

Pedestrian Timing Treatment for Coordinated Signal Systems

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ABSTRACT: Pedestrian timing has always been one of the major issues while developing signal timing plans for coordinated signal systems. There are two alternative treatments on pedestrian timings: timing based on pedestrian minimums where the required pedestrian crossing times are accommodated in the signal phase splits, and timing based on vehicle minimums where the phase splits are determined only based on vehicle demand. The purpose of the paper is to analyze the various effects of the two pedestrian treatment alternatives through a case study. Various timing strategies were identified to minimize the negative effect while timing based on pedestrian minimums. These timing strategies include the appropriate setting of offsets, the effective use of side-street phasing, and the use of maximum recall. It was found that although timing based on vehicle minimums can generally result in a shorter system cycle length, timing based on pedestrian minimums can normally achieve the same operational efficiency. The most significant advantage of timing based on pedestrian minimums is that the signal system will always remain in coordination. The only drawback of timing based on pedestrian minimums is the likely use of longer cycle length. It is recommended that timing based on pedestrian minimum technique should be applied when longer cycle length is required for the system, and medium to high level pedestrian crossing activities exist.

Key Words: Signal Timing, Coordinated Signal Systems, Pedestrian Timing

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INTRODUCTION

Pedestrian timing has always been an issue while developing signal timing plans for a coordinated signal system. The treatment of pedestrian timing has resulted in different signal timing strategies. For some agencies, pedestrian crossing time is provided for all timing plans, while other agencies allow traffic signals to go “off line” when there is a pedestrian call. Providing for pedestrian crossing time every cycle may result in a reduction in green time available for main street vehicle movements. These two issues, pedestrian crossing time and main street green time may drive the need for a traffic engineer to use a less than optimum arterial timing plan.

There are basically two strategies in dealing with pedestrian crossings: timing based on pedestrian minimums where the required pedestrian crossing times are accommodated in all the signal phase splits; and timing based on vehicle minimums where the phase splits are determined solely based on vehicle demand. The purpose of this paper is to evaluate the advantages and disadvantages of the two signal timing strategies. The evaluation of these timing strategies was based on a signal timing project in Vancouver, Washington, USA.

The first timing strategy, timing based on vehicle minimums does not require the phase splits of a signal controller to satisfy the pedestrian crossing times. When a pedestrian call occurs, the controller phase (normally the concurrent through movement phase) will be extended beyond the phase force-off point; thus causing the signal controller to go out of synchronization or coordination. It may take several cycles for the controller to come back to synchronization depending on the controller settings and controller features. When pedestrian crossings are rare, the signal timing plan developed in such a manner closely represents field traffic operations. In addition, it usually involves less effort to develop the timing plan using traditional signal timing software such as TRANSYT-7F [University of Florida, 1998], and PASSER II [Federal Highway Administration, 1991].

The second timing strategy, timing based on pedestrian minimums would provide sufficient phase splits to accommodate pedestrian crossings. For example, the concurrent through movement phase split should be equal to or greater than the sum of the Walk, Flash-Don't-Walk (FDW), and Clearance time. Timing plan developed in such a manner would always keep the signal in coordination regardless whether there is a pedestrian call or not. As most signal timing plans are to be developed towards the maximization of main street progression, pedestrian crossing time on the main street can normally be accommodated by the vehicle phase splits. However, the phase split required by the side street traffic demand is often less than that required by the pedestrian crossing time. If the side street's traffic demands are low, the consideration of pedestrian crossing time in the phase splits would result in excessive green time for the side street phase. In reality, the side street phase will gap out earlier if no pedestrian crossing exists, thus resulting in early release of the main street movements. The effect of such an early release could result in unnecessary vehicle stops at the downstream intersections.

Whether signal timing should be developed based on vehicle minimums or pedestrian minimums has been a debatable issue among practicing traffic engineers. No specific guidelines are available regarding when pedestrian minimum or vehicle minimum should be used. A questionnaire survey from the NCHRP 172 project [Parsonson, 1992] has indicated that as a general rule, pedestrian minimum time should be used for the side street when a pedestrian call occurs approximately 20 to 25 percent of the cycles.

The two signal timing strategies will result in different traffic operations. The system performance under each timing plan will depend on various factors, including traffic volumes, signal controller features, and pedestrian activities. Quantitative evaluation of the two signal timing strategies is desirable to assist the selection of a proper timing strategy. The paper attempts to address these issues, and to recommend alternative solutions while dealing with these issues.

PROJECT LOCATION AND DESCRIPTION

The project was located in Vancouver, Washington. The purpose of the project was to develop signal timing plans for Mill Plain Boulevard, one of the major arterials in the City of Vancouver. For the purpose of discussion, the result of the p.m. peak timing plan is presented. Figure 1 shows the signal system configurations, including traffic volumes and intersection geometry. The posted speed limits on Mill Plain Boulevard are 40 mph for both eastbound and westbound directions.

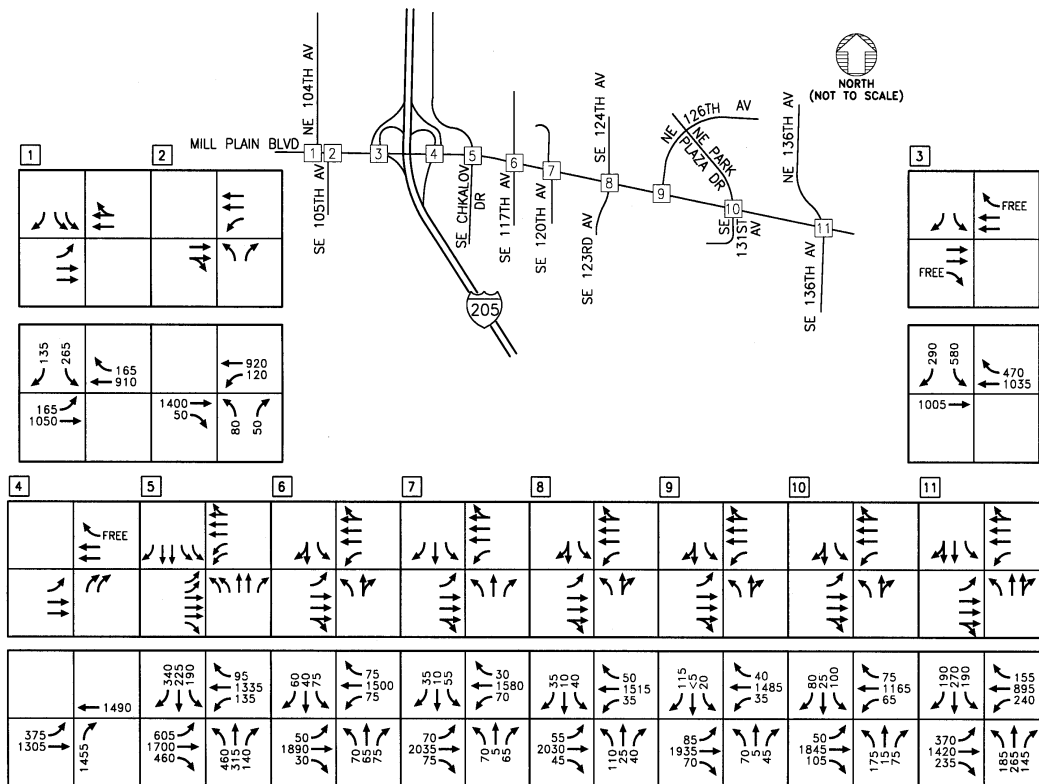


Figure 1 System Information: Intersection Geometry and Traffic Volumes

The system includes two freeway ramps where high traffic volumes exist for the two ramp approaches. The two ramp intersections do not form a standard diamond interchange and are currently controlled by two separate signal controllers. The two freeway ramps generate and absorb a significant portion of the system traffic flows. As a result, significant lane imbalances and weaving activities were observed in the freeway ramp vicinity. The lane imbalances resulted in ineffective use of the intersection capacity. Long vehicle queues were observed in the field on the westbound approach through lanes and the northbound approach left turn lanes

at the Chaklov intersection. Queue spillback often result for the westbound approach between the NE 117th and Chaklov intersections.

The system is currently operating under the TRACONEX traffic management system [TRACONEX Inc., 1989]. The intersections between Chaklov and 136th Avenue have relatively low side-street traffic demands.

SIGNAL TIMING DEVELOPMENT

As a typical signal timing project, it involved data collection, model coding and calibration, timing development, and field implementation. TRANSYT-7F was selected as the modeling software for this project.

One of the features of the TRACONEX controller is that the concurrent phase split has to satisfy the minimum pedestrian crossing time. Such a feature sets up a limit on how low the cycle length can be. It also presents problems for using traditional signal timing software such as TRANSYT-7F, because most of the software were designed to model pre-time operations. Such a software lacks the capability to consider the actuated controller features, such as phase early release (i.e. the side street phase terminates or the main street phase starts earlier than modeled). The appropriate application of the modeling software such as TRANSYT-7F under such circumstances should involve the following steps:

- Conduct optimization runs without pedestrian crossing times being considered. The timing plan produced would reflect the traffic operations when no pedestrian crossings exist.
- Set up the side street phase splits to satisfy pedestrian crossing minimums. Adjustments should also be made to other movement phases to ensure enough green time being provided.
- Produce a new time-space diagram with the pedestrian times being included, but to adjust the offsets in such a way that traffic would progress as if there are no pedestrian crossings.
- Further adjust the offsets so that traffic progression would not be completely destroyed (a driver would have to wait for a full cycle) when a pedestrian crossing does occur.

Figure 2 shows the finalized time-space diagram in a similar format as generated by TRANSYT-7F. The solid lines represent the progression band based on the pedestrian minimums at each intersection, while the dashed lines represent the progression band based on vehicle minimums. A timing plan developed in such a manner should aim at minimizing the negative effect of early release and maintaining traffic progression when pedestrian crossing does actually occur.

DISCUSSION

Although the signal timing plan developed for this project was tailored to the TRANCONEX controller specifications (the controller phase splits have to satisfy pedestrian crossing minimums), it does present an alternative signal timing strategy, which showed some advantages over the traditional signal timing strategy. Timing based on pedestrian minimum strategy will guarantee the system remain in coordination regardless whether there is a pedestrian crossing or not. However, this timing strategy does present a constraint on the system cycle length. Because the phase splits have to satisfy pedestrian crossing times, even though the pedestrian crossing is rare, a normally higher than optimal cycle length has to be implemented. The effect of running longer cycle is the increase of delay and queues to the minor movements.

Phase early release (i.e. side street phase terminates or main street phase starts earlier than modeled) is often expected. Modeling early release as an actuated controller feature cannot be handled by most signal timing software. Manual adjustments are generally involved, thus increasing the effort to produce a final timing plan. Early phase release may not result in capacity loss on the arterial since the extra green time allocated to the side street can normally get back to the main street, however, if not properly considered, unnecessary stops may occur at the downstream intersections.

If timing based on pedestrian minimum is a desired option, the following features should be considered in order to develop efficient signal timing plan.

Effective Use of the Side Street Phasing Scheme

As most signal timing software mainly focus on the optimization of main street phasing scheme (such as PASSER II), the effective use of side street phasing scheme is normally ignored. From a capacity point of view, the phasing scheme for the side street has no effect. However, the actuated controller feature does present different operational solution using different phasing scheme. This can be explained by how the “bonus time” is allocated. Bonus time refers to the extra time originally assigned to a phase but not actually being used. Depending on the controller features, the bonus time can either be re-allocated to the subsequent phases, or to the coordinated phases only. The effective use of such bonus time by applying appropriate phasing schemes can actually reduce the constraint on minimum cycle length and improve traffic operations. An example of this application is illustrated for the intersection at Mill Plain/Chaklov. At this intersection, minimal pedestrian crossings for the north/south direction were observed. A pedestrian crossing was observed to occur approximately every 4 to 5 cycles. Table 1 shows the average traffic demands for each side street movement given by the phase time (green + clearance). A minimum of 35 seconds was required by the pedestrian phases crossing north/south.

**Table 1
Phase Demand by Side Street Movements at Chaklov**

Movement	Average Demand, sec
Southbound Left Turn	10
Southbound Through	15
Northbound Left Turn	20
Northbound Through	20
Pedestrian Crossing	35

Figure 3 shows the two phasing schemes for the north/south approaches where pedestrian crossing times were accommodated in both phasing schemes.

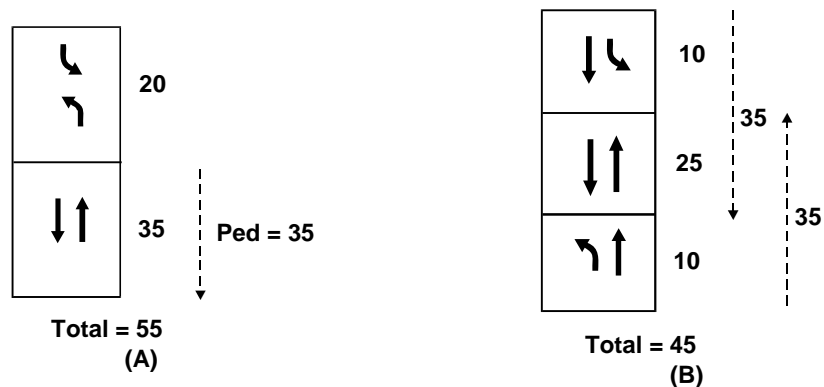


Figure 3 Alternative Side Street Phasing Schemes at Chaklov

Figure 3(A) is a normal dual left turn leading phasing scheme. In order to satisfy the average traffic demand for each movement, the first phase stage had to be set at 20 seconds, which was required by the northbound left turn demand. The second phase stage had to set at 35 seconds to satisfy the pedestrian crossing time. Since pedestrian crossing was rare, the second phase stage would normally terminate earlier than shown in the figure. Although such a phasing scheme did not significantly affect major street capacity, it did require a total of 55 seconds to be allocated to the side street, which imposed constraints on the minimum system cycle length.

Figure 3(B) is the proposed lead/lag phasing scheme for the side street. Such a phasing scheme would present a different operational effect. With the time allocated as shown in the figure, all the movements can be satisfied except for the northbound left turn movement. Ten seconds was allocated to the northbound left turn movement, which was 10 seconds shorter than as required by its vehicle demand. However, the actual operation will be better than shown. As pedestrian crossing was rare at this location, the second phase stage would last on an average about 5 seconds (the southbound through movement vehicle demand required 15 seconds). This would leave 20 seconds of bonus time to the third phase stage. The northbound left turn would actually have 30 seconds phase time before it reaches its force-off point. A total of 45 seconds of phase time could be allocated to the side street without actually creating operational problems for the side street. As a result, a timing plan could be developed using a shorter system cycle length based on the phasing scheme shown in Figure 3(B).

Use of Maximum Recall

Maximum recall is a controller feature that can be designated for each controller phase. When this feature is selected for a controller phase, the phase will always come on each cycle and would extend to the phase maximum or force-off point. The application of the maximum recall feature in conjunction with the signal timing plan developed based on pedestrian minimum could achieve better queue management for a congested system. In the system described in this paper, the westbound approach at Chaklov (Node 5) was operating near capacity. A significant amount of time was needed to clear the residual queue for the westbound approach each cycle. If traffic progresses according to the early release points as shown in Figure 2 (the dashed line), traffic released at Node 7 would almost always have to join the end of queue and stop before they could move again through the intersection. The effect of vehicles joining the back of queue would also result in queue spillback on the westbound approach at the Chaklov intersection. This can be avoided or minimized by setting a maximum recall at Node 7 for the side street

phase. Setting a maximum recall at this location would not affect normal traffic progression for the eastbound direction, but would achieve better queue management for the westbound direction, and avoid having vehicles leave the intersection to make another stop at the Chaklov intersection (Node 6). Although this approach would not reduce overall arterial travel time, it would reduce the number of stops for the westbound direction, and creates better driver perception. Caution must be made while using the maximum recall feature during off-peak operations. Setting up of the maximum recall during off-peak operations could result in unnecessary delay for the side street and could create citizen complains.

CONCLUSIONS

This paper addressed the two signal timing strategies evolved from the treatment of pedestrian crossings: timing based on vehicle minimums, and timing based on pedestrian minimums. Timing based on pedestrian minimums is a required feature by the TRACONEX operating system, which is the adopted system in the project location described in this paper. The study resulted in the following conclusions:

- Timing based on pedestrian minimums has the benefit that the signals will always remain in coordination, while timing based on vehicle minimum can result in a signal to go out of synchronization when there is a pedestrian call.
- Timing based on pedestrian minimum is likely to impose minimum cycle length constraint. A longer than the optimal cycle length may have to be applied.
- The timing plan developed based on pedestrian minimums must consider the effect of phase early release. Early release cannot be modeled directly by most signal timing optimization software. Significant manual adjustments are generally involved to produce the final timing solution.
- When timing based on pedestrian minimums, the minimum cycle length constraint can be minimized by using a lead/lag phasing scheme for the side street compared to a normal dual left turn leading phasing scheme.
- The maximum recall feature of signal controllers can be used in conjunction with the timing plans developed based on pedestrian minimums to achieve better queue management on an oversaturated arterial.

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