Bus Priority at Traffic Signals in Portland: The Powell Boulevard Pilot Project

KATHARINE M. HUNTER-ZAWORSKI, WILLIAM C. KLOOS, AND ALAN R. DANAHER

The city of Portland, Oregon, the Tri-County Metropolitan Transportation District of Oregon, and the Transportation Research Institute at Oregon State University have been involved in the Powell Boulevard Pilot Project to evaluate bus priority at traffic signals. Two priority techniques were tested in the pilot project. Green extension–early green return was tested at far-side stop locations, and queue jump was tested at a near-side stop location. In addition, two bus detection technologies were tested, which used different methods of bus detection. The pilot project involved four intersections along a 2-mi section of Southeast Powell Boulevard. Extensive traffic-impact studies were carried out before and after implementation of the bus priority technology. The project results include a summary of the equipment evaluation and the results of the traffic survey.

The city of Portland, Oregon, and the Tri-County Metropolitan Transportation District of Oregon (Tri-Met) are committed to providing excellent transit service to citizens in the Portland metropolitan area. Methods of improving transit service and performance include establishing through-transit priority, preemption at traffic signals, or both. The city and Tri-Met jointly undertook the Powell Boulevard Bus Priority Pilot Project. This project tested the effectiveness of two techniques for determining traffic signal priority for buses on Southeast (SE) Powell Boulevard in Portland. This project also evaluated two types of bus-detection technology. This pilot project is described in this paper.

PRIORITY TECHNIQUES TESTED

The two priority techniques tested in this pilot project were green extension–early green return and queue jump.

Green Extension–Early Green Return

If the signal phase serving the bus operating in a through lane approaching the intersection is already green, then the green can be extended past its normal end time. If the signal phase is red, then the green will return earlier than normal. For the Powell Boulevard test, the extensions or early returns typically ranged up to 10 sec per signal cycle in the off-peak period and up to 20 sec during peak periods. Because the overall cycle length remained the same, the added green time given to the main street was taken from the green time for the left-turn movements and the cross street. This technique was only applied when the bus had a far-side stop.

Queue Jump

A bus stopped at a red light at the stop bar will receive an advance green so that it can pull in front of the parallel stopped queue. This technique was used only at near-side bus stops with right-turn-only or bus-only lanes.

Test Locations

These two techniques were applied to four intersections along a 3.22-km section of SE Powell Boulevard between Milwaukie and 50th avenues in southeast Portland. Powell Boulevard is a major five-lane arterial road carrying 40,000 to 50,000 vehicles per day. With this heavy volume, Powell Boulevard was considered the "main street" for timing purposes. Green extension was used at three intersections (Milwaukie Avenue, 39th Avenue, and 50th Avenue), whereas queue jump was used only at only one intersection (26th Avenue). All four locations are controlled by Type 170 controllers with Wapiti IKS actuated firmware.

BUS DETECTION TECHNOLOGY TESTED

The city of Tri-Met also evaluated two bus detection technologies in this pilot project, designated System A and System B, which used different methods of bus detection. System A used radio frequency (RF) activated tags on the bus with special RF readers installed along the roadside. System B used a special transmitter on the bus that was read through standard vehicle loop detectors imbedded in the pavement. Tables 1 and 2 identify the basic characteristics of the two systems. For the pilot project, 75 buses operating on the Tri-Met Powell Number 9 Line were outfitted with both System A tags and System B transmitters.

GREEN EXTENSION OPERATION DESCRIPTION

Because the green extension–early return technique was applied to the Powell Number 9 Line buses using SE Powell Boulevard, the bus through movement was associated with the main-through coordinated phase. The result was that this bus priority technique generally added green time for the major traffic movement on SE Powell Boulevard.

K. M. Hunter-Zaworski, Transportation Research Institute, Merryfield Hall 100, Oregon State University, Corvallis, Oreg. 97331-4304. W. C. Kloos, Signal System Manager, City of Portland, Oreg. A. R. Danaher, Project Development Coordinator, Tri-Met, Portland, Oreg.
Current address of W. C. Kloos and A. R. Danaher: Kittelson and Associates, Inc., Transportation Planning/Traffic Engineering, 610 SW Alder, Suite 700, Portland, Oreg. 97205

TABLE 1 System A Description

General Description	Radio frequency activated tags on the buses with special RF readers installed along the wayside. Includes a master unit for interfacing with traffic controller and logging reader data.
Vehicle Tag/Transmitter	
Type	RF tag 236mmL x 61mmW x 19mmH
Equipment Cost per Bus	$40
Mounting Method	Tag is mounted on the outside front of the bus above the reader board. No power supply is required.
Wayside Cost per Intersection*	$29,000 (Hardware) $2,000 (labor)
Interface with traffic controller	The master System A controller receives info from all readers. System A controller provides 6.25 Hz priority call to traffic controller.
Data Logging Capabilities	The master should store data for up to 7,000 buses. Data includes time arrived, time departed, active phases at preempt call, and start / stop times of priority phase "green".

The two System A intersections had an advance RF tag reader about 122 to 183 m before the intersection. These readers were mounted on existing street lighting and signal poles in the street right-of-way. As a tagged bus passed the reader, the bus's identification number was passed to the System A controller, which activated a "bus priority call" to the traffic controller. The System A controller continued the call until the bus passed a checkout reader attached to the near-side traffic signal pole. The System A controller has a "max" timer to terminate excessively long bus priority calls should a checkout reader fail. The System A controller logged the in and out times for every bus. The System A controller also logged the "start and end of main street green" for every cycle with preemption at that intersection.

At the System B intersection an advance inductive loop was located in the curb lane for each direction. A receiver for System B was located in a remote amplifier cabinet near the loop. The receiver recognized buses with "legal" transmitters and passed a call on to the Type 170 controller City staff constructed an external logic package to receive the System B call and convert it to a call for bus priority to the controller. A second inductive loop with a receiver

TABLE 2 System B Description

General Description	Special transmitter on bus that transmits ID code that is read through a standard vehicle loop imbedded in the pavement. A detector reads the ID code and also acts as standard loop detector amplifier.
Vehicle Tag/Transmitter	
Type	Transmitter 114.3 mm diameter x 19mmH
Equipment Cost per Bus	$75
Mounting Method	Transmitter is mounted under bus 0.6 m behind front bumper. Transmitter requires power source
Wayside Cost per Intersection*	$15,000 (hardware) $3,500 (labor, inc. new loops)
Interface with traffic controller	Individual detectors tied to City external logic package. Logic package provides 6.25 Hz priority call to traffic controller.
Data Logging Capabilities	Each detector unit should store approx. 9,000 bus observations. Data must be retrieved from each Model 630.

* approximate cost for a typical intersection with "green extension" on two approaches (based on prices of equipment purchased for this pilot)

was located at the near-side stop bar to check out the bus. The city's external logic package also had a max timer that terminated the bus priority call should a checkout call be missed.

QUEUE JUMP OPERATION DESCRIPTION

The single queue jump test was conducted at 26th Avenue for eastbound (EB) buses. A single 6-m-long presence loop was cut into the existing near-side EB bus stop lane. This lane was designated Right Turn Only Except Buses. A receiver was installed in a remote amplifier cabinet near the loop. A properly detected bus caused system B to give the controller a call for the exclusive queue jump phase. If a bus was at the bus stop during a normal EB through red phase, the bus received a short advance green as displayed on a programmed visibility signal head, which was only visible to vehicles in the right-turn and bus-stop lane. This advance green occurred at the normal start of EB through green. The bus was then able to pull in front of the EB through queued traffic.

PILOT PROJECT RESULTS

Impact of Signal Priority on Traffic

Extensive field data were collected to evaluate the effectiveness of the bus priority techniques used in this project. Traffic studies undertaken simultaneously included turning movement counts and approach-vehicle delay measurements at the intersections of Milwaukie, 26th, 39th, and 50th with SE Powell Boulevard, plus bus travel time and delay, vehicle occupancy counts, and bus passenger counts for this corridor. Data were also collected for bus routes crossing SE Powell Boulevard. Data were collected for 3 days before and after the implementation of the priority operation, during three time periods each day: 7:00 a.m. to 9:00 a.m., 11:30 a.m. to 1:30 p.m., and 4:00 p.m. to 6:00 a.m. The logging abilities of the bus detection equipment also allowed a continuous accumulation of bus travel time information. The Oregon State University Transportation Research Institute analyzed the data from the field studies. The goal of the field data collection was to determine the following:

1. Reduction in bus travel time for Number 9 Line on SE Powell Blvd;
2. Effect on the length of delay to other vehicles; and
3. Total decrease (or increase) in person delay to people at these intersections.

Unfortunately, the before and after traffic surveys provided somewhat inconclusive data about the impact of bus signal priority on traffic conditions because of three factors:

1. Turnover in survey personnel led to some inconsistencies in the data collection procedures;
2. Two accidents during the a.m. peak period of the after study limited the sample size during this period; and
3. The signal operation at 26th Avenue was not optimally timed for the queue jump operation, resulting in reduced green time for the westbound (WB)-through movement.

Data Collection

A major problem with the experimental aspects of the pilot project included a 3-week time lapse between the before and after studies. This delay way caused by a city road crew grinding up one of the loop detectors at the intersection of 39th Avenue and SE Powell Boulevard. As a result of the delay, there was a significant turnover in data collection personnel. The training of the data collectors was inconsistent, and as a result, data sheets often were not filled in correctly or had a number of missed readings. In some instances there were significant gaps in the data because of late arrivals of data collectors. The large gaps in the before data were filled in with data collected at a later time. The types of data with the most problems were the tally of the number of nonstopped vehicles and the readings of queue length and number of stopped vehicles.

There were also a number of problems with the bus travel time data, including delays associated with driver changeovers, disruptive passengers, wheelchair boardings, and large numbers of passengers boarding at major transfer stops.

However, the following can be reported:

- Bus travel time—Figure 1 presents the comparison of the total corridor bus travel times for Powell Number 9 Line during weekday peak periods, based on the bus check-in and checkout times logged by the bus detection equipment. Generally the bus travel times decreased in the peak period in the peak direction (5.0 percent decrease for inbound in the a.m. and 7.8 percent decrease for outbound in the p.m.). Part of the reason for increased WB travel time during the p.m. peak can be attributed to the signal timing problems that occurred at the queue jump intersection (26th Avenue). The method used to provide the EB queue jump resulted in a higher traffic delay for SE Powell Boulevard through traffic, especially WB. The city has analyzed the potential causes and is developing an improved method for providing queue jump operation, which is expected to reduce the impact on through traffic.
- Delay to other vehicles—No clear pattern developed from the delay studies at the four intersections studied. Overall there was no substantial change in total vehicle delay.
- Total bus passenger delay—Figure 2 indicates that the computed person delay for bus passengers on the Powell Number 9 Line decreased 12.3 percent with bus priority.
- Total person delay—Figure 3 indicates that the overall total intersection person delay (both bus and automobile modes) did not significantly change in the peak periods, although the delay did increase slightly during the off-peak period.

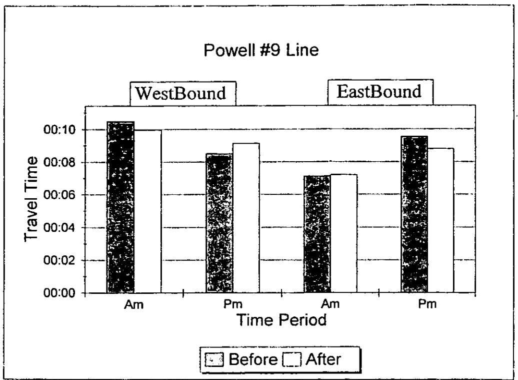

FIGURE 1 Bus average travel time.

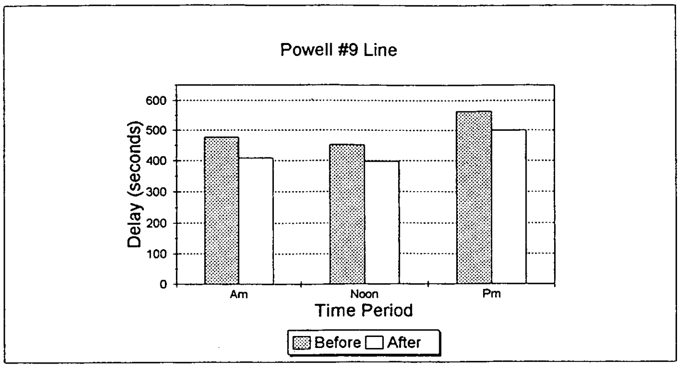

FIGURE 2 Bus passenger delay.

Equipment Performance

The equipment performance for Systems A and B is summarized in Tables 3 and 4.

System A

This pilot project was actually an equipment development project for System A. As with any development project, problems occurred. One of the biggest problems was that no written equipment specifications were prepared. Because of this lack, there were some misunderstandings about equipment design and expectations. Some of the more difficult problems occurred with the user interface, which did not allow the user to view the current master settings. Also, difficulty in communicating between the master and the personal computer led to lost data.

System B

The System B detectors worked simply and reliably, and city of Portland maintenance staff found the units easy to understand and well built. During the project, System B equipment supplied more sensitive "high gain" units, which improved the overall bus recognition accuracy. One problem with System B is that it does not provide a complete system for providing priority. An individual detector is installed at each loop, and the end user needs to provide the necessary external logic package to provide the priority call.

CONCLUSIONS

Impact of Signal Priority on Traffic

As noted above, the before and after traffic surveys provided inconclusive data about the impact of bus signal priority on traffic conditions. However, two conclusions can be drawn:

1. Bus travel time for the Powell Number 9 Line was reduced slightly in the peak direction of travel during peak periods with the bus signal priority; and
2. Bus passenger delay for the Powell Number 9 Line was reduced with the bus signal priority.

It should be realized that the test corridor on SE Powell Boulevard was only 2 mi long. Thus, the total bus travel time savings realized from signal priority might not be expected to be significant.

From a traffic survey perspective, it is important that there be more consistency in survey personnel and methods. In future projects the city and Tri-Met will look for streamlined survey procedures to obtain more reliable before and after data, possibly including some automation of the vehicle delay estimation process.

Equipment Performance

System A

Overall the results on this pilot project were mixed. System A is a complex design with several components (readers, reader inter-

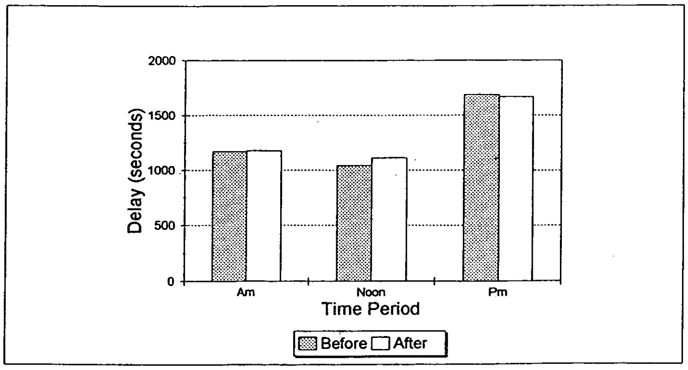

FIGURE 3 Total intersection person delay for all four intersections.

TABLE 3 Equipment Performance Evaluation—System A

Detection Location Issues	Generally limited to existing pole locations, unless willing to install new poles. May constrain getting desired detection point.
Ease of Installation	Used existing poles for antennas and readers. Required power and comm. cable from controller to readers. Requires fine tuning of antenna orientation.
Bus Reading Accuracy	Generally 96% to 99%.
Equipment/System Reliability	Overall poor performance on this pilot project. The equipment was still under development during our testing. Various errors occurred with all components.
Data Logging Issues	The System A master did not have specified capacity. Often staff were unable to retrieve data (Some records were lost).
User Interface	Generally easy to use. Unable to view the existing settings in an operating master.

TABLE 4 Equipment Performance Evaluation—System B

Detection Location Issues	Must make sure that the loop is in bus travel lane (may be problem where bus tends to use more than one specific lane). No easy way to "fine tune" loop location.
Ease of Installation	Generally will require installation of new vehicle loops at proper locations. Requires power and comm. cable for remote amplifier. Overall installation like standard vehicle detector.
Bus Reading Accuracy	Generally 97% to 99%, although had 90% to 95% with larger loops (i.e. 6x17).
Equipment/System Reliability	The Model 630 detectors worked reliably during the test period.
Data Logging Issues	The Model 630s appeared to properly record the bus data. Since there is no central master, the data had to be retrieved from each individual 630 (i.e. 4 different places at 39th).
User Interface	Intuitive interface that was easily mastered by staff. Issue of needing to verify PC time before connecting to the 630.

faces, and master). This complexity can lead to additional operation and maintenance problems. However, the contractors for System A have assured Tri-Met and the city of Portland that they will rectify the problems discovered on this project and provide upgraded equipment for further testing on SE Powell Boulevard. Assuming that this added testing is successful, System A could be considered for further installations in the Portland region.

System B

The System B detectors worked well on this pilot project. The city and Tri-Met will be considering this system for future installations in Portland.

FUTURE DIRECTIONS

The city of Portland and Tri-Met will continue other pilot projects in the bus priority field. This fall the city and Tri-Met will begin a pilot test of System C for the detection equipment. Future tests will also evaluate optimizing the traffic operations techniques used in this project.

Overall this project has helped city of Portland and Tri-Met staff to cultivate a strong, supportive relationship, which is required if bus priority is to become a reality.

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