TRAFFIC SURVEILLANCE IS USED TO COLLECT DATA ON 38 PERCENT OF FREEWAY MILES IN MAJOR METROPOLITAN AREAS.

FREEWAY MANAGEMENT

ROADWAYS

There are numerous ITS strategies to 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 now able to receive relevant information on location-specific traffic conditions in a number of ways including dynamic message signs (DMS), highway advisory radio (HAR), 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.

Several other chapters of this report discuss ITS applications relevant to freeway management. The traveler information chapter discusses the provision of information on traffic conditions to travelers on a regional basis. For example, technologies such as 511 and regional traveler information Web sites can provide important information to freeway travelers. Successful implementation of these strategies often requires collaboration with other agencies in a region, contrasted with the use of freeway DMS under the direct control of the freeway management agency. The crash prevention and safety chapter describes road geometry warning systems which have been helpful in addressing safety challenges on freeway downgrades and exit ramps. The electronic payment and pricing chapter discusses pricing strategies that are used on a growing number of freeways.

In addition to the individual ITS technologies profiled in this chapter, the Integrated Corridor Management (ICM) initiative, a major ITS initiative currently being conducted by the U.S. DOT, has the potential to improve freeway management strategies. The purpose of the ICM initiative is to demonstrate that ITS technologies can be used to efficiently and proactively manage the movement of people and goods in major transportation corridors by facilitating integration of the management of all networks in a corridor. The results of the initiative will help to facilitate widespread use of ICM tools and strategies to improve mobility through integrated management of transportation assets. [105] Additional information on this initiative is available at the ITS JPO's Web site: *www.its.dot.gov/icms.*

FREEWAY MANAGEMENT CATEGORIES IN THE ITS KNOWLEDGE RESOURCES

Surveillance
- Traffic
- Infrastructure

Ramp Control
- Ramp Metering
- Ramp Closures
- Priority Access

Lane Management
- High-Occupancy Vehicle Facilities
- Reversible Flow Lanes
- Pricing
- Lane Control
- Variable Speed Limits
- Emergency Evacuation

Special Event Transportation Management
- Occasional Events
- Frequent Events
- Other Events
- Temporary Traffic Management Center

Information Dissemination
- Dynamic Message Signs
- In-Vehicle Systems
- Highway Advisory Radio

Enforcement
- Speed Enforcement
- High-Occupancy Vehicle Facilities
- Ramp Meter Enforcement

Findings

Benefits

Metropolitan areas that deploy ITS infrastructure, including DMS to manage freeway and arterial traffic, and integrate traveler information with incident management systems can increase peak period freeway speeds by 8 to 13 percent,[106] improve travel time, and according to simulation studies, reduce crash rates and improve trip time reliability with delay reductions ranging from 1 to 22 percent.[107]

Ramp control systems continue to be effective. Available data shows that ramp metering can improve mainline traffic speeds by 13 to 26 percent,[108] increase throughput by 5 to 30 percent,[109] limit ramp meter delay, and reduce crashes by 15 to 50 percent.[110]

Surveys conducted in the U.S. and Europe found large numbers of drivers said they had changed routes based on the information provided by DMS (85 percent in Houston, Texas; and 40 percent in Glasgow, Scotland).[111]

Table 2—Measured Benefits of Freeway Management

Application	Measure	Benefits
Dynamic Message Signs	Freeway Travel Speed (Mobility)	Increase 8% to 13%
Ramp Metering	Freeway Speed (Mobility)	Increase 13% to 26%
	Freeway Throughput (Efficiency)	Increase 5% to 30%
	Crashes (Safety)	Decrease 15% to 50%
Automated Speed Enforcement	Number of Speeding Vehicles (Safety)	Decrease 27% to 78%

Several studies document safety improvements with the implementation of variable speed limits (VSL). These benefits stem from reduced speed variability and slower vehicle speeds during periods of hazardous traveling conditions. Another study documents increases in roadway capacity through more uniform traffic flow.[112]

Evaluation studies conducted in Canada, the Netherlands, Australia, and the United Kingdom show that roadways equipped with automated speed enforcement technologies can eliminate 27 to 78 percent of speeding vehicles.[113] In the United Kingdom, large scale deployments have been cost-effective.[114]

Table 3 presents qualitative ratings of the impact of freeway management ITS applications under each of the six ITS goals. Many of the strategies have been found effective in improving safety. Studies of ramp metering and information dissemination have shown mobility improvements. Ramp metering has also been found to enable the freeway system to accommodate larger traffic volumes. Ramp metering, information dissemination, and speed enforcement programs have been found, in surveys, to be well received by the traveling public. More study of the impact of using freeway ITS to manage traffic at special events is needed.

OTHER ITS KNOWLEDGE RESOURCE CATEGORIES RELATED TO FREEWAY MANAGEMENT

Refer to other chapters in this document.

Traveler Information

Pre-Trip Information

En Route Information

Tourism and Events

Crash Prevention and Safety

Road Geometry Warning

Electronic Payment and Pricing

Pricing

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AVAILABLE DATA SHOW THAT RAMP METERING CAN IMPROVE MAINLINE TRAFFIC SPEED BY 13 TO 26 PERCENT.

Table 3—Freeway Management Benefits Summary

	Safety	Mobility	Efficiency	Productivity	Energy and Environment	Customer Satisfaction
Surveillance	**Enabling technology**					
Ramp Control	✚	●	●			●
Lane Management	✚					
Special Event Transportation Management						
Information Dissemination	✚	✚				✚
Enforcement	●					●

● Substantial positive impacts
❍ Negligible impacts
✖ Negative impacts
✚ Positive impacts
✱ Mixed results
blank Not enough data

Costs

There are numerous ITS strategies to improve freeway operations. The costs of these strategies vary based on many factors including whether or not the deployment is part of a larger agency project and maintenance and operations costs, as many States are experiencing. The cost of Minnesota DOT (Mn/DOT) ramp metering operations in the Twin Cities metropolitan area in fiscal year 2000 was $210,000 and included staff to monitor and adjust meter settings, conduct field reviews, and respond to inquiries from the public and media.[115]

The Florida DOT (FDOT) deployed 31 DMS in Broward County including associated structures, foundations, controllers, cabinets, and installation, plus approximately 37 miles of in-ground fiber optic communications at a cost of $11 million. Annual operating costs were estimated at $22,320 and annual maintenance costs were estimated at $620,000. FDOT coordinates with other agencies to verify incident and congestion locations and then posts traveler information on the DMS along effected routes.[116]

Washington State DOT (WSDOT) deployed three HAR stations along the Blewett/Stevens Pass to provide weather and road condition information to travelers and State maintenance crews. One portable and two fixed HAR stations were deployed. Annual operations and maintenance (O&M) costs of $1,000 per HAR station were based on prior experience to operate and maintain.[117]

In 2000, the installation and operational costs for 599 speed cameras (mobile and fixed) deployed during a two-year pilot study in the United Kingdom were estimated at £21 million.[118]

Benefit-Cost Studies

In Minneapolis-St. Paul, the benefit-to-cost ratio of a ramp metering system was estimated at 15:1.[119]

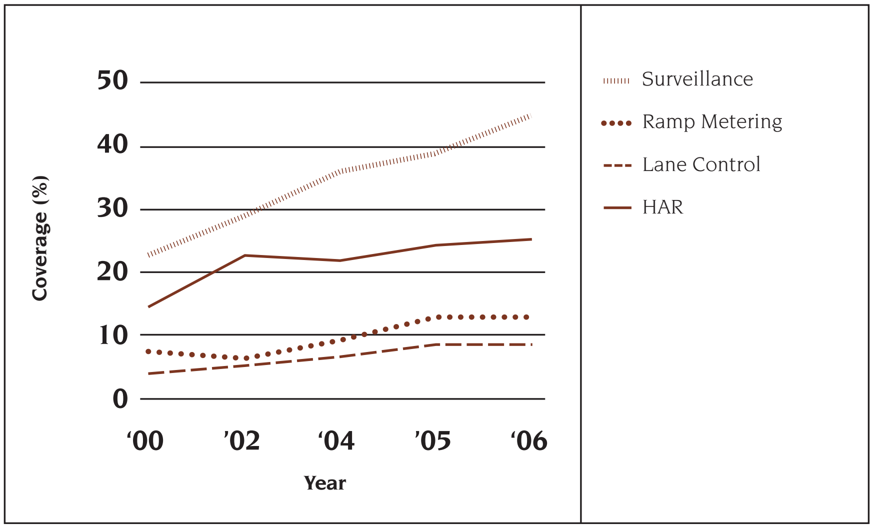

Figure 4 – Freeway Deployment Trends for 78 Major Metropolitan Areas

Deployment

Figure 4 shows deployment trends for four key ITS technologies in terms of coverage of metropolitan freeway miles. These data were collected through surveys of the 78 largest U.S. metropolitan areas from 2000 to 2006. The data show that significant progress has been made in deploying ITS technologies on freeways.

As of 2006, surveillance technologies—consisting of loop detectors, radar detectors, and acoustic detectors—are used to collect data on traffic conditions on 45 percent of freeway miles in the country's 78 largest metropolitan areas, up from 22 percent in 2000. The percentage of freeway miles served by HAR nearly doubled in the same period; HAR now services nearly one-fourth of all freeway miles. The growth rate of HAR has slowed in recent years, however, and may be leveling off.

Two other freeway management technologies have experienced slower growth. Ramp meters now manage access to 13 percent of freeway miles in the country's 78 largest metropolitan areas, up from 9 percent in 2000. Lane control strategies are used to manage travel on 9 percent of freeway miles in the country's 78 largest metropolitan areas, up from 4 percent in 2000.

In 2006, the survey of metropolitan areas was expanded to the country's 108 largest metropolitan areas. This survey is the source of deployment statistics presented later in this chapter.

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Selected Highlights from the ITS Knowledge Resources on Freeway Management

Surveillance

Traffic surveillance systems use vehicle detectors and video equipment to support the most advanced freeway management systems. These sensors can also be used to monitor critical transportation infrastructure for security purposes.

Surveillance
Deployment
Surveillance is used to collect information about traffic conditions on 38 percent of freeway miles in the country's 108 largest metropolitan areas.
Costs
Unit Costs Data Examples (See Appendix A for more detail)
Roadside Detection subsystem: • Inductive Loops on Corridor: $3K-$8K • Remote Traffic Microwave Sensor on Corridor: $9K-$13K • Closed Circuit Televsion (CCTV) Video Camera: $9K-$19K Transportation Management Center subsystem: • Hardware, Software for Traffic Surveillance: $131K-$160K Roadside Telecommunications subsystem: • Conduit Design and Installation—Corridor: $50K-$75K (per mile) • Fiber Optic Cable Installation: $20K-$52K (per mile)
Sample Costs of ITS Deployments
Florida: In 2006, FDOT District IV deployed 45 CCTV cameras and 106 vehicle detectors (67 side-fire radar stations). The cost of this Phase I deployment was **$2,845,462**. The cost included installation and associated structures, foundations, cabinets, and controllers. The CCTV cameras and detectors make use of existing fiber optics communications. Maintenance costs for Phase I were estimated at **$254,000**. Maintenance is contracted out and includes trouble-shooting and preventive maintenance. In 2007, the number of CCTV cameras increased to a total of 95 and the number of vehicle detection stations increased to a total of 170.[120] **Florida:** FDOT examined design factors for CCTV video camera sites and how the design and maintenance issues impacted the life cycle costs. Pole height and effect on camera system performance, site placement and spacing, coverage area, environmental impacts, and use of camera lowering devices are detailed. The costs of several alternatives based on pole height and mounting with and without camera lowering devices are compared in the report. Camera site initial costs range from **$16,550** to **$27,550**. Camera site life cycle costs range from **$403,650** to **$835,000**.[121]

Ramp Control

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.

Ramp Control
Deployment
Thirteen (13) percent of freeway access ramps in the country's 108 largest metropolitan areas are controlled by ramp meters. Three of these 108 metropolitan areas have the ability to close ramps automatically and give ramp access priority to transit vehicles on at least some of their ramps.

Ramp Control: Ramp Metering

Traffic signals on freeway ramp meters alternate between red and green to control the flow of vehicles entering the freeway. Metering rates can be altered based on freeway traffic conditions.

Ramp Control—Ramp Metering	
Benefits	
ITS Goals	**Selected Findings**
Safety	A study of the six-week shutdown of the ramp meters in Minneapolis-St. Paul, Minnesota found that ramp meters were responsible for a 21 percent crash reduction.[122]
Mobility	In Salt Lake Valley, Utah, a ramp metering study showed that with a metering cycle 8 seconds long, mainline peak period delay decreased by 36 percent or 54 seconds per vehicle.[123]
Efficiency	The Minneapolis-St. Paul, Minnesota shutdown study found that freeway volumes were 10 percent higher with ramp meters than they were during the shutdown.[124] A study in Glasgow, Scotland found freeway volumes increased five percent with ramp metering.[125]
Energy and Environment	A simulation study of the Minneapolis-St. Paul, Minnesota system found 2 to 55 percent fuel savings at individual ramp metering locations along 2 modeled corridors under varying levels of travel demand.[126]
Customer Satisfaction	Most drivers believed that traffic conditions worsened when the Minneapolis-St. Paul ramp metering system was shut down and 80 percent supported reactivation.[127] Fifty-nine (59) percent of survey respondents in Glasgow, Scotland found ramp metering to be a helpful strategy.[128]

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Ramp Control—Ramp Metering
Costs
Unit Costs Data Examples (See Appendix A for more detail)
Roadside Control subsystem: • Ramp Meter: $24K-$49K Roadside Telecommunications subsystem: • Conduit Design and Installation—Corridor: $50K-$75K (per mile) • Fiber Optic Cable Installation: $20K-$52K (per mile)
Sample Costs of ITS Deployments
Minnesota: The cost of Mn/DOT ramp metering operations in the Twin Cities metropolitan area in fiscal year 2000 was **$210,000** and included staff to monitor and adjust meter settings, conduct field reviews, and respond to inquiries from the public and media. This cost was for annual ramp metering operations on the approximately 230 miles of fully instrumented highway in the Twin Cities metropolitan area. State funds were used for ramp metering O&M.[129] **Colorado:** The Colorado DOT implemented ramp metering to regulate the flow of traffic onto freeways as part of the Transportation Expansion (T-REX) project. Each ramp meter site costs approximately **$50,000**, which includes the cost of the controller and approximately 15 percent mark-up for design.[130]
Benefit-Cost Studies
Minnesota: A 2001 study of the ramp metering system in Minneapolis-St. Paul estimated the benefit-to-cost ratio of the ramp metering system at 15:1.[131]

LESSONS LEARNED

Utilize public education and outreach in managed lane projects.

Use of managed lanes is a relatively new and complex concept to most travelers. Public understanding and acceptance are critical to the success of a managed lane project. Public education and outreach can take different forms including media coverage, surveys, and focus groups. Additionally, political champions who advocate on behalf of a project can help build public acceptance and can support any enabling legislation necessary for the managed lanes project.

- Provide ongoing public education.

Once the project has been implemented, it is important to continue providing the public with information. The Orange County Transportation Authority maintains a Web site for the State Route 91 Express Lanes that allows for online account applications and account maintenance. There is also a customer service center and an 800 number for customers' convenience. In addition, an advisory committee has been formed that includes representatives from several different transportation agencies and the general public. Based on the objectives of the project set by the community, the committee decides on future operational strategies and plans, as well as on the use of excess revenues.[133]

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Lane Management

Lane management applications can promote the most effective use of available capacity on freeways to encourage the use of high-occupancy commute modes.

Lane Management
Deployment
Lane control equipment is used on 5 percent of freeway miles in the country's 108 largest metropolitan areas, according to a 2006 survey. According to the same survey, 15 of these 108 metropolitan areas have high-occupancy vehicle (HOV) lanes and 8 have reversible flow lanes. Only 5 of these metropolitan areas employ VSL and 11 use lane control to support emergency evacuation.

Lane Management: Pricing

Traffic surveillance, electronic payment, video, global positioning systems, and automated enforcement technologies can support the implementation of congestion pricing strategies, which adjust the cost of transportation facilities based on demand or the time of day.

Lane Management—Pricing
Costs
Unit Costs Data (See Appendix A for more detail)
Roadside Information subsystem: examples include • Dynamic Message Sign: $48K-$119K Toll Plaza subsystem: examples include • Electronic Toll Reader: $2K-$5K • High-Speed • Camera: $7K-$10K Toll Administration subsystem: examples include • Toll Administration Hardware: $5.4K-$8.1K • Toll Administration Software: $39K-$78K Roadside Telecommunications subsystem: examples include • Conduit Design and Installation—Corridor: $50K-$75K (per mile) • Fiber Optic Cable Installation: $20K-$52K (per mile)
Sample Costs of ITS Deployments
California: Converting under-used HOV lanes to high-occupancy toll (HOT) lanes is often financially feasible. The primary capital cost includes plastic pylons, DMS, tolling and video enforcement equipment, and back-office processing systems. Implemented in April 1999, the cost to convert the existing HOV lane on I-15 in San Diego to a HOT lane was **$1.85 million**. The facility is an eight-mile stretch of 2 reversible lanes in the median of I-15 about 10 miles north of San Diego.[132]

Lane Management: Lane Control

Lane control signs, supported by surveillance and detection technologies, allow the temporary closure of lanes to avoid incidents on freeways.

Lane Management—Lane Control	
Benefits	
ITS Goals	**Selected Findings**
Safety	Traffic surveillance, lane control signs, VSL, and DMS in Amsterdam, the Netherlands have led to a 23 percent decline in the crash rate.[134]
Costs	
Unit Costs Data Examples (See Appendix A for more detail)	
Roadside Control subsystem: • Software for Lane Control: $24K-$49K • Lane Control Gates: $78K-$117K Roadside Telecommunications subsystem: • Conduit Design and Installation—Corridor: $50K-$75K (per mile) • Fiber Optic Cable Installation: $20K-$52K (per mile)	

Lane Management: Variable Speed Limits

VSL systems use sensors to monitor prevailing traffic and/or road weather conditions, and post appropriate enforceable speed limits on DMS.

Lane Management—Variable Speed Limits	
Benefits	
ITS Goals	**Selected Findings**
Safety	In Copenhagen, Denmark, a VSL system reduced mean vehicle speeds by up to five km/h and contributed to smoother traffic flow.[135] In England, VSL supplemented with automated speed enforcement have reduced rear-end crashes on approaches to freeway queues by 25 to 30 percent.[136]
Efficiency	Combined with automated speed limit enforcement, an English VSL system has increased freeway capacity by 5 to 10 percent.[137]
Customer Satisfaction	A survey of motorists in Copenhagen, Denmark found that 80 percent of respondents had favorable impressions of VSL and traveler information posted on DMS near a work zone.[138]

LESSONS LEARNED

Provide travel time messages on dynamic message signs for normal traffic and recurring congestion conditions.

Travel time messages on DMS are not appropriate for every location, but they are proven successful in regions or corridors that experience periods of recurring congestion—congestion generally resulting from traffic demand exceeding available capacity and not caused by any specific event such as a traffic incident, road construction, or a lane closure. The DMS can provide dynamic travel time information instead of generic messages such as "congestion ahead" or "stay alert."

- Generate travel times automatically.

Travel times should be generated automatically and not require a human operator to manually enter travel time data. All but one of the locations surveyed that provide travel time messages use automated processes to calculate the travel times. The majority of agencies surveyed use different technologies to measure the traffic flow including loop detectors, video detection systems, automatic vehicle identification transponders, and toll tags. The traffic data are processed to produce travel times over specified links between identified destinations. It is important to note that effective travel time messages do not require the data to be 100 percent accurate. Research has indicated that data with error rates of 20 percent produce useful traveler information. When presenting a range of travel times on DMS, the acceptable error rate may be even higher.[145]

Lane Management—Variable Speed Limits
Costs
Unit Costs Data Examples (See Appendix A for more detail)
Roadside Detection subsystem: • Remote Traffic Microwave Sensor on Corridor: $9K-$13K per sensor • Environmental Sensor Station (Weather Station): $30K-$49K Roadside Information subsystem: • Dynamic Message Sign: $48K-$119K • Highway Advisory Radio: $15K-$35K Transportation Management Center subsystem: • Labor for Traffic Information Dissemination: $107K-$131K (annually) Roadside Telecommunications subsystem: • Conduit Design and Installation—Corridor: $50K-$75K (per mile) • Fiber Optic Cable Installation: $20K-$52K (per mile)
Sample Costs of ITS Deployments
Washington: WSDOT implemented TravelAid, a VSL system that changes as the weather does, along the Snoqualmie Pass (I-90) east of Seattle, Washington. Approximately 13 miles are operated with VSL during the winter months. The system consists of radar detection, six environmental sensor stations, nine DMS, and radio and microwave communications systems. Design and implementation costs were **$5 million** (1997).[139]

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Special Event Transportation Management

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.

Special Event Transportation Management
Deployment
Fifty-seven (57) of the country's 108 largest metropolitan areas use portable transportation management systems, such as DMS, in various environments such as special event locations. Twenty-four (24) of these 108 metropolitan areas use temporary transportation management centers (TMC) or satellite locations for existing TMCs to support management of special event traffic.
Costs
Unit Costs Data Examples (See Appendix A for more detail)
Roadside Information subsystem: • Dynamic Message Sign: $48K-$119K • Dynamic Message Sign—Portable: $18.6K-$24K Roadside Detection subsystem: • Portable Traffic Management System: $78K-$97K Transportation Management Center subsystem: • Software for Traffic Information Dissemination: $17K-$21K • Labor for Traffic Information Dissemination: $107K-$131K (annually) Roadside Telecommunications subsystem: • Conduit Design and Installation—Corridor: $50K-$75K (per mile) • Fiber Optic Cable Installation: $20K-$52K (per mile)

LESSONS LEARNED

Display appropriate, concise messages on dynamic message signs to communicate effectively with travelers.

Design DMS messages to be brief, to the point, and have impact.

At typical highway speeds, the message posted on a DMS must be presented to motorists in about eight seconds or less. This translates to 8 words at 55 mi/h, 7 words at 65 mi/h, and 6 words at 70 mi/h. Therefore, the message must be concise and the words used must have impact.[146]

- Construct travel time messages to benefit not only the local commuters but also unfamiliar motorists where there is a mixture of traveler types.

Successful practices from the Atlanta, Georgia area demonstrate that a relatively simple change to local information can benefit unfamiliar travelers as well. By including the distance to the destination in addition to the travel time, even those travelers unfamiliar with the area can determine the approximate level of congestion ahead.[147]

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, HAR, in-vehicle displays, or specialized information transmitted to individual vehicles.

Information Dissemination
Deployment
HAR provides information to travelers on 21 percent of freeway miles in the country's 108 largest metropolitan areas. Eighty-six (86) of these metropolitan areas use DMS to provide information to travelers on freeways.

Information Dissemination: Dynamic Message Signs

DMS are permanent or portable electronic traffic signs that allow operators to give travelers information on traffic conditions, incidents, weather, construction, safety, and special events.

Information Dissemination—Dynamic Message Signs	
Benefits	
ITS Goals	**Selected Findings**
Safety	A San Antonio, Texas deployment of DMS, combined with an incident management program, resulted in a 2.8 percent decrease in crashes.[140]
Mobility	A simulation study of the system deployed on the John C. Lodge freeway in Detroit, Michigan estimated that HAR and DMS in combination with ramp metering may reduce vehicle delay by up to 22 percent.[141]
Customer Satisfaction	Mail-back questionnaires were sent to 428 drivers living near major freeways in Wisconsin to assess the impacts of posting travel time and traffic information on DMS throughout the state. A total of 221 questionnaires were returned and analyzed. The results indicated that 12 percent of respondents used the information more than 5 times per month to adjust travel routes during winter months, and 18 percent of respondents used the information more than 5 times per month to adjust travel routes during non-winter months.[142]

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Information Dissemination—Dynamic Message Signs
Costs
Unit Costs Data Examples (See Appendix A for more detail)
Roadside Information subsystem: • Dynamic Message Sign: $48K-$119K • Dynamic Message Sign—Portable: $18.6K-$24K Transportation Management Center subsystem: • Software for Traffic Information Dissemination: $17K-$21K • Labor for Traffic Information Dissemination: $107K-$131K (annually) Roadside Telecommunications subsystem: • Conduit Design and Installation—Corridor: $50K-$75K (per mile) • Fiber Optic Cable Installation: $20K-$52K (per mile)
Sample Costs of ITS Deployments
Florida: In 2006, FDOT District IV deployed 31 DMS. The cost of deployment was **$11 million** and included the signs, associated structures, foundations, controllers, cabinets, and installation, plus approximately 37 miles of in-ground fiber optic communications. The annual operating cost covered electricity and was estimated at **$22,320**. Maintenance costs of approximately **$620,000** included spare parts and labor for trouble-shooting problems, and preventative maintenance. DMS maintenance was contracted out. FDOT notes that employing an ITS maintenance contractor "… helps to avoid/minimize system downtime, reduces total cost of operation, improves effectiveness, and extends the life of ITS assets." Forty-one (41) additional DMS were planned for 2007.[143] **Utah:** The Utah DOT operates and maintains over 69 permanently mounted DMS on freeways and surface streets as part of the Utah advanced transportation management system (ATMS) known as CommuterLink. Portable message signs are also used along roadsides where there are no permanent DMS. The capital cost of the DMS system was **$15.25 million**. Annual operating cost of the DMS system, **$21,960**, is based on power consumption. The field devices and control centers are connected via a fiber optic network, which was installed as part of the ATMS deployment, at a cost of **$51.176 million**. Annual maintenance cost for the fiber optic communication system is **$50,000** and the annual operations cost is **$150,000**.[144]

Information Dissemination: Highway Advisory Radio

HAR uses low-power permanent or portable radio stations to broadcast traffic- and travel-related information to motorists using AM radio.

Information Dissemination—Highway Advisory Radio	
Benefits	
ITS Goals	**Selected Findings**
Customer Satisfaction	In a mountainous region near Spokane, Washington, about one-third of commercial vehicle drivers interviewed would consider changing routes based on the information provided on a road weather information Web site and HAR system; however, few could identify viable alternate routes.[148]
Costs	
Unit Costs Data Examples (See Appendix A for more detail)	
Roadside Information subsystem: • Highway Advisory Radio: $15K-$35K • Highway Advisory Radio—Sign: $5K-$9K Transportation Management Center subsystem: • Software for Traffic Information Dissemination: $17K-$21K • Labor for Traffic Information Dissemination: $107K-$131K (annually) Roadside Telecommunications subsystem: • Conduit Design and Installation—Corridor: $50K-$75K (per mile) • Fiber Optic Cable Installation: $20K-$52K (per mile)	
Sample Costs of ITS Deployments	
Washington: WSDOT installed a system in the rural and mountainous region of Spokane to collect and communicate weather and road conditions, border crossing status, and other information to commercial drivers, the motoring public, and WSDOT maintenance crews. As part of this system, two mobile HAR systems were deployed at and near the cities of Republic and at Kettle. Broadcasts warned motorists of road construction, incidents, dangerous driving conditions and restrictions, and border crossing conditions and closures. The total cost of the Republic and Kettle HARs was approximately **$111,073**. This cost included **$52,000** for two mobile HARs, and **$59,073** for signs, connectivity, clearing and other associated costs..[149] **Washington:** WSDOT has implemented three HAR stations along the Blewett/Stevens Pass to provide weather and road condition information to travelers and maintenance crews. One portable and two fixed HAR stations were deployed. Capital cost including equipment, cabinets, antennas, and installation was **$15,000 for each fixed site**, and **$30,000 for each portable unit**. Annual O&M costs of **$1,000** were based on prior experience to operate and maintain.[150]	

Enforcement

Automated enforcement systems—such as speed enforcement, HOV lane enforcement, and ramp meter enforcement—improve safety and reduce aggressive driving.

Enforcement
Deployment
Few jurisdictions use automated systems to enforce traffic laws on freeways. Seven of the country's 108 largest metropolitan areas use automated speed enforcement systems on freeways and 1 uses an automated system to enforce HOV restrictions.

Enforcement: Speed Enforcement

Automated enforcement technologies can assist with the enforcement of speed limit compliance. Still or video cameras, activated by vehicle detectors, can record vehicles traveling faster than the speed limit.

Enforcement—Speed Enforcement	
Benefits	
ITS Goals	**Selected Findings**
Safety	A study of 2 years of crash data following deployment of speed cameras at study sites throughout the U.K. found a 35 percent reduction in the number of people killed or seriously injured at camera locations. There was a 14 percent decline in the number of personal injury crashes.[151]
Customer Satisfaction	Seventy (70) percent of survey respondents in the U.K. thought that automated speed and red-light enforcement cameras were a useful way to reduce crashes and save lives.[152]

Enforcement—Speed Enforcement
Speed Enforcement Costs
Unit Costs Data Examples (See Appendix A for more detail)
Roadside Detection subsystem: • Portable Speed Monitoring System: $4.8K-$14.4K
Sample Costs of ITS Deployments
England, Wales and Scotland, U.K.: In April 2000, a system for speed and red light cameras was introduced in eight pilot areas in England, Wales, and Scotland, U.K. The Northamptonshire pilot consisted of 5 fixed camera sites and 45 mobile camera sites. Mobile enforcement was typically conducted on long stretches of roads known as red routes (corridors greater than 0.6 miles). Enforcement took place at 10 sites where the speed limit was 60 to 70 mi/h. The costs associated with camera enforcement and processing of fixed penalty notices were collected for the first two years. Costs increased for year two, which may be due in part to the fact that not all of the sites were fully operational during the first year. In the second half of year two, the number of fixed penalties paid began to plateau, which may be due to increased compliance. In terms of enforcement history, the Northamptonshire area was comparatively new to camera enforcement. First year costs were **£1,702,404** and second year costs were **£2,247,838.**[153]

86 Heminger, S. “Regional Signal Timing Program—2005 Cycle Program Performance,” Memorandum to the California Metropolitan Transportation Commission’s Operations Committee. Oakland, CA. October 2006. Costs ID: 2007-00112

87 *Evaluation of Automated Pedestrian Detection at Signalized Intersections*, U.S. DOT, Report No. FHWA-RD-00-097. August 2001. Benefits ID: 2004-00276

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