Transit Signal Priority on the Cheap

A solution to reduce bus delay at a Park & Ride in Bellevue, WA

Overview

In the Fall of 2005, King County Metro Transit in partnership with Sound Transit and the City of Bellevue installed a transit signal priority system (TSP) at a single intersection at Bellevue Way SE & 112th Avenue SE at the South Bellevue Park & Ride. This TSP installation is unique in that it utilizes low-cost standard loop detectors for bus detection, and also incorporates special blue indicator lights to acknowledge bus detection to transit operators. A before-and-after evaluation demonstrated that the TSP system was highly effective in reducing signal-related delay to transit vehicles.

Project Background

The South Bellevue Park and ride is situated adjacent to a major arterial, Bellevue Way. The Park & Ride serves two Sound Transit regional express bus routes as well as several local bus routes operated by King County Metro Transit. In an average weekday, a total of 371 buses operate through the Park & Ride in both directions, with a total daily ridership of 5,860 passengers. Bellevue Way has an AAWT of 37,100 vehicles per day and is a major feeder route for traffic going to and from Interstate 90, located just to the south of the Park & Ride.

The Park & Ride is served by two bus stops, one for northbound and one for southbound buses. The northbound bus stop is situated as a pullout along Bellevue Way, and the southbound bus stop is situated in a transit roadway off of the main arterial. The transit roadway also serves a small volume of general traffic ,n addition to southbound bus traffic; several mobility-impaired parking stalls are accessed via the transit roadway, and it is also used for "kiss & ride" drop-off traffic.

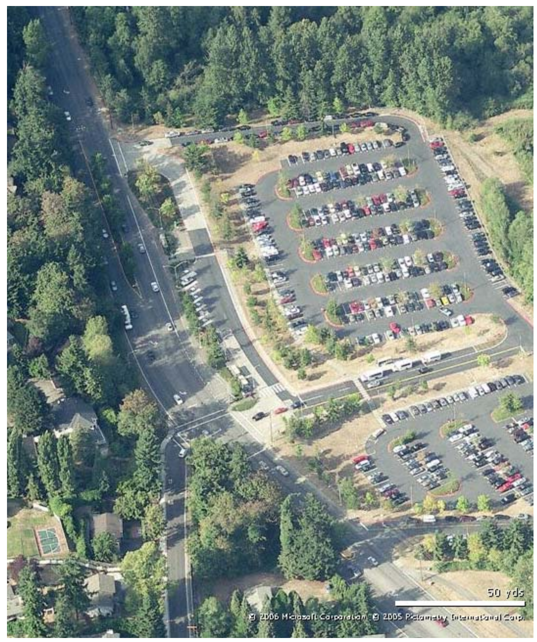

Figure 1: Aerial photo of the South Bellevue Park & Ride

The Park & Ride has two driveways that connect to Bellevue Way, as shown in Figure 1. The north driveway is for entering traffic only, and is used for general traffic accessing the park & ride, as well as southbound buses serving the southbound bus stop. A left turn pocket is provided on Bellevue Way for this left-turn movement. The south driveway is for both entering and exiting general traffic, and is used by southbound buses when they return to Bellevue Way after serving the bus stop. Opposite of the Park & Ride driveway is a minor arterial, 112th Avenue SE. The south driveway is controlled by a traffic signal, with protected left turn phases for northbound and southbound left turns.

The traffic signal at Bellevue Way SE & 112th Ave SE (south entrance of the P&R) is controlled by an Econolite ASC/2 controller. The signal is isolated and runs in 'free' mode, fully actuated, non-coordinated, at all times of day. Loop detectors are installed on all approaches and in the left turn lanes. The controller was upgraded with firmware that supports the TSP features, which was provided by Econolite.

Prior to the installation of the TSP system, transit coaches experienced long delays while accessing the park and ride, especially in the southbound direction when making the left turn to return to Bellevue Way. Staff at Metro Transit had requested signal timing adjustments to reduce this delay, but due to the heavy traffic volumes on Bellevue Way and fact that the signal was not on an exclusive busway, the City of Bellevue could not justify reducing the normal green time on Bellevue Way.

The TSP Solution

The King County Metro Speed & Reliability group designed a solution that would reduce delay to transit vehicles while having minimal impact to general traffic on Bellevue Way. Several strategically-placed loop detectors were installed to detect buses and activate TSP routines in the Econolite controller. TSP is provided for three different transit coach movements, as described below and illustrated in Figure2:

1. **Northbound bus zone pullout merge.** Northbound buses had experienced delay while merging onto Bellevue Way after serving the bus zone. A single loop detector was installed at the end of the pullout to detect buses as they prepare to merge back onto the arterial. A 5-second delay is programmed with this detector.
2. **Southbound left turn into the P&R entrance.** A set of three loops is used in the southbound left turn lane on Bellevue Way to detect when buses are attempting to turn left into the Park & Ride. When all three loops are occupied for a period of 5 seconds, a TSP call is placed.
3. **Southbound P&R exit onto Bellevue Way.** Two loop detectors are installed near the southbound bus zone in the transit roadway. The first loop is located near the front of the bus zone, intended to be activated as buses pull away from the bus stop, and the second loop is exactly 25' behind the first loop. When both loops are occupied simultaneously for a period of 2 seconds, a TSP call is placed to the controller

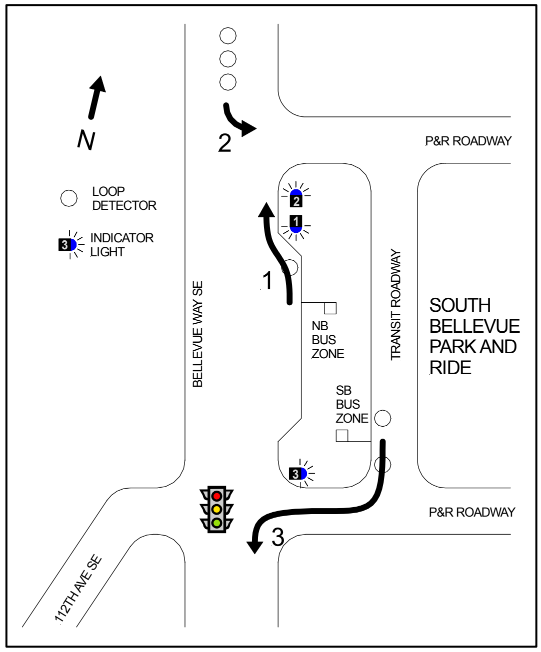

Figure 2: Diagram of Park & Ride and TSP movements.

For movements 2 and 3, the detectors are tied together with AND logic so that TSP is only called when a long vehicle occupies all loops simultaneously, this ensures that smaller vehicles do not activate the TSP routines. Movement 1 uses a single loop because the pullout is used only by buses. A system of relay circuits inside the signal cabinet, shown in Figure 3, provides the logic for these loops. All three movements activate a bus preemptor input on the controller tied to the signal phase associated with the exiting movement for the Park & Ride driveway; for movements 1 and 2, the purpose of TSP is to halt northbound traffic at the signal in order to create a gap so that the bus can complete the left turn or merging movement. Green extension and early green TSP strategies are used to service the TSP call; phase skipping is not used. A reservice timer setting implemented in the signal controller prevents another TSP call from being serviced for a period of time following an initial TSP call; this provides a recovery period for general traffic flow on Bellevue Way.

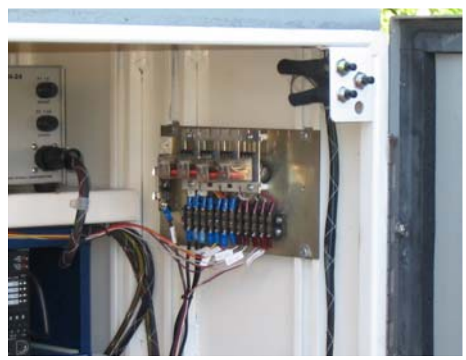

Figure 3: Relay board installed in signal cabinet to provide logic for TSP loops.

Transit Operator Education and Training

The TSP solution required a special effort to educate and train transit operators on the proper use of the TSP loops, otherwise, buses might activate TSP too early or miss the loops entirely. A working group including representatives from operations, training, and supervisory groups within the transit agency was brought together to develop a strategy for this task.

Devices were placed in the field to help operators use the TSP loops correctly. For each of the three TSP movements, a special blue LED light was installed that illuminates when a bus is detected, as shown in Figure 4. Pavement markings were installed to help indicate the locations of the detection loops. In addition, informative posters were created and placed at the transit bases so that operators could learn about the new TSP system.

Figure 4: Blue indicator light for the northbound merge movement.

Evaluation of TSP

A simple before-and-after study was completed to evaluate the effects of the TSP system. Prior to TSP installation, transit delay was measured in the field for each of the three movements, by recording the elapsed time associated with each of the three movements. Data was collected for a 90-minute period on an average weekday during AM and PM peak periods. The study was repeated after the TSP was activated and fine-tuned. During the 'after' study, it was also noted whether each coach triggered the TSP detection; this was accomplished by observing the blue indicator lights or the coach positioning.

The results of the before-and-after study are shown in the table below. Delays are reported in seconds, and '%use' is the percentage of coaches that were observed triggering a TSP call. Note that a TSP call may not necessarily modify signal timing, depending on when the call is placed in relation to the signal cycle.

	AM Peak Average Delay				PM Peak Average Delay			
Movement	TSP Off	TSP On	Savings	%use	TSP Off	TSP On	Savings	%use
1: Northbound Merge	15.6	19.6	**-4.0**	0%	7.9	10.9	**-3.0**	21%
2: Southbound Left into P&R	45.6	19.5	**26.1**	45%	23.5	13.5	**10.1**	36%
3: Southbound Exit from P&R	69.7	34.3	**35.3**	73%	78.9	55.4	**23.5**	100%

Impacts to general traffic were not measured directly; however some qualitative observations were made over the course of the evaluation. Traffic queues on Bellevue Way typically recovered within the next cycle after a TSP call, even though traffic on Bellevue Way was stopped and experienced some additional as TSP was initiated. At times, significant queues exist on southbound Bellevue Way when I-90 is congested, but the signal operation at Bellevue Way SE & 112th Ave SE did not seem to impact this situation.

Challenges

Despite the extensive training effort that was launched with the TSP activation, operator compliance continued to be an issue that initially hindered optimal performance of the TSP system. At the southbound bus stop in particular, buses would often pull too far forward while loading passengers, which would cause TSP to be activated too early. After several months of operation, new pavement markings were installed that provided unmistakable visual cues about where buses should stop and then be detected when ready; these new markings are shown in Figure 5. After this measure was taken, operator compliance improved greatly.

Figure 5: Pavement markings installed over TSP loops near the southbound bus stop.

Another challenge resulted from the fact that southbound buses would call TSP when making the left turn into the park and ride, and then would be locked-out of TSP when exiting, due to the reservice timer. Careful adjustment of the delay setting used with the left-turn detection ensured that TSP was called only after buses were delayed for a period of time for this movement. During these peak periods, buses usually experience a longer dwell time at the bus stop, and so the reservice time passes before the bus is ready to exit and call TSP again.

Conclusions

The results of the before-and-after study show encouraging results for both southbound movements. The greatest savings is for the movement exiting the P&R during the AM peak, where on average, over 30 seconds of delay are saved per trip. Combining the savings from both southbound movements during the AM peak results in over one minute of savings.

In the northbound direction, however, no improvement was seen in average delays. This is probably due to the low amount of delay that existed prior to TSP, and also due to inconsistent usage of the TSP loop by transit operators. The small increase in delay that was observed was likely due to random and seasonal traffic variations.

Over the course of a year, the delay reductions to the southbound movements have the potential to save over $29,000 in annual operating costs to the transit agencies, considering only the AM and PM peak periods. Additional savings are likely to be realized during off-peak periods.

The success of this TSP installation shows that TSP can be implemented in certain situations, such as Park & Ride lots and transit centers, at low cost and without the need for more complex and expensive bus detection hardware.

For More Information

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