U.S. Department of Transportation

Freeway Management: Overview

ITS Benefits, Costs, and Lessons Learned: 2017 Update Report

Freeway Management

- Surveillance
- Ramp Control
- Lane Management
- Active Traffic Management
- Special Event Transportation Management
- Information Dissemination
- Enforcement

Highlights

- ITS strategies and applications such as traffic surveillance systems, ramp meters, lane management applications, special event transportation management systems advanced communications, and automated speed limit enforcement are being used to actively manage traffic on our freeways today to influence traveler behavior in real-time improving safety, reducing emissions and improving system efficiency and reliability.
- Ramp Metering and variable speed limit (VSL) systems improve traffic flow and increase safety.

Introduction

This factsheet is based on past evaluation data contained in the ITS Knowledge Resources database at: www.itskrs.its.dot.gov. The database is maintained by the U.S. DOT's ITS JPO Evaluation Program to support informed decision making regarding ITS investments by tracking the effectiveness of deployed ITS. The factsheet presents benefits, costs and lessons learned from past evaluations of ITS projects.

A variety of ITS strategies improve the operation of the freeway system. Traffic surveillance systems use vehicle detectors and cameras to support freeway management applications. Traffic control measures on freeway entrance ramps, such as ramp meters, can use sensor data to optimize freeway travel speeds and ramp meter wait times. Lane management applications can promote the most effective use of available capacity on freeways and encourage the use of high-occupancy commute modes. Special event transportation management systems can help control the impact of congestion at stadiums or convention centers. In areas with frequent events, large changeable destination signs or other lane control equipment can be installed. In areas with occasional or one-time events, portable equipment can help smooth traffic flow. Advanced communications have improved the dissemination of information to the traveling public. Motorists are able to receive relevant information on location-specific traffic conditions in a number of ways including dynamic message signs (DMS), highway advisory radio (HAR), and even in-vehicle systems. (Other methods of providing traveler information, including those covering multiple modes or travel corridors, are discussed in the traveler information chapter.) Automated systems enforcing speed limits and aggressive driving laws can lead to safety benefits.

Many of the ITS strategies and applications are being used to actively manage traffic on our freeways today. Technologies such as adaptive ramp metering, variable speed limits, dynamic merging, dynamic pricing, and information dissemination can influence traveler behavior in real-time to improve safety, reduce emissions and improve system efficiency and reliability.

Several other chapters of this report discuss ITS applications relevant to freeway management. There are chapters on Transportation Management Centers, Roadway Operations and Maintenance, Traffic Incident Management, Electronic Payment and Pricing, and Traveler Information, all of which use ITS technologies and applications that pertain to freeway management. In addition there is a separate chapter on Freeway Management: Integrated Corridor Management (ICM) that emphasizes the integration of freeway management, arterial management and transit management to combine strategies and apply a decision support system to operate facilities safely and efficiently.

Benefits

Ramp Control

Traffic signals on freeway ramps alternate between red and green signals to control the flow of vehicles entering the freeway. Metering rates may be altered based on freeway traffic conditions, ramp or local arterial traffic, or real-time vehicle emissions data. The Kansas City Scout program has implemented and evaluated ramp metering over the past few years. Selected results from these evaluations are listed in Table 1.

Table 1: Selected Benefits of Ramp Metering in Kansas City.

Selected Findings
Initial findings from a ramp meter evaluation in Kansas City were consistent with findings in other cities that show ramp metering can reduce crashes by 26 to 50 percent. (2012-00795)
The Kansas City Scout program used ramp meters to improve safety on a seven mile section of I-435; before and after data indicated that ramp meters decreased crashes by 64 percent. (2012-00799)
Initial findings from a ramp meter evaluation in Kansas City show that ramp meters make it easier for drivers to merge and reduce overall travel times. (2012-00796)
The implementation of ramp metering in Kansas City increased corridor throughput by as much as 20 percent and improved incident clearance by an average of four minutes, with these benefits remaining consistent in the long term. (2013-00852)
The Kansas City Scout program used ramp meters to improve traffic flow and reduce overall peak period travel times on a seven mile section of I-435 by 1 to 4 percent. (2012-00800)

Lane Management - Variable Speed Limits (VSL)

VSL systems have been used in a number of countries, particularly in Europe, as a method to improve flow and increase safety. VSL systems use detectors to collect data on current traffic and/or weather conditions. Posted speed limits are then dynamically updated to reflect the conditions that motorists are actually experiencing. Presenting drivers with speed limits that are appropriate for current conditions may reduce speed variance, a concept sometimes called speed harmonization. If properly designed, VSL systems have been shown to reduce crash occurrence and can also reduce system travel time and vehicle emissions through increased uniformity in traffic speeds.

Table 2: Selected Benefits of Variable Speed Limit Systems on Freeways.

Selected Findings
Field data collected over the last two decades show variable speed limit (VSL) systems can reduce crash potential by 8 to 30 percent. (2012-00806)
Variable Speed Limit System shows promise; crashes reduced to lowest level in a decade. (2011-00733)
A variable speed limit system used to regulate traffic flow through work zones on a 7.5 mile section of I-495 saved motorists approximately 267 vehicle-hours of delay each day. (2011-00765)

Collisions on I-5 in Washington State have been reduced by 65-75 percent in a 7.5 mile corridor where an active traffic management system was deployed. (2012-00803)
A Variable Speed Limit (VSL) system on the I-270/I-255 loop around St. Louis reduced the crash rate by 4.5 to 8 percent, due to more homogenous traffic speed in congested areas and slower traffic speed upstream. (2011-00735)
Implementing variable mandatory speed limits on four lanes with the optional use of the hard shoulder as a running lane resulted in a 55.7 percent decrease in the number of personal injury accidents on a major motorway in England. (2011-00724)
17 percent reduction in NOx on "Ozone Action Days" with Variable Speed Limits. (2014-00909)

Information Dissemination

Advanced communications have improved the dissemination of information to the traveling public. Motorists are now able to receive relevant information on location-specific traffic conditions in a number of ways, including DMS, websites and in-vehicle systems, or specialized information transmitted to individual vehicles.

Organizations operating ITS can share information collected by sensors or probe vehicles with road users through technologies within the freeway network, such as DMS or HAR. ITS operators may also send information to in-vehicle devices capable of displaying traveler information. Coordination with regional or multimodal traveler information efforts, as well as arterial and incident management programs, can increase the availability of information on freeway travel conditions.

Surveillance

Traffic surveillance systems use detectors and video equipment to support the most advanced freeway management systems. Surveillance technology, either in-ground or overhead, is used to provide real-time traffic data that is communicated to TMCs to assist agencies with decision making support to improve freeway operations. Table 3 includes selected benefits for freeway systems related to surveillance and information dissemination applications.

Table 3: Selected Benefits of Freeway Management.

	Selected Findings
Information Dissemination - DMS	When link travel times posted on DMS are twice as long as typical travel times, drivers begin to favor alternate routes. (2013-00846)
Information Dissemination - DMS	Ninety-four percent of travelers took the action indicated by the DMSs in rural Missouri and drivers were very satisfied by the accuracy of the information provided. (2013-00828)
Information Dissemination - In-Vehicle	Intelligent speed control applications that smooth traffic flow during congested conditions can reduce fuel consumption by 10 to 20 percent without drastically affecting overall travel times. (2010-00646)
Surveillance	NY State DOT TMC operators and NY State Thruway Authority staff were able to reduce traffic queues by 50 percent using vehicle probe data available through the I-95 Corridor Coalition. (2010-00653)

Costs

The purpose of the I-70 Corridor Intelligent Transportation Systems (ITS) and Technology Applications Study was to evaluate and plan for innovative technologies that could enhance the safety and mobility within the I-70 Corridor between

Kansas City and St. Louis, Missouri. This report discussed the following ITS applications currently implemented or planned for deployment by the Missouri Department of Transportation (MoDOT).

Table 4 provides general cost estimates for data sharing components for I-70 Corridor ITS Project.

Table 4: I-70 Corridor ITS Project - Estimated Costs (2013-00287).

Application	Description/Units	Cost Estimates*
Road Weather Information Systems (RWIS)	Number of Electronic Sensor Stations <25	$10,000 each
	Number of Electronic Sensor Stations >25	$12,500
Fog Warning Systems	Cost of New Infrastructure	$125,000
	Cost of Modifying an Existing Road Weather Information System (RWIS)	$75,000
Dynamic Message Signs (DMS)	Relocate Existing Signs	$30,000 to $40,000 each
	New DMS Installed	$100,000 to $120,000
Lane Control Signal System	Per Ramp	$80,000 to 90,000
Closed Circuit Television (CCTV)	Cost per camera site	$50,000
Traffic Flow Monitoring	Transponder based systems – one direction of traffic	$15,000
	Transponder based systems – both directions of traffic	$30,000
Emergency Response System	Web-based system	$50,000
Virtual Weigh Stations		$300,000 to $1.4 million
Enhanced Work Zone Systems		$785,000
Tolling Systems	Toll Gantry/Per Gantry	$300,000
	Toll Lane Equipment/Per Lane	$200,000
	Toll Vehicle Enforcement System (VES) Data Host/Per Toll System	$1.0 million to $1.5 million
	Host Servers and Functions/Per Toll System	$300,000
	TMC/Video Control/Per TMC	$500,000
	Transponders/each	$10 to $40
Communications/Fiber Optic Backbone	Per Mile	$70,000 to $200,000

*Estimates come from several sources including FHWA or based on national averages

Lessons Learned

Ensure proper placement of variable speed limit (VSL) signs in a work zone and operate the VSL system consistently on a long term basis.

In July 2008, a VSL system was installed along a segment of heavily traveled urban interstate in Northern Virginia (I-495) that will undergo several years of continuous construction. This was the first deployment of a traffic-responsive VSL system in Virginia. The following on lessons learned from this deployment:

- **Ensure proper placement of VSL signs in a work zone.** VSL signs are to be located in such a way that they facilitate driver understanding and smooth operations. Signs should be placed so that they are not at risk of being obstructed and are not generally difficult to see under normal circumstances.
- **Operate the VSL system consistently on a long term basis.** A concept of operations for future VSL systems should be developed and followed to ensure consistent application of VSL.
- **Design VSL control algorithm to facilitate rapid response to changing traffic patterns in a work zone.** Agency operations staff has to ensure that the VSL control algorithm is designed to facilitate rapid response to changing traffic in a work zone.
- **Consider operational and safety tradeoffs prior to installing VSL systems on roads where demand far exceeds capacity.** Agencies should carefully consider operational and safety tradeoffs prior to installing VSL systems on roads where demand far exceeds capacity. VSLs do not appear to provide significant operational benefits where there is a sudden onset of severe congestion.

Virginia's experience suggests that a well-configured VSL system can provide operational benefits and improvements in safety surrogate measures provided that demand does not exceed capacity by too large a margin. Prior to deploying future VSL systems, it is suggested that departments of transportation perform site specific simulations to determine likely operational impacts (2011-00599).

Case Study – Oregon's 217 Active Traffic Management (ATM) Project

Oregon Route (OR) 217 is a 7.5 mile limited-access expressway in the Portland Metropolitan area that runs north-south between US 26 and I-5. It includes two travel lanes in each direction with a third weave lane to accommodate exiting and merging traffic. The corridor, characterized by nine closely spaced interchanges, often operates at or above capacity during peak and off-peak hours. It has highly unpredictable traffic patterns created by the more than 122,000 daily travelers [1].

Figure 1: VMS on OR217 ATM Corridor. (Source: Oregon DOT [2])

With limited funding available and numerous corridor studies recommending costly capacity and interchange improvements, Oregon DOT implemented long-term Active Traffic Management (ATM) strategies to help increase mobility, safety, and travel time reliability along the corridor. Deployed on July 22, 2014, the system was designed to respond to road, traffic, and weather conditions in real-time. It is composed of the following systems elements:

- **Congestion and weather responsive variable advisory speeds** are part of a fully automated traffic and weather responsive system. The system includes traffic sensors, inductive loops, and radar as well as road weather data (grip factor, visibility, and roadway surface classifications). Based on prevailing congestion – speeds below free-flow conditions, and weather conditions, the signs provide drivers with suggested speeds helping to reduce rear-end crashes and congestion.

- **Travel time estimates on variable message signs (VMS);** The system calculates how long it will take drivers to reach common destinations using real-time traveler information. These estimates are posted to VMS to help travelers plan and adjust to prevailing traffic.
- **Traveler information on VMS** alerts drivers to traffic-related issues up ahead (e.g., crashes, congestion, road conditions, closures) to allow for better real-time travel decisions.
- **Queue Warning System** warns drivers of slowed or stopped traffic ahead, signifying reductions in expected speeds.
- **Adaptive Ramp Metering** using real-time traffic conditions collected from field data, ramp functionality is adjusted as needed based on system performance.
- **Curve Warning System** provides roadway surface information at localized high risk areas - warning drivers of slippery conditions during heavy precipitation (rain, ice, snow). The goal is to reduce speeds based on conditions resulting in reductions in the number and severity of crashes due to weather.
- **Targeted shoulder widening** was constructed to improve emergency vehicle access at key locations.

To evaluate system performance (i.e., determine operational and safety improvements), key metrics were assessed before and one-year after system deployment. Results showed: (1) a significant reduction in crashes and crash severity, (2) improvements in reliability, and (3) an increase in peak period vehicles per lane per hour (VPLPH).

Evaluation Results

- Crash data was collected from several independent sources. Data from one source indicates a reduction in total crashes with a significant reduction in severity (60%) and targeted crash types, rear-end and side-swipe overtaking, (18.6%) associated with congestion. This data source shows a reduction of nearly 21% of total crashes, whereas another data source yielded a reduction of 13.5%.
- Volume data was collected through the system using two week samples of hourly peak period weekday volumes for the months of August, November, February and May. This data indicates a 5.8% combined increase in vehicles per lane per hour (VPLPH). The NB corridor saw the largest increases in volume with PM peak seeing increases of over 9.3%.
- Using HERE travel time data, overall average travel times along the OR217 corridor changed by less than 1% while the vehicles per lane per hour values increased by over 5%.
- HERE data was evaluated on the OR217 corridor using a SB route from MP1.11 to MP6.19 and NB route from MP6.51 to MP1.24. The results indicate that, with the steadily increasing traffic volumes, the corridor was able to maintain overall average travel times while the 95% travel times were reduced by over 5%.

References

1. OR217: Active Traffic Management. Oregon DOT. December 29, 2015.
2. "OR 217 Active Traffic Management, Category: Best New Innovative Product, Service, or Application." Oregon DOT.
3. "OR217 Active Traffic Management (ATM) Project." Oregon Department of Transportation. http://www.nascio.org/portals/0/awards/nominations2015/2015/2015OR6-Oregon-ODOT-2015%20-%20OR217%20ATM%20Project.pdf

All other data referenced is available through the ITS Knowledge Resources Database, which can be found at http://www.itsknowledgeresources.its.dot.gov/ .

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