EFFECTIVENESS OF WORK ZONE INTELLIGENT TRANSPORTATION SYSTEMS

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EXECUTIVE SUMMARY

Intelligent Transportation Systems (ITS) are increasingly being deployed in work zones to improve traffic operations and safety. Also known as Smart Work Zone Systems, these deployments provide real-time information to travelers, monitor traffic conditions, and manage incidents. Despite numerous ITS deployments in work zones, a framework for evaluating the effectiveness of these deployments does not exist. To justify the continued development and implementation of ITS in work zones, there is a need to develop a uniform framework to determine the effectiveness of ITS for specific work zone projects. In addition, guidance on the circumstances under which ITS deployment is recommended for a work zone would be beneficial to agencies. Such a framework is developed in this report. The framework consists of four steps, as shown in Figure 1. In the first step, criteria for selecting work zone sites for ITS deployment are established. The second step consists of selecting operational and safety-related performance measures for evaluating an ITS deployment. Data needs for measuring and estimating the chosen measures are then determined. In the fourth step, performance benefits are quantified, the total costs of ITS deployment are estimated, and a benefit-cost ratio is computed.

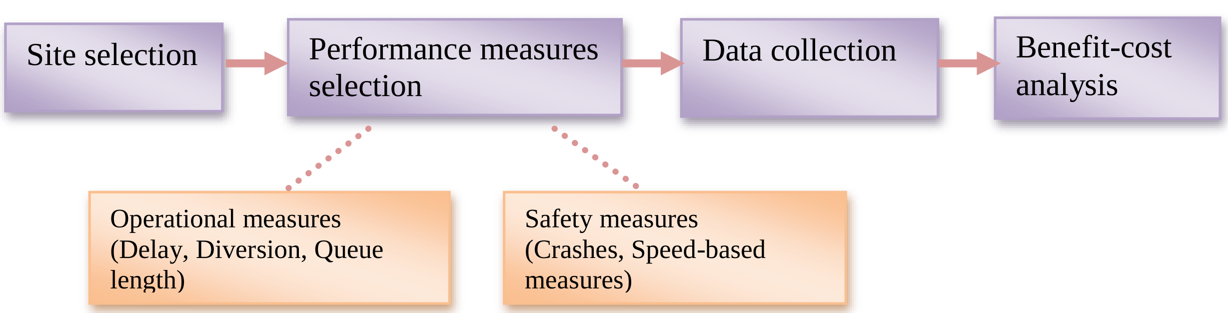

Figure 1 Work zone ITS evaluation framework

The site selection criteria for choosing work zones that offer the greatest potential for traffic and safety improvement through ITS deployment are presented in Figure 2. They include frequent congestion, high traffic impact at the work zone, the availability of alternative routes, and over-capacity demand. Depending upon the goals for the deployed ITS, one or more of the following five performance measures is recommended: delay, diversion rate, queue length, crash frequency, or speed. These measures were obtained from a synthesis of the existing literature on ITS deployment. Using the same measures across ITS deployments simplifies the process of comparing results. Traffic sensors that collect traffic flow, speed, and occupancy are key to the selected performance measures. Additional equipment, such as temporary detectors and queue detection trailers, may also be required in order to accurately measure queue length. For example, diversion rates can be computed using traffic flow data collected from temporary traffic sensors deployed on the mainline and ramp. Crash data collected by law enforcement agencies are typically archived by the state DOT. Though a benefit-cost methodology has been implemented in other transportation areas, its application in work zone ITS involves additional wrinkles, such as the need to include technology cost factors and the computation of dynamic road user costs.

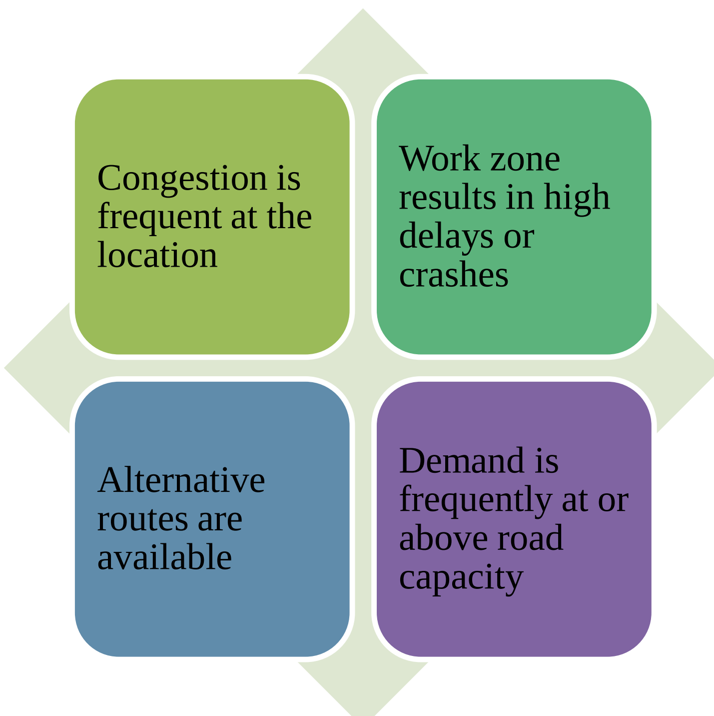

Figure 2 Site characteristics warranting ITS deployment

The proposed work zone ITS deployment framework is illustrated using two case studies. The case study sites were located in the St. Louis region of Missouri. According to the Texas Transportation Institute's Urban Mobility Report, the St. Louis urban region is frequently ranked near 20th in the U.S. in terms of annual delay. The first case study, the I-70 Blanchette Bridge, involved an urban setting with two major alternative routes. Five lanes were reduced to three lanes in each direction during construction. Only permanent ITS equipment that was already in place was used for the project, and no temporary ITS equipment was deployed. The second case study, the I-44 Antire Road work zone, was a rural area with no alternative routes. Three lanes in the eastbound direction were reduced to two lanes. Temporary ITS equipment consisting of four portable DMS signs, eight queue detection trailers, and two Bluetooth travel time sensors were added to complement the eight existing permanent DMS.

The expected benefit of ITS at the I-70 site included improved mobility through encouraging traffic to divert to alternative routes. Thus, the benefits of diverting traffic to alternative routes were estimated. A significant field data collection effort was employed using portable surveillance that blanketed the entire network, including the major alternative routes. This effort was significant, since diversion rates are often not measured in the field, usually being estimated through driver choice models. Diversion rates were measured using traffic data collected prior to and during the duration of the work zone. A traveler survey was conducted to assess the extent to which drivers were influenced by ITS in terms of their diverting behavior. The survey revealed that 52% of those that diverted to an alternative route did so due to ITS; specifically, DMS. The percentage of reliance upon DMS was utilized in a traffic simulation model to estimate the mobility-related impacts of ITS. Two scenarios were simulated: a “without DMS” scenario in which the proportion of traffic diverting to each alternative route was adjusted using the 48% value, and a “with DMS” scenario in which the observed diversion rates during the presence of the work zone were utilized. The effect of ITS on delay was then computed by subtracting the delays for the without DMS and with DMS scenarios. The permanent DMS equipment in the study corridor served multiple purposes, therefore the costs should not be attributed solely to the work zone project; however, the equivalent costs during the work zone period were included in this study in order to estimate the benefit-cost ratio of permanent ITS deployments. The total cost of ITS deployment was estimated to be $198,530 when equipment costs were included, and $59,130 when only operating costs were included. Benefits in terms of delay reduction were estimated to be $407,694.05—resulting in a benefit-cost ratio of 2.1 to 1.0 with equipment costs and 6.9 to 1.0 without equipment costs. The use of ITS in the I-44 Antire Road work zone focused on safety: by warning drivers of downstream traffic speeds and queuing, the potential for rear-end crashes could be reduced. Accordingly, safety benefits were computed based on reductions in different types of crashes as a result of ITS deployment. Fatal, injury, and property damage only crash severities were considered in the analysis. It was estimated that 5.6 property damage only crashes and 0.96 injury crashes were eliminated due to ITS deployment in the work zone. No fatal crashes occurred during the duration of the work zone. The safety benefits were then quantified using AASHTO Red Book unit cost values, which resulted in a total benefit of $345,900. The benefit-cost ratio was then computed using the actual ITS deployment cost of $106,700, which produced a benefit-cost ratio of 3.2 to 1.0.

One recommendation resulting from the current study is to encourage state DOTs to collect baseline data at study sites in the absence of ITS. This may entail turning off ITS equipment for a few days while the work zone is deployed. Agencies are usually hesitant to turn off ITS systems when they are available in the field; there is a public expectation to receive traveler information through ITS, and there could be liability concerns associated with available equipment not being utilized. One possible alternative is to delay the deployment of ITS in the work zone for a few days in order to collect “without-ITS” data, before activating ITS. The overall concern with this approach is that ITS may provide valuable traveler information during the crucial initial period when drivers are unfamiliar with work zone conditions. Therefore, the absence of ITS during the initial period could be of concern.