Evaluation of Bus Priority Signal Strategies in Ann Arbor, Michigan

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With the emergence of intelligent transportation system technologies there has been a renewed interest in the bus priority signal (BPS). The effect of providing the BPS treatment on the Washtenaw Avenue Corridor in Ann Arbor, Michigan, was studied. The NETSIM graphic animation feature was used to detect the bus arrival and award preemption. The signal timing plan was then restored to the original signal setting in subsequent cycles. The model was calibrated using field data, and the sensitivity of the model to several variables was tested. The corridor's signal timing was first optimized using the TRANSYT-7F model. The green extension and red truncation with and without compensation, the skip phase with and without compensation, and the conditional preemption plans were evaluated. It was found that in all cases signal preemption disrupts traffic progression and, thus, increases overall vehicle delay. The results of preemption were analyzed at each intersection as well as over the entire simulation network. The most appropriate preemption strategy for each intersection was determined and used in the simulation. Bus travel time and delay were reduced when this optimal BPS plan was used.

The use of the bus priority signal (BPS) is a method of providing preferential treatment to buses and other high-occupancy vehicles (HOVs) by altering the signal timing plan to favor those vehicles. The concept of bus priority treatment is not a newly introduced strategy. In fact, an early experiment was conducted in Washington, D.C., in 1962. In that study the offsets of a signalized network were adjusted to better match the lower average speed of buses (*1*).

Two techniques can provide priority treatment for HOVs at traffic signals. These are passive and active detection and granting of priority. Passive priority systems are characterized by the fact that the flow of buses need not be recorded at a particular instant to grant priority. Instead, the intensity of bus (or HOV) movements is deduced from historical measurements of traffic flow. An active priority system is defined as one in which the passage of an individual bus is detected and priority is awarded to the bus as a result of this detection.

Several active priority techniques were tested in the present study. These are (*1–3*):

- Green extension. This means extending the green phase beyond its normal setting to allow the bus to pass the intersection; it is usually limited to some maximum value.
- Phase recall (early start or red truncation). This priority treatment advances the bus street green phase by prematurely terminating all other nonbus phases (and truncating the bus red phase). This may be constrained by providing a minimum green time for the phase to be prematurely terminated.
- Phase skipping. To facilitate the provision of the bus priority phase, one or more nonpriority phases may be omitted from the normal phase sequence.
- Compensation. One may choose to compensate for the time lost (skipped or cut) from the other nonbus phase in the next cycle to limit the adverse effects that priority has caused to the nonpriority traffic.
- Conditional versus unconditional priority. Unconditional priority is the provision of signal priority each time it is requested, after all other vehicular and pedestrian safety-required intervals are satisfied. Some professionals argue that because (unconditional) preemption is disruptive to the cross-street traffic, it would be better to subject preemption to certain conditions. These selective conditions determine when or if the signal priority will be granted to the bus. There are several factors that can be used to make this decision. In the present study, providing the BPS treatment conditional on the bus's being behind schedule was tested.

LITERATURE REVIEW

Several simulation models and field experiments with signal preemption have been conducted in the United States and Europe since the early 1960s. Most of these involved isolated intersections, and only limited information is available on network-level experiments. With the recent emergence of intelligent transportation system technologies, there is a renewed interest in this subject.

Vincent et al. (*4*) used a microscopic bus priority assessment simulation (BUSPAS) program to test five preemption control strategies at an intersection. They examined (a) green extension only; (b) green extension, red truncation, and no compensation; (c) green extension, red truncation, and compensation; (d) red truncation and no compensation; and (e) red truncation and compensation. Their experiments considered several traffic volumes, saturation flow rates, and signal timings. For the three main priority control methods, Methods a, b, and c, it was found that Method a gave limited benefits to buses (0 to 8 sec), with little disbenefit to other traffic [less than 1 vehicle-hour/hour (veh-hr/hr)]. Method b gave larger benefits to buses (4 to 24 sec) but also larger losses to nonbus traffic (1 to 24 veh-hr/hr). Method c produced smaller benefits for buses (0 to 14 sec) than Method b but also less disbenefit to other traffic (1 to 14 veh-hr/hr). This approach is somewhat similar to that used in the present study for an arterial.

Jacobson and Sheffi (*5*) developed an analytical model of delay at isolated signalized intersections with a bus preemption scheme. The model treated the beginning time of the green period as a random variable, the density function of which was developed. The model also assumed a Poisson arrival process for the vehicles approaching the intersection. Four cases were analyzed: (a) no pre-

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