SIGNAL IMPROVEMENTS TO BLUE HILLS PARKWAY AND BROOK ROAD INTERSECTION

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Background

The Department of Conservation and Recreation is planning traffic and roadway improvements on Blue Hills Parkway – Eliot Street to Mattapan square area. Included in the project are improvements to the intersection of Blue Hills Parkway and Brook Rd. This intersection currently operates in a fully actuated (and therefore uncoordinated) mode. There is an all-pedestrian phase that can lead to long cycles. In addition to that, pedestrians have multi-stage crossings that can involve long waiting times. Cyclists have bike lanes on Blue Hills Parkway, but none on Brook Road even though it's an important bike route through Milton.

The objective of this project is to see whether performance and safety might be improved by alternative signal and intersection layout schemes that serve pedestrians with concurrent crossings.

Current Intersection Operation

The layout of the intersections is shown below in Figure 1, with the primary movements numbered. State Route 28 follows the northern leg of Blue Hills

Parkway and the eastern leg of Brook Road, and the heaviest traffic is the movements connecting these legs (movements 2 and 3). Note that westbound traffic approaching on Brook Road may only turn right. There are bike lanes on Blue Hills Parkway.

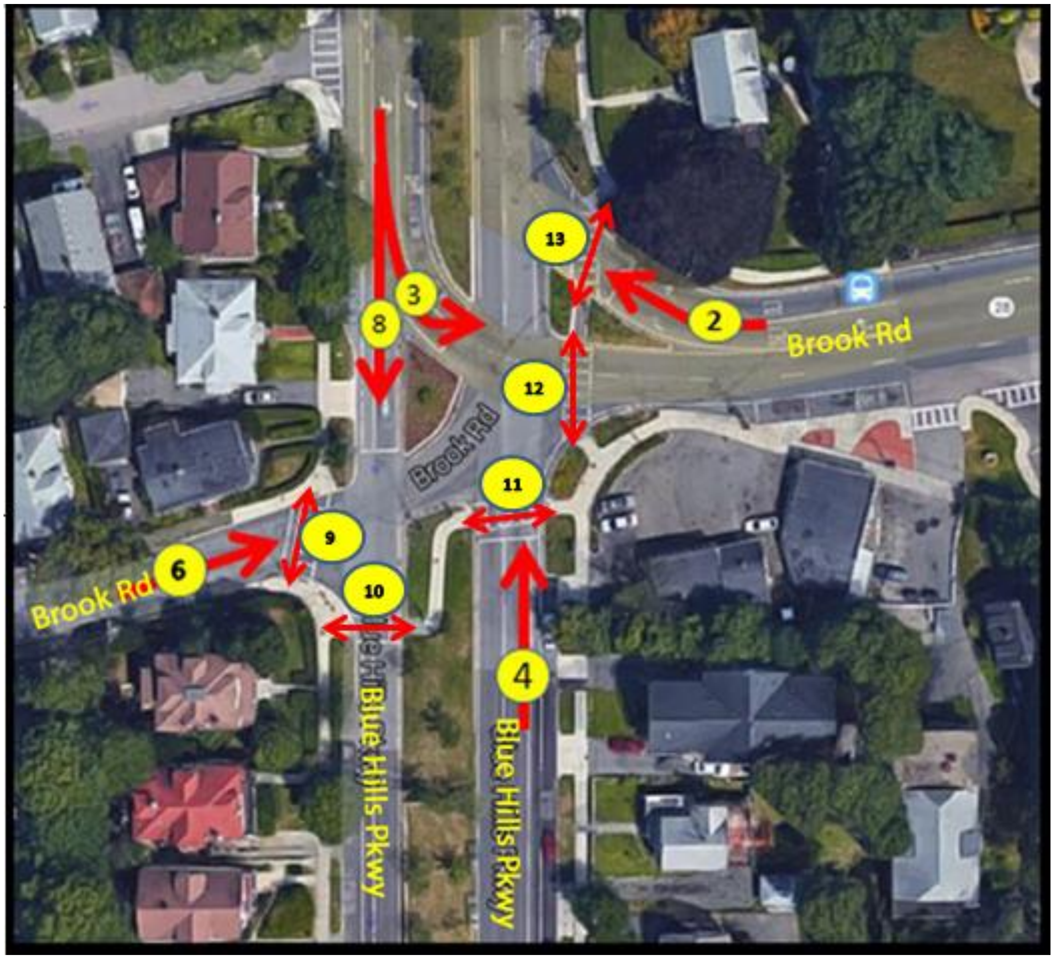

Figure 1: Intersection and turning movements. Image from Google Maps.

Existing Signal Phasing

The current signal phasing is illustrated in Figure 2. The signal is fully actuated, meaning that phases end when a gap in traffic is detected, subject to minimum and maximum green constraints.

The intersection has five controlled crosswalks. Due to the heavy traffic demand on movements 2 and 3, there is no East-West crossing across the northern legs of Blue Hills Parkway. There is an all-pedestrian phase that comes up only when actuated by a pushbutton; pushbuttons are provided at all the crosswalks. All the crosswalks get a WALK during the all-ped phase. Four of the crosswalks also get a WALK during a concurrent vehicular phase as well, but the crosswalk across the west side receiving lanes of Brook Road gets a WALK only during the all-ped phase.

The vehicular movements are controlled by a scheme called split phasing, in which southbound movements (phase 8) do not overlap at all with northbound movements (phase 4). The reason for split phasing is that southbound lefts are protected only because it's a heavy movement and can be done in two lanes, and the lane assignments on the southbound approach allow left turns as well as through movements from the right lane. Because the queues for SBT (southbound through) and SBL (southbound left) traffic cannot be separated, those two movements (8 and 3) have to run concurrently; and then because NBT conflicts with SBL, NBT (movement 4) has to run in a non-overlapping interval.

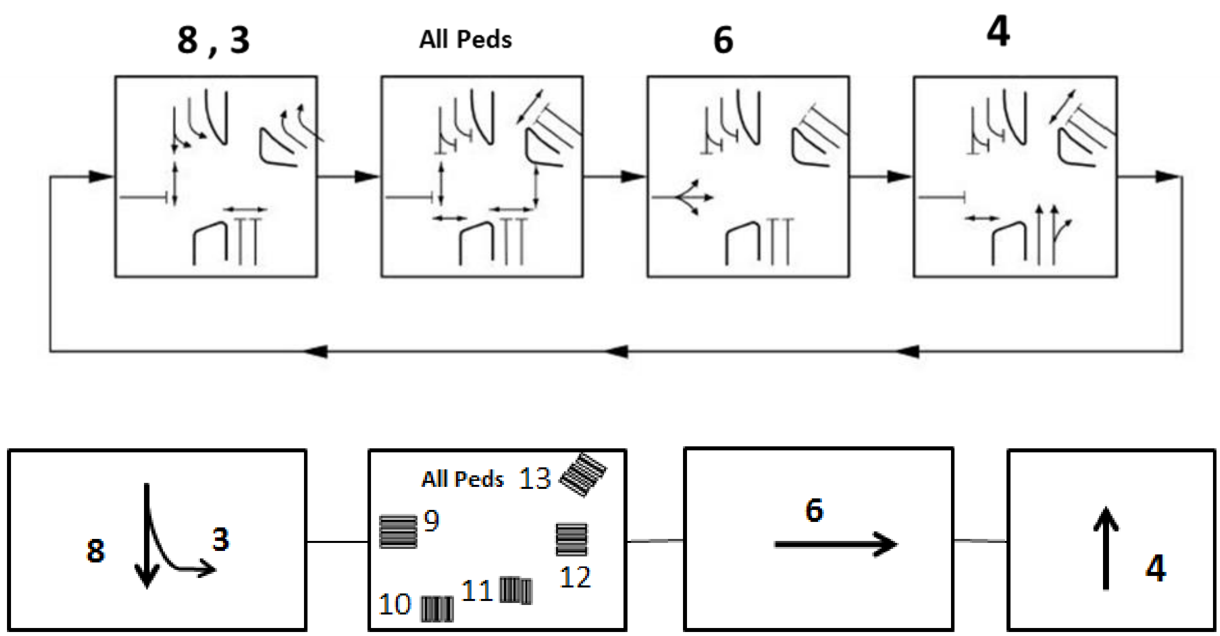

Figure 2: Existing signal plan, shown two different ways

Pedestrian Crossing Issues

1. Need for All-Ped Phase?

Historically, all-ped phases have been the preferred way to provide for pedestrian crossings on state highways in Massachusetts. However, they have two large drawbacks compared to concurrent crossings (meaning peds cross concurrently with a parallel vehicular phase). One is that they consume a lot of intersection capacity, increasing delay for motorists, increasing the cycle length, and possibly creating a need for additional lanes. The second is that, because they lead to long cycles, they result in long pedestrian delay – if pedestrians actually wait for the all-ped phase. In practice, most pedestrians usually tend not to wait for the all-ped, but rather will walk with a parallel vehicular phase if it comes up first.

On the other hand, concurrent phases have a drawback, too – they usually involve a (permitted) conflict with right-turning cars. When the right turning volume is light and when the corner geometry forces right turning cars to go slowly, this conflict is considered acceptable, and is the standard treatment used across the U.S. and the world. However, if there is a heavy right turning volume, conflicts can become a serious nuisance to both pedestrians and right-turning traffic. In Massachusetts, a commonly used guideline is to prefer an all-ped phase (or otherwise protected crossing) when the right turning volume in the peak hour exceeds 250 vehicles/h. Protected crossings can also be needed where the corner geometry allows high speed right turns, such as a skewed intersection.

At this intersection, the only heavy right turn movement (movement 3) is controlled by its own signal; when it is red, pedestrians can cross it with full signal protection. The other right turn movements (minor parts of movements 4, 6, and 8) have volumes less than 50 vehicles per hour, and their corner geometry forces right turns to be made at low speed. Therefore, there does not appear to be a reason to keep an all-ped phase.

2. Two-Stage Crossings

A second pedestrian issue is that in the current plan, all crossings except the one across the narrow western leg of Brook Road are two-stage crossings. That is, pedestrian crossing North-South along the eastern side of Blue Hills Parkway, or East-West along the northern side of Brook Road, follow one WALK signal to cross one roadway to an island, then follow a second WALK signal to complete their crossing. Two stage crossings can force large delays on pedestrians because they have to wait twice, especially if the cycle is long and / or the crossings are not well coordinated. On the other hand, the large size of the medians means that providing enough time for pedestrians to cross in one stage would force phases to run much longer than they would otherwise need to, increasing the cycle length and with it, delay for pedestrians as well as motorists.

Therefore, it seems reasonable to maintain a scheme with two-stage crossings, but at the same time to attempt to lower the cycle length and / or coordinate the crossings so that pedestrian delay is limited.

3. Shortening One of the Crossings

The crossing across the mouth of Brook Road's westbound right turn lanes is currently oriented in a way that makes the crosswalk far longer than it would be if it were oriented perpendicular to the road being crossed. Changing the crosswalk orientation will reduce the crossing length by 10 ft, shortening exposure, making it easier for peds to cross, and reducing the minimum length of crossing interval. The reoriented crosswalk will impose a small detour on pedestrians, but because it will increase pedestrian walking distance by only 4 ft, the tradeoff is favorable. Therefore, in both alternatives, this crosswalk is assumed to be reoriented.

Alternative Signalization Plans

Two alternative signalization plans are presented, both of which involve concurrent ped crossings without any all-ped phase. First, we present the preferred plan, in which lane assignments on the southbound approach are changed so that left turns can be made from the left turn lane only. Second, we present a plan that keeps the existing lane assignments and split phasing scheme that currently exists, but without the all-ped phase.

Alternative 1: Dual Ring Phasing with Overlaps

The first alternative is called “dual ring phasing” because control of the thru and left-turning vehicular movements follows two concurrent rings. In this case, movement 8 (SBT) is controlled in one ring while movements 3 (SBL) and 4

(NBT), which are compatible with movement 8 but incompatible with each other, run in series in a second ring.

Movement 2, which is the heavy right turn movement that is controlled by its own signal, runs during all of phase 3 and it is interrupted to allow crossing 13 – which in turn overlaps phases 4 and 8 (part of the first half-cycle). When crossing 13 is finished, phase 2 can resume, this time in parallel with movement 6. This plan is shown in Figure 3.

With this plan, lane assignments on the southbound approach are changed so that left turns can only be made from the left lane; the right lane is for thru and right turn movements only. For this alternative, left-turning traffic was modeled as moving in a single lane.

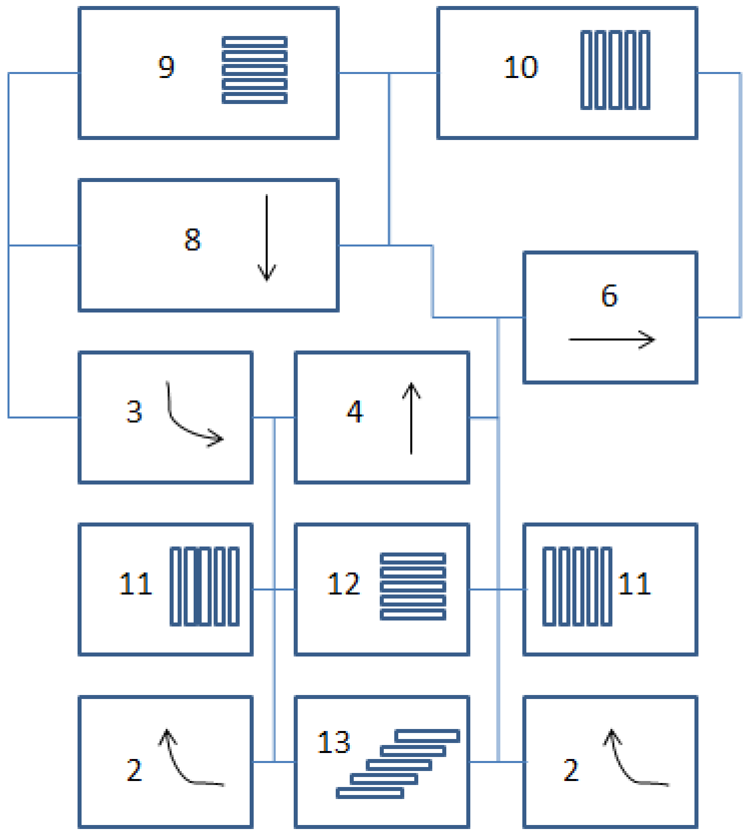

Figure 3: Overlapping phasing scheme

Alternative 2: Split Phasing without an All-Ped Phase

The second alternative keeps the existing lane assignments and split phasing scheme that currently exists, but without the all-ped phase. The phasing plan is shown in Figure 4.

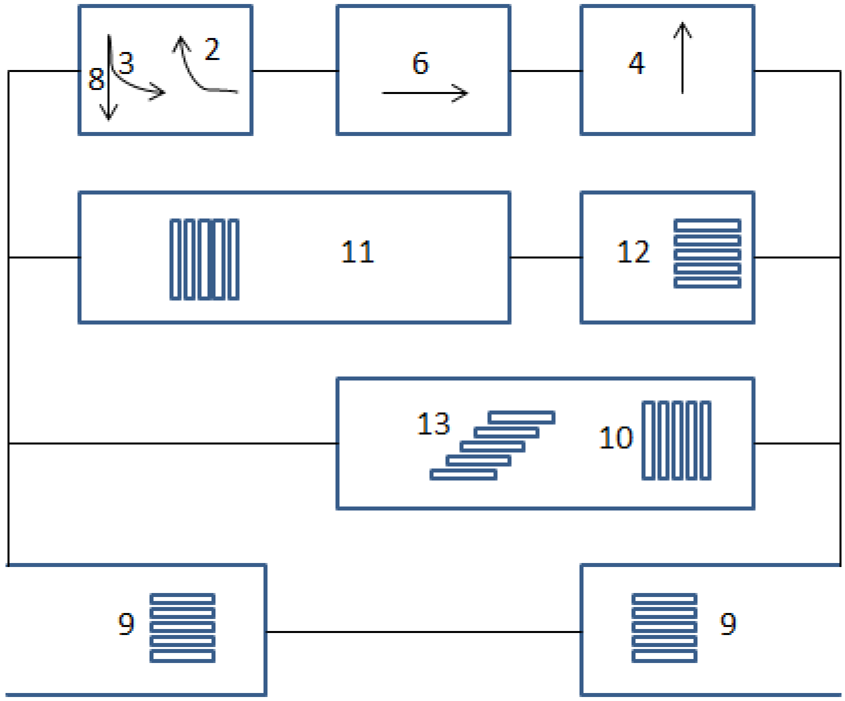

Figure 4: Alternative split phasing without the all-ped phase

Data and Evaluation Measures

P.M. peak hour data was collected by two fellow students, Nan Deng and Qichen Zhang. Only the p.m. peak hour, during with the dominant traffic movement is southbound, was evaluated in this project; further evaluation should, of course, consider the a.m. peak hour.

The intersection was modeled using VISSIM, a microscopic simulation model. The simulation was run for 2 hours with a warm up period of 2 minutes and the results were analyzed for one replication.

In all three evaluations, pedestrian phases were on recall, meaning they were run during every cycle. This treatment seems appropriate for a location in a densely populated area a short distance from a major transit station (Mattapan station).

Motorist delay was calculated directly from VISSIM as the difference between the average time it takes vehicles to pass through the intersection and the time it would take if they had the right of way at all times and therefore didn't have to stop.

Pedestrian delays were calculated using the Northeastern University Multistage Crossing Delay Calculator using average timings obtained from the simulation results. The focus for pedestrian delay is on the long two-stage crossings, one East-West (across the southern leg of Blue Hills Parkway) and one North-South (across the eastern leg of Brook Road). Assumed walking speed for this evaluation measure was 4.5 ft/s, which is average pedestrian walking speed. (Note that in contrast, minimum pedestrian intervals are based on a speed of 3.5 ft//s, the speed of pedestrian who walks much more slowly than average.) The crossing across the narrow, low-traffic western leg of Brook Road will have very good service in any alternative and so was ignored in the evaluation. Because we did not have reliable counts of pedestrian flows, average pedestrian delay overall was calculated as a simple average over the four crossing movements (E-W, W-E, N-S, and S-N).

Results

Average delay for vehicular traffic for the existing timing plan and the two alternatives is shown in Table 1 and Figure 5. All values in seconds. Compared to the current plan, both alternative plans have a substantially shorter cycle length (because they eliminate the all-ped phase) and with it vastly reduced motorist delay. The split phasing alternative has the shortest cycle length because in that alternative, phase 6 can have a short minimum green (we used 8 s) because there is no concurrent crosswalk that relies exclusively on it.

Table 1: Delay and Cycle length

	Car delay (s)	**Cycle length (s)**
Current signal plan	24.5	82
Split phasing with parallel ped phases	21.7	77.8
Overlapping phasing	17.1	68.8

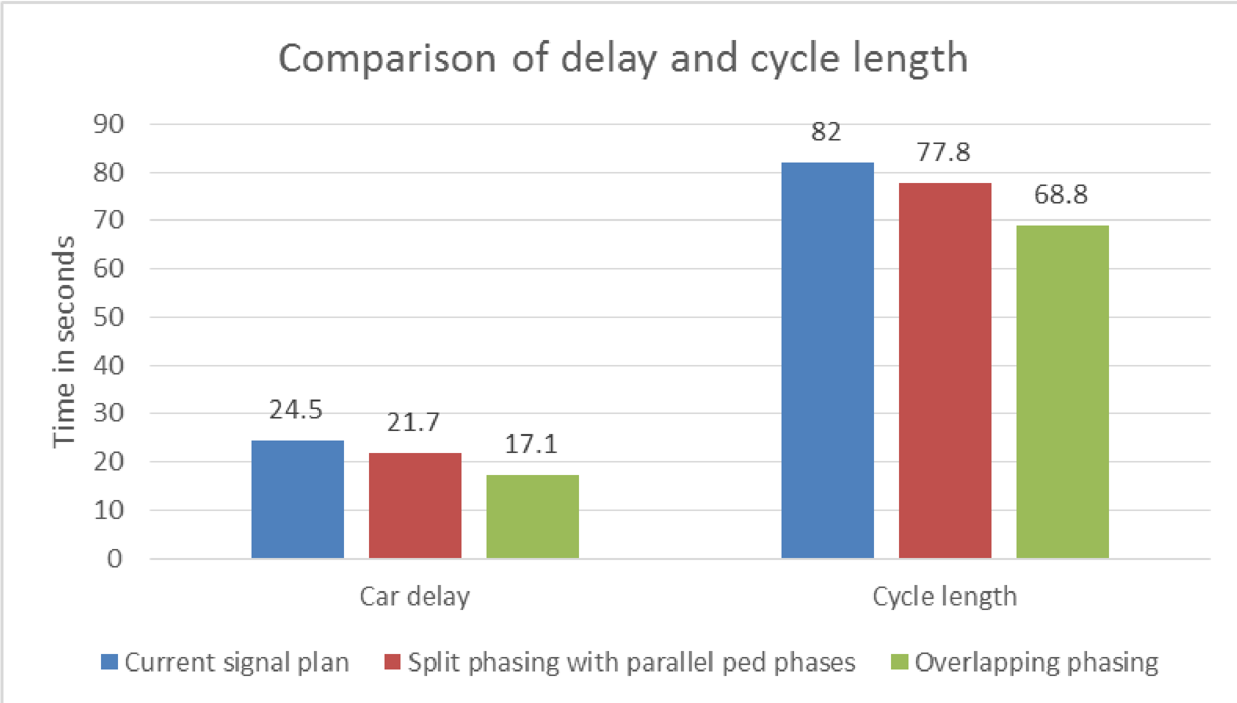

Figure 5: Comparison of delay and cycle length

Pedestrian crossing delay, calculated using the Northeastern University Multi-Stage Pedestrian Delay Calculator, is shown for the existing plan and the two alternatives in Table 2 and in Figure 6. With both alternatives, pedestrian delay is drastically reduced thanks to using concurrent phasing. In the dual ring with overlap alternatives, one of the four two-stage crossings has poor coordination and therefore a substantially longer wait than the others, but still well below the delay in the current timing plan.

Table 2: Pedestrian crossing delay in seconds

	E-W	**W-E**	**S-N**	**N-S**
Current signal plan	92.8	90.5	99	98.3
Split phasing with parallel ped phases	25.7	10.1	20.3	16.8
Overlapping phasing	8.4	15.3	19.7	19.2

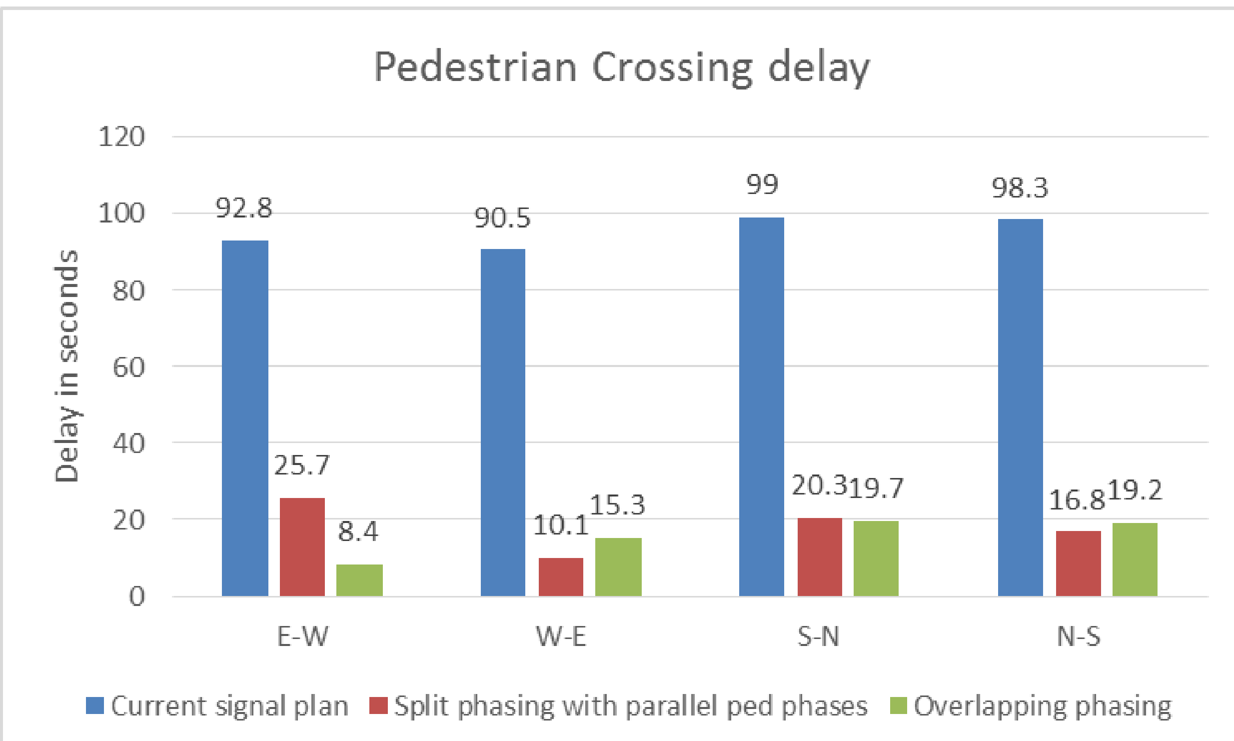

Figure 6: Pedestrian crossing delay

Conclusion

The current signal phasing plan is very inefficient especially due to the presence of an all pedestrian phase. The other two proposed models performed significantly better than the existing plan especially in reducing the pedestrian crossing delays. The overlapping signal plan performed better that the other alternative mainly due to the presence of concurrent westbound right turns and eastbound left turns. This plan also requires changing the lane assignment for the southbound left turning vehicles.