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Project Summary Report 0-4657-S

Project 0-4657: Guidelines for the Use of Advance Coordination Features in TxDOT Controllers

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PROJECT SUMMARY REPORT

Use of Advance Coordination Features in TxDOT Traffic Signal Controllers

Most of the delay experienced by motorists in Texas cities is at traffic signals. Improving signal timing is a cost-effective way to improve traffic operations and reduce motorist delay. Traffic engineers are constantly striving to improve traffic operations along arterials by providing signal coordination.

Traffic signal controllers today are very sophisticated and contain many advance coordination features that have the potential to improve traffic operations; however, traffic engineers seldom have the time and the resources to fully investigate these advance coordination features and usually use only the basic features to operate signals. Many of the features provided are beyond required Texas Department of Transportation (TxDOT) specifications.

To address this issue, TxDOT sponsored a project to investigate the advance controller features in controllers that meet TxDOT specifications. Currently, Eagle and Naztec traffic signal controllers meet TxDOT specifications. The project identified coordination features in these controllers, investigated their functionality, and developed some methodologies to use and program features that would benefit signal operations.

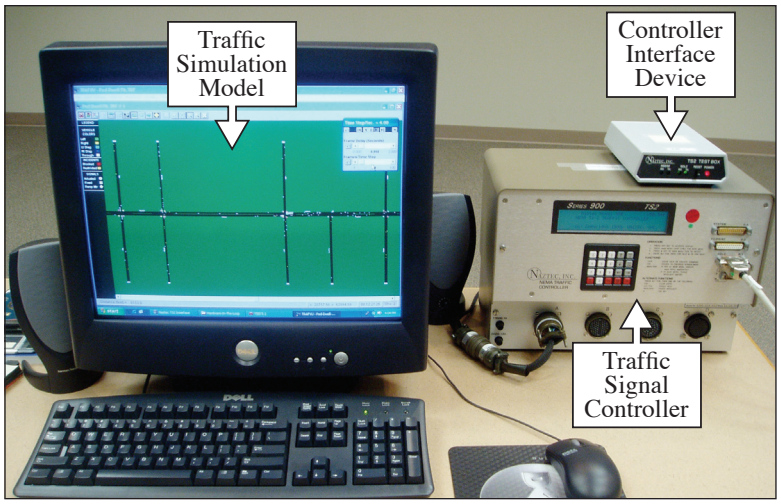

Figure 1. Hardware-in-the-Loop Simulation Setup.

What We Did...

We identified the features affecting coordinated operations in the EPAC 300 Eagle and Naztec 980 controllers. These features included force-off modes, transition modes, and coordination modes. Some of these features are provided in addition to the requirements of TxDOT specifications. Hence, the implementation of some of these features may not be as specified. The force-off and transition modes in the Eagle and Naztec controllers are very similar in functionality and implementation. However, implementation of coordination modes in the two controllers is totally different.

The coordination modes in the Eagle controller are implemented as specified in TxDOT specifications. Most of the coordination modes in a Naztec controller are not implemented as specified. Therefore the use of advance coordination modes in Naztec controllers is not recommended. However, Naztec controllers have a rich array of other coordination features that can be used in various combinations to provide operations similar to the operations provided by the coordination modes in the Eagle controllers.

We used hardware-in-the-loop (HITL) simulations to evaluate these coordination features. HITL simulation uses a model to simulate and control traffic signals in a real-time manner using actual hardware. The CORSIM simulation model was used to simulate traffic conditions. Traffic signal controllers were connected to the computer running the simulation model through a TS-2 controller interface device as shown in Figure 1. HITL ensures that we could create the same traffic conditions to evaluate different coordination features for a fair comparison, compare these features using an extensive series of measures of effectiveness, and add realism to the evaluation process by using real and actual traffic signal controllers.

What We Found...

Following are some of the features that were evaluated.

- Force-Off Modes
  - Floating force-off
  - Fixed force-off
- Transition Modes
  - Shortway
  - Shortway+
  - Dwell
  - Dwell with interrupt
- Coordination Modes (or Features)
  - Extend or truncate coordinated phase
  - Dwell or provide the minimum Walk indication
  - Eliminate or minimize the early return to the coordinated phase
  - Control when the Walk indication terminates
  - Control the recycle of pedestrian indication
  - Operate the coordinated phase in an actuated manner

We found that the fixed force-off mode has the potential to distribute any excess time from one non-coordinated phase to the next. This mode can improve operations on the side street where there is some cyclic variation in traffic demand and one of the side-street approaches is more critical than the other.

Figure 2 illustrates the benefits of using fixed force-off on intersection approach delay. The delay experienced by the southbound approach is significantly reduced when using fixed force-off, while the delay experienced by the remaining three approaches remains almost the same. The figure also illustrates the standard deviation of the approach delay. In the Eagle controller, floating force-off is known as Plan, and fixed force-off is known as Cycle.

We evaluated the transition modes in both Eagle and Naztec controllers and found that Shortway mode causes the least disruption on the overall intersection operations. Other modes either did not make any difference or had a negative impact on cross-street operations. In Naztec controllers, Shortway transition mode is achieved by programming a percentage value for both Short and Long.

Upon evaluation of the coordination modes in Eagle controllers, we found that no mode was significantly better than the others. However, we did find that a mode that dwells in Walk indication provides superior pedestrian service at the intersection. Two modes, Yield and Permissive, dwell in the Walk indication and are suitable modes at intersections where there are large numbers of pedestrians. Figure 3 illustrates the benefits of using these modes to improve pedestrian service.

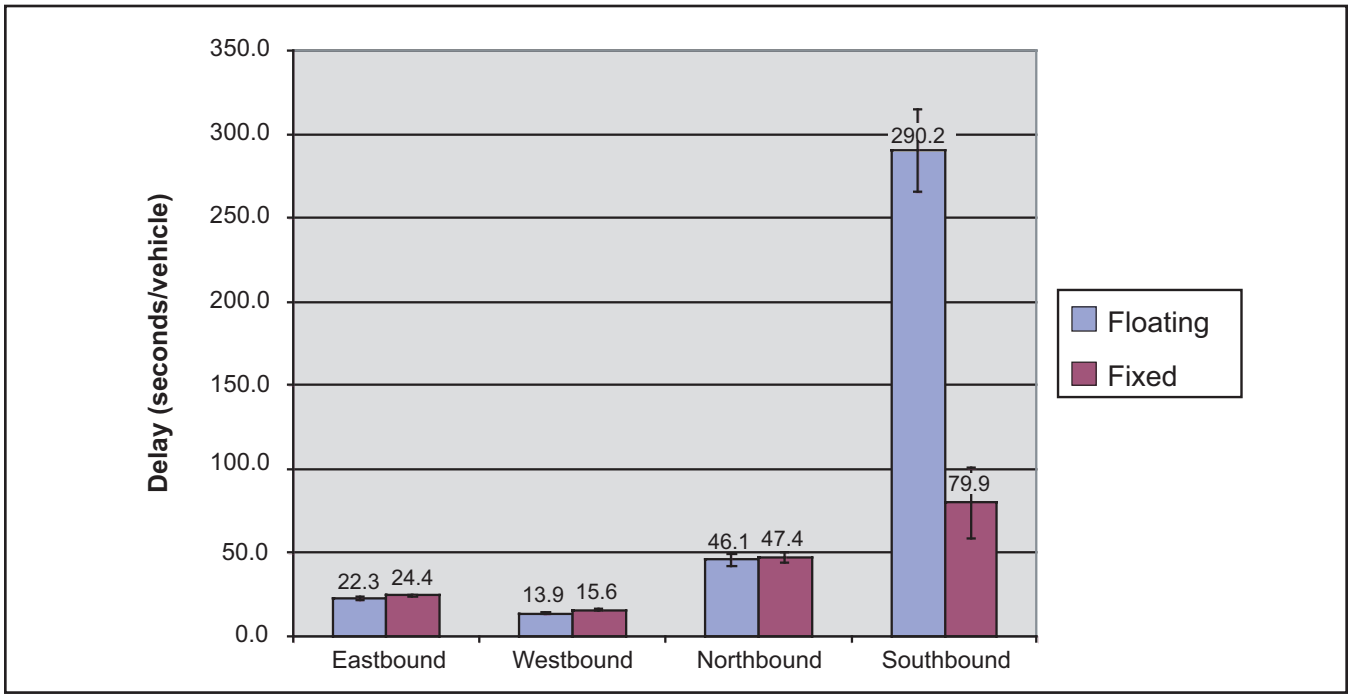

Figure 2. Reduction in Approach Delay due to Fixed Force-Off.

We also found that modes that omit or restrict an early return to the coordinated phase tend to increase the intersection delay and arterial travel time. Two modes, Permissive Omit and Sequential Omit, either omit or restrict an early return to the coordinated phase and hence are not desirable to use.

We evaluated various coordination features like Easy Yield, Rest in Walk, Stop in Walk, Walk Recycle, Return Hold, Leave Walk, and Minimum Permissive. These features can be used in combination to obtain the desired type of intersection operations. For example, Easy Yield can cause the coordinated phase to be terminated early, Rest in Walk can be used to dwell in Walk, and Stop in Walk can be used to allow a pedestrian interval larger than the split time to be serviced with minimum disruption to coordinated operations.

The Researchers Recommend...

We found that a number of coordinated features in existing signal controllers improve coordinated operations. We recommend using fixed force-off mode to improve operations on the side street when there is a reasonably large cyclic variation in the side-street approach volumes. This option would enable a later side street phase to take advantage of any excess time provided to the earlier non-coordinated phase. Of course, sometimes it may be necessary to switch the signal phasing on the side street to take advantage of this feature.

We recommend the use of Shortway mode to transition from one pattern to the other. Shortway mode transitions gradually without causing a significant disruption in signal operations. Dwell transition mode causes excessive delays to the side street phases without giving any benefits to the main street phases. In a Naztec controller, Shortway mode is achieved by giving a percentage value for both Short and Long. We recommend a percentage value of 17 percent to achieve optimum operations.

Upon evaluation of the coordination modes in the Eagle controller, we did not find any single mode better than the other modes. Hence, we recommend the development of an operational strategy that selects the coordination mode that best fits the desired strategy. We recommend a similar approach when using Naztec controllers. An example would be the selection of a mode or features at a location where the pedestrian timing requirement for a side street is high, pedestrian volume is low, and the vehicular demand is low.

We recommend the use of Permissive Yield mode with Shortway Transition when using an Eagle controller. When using a Naztec controller, we recommend using Stop in Walk – ON, Minimum Permissive – ON, and Short/Long transition mode. Selecting the recommended settings will cause minimum disruption to intersection as well as arterial operations.

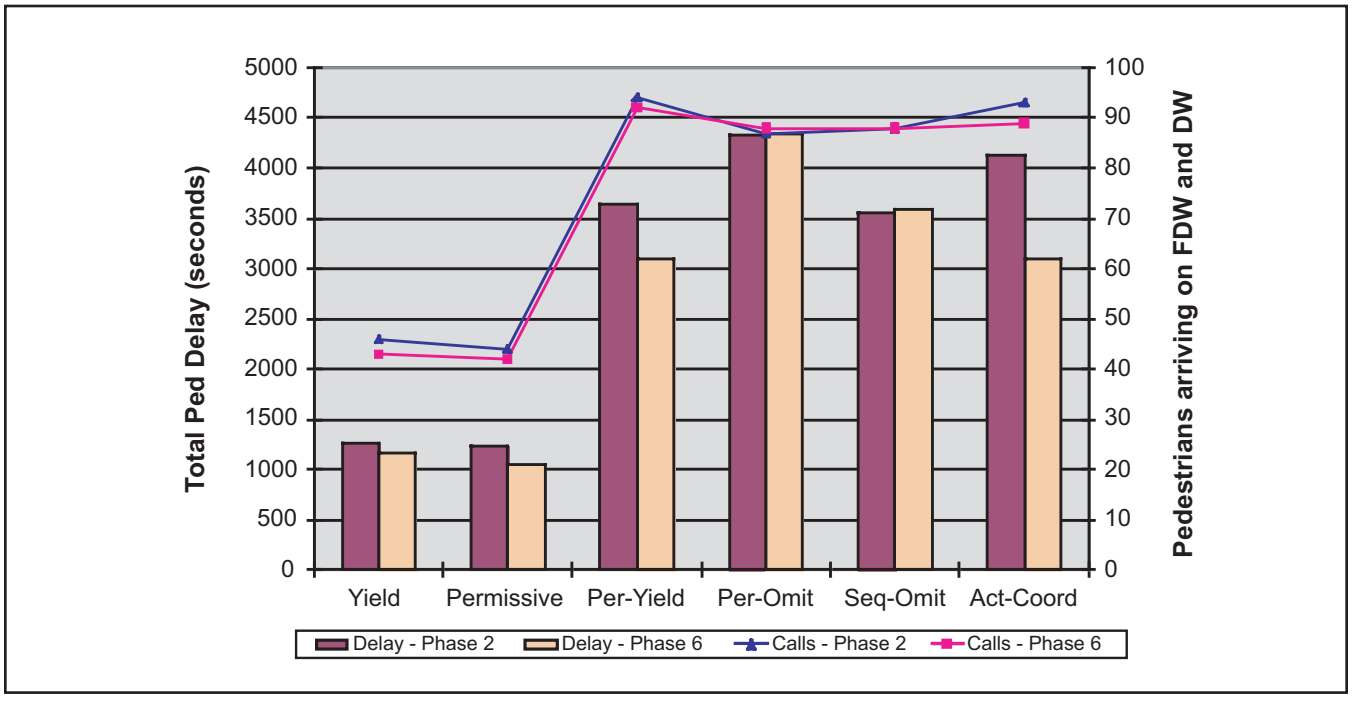

Figure 3. Coordination Modes Benefiting Pedestrian Service.

For More Details . . .

The research is documented in Report 0-4657-1, *Evaluation of Advance Coordination Features in Traffic Signal Controllers*.

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TxDOT Implementation Status
December 2004

This research project evaluated traffic signal controllers by identifying advance coordination features, investigating their functionality, and developing methodologies that would benefit signal operations. Three products were required for this project: 1) implementation guidelines manual, 2) engineer and technician implementation guidebook, and 3) catalog of advance coordination features. These products are available for implementation by traffic signal engineers and technicians for the purpose of evaluating advance coordination features in traffic signal controllers, pending review and approval by TxDOT traffic signal operations personnel.

For more information, contact Mr. Wade Odell, P.E., RTI Research Engineer, at (512) 465-7403 or e-mail wodell@dot.state.tx.us

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