

Investment Opportunities for Managing Transportation Performance: Background Information on Candidate ITS Technologies

Background Information on Candidate ITS Technologies

This section provides more information on the benefits and costs of the technologies listed in the tables 1 and 2 of the summary paper.

Traffic Signal Optimization/Retiming

Traffic signal system retiming and optimization ranks as one of the most cost-effective urban transportation improvement actions, increasing mobility, reducing fuel consumption, and improving environmental quality. The extent of benefits realized from traffic signal retiming depends on various factors including the quality of existing timing plans, street network configuration, and traffic patterns. For example, the Traffic Light Synchronization Program in Texas reduced delay by 24.6 percent, lowered travel time by 14 percent, and demonstrated a benefit-to-cost ration of 62:1.¹ Signal retiming projects in several U.S. and Canadian cities have been shown to reduce fuel consumption by 2 to 9 percent and emissions by 1 to 6 percent. For optimal performance, traffic signal timing plans need to be updated at least every three to five years, and possibly more frequently depending on growth and changes in traffic patterns. The cost of retiming a signal is approximately \$3,000. Based on the estimated 272,000 traffic signals in the United States and assuming that a fourth of these signals are retimed every year, the annual costs of signal retiming is roughly \$200 million.

Depending on the condition of existing hardware and need for replacement, traffic signal timing projects provide a good opportunity for skilled technology jobs. These projects can be started and implemented immediately and deliver mobility and environmental benefits quickly.

Traffic Incident Management

Traffic incident management programs have demonstrated success in improving mobility, safety, efficiency, productivity, energy and environment, and customer satisfaction. Managing traffic incidents is a proven strategy for addressing significant portions of the Nation's traffic congestion problems. Traffic crashes are the most time-consuming of these incidents, but the more numerous cases of stalled vehicles, roadway debris, and other incidents also contribute significantly to the problem. Traffic incident management programs make use of a variety of ITS technologies to successfully detect, manage, and clear traffic incidents; improving safety for travelers by reducing the risk of secondary crashes; and reducing time lost and fuel wasted in traffic backups. The most significant findings of traffic incident management programs are the ability to dramatically reduce the duration of traffic incidents, from 15 to 65 percent, with the bulk of studies finding savings of 30 to 40 percent.² Studies have also shown that integrating traveler information with traffic and incident management systems could reduce emissions by up to 3 percent and could improve fuel economy by about 1.5 percent. Traffic incident management programs can have a short start up depending on the resources a region has available and if a current system is being enhanced or expanded.

Safety Service Patrols

Safety Service patrols, which preceded the emergence of ITS technologies, are now frequently incorporated into traffic incident management programs. The patrol vehicles and staff, supported by an array of other ITS components, enable significant reductions in the time to respond to and clear incidents.

¹ ITS Benefits Database. [Benefits ID: 2007-00311](#)

² ITS Benefits Database. [Benefits ID: 2000-00123](#), [Benefits ID: 2007-00483](#), [Benefits ID: 2007-00425](#), [Benefits ID: 2007-00485](#)

Service patrols are considered one of the most essential components of a successful traffic incident management program. In Florida, the Road Ranger Service Patrol program saved over 1.7 million gallons of fuel by eliminating over one million vehicle-hours of delay in 2004.³

More recently, safety service patrols have become an effective component of work zone management systems, especially for long-duration work zones. State DOTs typically spend from \$5.6 million to \$13.6 million per year on these programs. Proactive incident management via service patrols represents a benefit heartily welcomed by travelers. Service patrols are perhaps the most prominent and widely evaluated component of traffic incident management programs. Safety service patrol services can be implemented quickly as they can be successful with minimal infrastructure support.

"I truly felt my life was in danger as cars and trucks whizzed by...I felt my life was saved today due to this service..."⁴

Surveillance and Detection

Many strategies for arterial, freeway, and incident management systems are enabled by traffic surveillance and detection technologies, such as sensors or cameras monitoring traffic flow. A variety of surveillance and detection technologies can help spot incidents quickly. These include inductive loop, acoustic, and microwave vehicle detectors, and camera systems providing frequent still images or full-motion video. These types of ITS technologies help incident management staff identify incidents quickly. Surveillance and detection solutions along a corridor or within a region can provide considerable long-term benefits and are critical elements for establishing nationally available, real-time traffic and travel condition monitoring system.

A variety of technologies are used to detect incidents. Traffic surveillance cameras monitor 34 percent of freeway miles in the country's 108 largest metropolitan areas. Free cellular telephone calls to a dedicated number are available for 24 percent of the freeway miles, automatic incident detection systems monitor 17 percent, and call boxes monitor 12 percent.⁵

Road Weather Information Systems

Road weather management systems mitigate weather impacts by using technology to promote safety, increase mobility, improve productivity, and protect the environment. Adverse weather conditions pose a significant threat to the operation of the Nation's roads. According to the National Research Council, motorists endure more than 500 million hours of delay each year as a result of fog, snow, and ice. Rain, which occurs more frequently than snow, ice, and fog, leads to even greater delay. Adverse weather not only affects safety but also degrades traffic flow and increases travel times. Under extreme conditions (such as snowstorms), travel times can increase by as much as 50 percent.

Road Weather Information Systems (RWIS) are now critical components of many agencies' winter maintenance programs. Accurate and timely road weather information helps maintenance managers react proactively before problems arise, improving safety while reducing costs. RWIS systems are designed to help winter maintenance operations decisions by facilitating the sharing of information about hazardous road conditions. In addition, the implementation of these systems improves the overall transportation infrastructure by reducing operations and maintenance costs, increasing safety of drivers, and decreasing damage to the environment from salt and other de-icing agents.

³ ITS Benefits Database, [Road Ranger Benefit Cost Analysis](#).

⁴ HELP Annual Operating Report, July 1, 2004 - June 30, 2005

⁵ Intelligent transportation systems Benefits, Costs, Deployment, and Lessons Learned 2008 Update.

Ninety-four percent of surveyed users of a road weather information Web site covering roadways in Washington agree that the weather information made travelers better prepared for their trips. Over half of the respondents (56 percent) agreed the information helped them avoid travel delays.⁶

Electronic Toll Systems/Open Road Tolling

Electronic Toll Collection (ETC) is one of the most successful ITS applications with numerous benefits related to delay reductions, improved throughput, and fuel economy. For example, New Jersey Turnpike's EZ-Pass system provided annual fuels savings of 1.2 million gallons across 27 tolling locations; Baltimore cut environmentally harmful emissions by 16 to 63 percent at toll plazas that were upgraded to ETC. With advanced technologies such as open road tolling (ORT), toll transactions can be processed automatically at freeway speeds reducing the need for tollbooth barriers and improving performance. ORT concepts can be incorporated into new toll plaza designs or constructed at existing plazas that currently have speed-controlled, dedicated ETC lanes. For example, in Florida, the addition of ORT to an existing ETC mainline toll plaza decreased delay by 50 percent for manual cash customers and by 55 percent for automatic coin machine customers, and increased speed by 57 percent in the express lanes.⁷ A feasibility study for electronic toll collection on the Florida Turnpike indicated that a 10 to 30 percent participation rate would yield benefit-to-cost ratios of 2:1 to 3:1, respectively.⁸

ORT is being implemented to replace existing toll booth facilities that impede traffic flow and create congestion. Many ORT projects can be implemented near-term as enhancements to existing toll facilities, creating an immediate economic benefit that will improve long-term safety, mobility and environmental impacts.

Ramp Metering Systems

Ramp metering systems use traffic signals at on-ramps to control the rate of vehicles entering the freeway. The signals can be set for different metering rates to optimize freeway flow and minimize congestion. Signal timing algorithms and real-time data from mainline loop detectors are often used for more effective results.

Ramp metering systems provide a high rate of return on investment offering considerable safety, mobility and environmental benefits in congested urban areas. For example, in the St. Paul, MN region, ramp metering has increased throughput by 30 percent and increased peak period speeds by 60 percent.⁹ Simulation studies estimate that ramp metering can save 2 to 55 percent of the fuel expended at each ramp. Ramp metering systems can be a low cost solution for maximizing existing capacity, either as a stand-alone project or as one component of a larger transportation management system.

Electronic Border Crossing Systems

ITS applications for commercial vehicle operations (CVO) are designed to enhance communication between motor carriers and regulatory agencies, particularly during interstate freight movement. ITS applications can assist carriers and agencies in reducing operating expenses through increased efficiency and aid in ensuring the safety of motor carriers operating on the Nation's roadways. ITS/CVO is the term used for the ITS elements that support commercial vehicle operations. These include information systems, networks, sensor systems such as weigh-in-motion (WIM), technologies such as electronic border crossing systems, brake testing equipment, and the components of intelligent commercial vehicles.

⁶ ITS Benefits Database, [Benefits ID: 2004-00274](#)

⁷ ITS Benefits Database, [Benefits ID: 2008-00553](#)

⁸ ITS Benefits Database, [Benefits ID:2000-00031](#)

⁹ *Ramp up the Volume* Published By: ITS International Source Date: November 1997.

Electronic border crossing components are implemented to improve the safety, security and efficiency of legal crossings between the United States and Canada or Mexico. Border crossing deployments could realize a return on investment the first year of deployment because of the high volume of transponder-equipped trucks.¹⁰ While an integrated system may not be feasible in the short-term, the deployment of electronic border crossing components to enhance existing facilities can have near-term economic benefits while providing positive long-term transportation investments. The implementation of electronic border crossing components are relatively low cost solutions with high benefits to the overall system infrastructure, including reduced operational costs, improved mobility through travel time savings at the border, and reduced energy and environmental impacts.

CVISN/Electronic Credentialing and Electronic Screening

The Commercial Vehicle Information System and Networks (CVISN) program has created a nationwide framework of communication links that State agencies, motor carriers, and stakeholders can use to conduct business transactions electronically. Electronic registration and permitting at State agencies allows carriers to register online, decreasing the turn-around time associated with permit approval. In addition, safety information exchange (SIE) programs have been implemented as part of CVISN to standardize the exchange of vehicle and driver safety information among states and jurisdictions. Enforcement personnel at check stations can use national database clearinghouses to confirm carrier regulatory compliance data and crosscheck safety assurance information. CVISN includes information systems owned and operated by governments, carriers, and other stakeholders, but excludes the sensor and control elements of ITS/CVO.

Implementing electronic screening and electronic credentialing can provide low cost solutions that result in high benefits to the overall system infrastructure. For example, electronic credentialing reduced paperwork and saved carriers participating in the CVISN Model Deployment 60 to 75 percent on credentialing costs.¹¹ Significant benefits to commercial vehicles include reduced operational costs, improved mobility through travel time savings, and reduced energy and environmental impacts.

Bus Rapid Transit

Bus Rapid Transit (BRT) systems can significantly benefit from numerous ITS technologies such as TSP, fare payment systems, and CAD/AVL. Vehicle Assist and Automation Systems (VAA) are unique to BRT and consist of four applications that provide driver assistance and automation capabilities to a transit vehicle including precision docking, vehicle guidance, platooning, and automated vehicle operations. These applications become an integral component of bus rapid transit (BRT) systems that have gained prominence in the United States. The development and deployment of VAA technologies requires skilled labor capable of integrating technology and software with transit vehicles. An analysis conducted in 2005 demonstrated a significant benefit/cost ratio for several different case study applications ranging from 1.9 to 9.5. The overall benefits were often seen within the first year of operation and were valued, over the life of the technology, upwards of \$7 million.¹² There are several planned and designed systems in the United States that "shovel-ready."

Traffic Adaptive Signal Control

Traffic signal optimization provides coordination along arterials to improve traffic flow, reduce delays and stops at traffic signals, and cut harmful emissions. These projects are among the most cost effective projects a traffic engineering agency can undertake. Some agencies have chosen to take optimization one step further by implementing Traffic Adaptive Signal Control. Traffic adaptive signal control systems coordinate the control of traffic signals along arterial corridors, adjusting the lengths of signal phases

¹⁰ ITS Lessons Learned Database. [Lesson ID: 2006-00211](#)

¹¹ ITS Benefits Database. [Benefits ID: 2002-00241](#)

¹² Hardy, M. *Analyzing the Impacts of Vehicle Assist and Automation Systems on BRT*. Journal of Public Transportation 9(3): 257. 2006.

based on prevailing traffic conditions. Adaptive signal control systems use algorithms that perform real-time optimization of traffic signals based on current traffic conditions, demand, and system capacity. Detection systems in the roadway or overhead inform the controllers of actual traffic and the signals adapt to prevailing conditions. Traffic adaptive signal control can improve traffic flow under recurring congestion as well as traffic conditions caused by incidents and special events and deliver environmental benefits. For example, adaptive signal control in Toronto, Canada has yielded emission reductions of three to six percent and fuel savings of four to seven percent.¹³

Traffic adaptive signal control can be used to either enhance or expand an existing traffic signal system. Traffic adaptive projects can be started and implemented quickly in an existing system, providing a good opportunity for immediate skilled technology jobs.

Transit Signal Priority

Transit Signal Priority (TSP) is a cost-effective method to make bus-based transit service more reliable.¹⁴ TSP is often implemented on a conditional basis intended to help transit vehicles improve schedule performance by granting priority to transit vehicles at signalized intersections when they are behind schedule. TSP systems use sensors or transponders to detect approaching transit vehicles and alter the traffic signal timing to improve transit performance. For example, some TSP systems extend the duration of green signals for transit vehicles when necessary. TSP systems, through coordination with arterial management systems, can improve service quality and transit agency productivity resulting in additional ridership. Environmental benefits to the system include fuel consumption reductions for buses up to 19 percent and a reduction in bus emissions up to 30 percent.

Surveys found that riders on Vancouver's 98 B-line BRT service, which implemented transit signal priority to improve schedule reliability, rated the service highly with regard to on-time performance and service reliability (an average of 8 points on a 10-point scale).¹⁵

Transit priority systems can be implemented to improve the mobility of the bus system making it more reliable. These projects can be started and implemented quickly should an agency desire.

Traveler Information/Dynamic Message Signs

State, regional, and local transportation agencies have responsibility for the operation of large permanent dynamic message signs (DMSs) or portable DMSs. DMSs are traffic control devices used for traffic warning, regulation, routing and management, and are intended to affect the behavior of drivers by providing real-time, traffic-related information such as traffic conditions, incidents, weather, construction, safety, and special events. DMSs are ITS solutions that provide safety and mobility benefits in many settings including urban, suburban, rural, and work zones. For example, in Houston, real-time travel time information posted on DMS influenced drivers' route choice. Eighty-five percent of respondents indicated that they changed their route based on the information provided. Of these respondents, 66 percent said that they saved travel time as a result of the route change. Overall, drivers were primarily interested in seeing incident and travel time information.¹⁶ DMSs can have environmental benefits as well. In San Antonio, Texas, an evaluation study found that using roadside dynamic message signs for incident management could reduce fuel consumption by 1.2 percent.

DMSs can be deployed quickly one at a time, in multiples as a DMS system, or as part of an advanced traveler information system.

¹³ ITS Benefits Database. [Benefits ID: 2007-00361](#)

¹⁴ Much of the transit service provided in the United States is bus-based.

¹⁵ ITS Benefits Database. [Benefit ID:2008-00545](#).

¹⁶ ITS Benefits Database. [Benefits ID: 2007-00304](#)

Parking Management Systems

Parking management systems are most commonly deployed in urban centers or at modal transfer points such as airports and outlying transit stations. They monitor the availability of parking and disseminate the information to drivers, reducing traveler frustration and traffic congestion associated with searching for parking spaces. Studies of parking management systems demonstrate the potential of these systems to improve traffic flow in congested urban areas and improve travelers' experiences at major transportation facilities such as airports and suburban transit and commuter rail stations.

In Baltimore Maryland at the Baltimore/Washington International Thurgood Marshall (BWI) airport a parking guidance system was implemented which directs travelers to individual available parking spaces. An October 2003 survey of BWI travelers found that 81 percent of surveyed travelers indicated that parking was easier at BWI than at the other airports they frequented and 68 percent agreed that parking was faster.¹⁷

Transit Automated Vehicle Location/Computer-Aided Dispatch

Transit operations and fleet management ITS applications improve transit reliability through the implementation of automated vehicle location (AVL) and computer-aided dispatch (CAD) systems. These systems can improve both the experience for transit riders by reducing passenger wait times and the efficiency of transit operations by enabling more efficient planning, scheduling, and management of transit assets and resources. Information on current vehicle location and schedule status can also support transit signal priority, which improves transit trip times and schedule adherence. Data records from AVL/CAD systems, along with automated passenger counters, are enabling a transition to improved transit planning and management strategies which rely on large quantities of system operations data.

Transit agencies have reported reductions in fleet requirements ranging from two to five percent as a result of improved fleet utilization. Data from transit systems in Portland, OR; Milwaukee, WI; and Baltimore, MD show that AVL/CAD systems have improved schedule adherence by 9 to 23 percent.¹⁸

High Occupancy Toll Facilities

High-occupancy toll (HOT) lane facilities charge single-occupancy vehicles (SOV) for the use of a high-occupancy vehicle (HOV) lane. Accessing HOT lanes remains free for transit vehicles, vanpools, and carpools. The toll charged for SOVs can be dynamically adjusted to ensure traffic volume does not exceed an established threshold for all vehicles in the HOV lanes such that free-flow travel conditions are maintained. Toll collection is performed electronically using open road tolling to allow high speed toll collection. Tolls are charged at fixed points along the facility.

In Minneapolis, MN, survey data collected prior to the deployment of MnPASS Express Lanes (HOT lanes) on I-394 were examined to determine travelers' willingness-to-pay to avoid congestion. The results indicated that 59 percent of travelers would pay \$2 to save 20 minutes; 40 percent would pay \$2 to save 15 minutes; 23 percent would pay \$2 to save 10 minutes; and less than 10 percent would pay \$2 to save 5 minutes. Willingness-to-pay also decreased as toll rates increased. Virtually no one was willing to pay more than \$6 for any amount of time savings.¹⁹

HOT facilities are being built into new HOV construction projects, as well as being implemented on existing HOV facilities to provide system enhancements with minimal construction. Many HOT projects can be implemented near-term, creating an immediate economic benefit that will produce both skilled and unskilled job opportunities.

¹⁷ ITS Benefits Database. [Benefit ID:2008-00511](#)

¹⁸ ITS Benefits Database. [Benefits ID: 2000-00028](#), [Benefits ID: 2000-00151](#)

¹⁹ ITS Benefits Database. [Benefit ID: 2008-00550](#)

Work Zone Management Systems

ITS applications in work zones include the temporary implementation of traffic management or incident management capabilities. These temporary systems can be stand-alone or they may supplement existing systems during construction. Other applications control speed limit displays or notify travelers of changes in lane configurations, travel times, and delays through the work zones. Systems for work zone incident management can also be used to more quickly detect incidents and better determine the appropriate degree of response needed, thereby limiting the amount and duration of additional capacity restrictions.

ITS solutions for work zone management include components such as smart work zones, traveler information/portable DMS, dynamic lane merge systems, variable speed limit systems, and portable traffic management systems including surveillance and detection, and safety service patrols. ITS may also be used to manage traffic along detour routes during full road closures. Network simulation models estimate that smart work zones can reduce total delay by 41 to 75 percent.²⁰

As "shovel ready" highway projects begin during the next few months, this tremendous construction program may, in the short run, reduce traffic safety and mobility across the country. Work zone management programs in the form of smart work zones coordinated with traffic incident management programs will be essential in mitigating these impacts and keeping the public moving safely and efficiently through these construction zones. A properly designed smart work zone will keep motorists informed, encourage motorists to take alternate routes, reduce congestion through the work zone, improve clearance of incidents, and make work zones safer for workers and the traveling public. Implementing smart work zones will help mitigate traffic congestion and traveler delay associated with these construction projects.

²⁰ ITS Benefits Database. [Benefits ID: 2007-00326](#), [Benefits ID: 2007-00400](#)