sites which feature an isolated pedestrian crossing on a main road. This intervention can be brought on at particular times of the day to double the frequency of the pedestrian crossing.

- **Master Isolated Operation**
  One of the operational modes of SCATS permits the site to operate in a similar fashion to an isolated site where all phases can gap off. This allows phases, including pedestrian phases, to be introduced earlier than they otherwise would have.

These in-built facilities may not be enough to deliver the improvements to pedestrian facilities required in all circumstances. Fortunately, they can be augmented with some of the features that SCATS provides for users to enhance the adaptability and intelligence of traffic signals, such as:

- **Variation Routines**
  SCATS provides the facility to alter the operation at a site using predefined variation routines. The routines are built up in a TEST-ACTION format and can be accumulated so that complex algorithms can be constructed. For example, some popular variation routine tests check for a phase start or time of day; popular actions involve adding phase features such as permanent demand (PD) or Time Gain (TG) to a phase.

- **Hidden or Secret Pedestrian Crossings**
  A standard pedestrian crossing is restricted to running within a particular phase. Walk or Clearance times may overlap two or more phases but the pedestrian crossing operation is phase-based. In contrast, Hidden Pedestrian Crossings are operated by the settings in the local controller and can run outside of the confines of phases. In practice, the commencement of a Hidden Crossing is controlled by SCATS by means of a flag sent to the controller.

- **Use of MSS/XSF/RSF Bits**
  The use of transmitted bits is common in SCATS as flags to convey information or to initiate a certain type of operation. Miscellaneous Status Signal (MSS) bits are sent from the local controller to SCATS, Extra Special Facility (XSF) bits are sent from SCATS to the local controller, and Remote Special Facility (RSF) flags are sent by a site on SCATS to another site.

Using the above SCATS features a number of pedestrian interventions were put in place at sites in the city. The following section describes these operations.

PEDESTRIAN INTERVENTIONS USING SCATS

With a view to improving pedestrian provision using SCATS, a number of sites were chosen for the purpose of using SCATS methods that should result in improved operation. A close working relationship between Dublin City Council and the traffic signals contractor, Imtech, enables detailed operations to be implemented on site. Traffic signal designs are prepared in Dublin City Council, coded by Imtech, and the final testing is carried out by Dublin City Council with the use of simulation packages such as WinTraff or SCATS SIM.

1: Duplicate Phase - Increased Opportunity to Cross

The purpose of this intervention is to reduce the maximum wait-time at the site and militate against particularly long delays. A characteristic of this particular site that makes it amenable to the amended operation is that B phase can run either before or after C phase. That is, the traffic signals at the site support the left turn from Meath Street running either before or after P3.

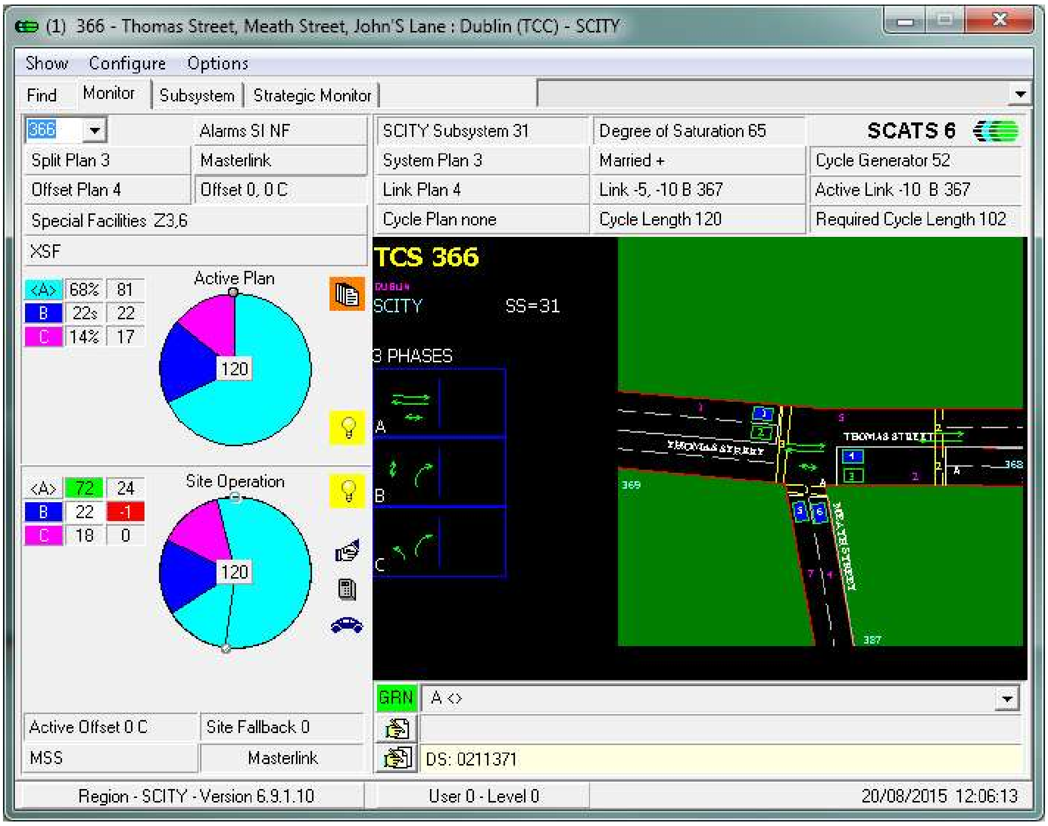

Figure 2: SCATS graphic of Thomas St/Meath St junction with original phases

The junction of Thomas Street/Meath Street is a city-centre site along a well-used commuter route in a busy urban neighbourhood. There are high numbers of pedestrians throughout the day. The site employs a three phase operation where P3 runs in B phase in conjunction with the right-turning movement from Meath Street. The main road, Thomas Street, is serviced by phase A which is the stretch phase. A feature of the stretch phase is that it does not gap out. This can often work well for vehicles but can impose longer wait-times for pedestrians. For example, if B phase was not demanded in a cycle, then C phase would run in its place and the subsequent A phase would gain the time not used by B phase in the previous cycle.

To avoid this scenario, an additional phase D is added to the sequence. This new phase is a duplicate of phase B but only runs if phase B has not previously been called. The effect of this intervention is that the pedestrian crossing now has two opportunities to run in a cycle: either after A phase or after C phase.

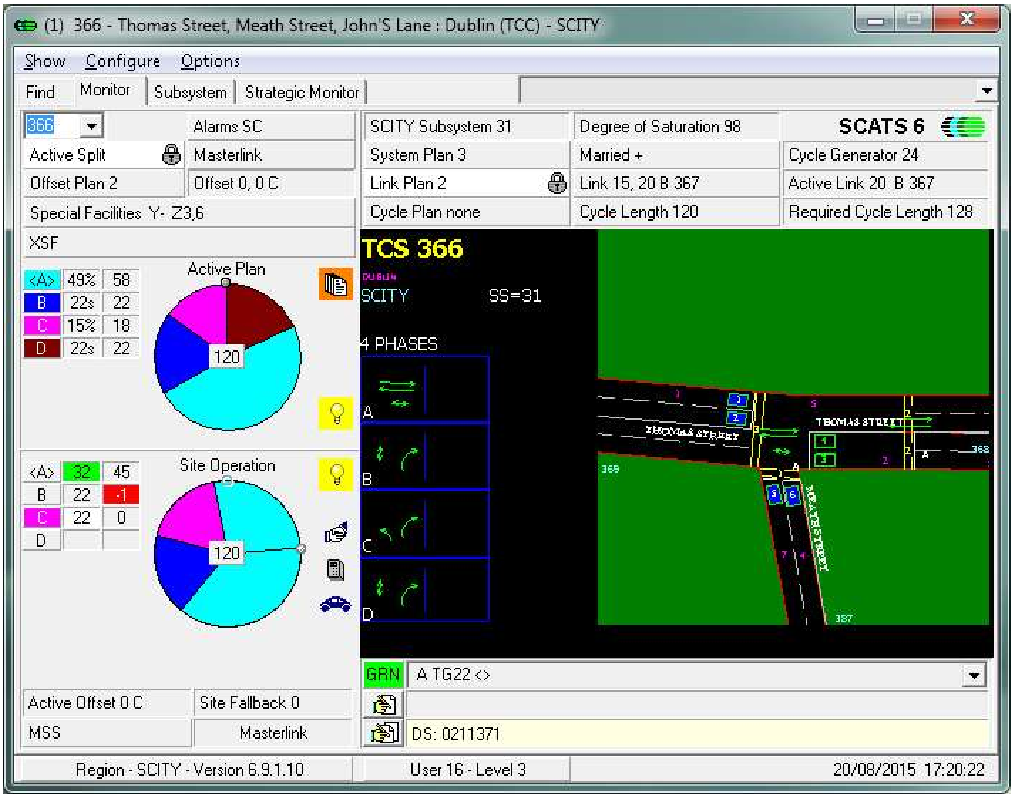

Figure 3: SCATS graphic of Thomas St/Meath St junction with four phases

Comparisons of the maximum and minimum wait-times before and after the intervention are shown in the table below[5]. As explained above, the worst case scenario for a pedestrian looking to use P3 would be to arrive just after the planned start time for phase B. Without a demand for the B phase, the C phase would run in its place. Then A phase begins and runs a long phase due to the fact that it has picked up the time allocated to B phase in the previous cycle. Under the new operation, the worst case scenario for a pedestrian is to arrive just after the planned starting point for D phase (and B phase did not run in that cycle).

Max/Min Delay	**Original Operation**	**Amended Operation**	**Reduction**	**% reduction**
Arrival start of A (seconds)	102/80	102/58	-/22	-/28%
Arrival start of C (seconds)	120/98	98/18	22/80	18%/82%

Table 1: Maximum & minimum pedestrian delays

[5] Assumptions used for calculations of delay times: C phase always called and runs full time. Cycle time is 120s. Split for original operation A – 80s, B – 22s, C – 18s; Split for new operation A – 58s, B – 22s, C – 18s, D – 22s

2: Hidden Pedestrian – Improved Coordination at Staggered Crossing

The purpose of this intervention is to improve the coordination between two pedestrian crossing used in a Staggered Crossing. The site, located on Malahide Road outside Mount Temple School, experiences heavy pedestrian demand at certain times of the day. As such, coordination of the two pedestrian crossings is very important.

Staggered crossings are often used on busy, wide roads where high vehicle volumes and speeds necessitate their use. The pedestrian delay at multi-stage facilities like this can often be very long, as there is a delay associated with each crossing. Coordination of the crossings can also be an issue. The intervention uses a hidden pedestrian crossing for P2 in order to improve coordination. SCATS controls when P2 is called, and, as it is a hidden pedestrian crossing, it is not restricted to running within a phase. The site below employs a four phase operation, effectively double cycling. Phases A and C service the main road while phases B and D are called by P1.

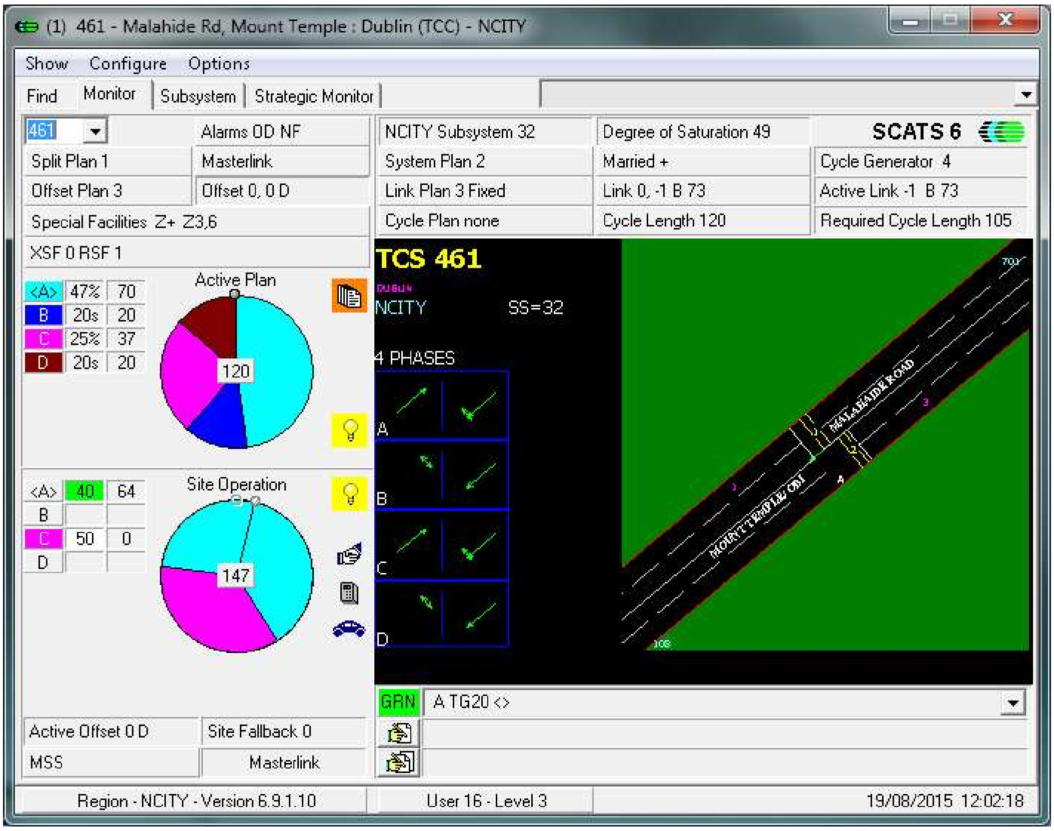

Figure 4: SCATS graphic of Malahide Rd/Mount Temple School site

As a way to gather additional information from the site, Remote Special Facility (RSF) flags are used. RSF flags can be sent between two or more SCATS sites. In this case the RSF flag is sent to the site itself when a particular condition is met. This facility, coupled with the information obtained from variation routine tests, enables coordination to be achieved between the two pedestrian crossings. An explanation of the operation and the variation routines that applied the necessary tests and actions are shown on the following page.

The XSF flag, when sent by SCATS to the controller, releases the hidden pedestrian crossing. In order to achieve coordination with P1, the XSF flag is sent at the start of C phase or at the end of D phase. These points in the sequence correspond to when P1 has just finished. The variation routine VR69 is used to identify the appropriate phase intervals and the XSF flag is sent using VR25 when either of the tests is evaluated as true.

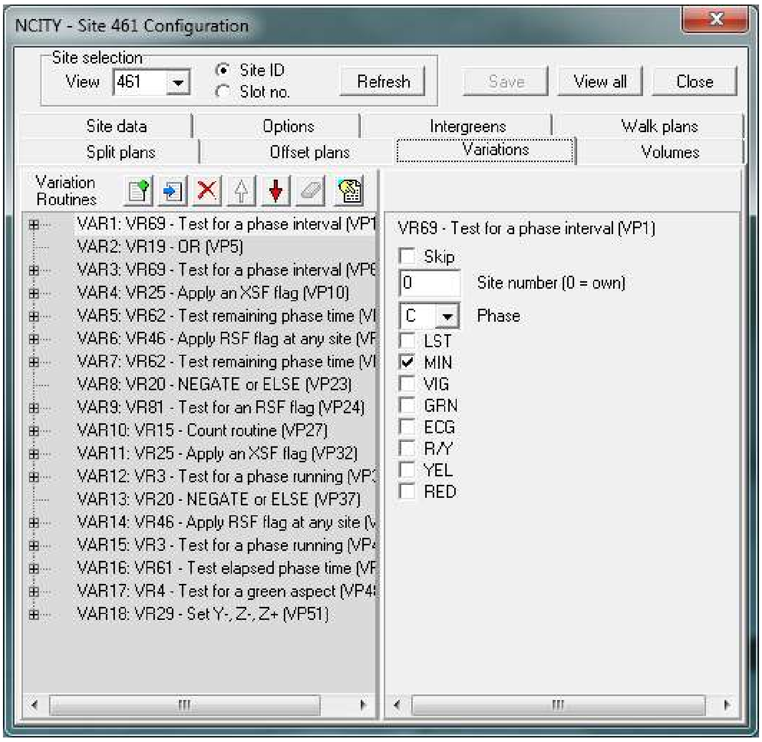

Figure 5: Variation Routine Monitor

A variation routine is used to test the length of the A phase in the current cycle. If it is higher than a user-defined threshold, an RSF flag is applied. This serves as a trigger for an action. Another variation routine is used to check for the same RSF flag. If the test evaluates as true, the XSF flag is sent, releasing the hidden pedestrian. The purpose of this algorithm is to allow P2 to run if A phase has been long; that is, if A phase, being the stretch phase, picked up time from the previous cycle it will be longer than planned. In this case, P2 is permitted to run just before B phase, when P1 runs if demanded.

A further intervention at this site, contained within the variation routines is an automatic call for P1 when P2 is running. Obviously, the central refuge is not a final destination for anyone, so it makes sense that a call at one side of the road should demand both pedestrian crossings. The variation routine uses VR4 to test for a green aspect at signal group 4 (P2) and when true, another flag is sent by SCATS to the controller to place a demand for P1.

The original operation at this site constrained P2 to run only at the end of A phase. If P1 was also demanded, B phase would run and both crossings would then run concurrently. However, if P1 was not demanded, P2 would run in C phase. This resulted in poor coordination if crossing from the west to east (left to right in the SCATS graphic). In the original operation, the worst case for a pedestrian crossing from west to east is to arrive at the start of A phase after a time when the pedestrian phase had not been called in the previous cycle. P1 would run in the subsequent B phase and then you would have to wait until the end of A phase of the following cycle for P2. The worst case scenario in the original operation when crossing from east to west was also to arrive at the start of A phase. P2 would run in C phase (assuming no demand for p1) and P2 would run in D phase. The coordination in this direction is good. Comparisons of the maximum and minimum delays are given in the tables below[6].

Crossing from West to East

Max/Min Delay	**Original Operation**	**Amended Operation**	**Reduction**	**% reduction**
Arrival start of A (seconds)	180/50	80/50	100/-	44%/-
Arrival start of C (seconds)	110/90	40/40	70/50	63%/56%

Crossing from East to West

Max/Min Delay	**Original Operation**	**Amended Operation**	**Reduction**	**% reduction**
Arrival start of A (seconds)	90/70	70/50	20/20	22%/29%
Arrival start of C (seconds)	150/30	40/20	110/10	73%/67%

Table 2: Maximum & minimum pedestrian delays

[6] Assumptions: Permanent demand for A phase. C phase always runs and has a Time Gain feature so that it gets all of B phase time when B phase not called. Cycle time is 120s. Split is A – 50s, B – 20s, C – 30s, D – 20s. Walk time for each crossing of 10s.

3: Wasted Stretch Phase Time – Conditional Double Cycling

Where traffic flows on different approaches within a phase are not balanced the busier approaches tend to dominate, extending the duration of the phase to cater for the demand on those approaches. This can lead to wasted time on less heavily trafficked approaches, which may not need the extended time. This in turn can lead to unnecessary delays for pedestrians on the quieter approaches. The purpose of the intervention described in this example is to make use of such wasted time using variation routines to allow a pedestrian phase to double cycle when gaps are detected on that approach.

A pedestrian crossing on Essex Quay (Site 793), approximately 700 metres west of O'Connell Street, was used as the test site for this intervention.

Site Description:

Dublin's Quays operate largely on a one-way system: the North Quays carry inbound traffic towards the city centre, and the South Quays carry outbound traffic (see figure 6). As a result of this system, the quays experience very distinct tidal flows – during the morning peak hours the North Quays are heavily congested, with the South Quays carrying greater volumes during the evening peak.

For the most part, junctions to either side of crossings over the River Liffey operate as a single intersection, with a single traffic controller serving both sides of the crossing. In addition, the signals are co-ordinated to cater for the tidal flows described above. A result of this arrangement is that cycle times are dictated by traffic volumes on the busier side of the Quays, with the less heavily trafficked side therefore operating at cycle times that may not be appropriate to the traffic volumes experienced on that side. Site 793 is a mid-block pedestrian crossing that is within the same subsystem as the nearby junction at Capel Street Bridge, site 26, approximately 80 metres to the east (see figure 6), meaning that it's cycle time is governed by site 26.

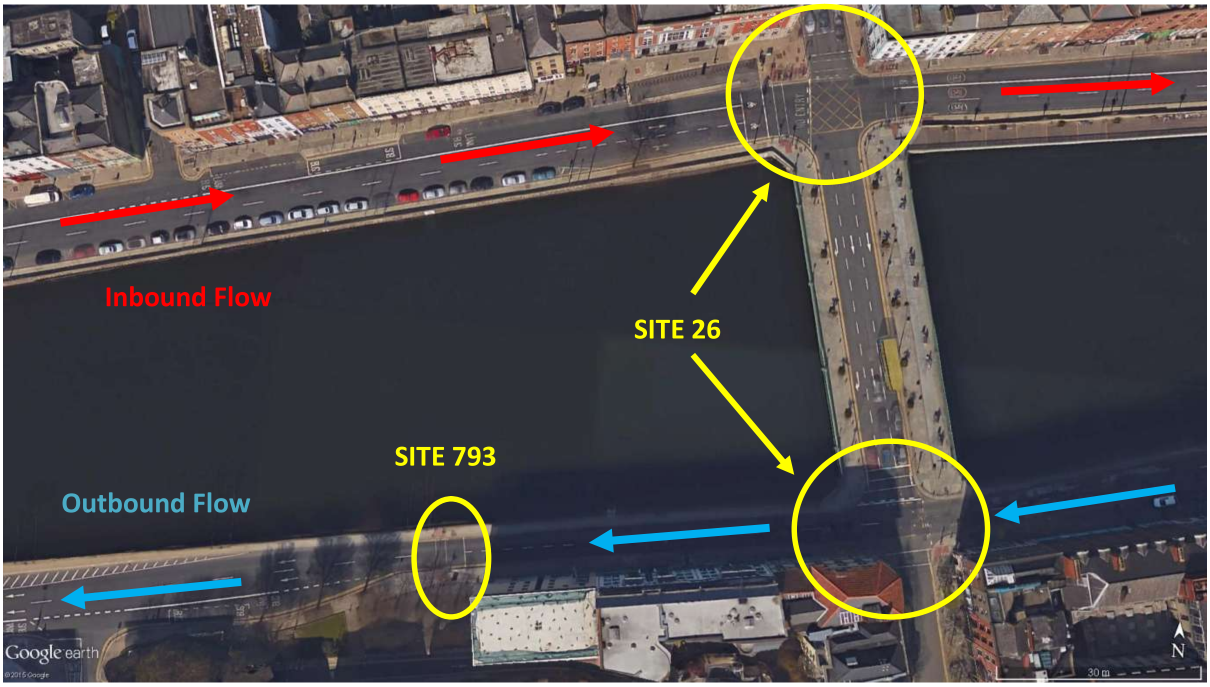

Figure 6: Essex Quay & Capel Street Bridge

The cycle time is extended to 120 seconds during the morning peak at this location by traffic on the North Quays, leading to extended waiting times for pedestrians at site 793.

Original Operation

This pedestrian crossing has no vehicle detection, and although there is a facility to double cycle the crossing, this had been disabled in order to maintain co-ordination for outbound traffic on the South Quays. In addition, a permanent demand was placed on the pedestrian phase such that it ran in every cycle of the signals, presumably in an attempt to provide some level of consistent pedestrian provision.

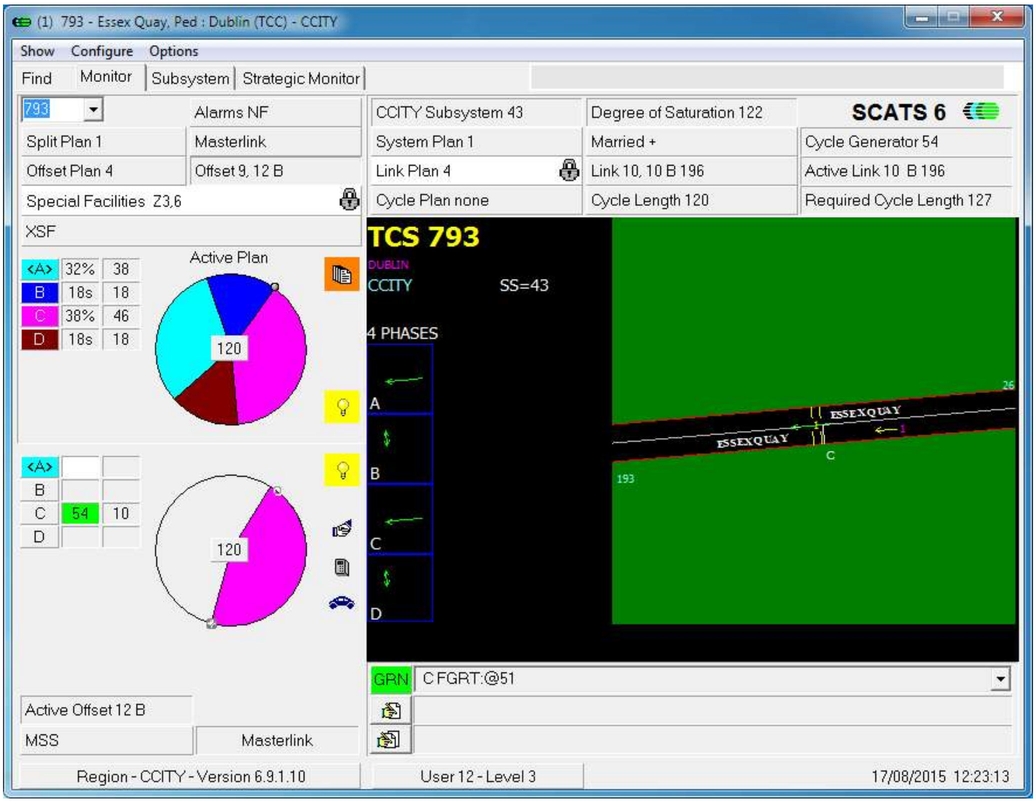

Figure 7: SCATS Graphical User Interface for Site 793

Long pedestrian wait times, coupled with the low traffic volumes on the South Quays during the morning peak resulted in a significant amount of wasted time that could have been better used to service pedestrian demands. From monitoring of the site it was observed that very few pedestrians actually waited for the pedestrian phase to run, with most people choosing to cross during gaps in traffic, either at the crossing itself or before they reached the crossing. In addition, due to the permanent demand placed on the pedestrian phase, in the majority of cycles vehicles were stopped on red at the crossing with no pedestrians present.

In order to quantify these behaviours, pedestrian counts were conducted from 08:00 to 09:30 in dry weather conditions on Wednesday the 15th of July, and again in wet weather conditions on Wednesday the 22nd of July 2015. The results of these counts are presented later in the paper.

Amended Operation

In order to reduce these delays it was considered desirable to allow the pedestrian phase to take advantage of gaps in traffic on the approach to it, in order to more closely service actual pedestrian behaviour. The absence of vehicle detectors at the crossing negates the possibility for gap detection at the site, however the nearby junction at Capel Street Bridge (Site 26) is equipped with vehicle detection. Therefore it was proposed to use the gap timers associated with these detectors to identify appropriate gaps in traffic on the South Quays during which the pedestrian phase could be allowed to run.

Ordinarily in SCATS a phase can 'gap off' when all of the gap timers associated with all of the detectors on each of the approaches that run in that phase have timed out. This allows the next demanded phase to be introduced earlier in the cycle than it otherwise would have. However, in this case it was proposed to use only the gap timer associated with the detectors on a single approach to influence the pedestrian crossing.

As this differs from the normal operation of these timers, a change to the code for site 26 was required. This change was minor, and simply involved programming the controller to send an MSS bit to SCATS when the gap timer associated with detectors 1 & 2 on the Wellington Quay approach to site 26 timed out during the rest or extension periods of phase A.

Figure 8: SCATS Graphical User Interface for Site 26

The amended code was tested using SCATS simulation mode. It does not have access to live detector information, so detector inputs were simulated by connecting WinTraff to the SCATS simulation and manually applying detector activations. Once satisfied that the amended programming was sending the required MSS flag when the appropriate conditions had been met a new EPROM programmed with the amended code was installed on site to permit live testing of the proposed operation.

A number of changes were then made in SCATS at site 793 in order to make the pedestrian crossing more responsive. First, the ability to double cycle the pedestrian phase was reinstated at the site. A number of variation routines were then implemented to control the introduction of the second pedestrian phase. The logic of these routines is as follows, and a screenshot of the SCATS interface is provided below:

1. Test for the Phase C. As the intervention controls the introduction of the 2nd pedestrian phase, D, only pedestrian demands received during the previous vehicle phase, C, are of interest.
2. Test for the MSS flag at site 26 to indicate that a gap in traffic has occurred.
3. Begin a latched timer.
4. Send Z+ flag from SCATS to the controller. Typically Dublin City Council uses Z flags to control the introduction of pedestrian phases. In this case, the Z+ flag permits the pedestrian push button to demand the 2nd pedestrian phase, D as well as the primary pedestrian phase, B.

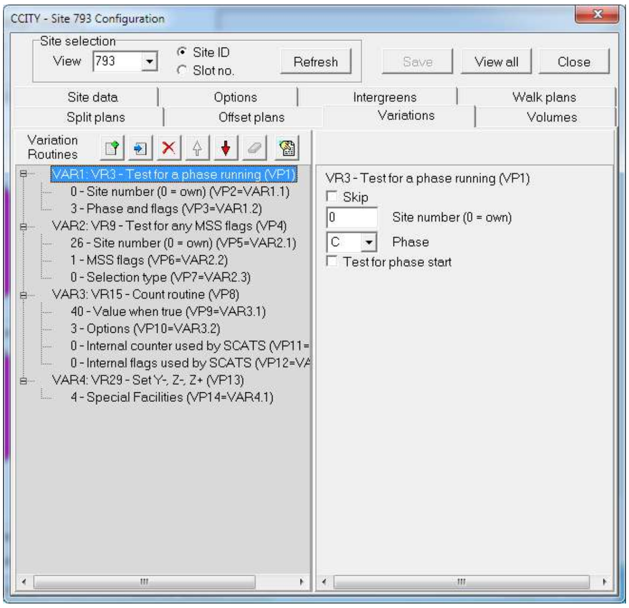

Figure 9: Variation Routines Implemented at site 793

The purpose of the latched timer is to maintain the 'true' state for the preceding MSS flag test, as the MSS flag would be removed on activation of one of the detectors at site 26 by a late arriving vehicle, and it would not be desirable to inhibit the introduction of Phase D at site 793 as a result of isolated vehicles outside of the main platoon.

Finally, the offsets between site 26 and site 793 were adjusted to ensure that a platoon of vehicles travelling from site 26 was able to pass the crossing before the end of Phase C, and the beginning of Phase D at site 793.

This amended operation is, in essence, double cycling of the pedestrian phase. However, the use of the variation routine functionality of SCATS allows for more adaptive operation than traditional double cycling, as the second pedestrian phase is only introduced when the platoon of vehicles has passed the pedestrian crossing.

Following a period of testing and refinement of the parameters of the variation routines pedestrian counts were again undertaken, again in both dry and wet weather conditions. Counts for dry weather conditions were on Thursday the 13th of August and wet weather counts were undertaken on Wednesday the 19th of August 2015. The results of these counts, and a comparison with the original operation are presented in the following section.

Results & Analysis

The results of the pedestrian counts conducted at the site and estimations of the average and maximum pedestrian delays for the original and amended operations are presented in this section.

Pedestrian Counts

Pedestrian counts were undertaken at the site before and after the implementation of the amended operation, in both dry and wet weather conditions. The counts were undertaken during the morning peak, from 08:00 to 09:30, on each day. Pedestrians were classified into 5 groups as follows:

1. Pedestrians who crossed near to, but not at the crossing. The requirement for a pedestrian to be counted within this cohort was not based on the distance from the crossing, but rather a pedestrian was counted if the route of their trip could have included the crossing.
2. Pedestrians who crossed at the crossing, without pushing the button to demand the pedestrian phase.
3. Pedestrians who pushed the button to demand the pedestrian phase, or arrived at the crossing when another pedestrian at the crossing had already pushed the button, but crossed before the pedestrian phase commenced.
4. Pedestrians who pushed the button, or arrived at the crossing the button was already pushed, and waited for the pedestrian phase to commence before crossing.
5. Pedestrians who crossed during the pedestrian phase, having arrived during the pedestrian phase.

In addition, the number of cycles where the pedestrian phase ran without any one crossing the road was also recorded. The results of these counts are presented in tables 3 and 4.

Dry Weather Counts		**Wed 15-07-2015**		**Thurs 13-08-2015**	
		Count	**% of Total**	**Count**	**% of Total**
1	Near crossing	49	32	24	20
2	At crossing, no pedestrian demand	26	17	45	38
3	Pedestrian demand, didn't wait	51	34	22	18
4	Pedestrian demand, did wait	8	5	24	20
5	Arrived during pedestrian phase	17	11	4	3
	Total	**151**	**100**	**119**	**100**
	Times pedestrian phase ran	45		19	
	Cycles with pedestrian phase - no pedestrians crossed	22		6	

Table 3: Dry Weather Pedestrian Count Results

Wet Weather Counts		Wed 22-07-2015		Wed 19-08-2015	
		Count	**% of Total**	**Count**	**% of Total**
1	Near crossing	47	32	46	30
2	At crossing, no pedestrian demand	44	30	59	39
3	Pedestrian demand, didn't wait	50	34	31	21
4	Pedestrian demand, did wait	0	0	11	7
5	Arrived during pedestrian phase	7	5	4	3
	Total	**148**	**100**	**151**	**100**
	Times pedestrian phase ran	45			
	Cycles with pedestrian phase - no pedestrians crossed	33		12	

Table 4: Wet Weather Pedestrian Count Results

Pedestrian Delays

The maximum delay a pedestrian could experience and the average delay per pedestrian have been estimated for both modes of operation, and these estimates are presented in table 5.

Average Delays:

The average delay per pedestrian was estimated using the standard formula from the Highway Capacity Manual (ref. equation 18-5):

$$d_p = \frac{0.5(C-g)^2}{C}$$

Where:

- d_p = Average pedestrian delay in seconds per pedestrian (s/p)
- C = Cycle time in seconds (s)
- g = Effective pedestrian green time in seconds (s)

The effective pedestrian green time is an estimation of how much time is available to pedestrians to being crossing the road. In road traffic legislation in Ireland pedestrians are only permitted to commence crossing during the green pedestrian signal. In practice pedestrians continue to commence crossing during the first part of the amber signal. As per the Highway Capacity Manual effective green time is therefore taken as the walk time plus the first 4 seconds of amber time.

Original Operation

The walk time at this crossing is 6 seconds, giving an effective pedestrian green of 10 seconds. The cycle time for the site is 120 seconds, therefore the pedestrian delay is given by:

$$d_p = \frac{0.5(120-10)^2}{120}$$

Amended Operation

The pedestrian phase can run twice in a cycle, so the cycle time is reduced to 60 seconds to account for this. The effective green time remains 10 seconds, giving the average pedestrians delay as:

$$d_p = \frac{0.5(60-10)^2}{60}$$

Maximum Delays:

The maximum delays are based on the worst case scenario, the point in a cycle that would result in the longest wait time before the pedestrian phase commences.

Original Operation

The worst case is taken to have occurred for a person arriving during the amber pedestrian signal. An assumption is made that pedestrians cross during the green time and the first part of the amber time. This is analogous to the effective green time used in average delay calculations, and is equal to the walk time plus the first 4 seconds of amber time. Therefore the maximum delay is given by:

$$Max.delay = Cycle\ time - effective\ green$$

Amended Operation

The worst case for the amended occurs for a pedestrian who has missed the opportunity for phase D to run, that is someone who arrived at the crossing at the nominal end point of phase C. (If phase D is not demanded it’s time is awarded to phase C. For D to run, a demand needs to be registered within phase C’s own allocation). The max. delay is therefore the duration of phase D (now subsumed into phase C) and phase A, i.e.:

$$Max.delay = Phase\ D + Phase\ A$$

	Original Operation	Amended Operation	Reduction	% reduction
Average delay (seconds per pedestrian)	50.4	20.8	29.6	59%
Maximum delay (seconds)	104	58	46	44%

Table 5: Pedestrian Delay Estimations

Analysis

- While approximately one third of pedestrians crossed the road before reaching the crossing, the remaining two thirds walked to the crossing point before crossing the road. This indicates that there is a pedestrian desire line at this location.
- The very low number of pedestrians who waited for the green pedestrian signal before crossing the road under the original operation mode suggests that the pedestrian crossing was not servicing pedestrian demands efficiently.
- The high number of occurrences of vehicles stopped at the crossing without any pedestrians present indicates that the crossing was causing unnecessary delays to vehicular traffic.
- The amended operation results in significant reductions in pedestrian delays; the maximum delay a pedestrian experiences is reduced from 110 seconds to 58 seconds, a reduction of 44%, and average delays per pedestrian are reduced by 59% from 50.4 s to 20.8 s.
- In both wet and dry weather conditions the amended operation resulted in an increase in pedestrians that waited for the green pedestrian signal. This appears to correspond with a reduction in those who registered a demand but didn’t wait, suggesting that the intervention was successful in reducing waiting times.
- The number of pedestrians who crossed the road without registering a demand was largely unaffected by the changes. This would suggest that there are still appreciable gaps in traffic on the South Quays that could be exploited. It may be that familiarity with the longer waiting times of the original operation has influenced the behaviour of pedestrians. It will be worthwhile to monitor the crossing to see if this cohort reduces as people become more familiar with the new operation.
- Permitting the pedestrian phase to be more responsive to demands has significantly reduced the occurrences of traffic stopped on a red signal when there are no pedestrians present, improving traffic flow and reducing the perception among drivers that the crossing is faulty.

CONCLUSIONS & RECOMMENDATIONS

The aim of this paper was to illustrate the use of various SCATS interventions that are currently being employed in Dublin with a view to controlling traffic signals in an intelligent way for the benefit of pedestrians. We demonstrated that it is possible to use features of SCATS to develop specific interventions that function coherently. The paper has shown that:

- Duplicate phases allow pedestrian signals a second chance to be introduced within the cycle
- Hidden pedestrian operation can be incorporated into staggered crossings in order to coordinate the different stages of the crossing to ensure progression for pedestrians.
- Vehicle detection information can be used to increase the frequency of the pedestrian phase at mid-block crossings and thus reduce delays for pedestrians, making use of otherwise wasted time to ensure that there is little to no impact on vehicular traffic flow.

The results of the interventions were reduced pedestrian delay and increased coordination, with minimal impact on other modes. Compliance at pedestrian crossings was also found to have improved (site 793) as a result of the intervention; at the same site the frequency of pedestrian crossings running with nobody there was reduced, thereby promoting confidence in the signals. It is planned to continue to develop and improve these interventions with a view to using them as templates for other suitable traffic sites.

Further modifications of existing signal operations along the same lines of the interventions described in this paper are possible and could also be used to benefit pedestrians. It was shown in this paper that SCATS is amenable to the development of this kind of site-specific traffic signal operation. Any information gathered by detectors that could assist in making the signal operation more intelligent would be of use and this is an area for further study. In addition, investigation into the use of Variation Routines or Action Lists not explored in this paper would be of interest.

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