



Project Summary Report O-4422-S

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Project O-4422: Measuring Performance of Traffic Signal Systems  
Using Existing Detector Technology

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## Real-Time Measures of Traffic Signal Performance

Agencies use performance measures to quantify the effectiveness of signal timing and assess the operations at intersections. The Federal Highway Administration (FHWA) defines a performance measure as the “use of statistical evidence to determine the progress towards specific defined operational objectives.” Performance measures provide a basic understanding of whether congestion, reliability, and other aspects of the transportation system performance are getting better or worse.

Many tools can help assess the effectiveness of timing. For example, the *Highway Capacity Manual* provides a procedure for estimating control delay and assessing the level of service at an intersection based on relationships derived from empirical data. Computer simulation and optimization tools can estimate performance

measures such as delay, stops, vehicle emission, fuel consumption, etc., based on traffic flow theory. However, these tools generally provide an off-line assessment of intersection performance and require data to be collected in the field and returned to the office for further processing. Although field studies directly assess the performance of traffic signal timing strategies, they are very labor intensive and expensive. As such, field studies are generally used to assess the effectiveness of operations only during a specified period or at a particular intersection that has been reported as operating poorly.

A tool that could be installed in a traffic signal cabinet to measure the effectiveness of signal timing strategies directly in the field would be more cost-effective than field studies and more accurate than simulation or manual estimation procedures.

### What We Did...

In this project we investigated the development and use of real-time performance measures for traffic signals. More specifically, we examined what measures should be used to assess the operations of a traffic signal, and how these measures should be collected using the capabilities and features of the existing traffic control and detection technologies.

We began the research by first conducting a needs assessment of Texas Department of Transportation (TxDOT) practitioners to determine what performance measures and tools they were currently using to assess signal timing performance. Through site visits to three districts, we examined the type and level of information that the districts wanted from an automated system. We also conducted an assessment of existing traffic signal controller and detection capabilities to produce the desired performance



measures. Using the results of both of these efforts, we developed a series of innovative measures that could be used to assess performance.

During the second year of this project we developed and tested, in a series of proof-of-concept studies, a prototype system that could be installed in a traffic signal cabinet. The system, called the Traffic Signal Performance Monitoring System (TSPMS), resides in the traffic signal cabinet. It uses signal phase status information, input from the signal phase detectors, and information from special count detectors installed downstream of the stop line to produce the following performance measures:

- *Cycle Time* — the time that elapses between subsequent activations of a particular phase. It is measured as the difference in time between the start of green for the current phase and the previous start of green for the same phase.
- *Time to Service* — the time interval from when a call was first placed for a phase to the start of green for that phase.
- *Queue Service Time* — the time required to clear the queue on a particular approach. It is measured as the difference in time between the start of the green for a particular phase and when a constant call on the phase detector is extinguished.
- *Duration of Green, Yellow Change, All-Red Clearance, and Red Intervals* — the

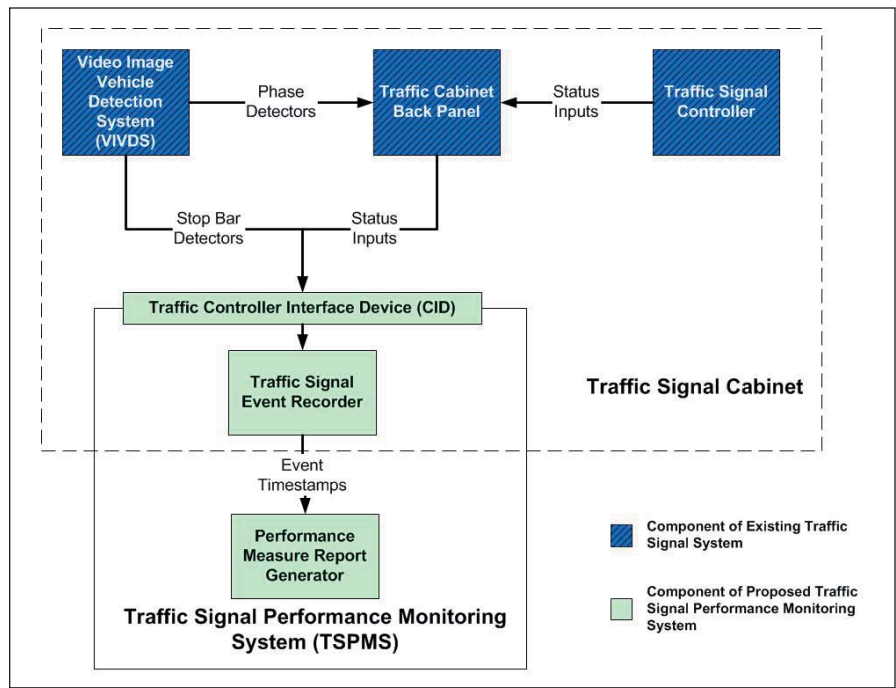


Figure 1. Basic System Architecture of TSPMS.

duration of the green, yellow change, all-red clearance, and red intervals during each phase. It is measured as the elapsed time between the beginning and end of each interval in the phase.

- *Number of Vehicles Entering during Green, Yellow Change, All-Red Clearance, and Red Intervals* — the number of vehicles that enter the intersection (measured at the stop bar) while each interval during a phase is active.
- *Yellow Change and All-Red Clearance Violation Rates* — the rate at which a vehicle was recorded entering the intersection during the yellow change and all-red clearance portion of the phase. It is computed by dividing the number of cycles during which at least one vehicle was observed entering the intersection during the

yellow change and all-red clearance intervals by the total number of cycles observed during the evaluation period.

- *Phase Failure Rate* — the rate (in terms of number of cycles) at which the queue fails to clear during a specific phase. The queue is assumed not to have cleared the approach if the call on the vehicle detector for that phase never clears.

The basic system architecture of the TSPMS is shown in Figure 1. The TSPMS consists of three components: the controller interface device (CID), the traffic signal event recorder, and the performance measure report generator. The CID is a piece of hardware that ties into the traffic signal cabinet and allows the system to obtain traffic signal phase status and phase call detection information. The traffic signal event recorder



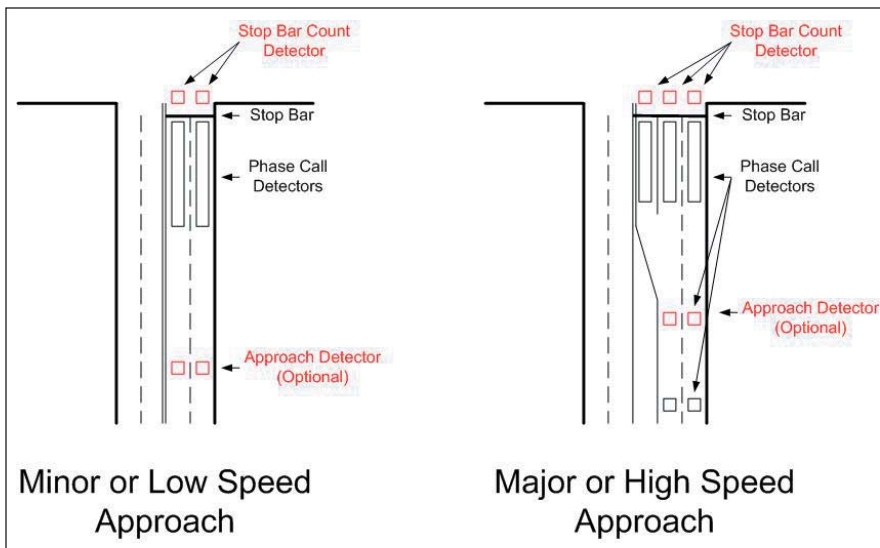


Figure 2. Placement of Detection Zones Used by the TSPMS.

monitors the status of the signal and detection system information every 10 milliseconds, and it records the time at which these controller outputs change. The performance measure report generator is a separate software system that agencies run to produce the actual performance measure report.

We also conducted a series of simulation studies to examine different detector configurations to provide accurate count information in the TSPMS. The recommended detector configuration is shown in [Figure 2](#).

### What We Found...

Through this research, we developed the following findings:

- Several detection and signal controller manufacturers offer built-in capabilities to collect some signal timing performance measures; however, these capabilities need to be greatly expanded in order to provide

accurate measures of signal performance.

- The effectiveness and accuracy of these systems is highly dependent upon the design of the detection system and the placement of the detection zones. Care must be taken in designing and placing detection zones for traffic monitoring purposes to ensure that individual traffic streams can be measured and monitored. TxDOT's current practice of combining detection zones limits the ability to collect accurate and meaningful performance measures. In order to produce accurate performance measures, TxDOT should measure traffic arrival patterns separately on a lane-by-lane basis. In addition, the system must have special detection zones, generally located downstream of the stop bar, to provide accurate count information on each approach.

- The traditional measures that we have used to assess performance, such as intersection control delay, are difficult to measure accurately in the field because the current state-of-the-practice of our detection systems does not permit the tracking of individual vehicles. As the capabilities of detection technology continue to evolve, many of the refinements and new features of this technology have the potential to improve performance monitoring capabilities.

### The Researchers Recommend...

Based on the results of this research, we recommend that, given the current state-of-the-practice of vehicle detection and traffic signal systems used to generate and collect intersection performance measures, we need to reassess how we gauge performance at an isolated intersection. Several non-traditional performance measures, such as time-to-service and queue service time, represent new measures that can assess signal performance and that are direct measures of the quality of the signal timing at an isolated intersection. These measures can act as surrogates for more traditional performance measures that require expensive and time-consuming manual observations.



## For More Details...

The research is documented in:

- Report 0-4422-1, *Potential Measures of Assessing Signal Timing Performance Using Existing Technologies*
- Report 0-4422-2, *Development of a Traffic Signal Performance Measurement System (TSPMS)*

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## TxDOT Implementation Status—April 2005

The purpose of this research was to examine the type of performance measures that could be collected at an intersection and develop a system for automatically collecting these performance measures in the field. One product was required for this project: implementation guidelines. This product is included in Chapter 2 of technical report 0-4422-2, *Development of a Traffic Signal Performance Measurement System (TSPMS)*, and is available for use by traffic signal engineers.

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

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