Executive Summary

TRANSIT SIGNAL PRIORITY PROJECT ALONG ROUTE 1: LESSONS LEARNED

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Transit Signal Priority (TSP) is recognized as an emerging technology that is capable of enhancing traditional transit services. According to a recent study, TSP is defined as "*an operational strategy that facilitates the movement of in-service transit vehicles, either buses or streetcars, through traffic-signal controlled intersections*." TSP is deployed to improve transit operations and service quality and eventually promote more ridership, improve person mobility, reduce traffic congestion, and reduce mobile-source emissions and fuel consumption rates.

In recent years, TSP has been widely implemented by transportation agencies in North America and worldwide. The growing deployments of TSP across the nation require extensive evaluation studies. A number of studies have attempted to evaluate TSP using either empirical, analytical, and/or simulation tools (Ngan, 2003; Dion et al., 2004; Kimpel et al., 2004; Rakha and Zhang, 2004; Bertini et al., 2005; Dion and Rakha, 2005). Analytical studies typically utilize mathematical formulations to quantify the impact of TSP operations, while simulation studies investigate the effectiveness of TSP strategies using simulation software. Alternatively, empirical studies quantify the impact of TSP on a number of measures of effectiveness (MOEs) by gathering field data. While analytical and simulation studies are widely used for the evaluation TSP projects, relatively few empirical studies have been conducted because of the high cost and manpower required to conduct such studies, the potential for errors, and unpredictable transit-vehicle schedules. This study quantifies the impact of TSP technology on transit-vehicle performance using field collected Global Positioning Systems (GPS) data and evaluates the system-wide benefits of TSP operations using computer simulations to expand on the field evaluation study findings.

U.S. Route 1, also known as the Richmond Highway, is one of the most heavily congested arterials in the Northern Virginia Area (or Washington, DC metropolitan area). The corridor connects two highly congested interstate highway interchanges on I-495 and I-95 and serves a closely located metro station, Huntington Station. On typical weekdays morning traffic congestion continues until noon on I-95. The study corridor is frequently used as an alternative route to I-95. The corridor also serves one of the busiest fire stations in the Northern Virginia Area and provides frequent preemptions requested by emergency vehicles in order to provide safer and faster service. Thus, the impacts of TSP on the Route 1 corridor are a matter of common interest to local government, traffic signal operators, transit bus operators/riders, and local road users.

The study quantified the impact of green extension TSP using the 171 line along the Route 1 corridor. A detailed description of the study findings are provided in the literature (Ahn et al., 2006; Collura et al. 2006; and Rakha and Ahn, 2006).

The priority logic that was implemented along the study corridor involved a simple green-extension logic. Green extension was granted when a transit vehicle was detected or expected to arrive at a traffic signal a few seconds after the end of the green indication. Consequently, the transit vehicle utilized additional green time to allow it to clear the intersection before the traffic signal indication changed. This strategy was only provided when the signal was in a green indication and the approaching vehicle was equipped with a transit priority device; thus if the TSP-equipped vehicle arrived during a red indication, signal priority was not granted. The green-extension strategy is known to be one of the most effective approaches in granting priority to transit vehicles. The method allows a transit vehicle to be served and significantly reduces the delay to that vehicle relative to waiting for an early green or special transit phase. Also, green extension does not require additional clearance intervals (Baker et al., 2002). The green-extension strategy for the study corridor utilized a constant green extension of 10 s because of the high traffic demand and long cycle length (180 s) along the corridor. A 3M Opticom emitter was utilized as part of system. The system consisted of emitters on the transit vehicles and optical detectors located at the traffic signals. The emitter was typically installed on the roof of transit vehicles while an optical detector and a confirmation light were set up on the traffic signal head. The TSP system was processed when the optical detector received a request from a transit vehicle during a green indication if there was no ongoing pedestrian phase at the time and no emergency vehicle preemption call was being made simultaneously.

The field study demonstrated that overall travel-time improvements in the order of 3% to 6% were observed for TSP-operated buses, these results were not statistically significant. However, the results also demonstrated that green-extension TSP can increase transit-vehicle travel times by approximately 2.5% during congested morning peak periods. In addition, the study demonstrated that TSP strategies reduce transit-vehicle intersection delay by as much as 23%. The field study demonstrated that the benefits associated with TSP were highly dependent on the roadway level of congestion and were maximized under moderate to low levels of congestion.

Similarly, the simulation results using the INTEGRATION software (Rakha and Ahn, 2004; M. Van Aerde and Assoc., 2005) indicated that a combination of green extension and red truncation TSP did not result in statistically significant changes to transit vehicle travel times. Furthermore, auto or system-wide travel times were not affected by the TSP logic (differences less than 1%). A paired t-test concluded that basic green-extension/red truncation TSP did not increase side-street queue lengths. An increase in the traffic demand along Route 1 resulted in increased system-wide detriments; however, these detriments were minimal (less than 1.37%). The study demonstrated that an increase in side-street demand did not result in any statistically significant system-wide detriments. Increasing the frequency of transit vehicles resulted in additional benefits to transit vehicles (savings in transit vehicle travel times by up to 3.42%), but no system-wide benefits were observed. Finally, TSP operations at near-side bus stops (within the detection zone) resulted in increased delays in the range of 2.85%, while TSP operations at mid-block and far-side bus stops resulted in network-wide savings in delay in the range of 1.62%. Consequently, it is recommended that TSP not be implemented in the vicinity of near-side stops that are located within the TSP detection zone.

It should be noted that the results of the study may be specific to the Route 1 corridor because of the unique characteristics of the study corridor and the specific traffic demand. Furthermore, the results are specific to green extension/red truncation TSP logic that maintains traffic signal coordination. Nevertheless, some general recommendations can be made with regards to future TSP implementations. These recommendations include:

- TSP impacts are highly dependent on the level of congestion and can be maximized under moderate-to-low levels of congestion. TSP should not be implemented when the approach volume-to-capacity ratios are greater than 80 %.
- Green-extension TSP should be carefully implemented under congested traffic conditions. The reason is that even when green extension is granted, the existence of queues on heavily congested signalized approaches can prevent the transit vehicle from reaching the intersection. An enhancement to the TSP logic to account for when a vehicle will actually clear the intersection could enhance the TSP logic.
- We recommend not implementing TSP in the vicinity of near-side stops that are located within the detection zone of a TSP system.
- Signal timings should be adjusted so that the roadway receiving priority actuation operates in earlier phases within a cycle. This ensures that priority can be granted with minimum impacts on the latter phases within the signal timing plan.
- Any agency contemplating the installation of a TSP system should invest resources in the calibration of TSP settings in order to maximize the potential benefits of such a system.

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