Intelligent Transportation Systems Benefits: *2001 Update*

U.S. Department of Transportation
Federal Highway Administration

Intelligent Transportation Systems Benefits:

2001 Update

Prepared by
Mitretek Systems
600 Maryland Avenue SW, Suite 755
Washington, D.C. 20024

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16. Abstract

This report continues the series of reports that document evaluation results of ITS user services and the benefits these services provide to the surface transportation system. The organization of this report differs from that of the previous ITS Benefits reports. While previous reports were cumulative, this report only summarizes major findings of data included in previous reports in the series. More detailed discussion is included for data collected since the 1999 report. Referenced data are classified into a structure that reflects individual ITS program areas. These program areas include metropolitan and rural infrastructure, ITS for Commercial Vehicle Operations (ITS/CVO), and Intelligent Vehicle user services. Data within the report reflect empirical results from field operations of deployed systems, supplemented with benefits information based upon modeling studies and statistical studies.

This is a reference report. It provides a snapshot of the information contained in the ITS Benefits Database (www.benefitcost.its.dot.gov), as of February 15, 2001. The online database is updated more frequently and provides more detail on specific references than this report. Both the report and database highlight benefits identified by other authors and refer the reader to information sources. The interested reader is encouraged to obtain source documents in order to appreciate the assumptions and constraints placed upon interpretation of results. It is the intent of the ITS Joint Program Office to update this report periodically.

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PREFACE

Since December of 1994, the United States Department of Transportation's (U.S. DOT's) ITS Joint Program Office (JPO) has been actively collecting information regarding the impact of ITS projects on the surface transportation network. In support of this effort the JPO sponsored the development of the National ITS Benefits Database. The database, updated quarterly, is available to the public at www.benefitcost.its.dot.gov and contains the most recent data collected by the JPO. Its purpose is to provide the JPO with a tool to transmit existing knowledge of the benefits of ITS products and services to transportation professionals. The database also provides the research community with information on ITS areas where further analysis may be required.

This document is a compendium of reported impacts of ITS collected for this effort. It builds on previous ITS Benefits reports, and is intended to be used as a reference report. It highlights benefits identified by other authors and refers the reader to information sources. The interested reader is encouraged to visit the ITS Benefits Database to obtain the most recent information and to obtain source documents in order to appreciate the assumptions and constraints placed upon interpretation of results. This report concentrates on summarizing data collected since the last update report, published in May 1999. However, general conclusions and summary information are developed using all data available in the database.

To aid the distribution of this report, it has been placed in the U.S. DOT's ITS Electronic Document Library at www.its.dot.gov/itsweb/welcome.htm as document number 13463.

Many ITS efforts initiated by states, local governments, and private enterprises do not have their benefits or costs documented in the database or this report. Readers who are aware of important ITS benefits and cost information from these and other sources are encouraged to submit them using the online database or to send reference documents to:

Joseph I. Peters

Joseph I. Peters, Ph.D.
Manager, ITS Program Assessment
ITS Joint Program Office
Federal Highway Administration (HOIT)
400 Seventh Street, SW
Washington, D.C. 20590

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EXECUTIVE SUMMARY

Since December of 1994, the United States Department of Transportation's (U.S. DOT's) ITS Joint Program Office (JPO) has been actively collecting information on the impacts that ITS and related projects have on the operation and management of the nation's surface transportation system. The evaluation of ITS is an ongoing process. Significant knowledge is available for many ITS services, but gaps in knowledge also exist.

The purpose of this report is to provide a summary of data available in the ITS Benefits Database. It is a compendium of reported impacts of ITS that have been collected from a number of sources, and builds upon a history of similar summary reports that have been authored over the last six years. Intended to be a reference report, this report highlights benefits identified by other authors. The purpose of this report is to provide the JPO with an additional tool to transmit existing knowledge of ITS benefits to the transportation professional who may not be well versed in ITS products and services. This report can also provide the research community with information about where further analysis is required in the ITS program. It demonstrates that in general all ITS services have shown some positive benefit and that negative impacts are usually outweighed by other positive results. For example, higher speeds and improved traffic flow result in increases in Nitrous Oxides, while other measures which indicate increased emissions, such as fuel consumption, travel time, and delay, are reduced.

General conclusions and results are developed throughout the body of the report. Due to the nature of the data, it is often difficult to compare data from one project to another. This is because of the differences in context or conditions between different ITS implementations. Thus, statistical analysis of the data is not done across data points. In several cases, ranges of reported impacts are presented and general trends can be discussed. These cases include traffic signal systems, automated enforcement, ramp metering, and incident management.

As indicated in Table ES-1, most of the data collected to date are concentrated within metropolitan areas. The heaviest concentrations of data in the metropolitan area are in arterial management systems, freeway management, incident management, transit management, and regional multimodal traveler information. Most of the available data on traffic signal control systems are from adaptive traffic control. For freeway management, most data are concentrated around benefits related to ramp metering. There are also now several studies on the benefits of ITS at highway rail intersections, which differs from the 1999 report when no evaluations were available.

Number of References

- 0 - ○
- 1 to 3 - ◔
- 4 to 6 - ◒
- 7 to 10 - ◕
- >10 - ●

		Safety	Time & Delay	Capacity/Throughput	Cost	Customer Satisfaction	Energy & Environment	Other
Metropolitan	Arterial Management Systems	>10	>10	1 to 3	7 to 10	4 to 6	7 to 10	0
	Freeway Management	>10	>10	4 to 6	4 to 6	4 to 6	4 to 6	0
	Transit Management	4 to 6	>10	1 to 3	7 to 10	4 to 6	1 to 3	0
	Incident Management	4 to 6	>10	1 to 3	>10	4 to 6	4 to 6	0
	Emergency Management	4 to 6	1 to 3	0	0	0	0	0
	Electronic Toll Collection	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	1 to 3	0
	Electronic Fare Payment	0	1 to 3	0	1 to 3	1 to 3	0	1 to 3
	Highway-Rail Intersection	1 to 3	1 to 3	0	0	1 to 3	1 to 3	0
	Regional Mutimodal Travel Information	4 to 6	4 to 6	1 to 3	1 to 3	7 to 10	4 to 6	1 to 3
	Information Management	0	0	0	0	0	0	0
Rural	Traveler Safety and Security	1 to 3	0	0	0	1 to 3	0	0
	Emergency Services	1 to 3	1 to 3	0	1 to 3	0	0	0
	Tourism and Travel Information	0	0	0	0	0	0	0
	Public Transit and Mobility Services	0	0	0	1 to 3	0	0	0
	Infrastructure Operation and Maintenance	1 to 3	1 to 3	0	0	0	0	0
	Road Weather Management	4 to 6	4 to 6	1 to 3	4 to 6	0	0	0
ITS/CVO	Safety Assurance	0	0	0	4 to 6	1 to 3	0	0
	Credentials Administration	0	0	0	1 to 3	1 to 3	0	1 to 3
	Electronic Screening	1 to 3	1 to 3	0	4 to 6	1 to 3	0	0
	Carrier Operations	0	1 to 3	0	4 to 6	1 to 3	1 to 3	4 to 6
I.V.	Driver Assistance	1 to 3	4 to 6	1 to 3	0	1 to 3	0	0
	Platform Specific	0	0	0	0	0	0	0

Table ES-1: Summary of Available Data by Benefit Measure (as of 15 February 2001)

In past reports, rural applications have had few data points, but an increase in the implementation and evaluation of rural ITS has changed this. Several state and national parks are now examining and implementing improved tourism and travel information systems and several rural areas are implementing public travel services. Also, many states are now examining the benefits of incorporating ITS, specifically weather information, into the operation and maintenance of facilities and equipment. Much of the data reported for rural ITS are concentrated in the areas of crash prevention and security. Also, a significant amount of information is available for road weather management activities, including winter weather-related maintenance, pavement condition monitoring, and dissemination of road weather information.

ITS for Commercial Vehicle Operations (ITS/CVO) continues to provide benefits to both carriers and state agencies. ITS/CVO program areas usually report benefits data from directly measurable effects. Therefore, it might be expected that these data are accurate and only a few data points would be necessary to convince carriers, states, and local authorities of the possible benefits of implementing these systems. To date, most of the data collected for ITS/CVO are for cost, travel time, and delay savings for carrier operations.

ITS program areas and user services associated with driver assistance and specific vehicle classes are still being developed and planned. Although a few of these services are available in the marketplace, much of the data currently associated with these services are predicted or projected based on how systems are expected to perform. As market penetrations increase and improved systems are developed, there will be ample opportunity to measure and report data based on actual measurements.

The Benefits Database Desk Reference, Table ES-2 on the following page, also provides a brief summary of the metropolitan data available in the online database. The desk reference is updated regularly and is also available at the database website.

Given the continued investment in ITS that is occurring at the national, state, and local levels, there will continue to be opportunities to measure and report more data on the impacts of ITS. As these data become available, it may be possible to perform more detailed analyses for particular program areas or benefits measures, for example, through the use of meta-analysis techniques. These analyses are expected to assist in improving the estimated ranges of impact, and the level of confidence in those ranges.

Metropolitan Benefits By Program Area

Program Area	Benefit Measure	Summary
Arterial Management Systems	Safety Improvements	Automated enforcement of traffic signals has reduced violations 20% to 75%
	Delay Savings	Adaptive Signal Control has reduced delay from 14% to 44%
	Throughput	
	Customer Satisfaction	72% of surveyed drivers felt "better off" after signal control improvements in Michigan
	Cost Savings	Transit Signal Priority on Toronto transit line allowed same service with one less vehicle
	Environmental	Improvements to traffic signal control have reduced fuel consumption 2% to 13%
	Other	Adaptive Control has reduced stops from 10% to 41%
Freeway Management Systems	Safety Improvements	Ramp Metering has shown 15% to 50% reduction in crashes
	Delay Savings	11 to 93.1 vehicle hours reduced due to ramp metering I-494: Minneapolis
	Throughput	Systemwide study in Minneapolis - St. Paul found 16.3% increase in throughput
	Customer Satisfaction	After Twin Cities shutdown, 69% of surveyed travelers support modified continued operation
	Cost Savings	Georgia Navigator $44.6 million/year in incident delay reduction (integrated system)
	Environmental	
	Other	Ramp Metering has shown 8% to 60% increases in speed on freeways
Transit Management Systems	Safety Improvements	AVL with silent alarm supported 33% reduction in passenger assaults on Denver System
	Delay Savings	Reported improvements in on-time performance from 9% to 23% with CAD/AVL
	Throughput	
	Customer Satisfaction	Customer complaints decreased 26% after Denver installed CAD/AVL
	Cost Savings	AVL reduced San Jose paratransit expenses from $4.88 to $3.72 per passenger
	Environmental	
	Other	Reductions in fleet size from 4% to 9% due to more efficient bus utilization
Incident Management Systems	Safety Improvements	San Antonio, TX reports reduced crash rate of 41%
	Delay Savings	Reductions range from 95 thousand to 2 million hours per year
	Throughput	
	Customer Satisfaction	Customers very satisfied with service patrols (hundreds of letters)
	Cost Savings	Cost Savings from $1 to $45 million per year, varying with extent of system
	Environmental	TransGuide reduced fuel consumption up to 2600 gal/major incident
	Other	
Emergency Management Systems	Safety Improvements	
	Delay Savings	
	Throughput	
	Customer Satisfaction	95% of drivers equipped with PushMe Mayday system felt more secure
	Cost Savings	
	Environmental	
	Other	
Electronic Toll Collection	Safety Improvements	Carquinez Bridge, CA: Increase in crashes (27 to 30) and Injuries between 1996 and 1997*
	Delay Savings	Carquinez Bridge, CA: person time savings of 79,919 hours (per year) or about $1.07 million
	Throughput	Tappan Zee Bridge: Manual lane 400-450 vph, ETC lane 1000 vph
	Customer Satisfaction	
	Cost Savings	Roadway Maintenance can be reduced 14%
	Environmental	Florida: Reduced CO 7.3%, HC 7.2%, Increased NO_X 34% with 40% ETC usage
	Other	Value pricing using ETC in Florida resulted in 20% of travelers adjusting departure time
Electronic Fare Payment	Safety Improvements	
	Delay Savings	
	Throughput	
	Customer Satisfaction	In Europe, 71% to 87% user acceptance of coordinated smart cards for transit/city services
	Cost Savings	New Jersey Transit estimates $2.7 million cash handling reduction annually
	Environmental	
	Other	
Highway-Rail Intersections	Safety Improvements	92% of train engineers felt safety equal or greater with automated horn warning system
	Delay Savings	
	Throughput	
	Customer Satisfaction	School bus drivers felt in-vehicle warning devices enhanced awareness of crossings
	Cost Savings	
	Environmental	Automated horn warning system reduced noise impact area by 97%
	Other	
Regional Multimodal Traveler Information	Safety Improvements	Crash rate for drivers using web traveler information in San Antonio reduced 0.5%
	Delay Savings	San Antonio modeling results indicate a 5.4% reduction in delay for web site users
	Throughput	
	Customer Satisfaction	38% of TravTek Users found in-vehicle navigation useful in unfamiliar areas
	Cost Savings	ROUTES (London): estimated 1.3 million pounds sterling due to increased transit ridership
	Environmental	SmartTraveler Boston: estimated reductions NO_X 1.5%, CO 33%
	Other	

Source: www.benefitcost.its.dot.gov *Database also includes negative impacts of ITS. Date: 3/14/2001

Table ES-2: Benefits Database Desk Reference

1.0 INTRODUCTION

Americans drive more than 2.6 trillion miles a year on our nation's roadways. Transit ridership reached nine billion trips in 1999, the highest level in 40 years. The increasing demand for transportation caused by our expanding economy is causing the transportation system to reach the limits of its existing capacity. Intelligent Transportation Systems (ITS) can help ease this strain through the application of modern information technology and communications.

The goal of ITS is to improve the transportation system to make it more effective, more efficient, and safer. Building new transportation infrastructure is expensive and environmentally risky. In most urban areas where more capacity is needed, it is becoming physically impossible to build enough new roads or new lanes to meet transportation demand. By applying the latest technological advancements to our transportation system, ITS can help meet increasing demand for transportation by improving the quality, safety, and effective capacity of our existing infrastructure.

ITS represents a wide collection of applications, from advanced signal control systems to ramp meters to collision warning systems. In order to apply ITS technologies most effectively, it is important to know which technologies are most effectively addressing the issues of congestion and safety. Some technologies provide more cost-effective benefits than others, and as technology evolves, the choices to deployers change. Often, several technologies are combined in a single integrated system, providing synergistic benefits that exceed the benefits of any single technology. It is important to know which technologies and technology combinations provide the greatest benefits, so that transportation investments can be applied most effectively to meet the growing transportation demands of our expanding economy.[1]

1.1 GOALS OF THE ITS BENEFITS REPORT AND DATABASE

1.1.1 The ITS Benefits Database

To expand the understanding of ITS benefits, the United States Department of Transportation's (U.S. DOT's) ITS Joint Program Office (JPO) has been actively collecting information regarding the impact of ITS implementations. In support of this effort, the JPO sponsored the development of the National ITS Benefits Database. The database is available to the public at www.benefitcost.its.dot.gov. The database contains the most recent data collected by the JPO. Its purpose is to provide the JPO with a tool to transmit existing knowledge of ITS benefits to the transportation professional who may not be well versed in ITS products and services. The database also provides the research community with information on ITS areas where further analysis may be required.

The Benefits Database website contains detailed summaries of each of the ITS evaluation reports reviewed by the JPO. Summaries on the web pages provide additional background on the context of the evaluations, the evaluation methodologies used, and links to the source documentation, if available online. While the JPO publishes reports such as this periodically, the online database is updated quarterly to reflect the most recent reports reviewed. The online database also provides several capabilities to simplify access to information relevant to a researcher's purpose. In addition to using the classification system in this report, interested researchers can access document summaries classified by the location of the implementation, the performance measures reported for the projects, or

[1] *The Changing Face of Transportation.* U.S. Dept. of Transportation, Bureau of Transportation Statistics (BTS00-007). 2000.

relevant keywords. These capabilities of the online database simplify access to the most recently available data on ITS benefits identified by the JPO. The website also contains a discussion of the criteria and sources used to determine whether or not a report should be added to the ITS Benefits Database.

1.1.2 Purpose of this Report

This periodically updated report is a compendium of reported impacts of ITS that have been collected from a number of sources. Its purpose is to provide a summary of data available in the ITS Benefits Database. The report builds upon a history of similar summary reports that have been authored over the last six years. The last report, titled *ITS Benefits: 1999 Update*,[2] was published in May of 1999. For this June 2001 report, a concentrated effort was made to include and highlight recent data. However, this report also references and contains data included in previous versions. Older data points are primarily used to develop general conclusions about the impacts of ITS services and are not described in as much detail as the more recent data. This report is intended to be a reference report; it highlights benefits identified by other authors. The interested reader is encouraged to obtain source information to appreciate the assumptions and constraints placed upon interpretation of results.

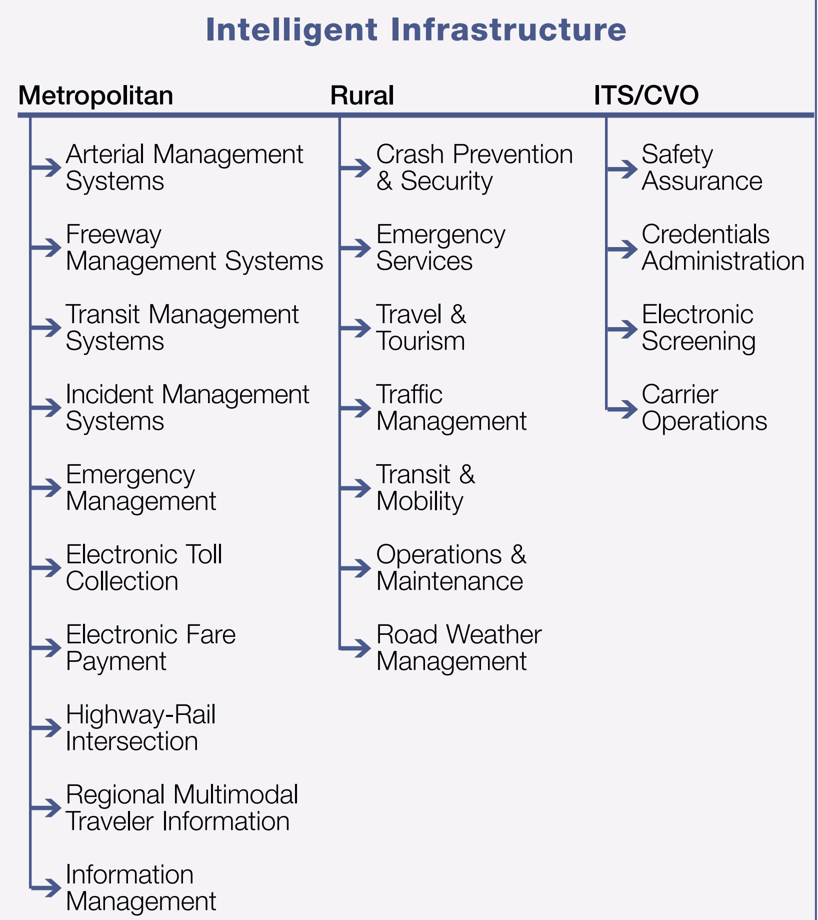


Figure 1-0: Intelligent Infrastructure Taxonomy for Reporting ITS Benefits

1.2 ORGANIZATION OF THIS REPORT

This report follows a taxonomy for reporting ITS benefits data. The ITS taxonomy used in this report groups benefits data into two major components: Intelligent Infrastructure and Intelligent Vehicles. These components are then divided into program areas and specific ITS application areas. While this taxonomy was not intended to reflect the official structure of the ITS program, it has proven useful in promoting discussion within the ITS community and has been used to demonstrate the breadth of the ITS program. An overview of this taxonomy is represented in Figures 1-0 and 1-1. A more detailed version of the taxonomy is available at the ITS Benefits Database website cited in the header of pages within this document.

[2] Proper, Allen T. *Intelligent Transportation Systems Benefits: 1999 Update*. U.S. Department of Transportation, ITS Joint Program Office (FHWA-OP-99-012). May 1999.

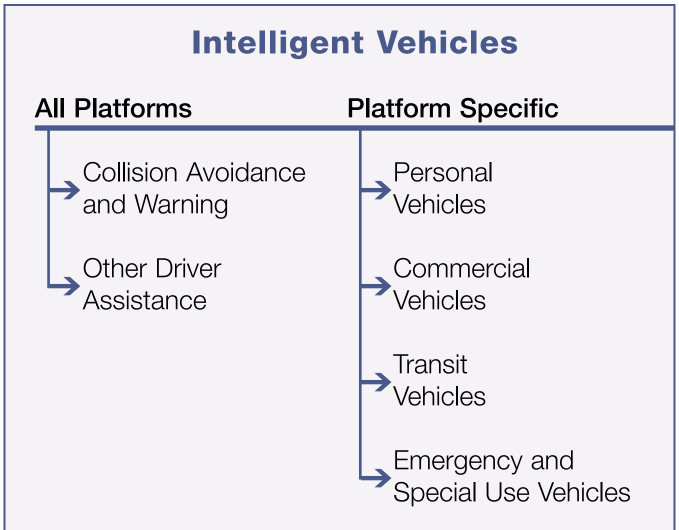


Figure 1-1: Intelligent Vehicles Taxonomy for Reporting ITS Benefits

It is realized that the taxonomy cannot represent all aspects of ITS. For example, many of the program areas can be dependent on or heavily influenced by other areas. This dependency is not well shown in the taxonomy. It is also understood that many ITS program areas share information and operate in a cooperative manner which is difficult to capture in this form. For example, incident management systems can directly influence emergency response by providing timely and accurate information on incident location and severity. Additionally, in-vehicle systems, such as route guidance, require a cooperative infrastructure that can provide routing and/or travel time information to vehicle systems.

It is also known that the taxonomy for classification of data by geographic setting (i.e., metropolitan, rural) may not be best suited for some data. For example, tourist information is generally classified in rural ITS infrastructure. However, most metropolitan areas also have tourism concerns. Therefore, this classification of data does not imply that systems are not implemented in or do not impact other geographic settings. In this report, data are classified by those settings most often associated with the current deployment of the ITS program area or service.

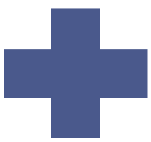
Classification of ITS benefits was based on the geographic setting (e.g., metropolitan) or functionality (e.g., ITS/CVO) of the ITS services referenced in the source documentation. This report attempts to account for the influences and cooperative aspects of ITS. In the case of integrated deployments, data are classified in this report under the program area that the implementation most directly supports. In some cases, source documents did not provide enough detailed information to classify referenced data. When this occurred, the authors made a judgment to determine how these data should be classified.

Sections within chapters of this report discuss each program area for which benefit data are available. Each section begins with a brief description of the ITS application and the current state of knowledge. Following this are overviews of all data and general conclusions that can be made about the ITS application. Finally, recent data, including what the authors consider to be the most important or interesting results collected since the 1999 report, are discussed.

1.3 A FEW GOOD MEASURES

In the spring of 1996, the ITS Joint Program Office (JPO) established a set of ITS Program goal areas directly related to the ITS strategic plan.[3] The goal areas include improving traveler safety, improving traveler mobility, improving system efficiency, increasing the productivity of transportation providers and conserving energy while protecting the environment. The JPO also identified several measures of effectiveness to evaluate the performance of ITS services in each goal area. The measures are known as the “Few Good Measures” and are intended to enable project managers to gauge the effects and impacts of ITS.

The remainder of this section is an overview of the various measures of effectiveness within each goal area. Throughout the document, icons are placed next to each summary to reflect the measures reported. Benefits that are not included in the set of measures are also included in the report, without using icons to reference them.



SAFETY

An explicit objective of the transportation system is to provide a safe environment for travel while continuing to strive to improve the performance of the system. Although undesirable, crashes and fatalities are inevitable occurrences. Several ITS services aim to minimize the risk of crash occurrence. This goal area focuses on reducing the number of crashes, and lessening the probability of a fatality should a crash occur. Typical measures of effectiveness used to quantify safety performance include the overall crash rate, fatality crash rate, and injury crash rate.

ITS services should also strive to reduce the crash rate of a facility or system. Crash rates are typically calculated in terms of crashes per year or crashes per million vehicle miles of travel.

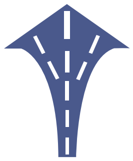
MOBILITY

Improving mobility by reducing delay and travel time is a major goal of many ITS components. To highlight this goal, in 1996 the Secretary of Transportation launched a new metropolitan ITS integration initiative, “Operation TimeSaver.” Measures of effectiveness typically used to evaluate the performance of such goal-oriented projects include the amount of delay or the variability in travel time.

Delay can be measured in many different ways, depending on the type of transportation system being analyzed. Delay of a system is typically measured in seconds or minutes of delay per vehicle. Also, delay for users of the system may be measured in person-hours. Delay for freight shipments could be measured in time past scheduled arrival time of the shipment. Delay can also be measured by observing the number of stops experienced by drivers before and after a project is deployed or implemented.

Travel time variability indicates the variability in overall travel time from an origin to a destination in the system, including any modal transfers or en-route stops. This measure of effectiveness can readily be applied to intermodal freight (goods) movement as well as personal travel. Reducing the variability of travel time improves the reliability of arrival time estimates that travelers or companies use to make planning and scheduling decisions. By improving operations, improving incident response, and providing information on delays, ITS services can reduce the variability of travel time in transportation networks. For example, traveler information products can be used in trip planning to help re-route commercial drivers around congested areas resulting in less variability in travel time.

[3] *Strategic Plan for Intelligent Vehicle Highway Systems in the United States.* ITS America Report (IVHS-Amer-92-3). Washington, DC: May 20, 1992.



EFFICIENCY

Many ITS components seek to optimize the efficiency of existing facilities and use of rights-of-way so that mobility and commerce needs can be met while reducing the need to construct or expand facilities. This is accomplished by increasing the effective capacity of the transportation system. Effective capacity is the "maximum potential rate at which persons or vehicles may traverse a link, node, or network under a representative composite of roadway conditions," including "weather, incidents, and variation in traffic demand patterns."[4] Capacity, as defined by the *Highway Capacity Manual*, is the "maximum hourly rate at which persons or vehicles can reasonably be expected to traverse a given point or uniform section of a lane or roadway during a given time period under prevailing roadway, traffic and control conditions."[5] The major difference between effective capacity and capacity is that capacity is generally measured under typical conditions for the facility, such as good weather and pavement conditions, with no incidents affecting the system, while effective capacity can vary depending upon these conditions and the use of management and operational strategies. Throughput is defined as the number of persons, goods, or vehicles traversing a roadway section or network per unit time. Increases in throughput are sometimes realizations of increases in effective capacity. Under certain conditions, it may reflect the maximum number of travelers that can be accommodated by a transportation system. Throughput is more easily measured than effective capacity and therefore can be used as a surrogate measure when analyzing the performance of an ITS project.

PRODUCTIVITY

ITS implementation frequently reduces operating costs and allows productivity improvements. In addition, ITS alternatives may have lower acquisition costs and life cycle costs compared to traditional transportation improvement techniques. The measure of effectiveness for this goal area is cost savings as a result of implementing ITS. Another way to view the cost savings is to quantify the cost savings between traditional and ITS solutions to addressing problems.

ENERGY AND ENVIRONMENT

The air quality and energy impacts of ITS services are very important considerations, particularly for non-attainment areas. In most cases, environmental benefits can only be estimated by the use of analysis and simulation. The problems related to regional measurement include the small impact of individual projects and large numbers of exogenous variables including weather, contributions from non-mobile sources or other regions, and the time-evolving nature of ozone pollution. Small-scale studies generally show positive impacts on the environment. These impacts result from smoother and more efficient flows in the transportation system. However, environmental impacts of travelers reacting to large-scale deployment in the long term are not well understood.

Decreases in emission levels and energy consumption have been identified as measures of effectiveness for this goal area. Specific measures of effectiveness for emission levels and fuel use include:

- Emission levels (CO, NO_X and HC) (kg or tons of pollutant)
- Fuel use (liters or gallons)
- Fuel economy (km/L or miles/gal)

[4] McGurrin, Michael and Karl Wunderlich. "Running at Capacity." *Traffic Technology International.* April/May 1999.

[5] *Highway Capacity Manual 2000.* Transportation Research Board, National Research Council. Washington, DC: 2000.

CUSTOMER SATISFACTION

Given that many ITS projects and programs were specifically developed to serve the public, it is important to ensure that user (i.e., customer) expectations are being met or surpassed. Customer satisfaction measures and characterizes the distance between users' expectations and experiences in relation to a service or product. The central question in a customer satisfaction evaluation is, "Does the product deliver sufficient value (or benefits) in exchange for the customer's investment, whether the investment is measured in money or time?" Typical results reported in evaluating the impacts of customer satisfaction with a product or service include product awareness, expectations of product benefit(s), product use, response (decision-making or behavior change), realization of benefits, and assessment of value. Although satisfaction is difficult to measure directly, measures related to satisfaction can be observed including amount of travel in various modes, mode choices, and the quality of service as well as the volume of complaints and/or compliments received by the service provider.

In addition to user or customer satisfaction, it is necessary to evaluate the satisfaction of the transportation system provider or manager. For example, many ITS projects are implemented to better coordinate between various stakeholders in the transportation arena. In such projects, it is important to measure the satisfaction of the transportation provider to ensure the best use of limited funding. One way to measure the performance of such a project is to survey transportation providers before and after a project was implemented to see if coordination was improved. It may also be possible to bring together providers from each of the stakeholder groups to evaluate their satisfaction with the system before and after the implementation of an ITS project.

1.4 IMPACTS OF ITS

This report includes both the positive and negative reported impacts of ITS implementations. The majority of available references demonstrate positive benefits. This is true both for actual deployments and for analytical studies predicting future benefits. The number of cases reporting negative results is fairly small. It is also recognized that negative impacts may be under-reported in the literature.

2.0 BENEFITS OF METROPOLITAN ITS INFRASTRUCTURE

Metropolitan ITS consist of those program areas that are primarily implemented in urban and suburban geographic locations. This does not imply that these systems are not implemented in or do not impact other geographic settings. However, they are more often associated with urban areas.

The metropolitan ITS infrastructure is classified into 10 major components. These components are summarized in Figure 2-0, below.

Metropolitan

- Arterial Management Systems
- Freeway Management Systems
- Transit Management Systems
- Incident Management Systems
- Emergency Management
- Electronic Toll Collection
- Electronic Fare Payment
- Highway-Rail Intersection
- Regional Multimodal Traveler Information
- Information Management

Figure 2-0: Metropolitan ITS Components

Several metropolitan areas are implementing ITS services that are very highly integrated. Integration is accomplished by creating a number of interfaces or "links" between components, systems, services, or program areas. These links are used to share operational information and allow for sharing of infrastructure. Figure 2-1 demonstrates a set of metropolitan integration links. A number is used to refer to the specific linkage made between each program area. For example, link number two represents the sharing of arterial traffic condition information originating from a traffic signal system with a freeway management system. To highlight the impact of the interaction between services on system benefits, data regarding integrated systems are highlighted in this chapter by icons with a connecting line that depicts the flow of information between systems. The example in Figure 2-2 represents integration between arterial management and incident management systems.

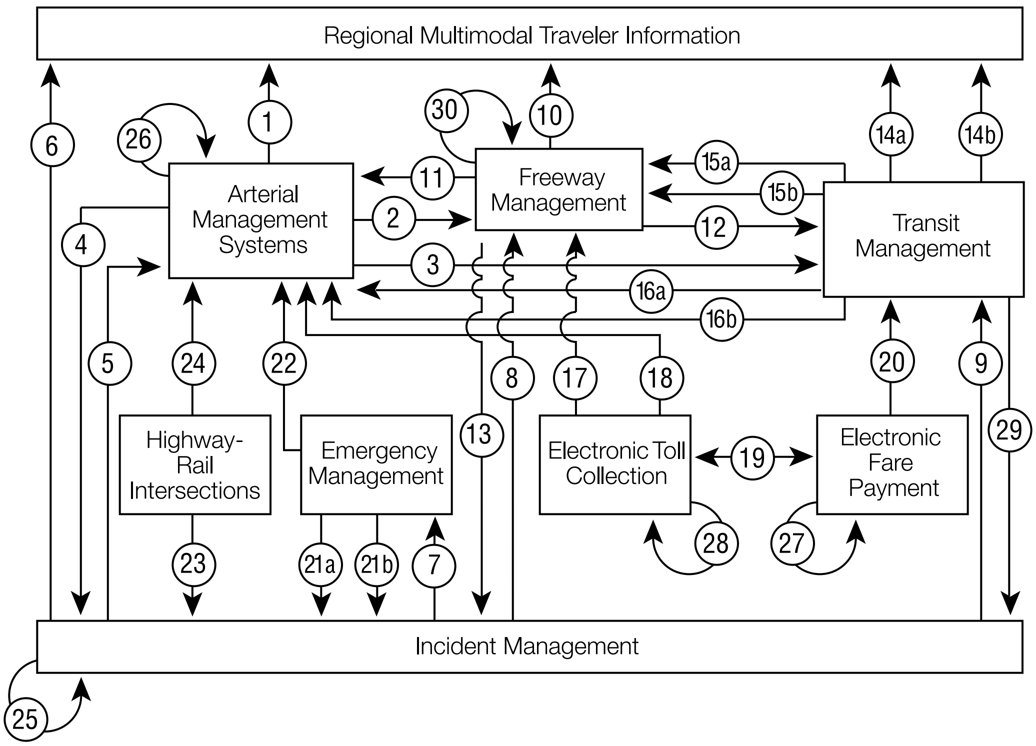


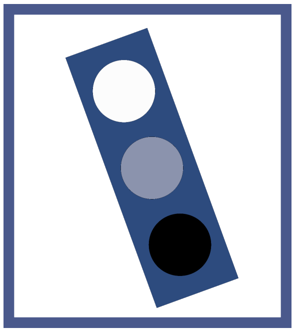
Figure 2-1: Integration of Metropolitan ITS Components

Figure 2-2: Arterial to Incident Management Integration Icon

For a more complete understanding of these components and how they are integrated, the reader is referred to the following documents:

- *Tracking the Deployment of Integrated Metropolitan Intelligent Transportation Systems Infrastructure in the USA: FY99 Results.* FHWA Report (FHWA-OP-00-016). March 2000. Electronic Document Number 13159.
- "Measuring ITS Deployment and Integration." Prepared for the FHWA ITS JPO. January 1999. Electronic Document Number 4372.

Both documents are electronically available on the FHWA electronic document library at www.its.dot.gov/itsweb/welcome.htm. The JPO-sponsored deployment tracking website, www.itsdeployment.its.dot.gov, contains updated information on ITS deployment in the United States. Results of the FY 2000 surveys are expected to be available at the deployment tracking website by Summer 2001.



2.1 ARTERIAL MANAGEMENT SYSTEMS

Arterial management systems are used to manage traffic by employing various detection and control devices along arterial roadways. Included in this program area are arterial traffic management systems that provide surveillance and traffic signal control, and some systems that provide travelers with audio or visual information on arterial roadway travel conditions.

Traffic signal control systems are upgraded for a number of reasons, primarily to improve traffic flow and simplify system maintenance. Adaptive control systems coordinate control of traffic signals across metropolitan areas, adjusting the lengths of signal phases based on prevailing traffic conditions. Information collected by detectors associated with arterial management systems may be shared between jurisdictional boundaries and with other components of metropolitan ITS infrastructure. Many jurisdictions have implemented traffic signal control systems that provide signal priority and preemption for transit and emergency vehicles, respectively. Arterial management systems may also include automated enforcement programs that increase compliance with speed limits and traffic signals. Figure 2-3 shows the format for the classification of benefits used in the taxonomy for arterial management systems.

For a summary of arterial management systems deployment in 78 of the largest U.S. cities, refer to www.itsdeployment.its.dot.gov.

Arterial Management Systems

- Traffic Surveillance
- Traffic Control
  - Adaptive Signals
  - Signal Priority
    - Transit
    - Emergency
  - Pedestrian Control
- Information Display
  - Dynamic Message Signs
  - Highway Advisory Radio
  - In-Vehicle Signing
- Public Safety
  - Enforcement

Figure 2-3: Taxonomy for Arterial Management System Benefits

2.1.1 Summary of Arterial Management System Impacts

Based on the results of published evaluations, it appears that advanced traffic signal control systems, such as those providing adaptive control, provide a significant positive benefit. However, it is difficult to generalize an expected benefit for these services. Benefits for an individual area depend on a number of operational variables that are unique to each implementation. Variables may include the number of intersections or signals in a corridor, spacing of intersections, size of study area, corridor lengths, vehicle demand patterns, etc. It is possible to make some general conclusions based on reported results that should be useful to decision-makers.

Figure 2-4 presents the measured values for percent reduction in the number of stops due to improved traffic signal control as detailed in previous reports and in the following section of this report. Studies evaluated systems implemented in Toronto, Canada;[6] Paris, France;[7] Oakland County, Michigan;[8] Los Angeles, California;[9] and Madrid, Spain.[10] Many of the cited studies evaluated the performance of adaptive control systems, while others investigated the impact of systems automating the selection of signal timing plans appropriate for particular time periods. As one would expect, if the flow of green bands in a corridor can be maintained as traffic patterns change, the number of stops can be reduced. The reported benefit of these systems ranges from a 10% to 41% reduction in stops; however, the small number of evaluations precludes statistical analysis of the results. Larger benefits are achieved when comparing improved signal control systems to systems using previously fixed timing plans in study corridors where significant variations in traffic patterns exist.

Figures 2-5 and 2-6 provide an overview of the impact of improved traffic signal operations on travel time and delay. The charts are based on evaluations of implemented systems discussed in the following section, as well as several discussed in previous ITS Benefits reports.[11, 12, 13, 14, 15, 16, 17, 18] As expected, the reductions in travel time are far less than those reported for delay avoided. Furthermore, there is an apparent large range of possible values for each measure. A likely contributing factor to this range is that individual studies may define or measure travel time and delay differently. Travel time may be defined as the time required for an entire trip or the time needed to traverse a corridor or fraction of the trip. Delay may be defined as stopped time due to signals only or as the time exceeding a predetermined base travel time. Depending on the definitions used, and other operational conditions, estimated changes in travel time range from a 6% increase in travel time and 20% decrease. Likewise, reductions in delay due to adaptive control may range between 14% and 44%.

Reports evaluating the impacts of arterial management systems on energy consumption and the environment indicate that the impacts are generally positive, though relatively minor. Figure 2-7 depicts the impact of improved traffic signal control on fuel consumption, as described in evaluations of systems in Phoenix, Arizona;[19] Paris, France;[20] Toronto, Canada;[21] and Los Angeles, California.[22] A few reports discuss the impacts of arterial management systems on motor vehicle emissions. The impact appears to be positive, with the exception of

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[6] Siemens Automotive, USA. "SCOOT in Toronto." *Traffic Technology International*. Spring 1995.

[7] Beteille, J. and Briet, G. "Making Waves in Traffic Control." *Traffic Technology International.* Annual Review, 1997.

[8] Barbaresso, James C. *Preliminary Findings and Lessons Learned From The Fast-Trac IVHS Program.* Road Commission for Oakland County. Beverly Hills, MI, 1994.

[9] City of Los Angeles Department of Transportation. *Automated Traffic Surveillance and Control (ATSAC) Evaluation Study.* June 1994.

[10] Peck, C., M. Blanco and J. Lopez. "Learning from the User: Next Steps for ITACA's Adaptive Control." *Traffic Technology International.* Annual Review, 1999. p. 155-158

[11] Zhou, Wei-Wu, *et al.* "Fuzzy Flows." *ITS: Intelligent Transportation Systems.* May/June 1997.

[12] Beteille, *et al.* 1997.

[13] Siemens Automotive 1995.

[14] Glassco, R, *et al. Studies of Potential Intelligent Transportation System Benefits Using Traffic Simulation Modeling.* Mitretek Systems Report (MP96W0000101). June 1996.

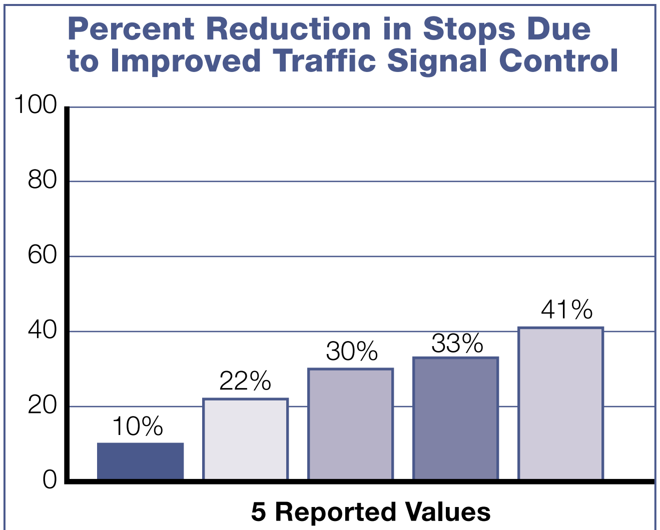


Figure 2-4: Reported Values of Stop Reductions under Improved Traffic Signal Control

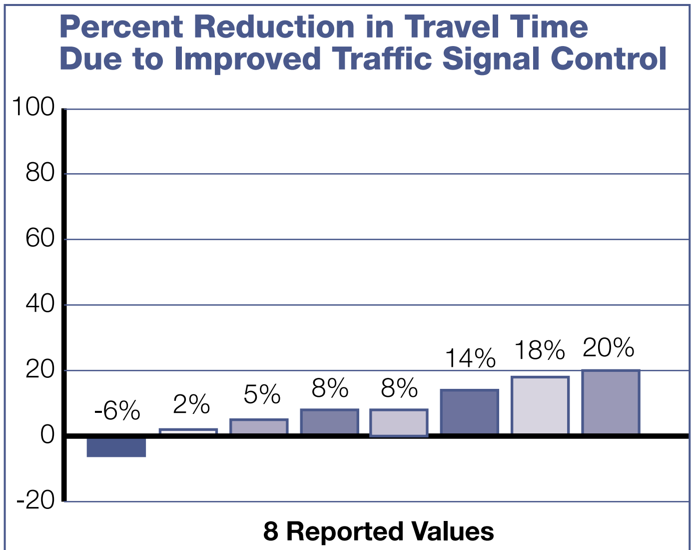


Figure 2-5: Travel Time Reduction with Improved Traffic Signal Control

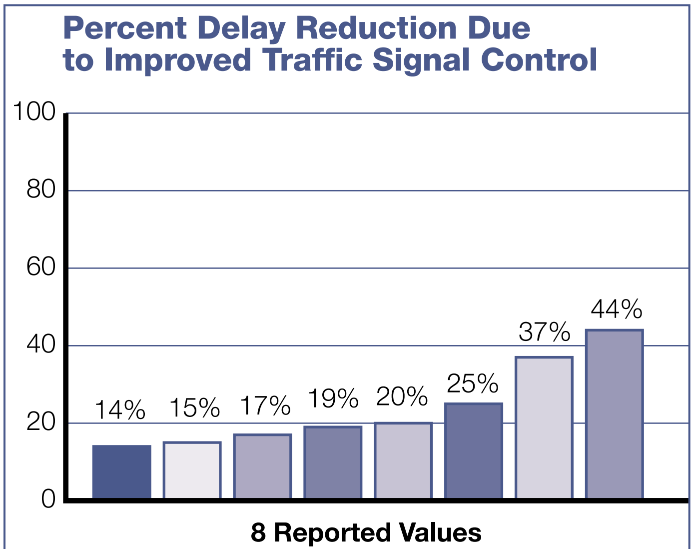


Figure 2-6: Delay Reduction with Improved Traffic Signal Control

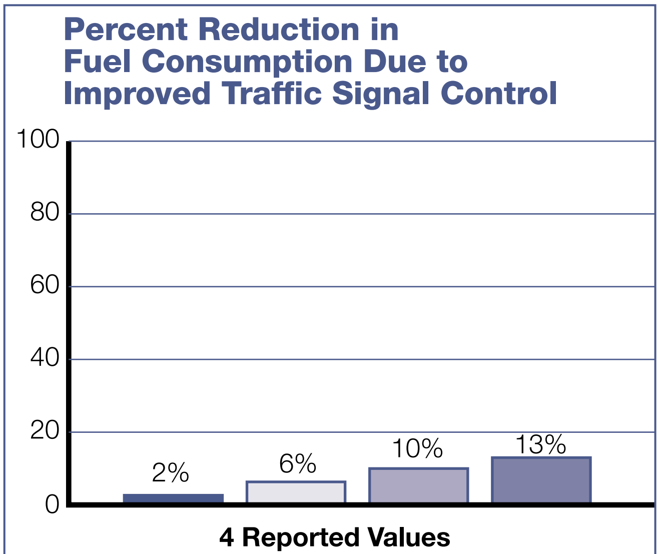


Figure 2-7: Fuel Consumption Reductions Due to Improved Traffic Signal Control

[15] Glassco, R, *et al. Studies of Potential Intelligent Transportation System Benefits Using Traffic Simulation Modeling: Volume 2.* Mitretek Systems Report (MTR 1997-31). June 1997.

[16] City of Los Angeles Department of Transportation 1994.

[17] Abdel-Rahim, Ahmed, William C. Taylor and Ashok Bangia. "The Impact of SCATS on Travel Time and Delay". Eighth ITS America Annual Meeting. Detroit Michigan. 4-7 May 1998.

[18] Peck, C. *et al.* 1999.

[19] Zimmerman, C., et al. *Phoenix Metropolitan Model Deployment Initiative Evaluation Report.* FHWA Report (FHWA OP-00-015). Washington, DC: 2000.

[20] Beteille, *et al.* 1997.

[21] Siemens Automotive 1995.

[22] City of Los Angeles Department of Transportation 1994.

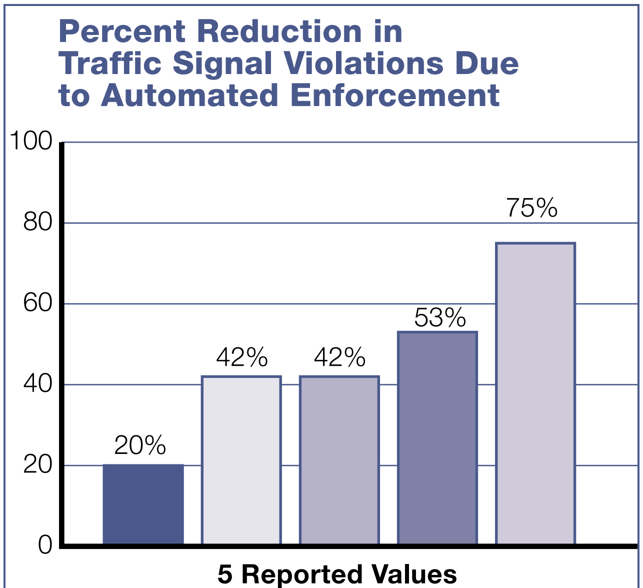


Figure 2-8: Reduction in Signal Violations Due to Automated Enforcement

emissions of nitrous oxides. This is expected because increases in average vehicle speeds due to improved traffic flows lead to increased production of nitrous oxides while decreasing other harmful emissions.

Figure 2-8 illustrates the reduction in violations recorded by several cities that have implemented automated enforcement of traffic signals. While violation reductions cannot be directly translated into safety impacts of the enforcement systems, reductions in the number of vehicles violating the signal do indicate a positive impact on safety at the enforcement locations. The wide variety of violation reductions represented in the figure below is likely due to both differences in individual enforcement programs as well as measurement differences between areas. The following section discusses most recent evaluations of implementations of arterial management systems.

2.1.2 Summary of Most Recent Evaluations

The City of Sao Paulo, Brazil, installed an adaptive signal control system along the commuter, commercial, and service route on the Av. Lins de Vasconcelos. The system resulted in an average reduction in delay of 14.4% for a 15-hour period while speeds improved 14%. Mid-day average speeds improved 25%. Floating vehicle analysis of a similar implementation at 107 intersections in Madrid, Spain, found a decrease in average travel time of 5%. Flow through the area was improved by reducing the number of stops by 10% and delay by 19%.[23]

A computer modeling effort investigated the potential impact of coordinating traffic signal timing plans among several jurisdictions along a congested arterial corridor leading into Seattle. The results of the model determined that coordinating the fixed signal timing plans along the corridor would result in a 7% reduction in vehicle delay, with no adverse impacts to cross-streets. The model also indicated that there would be no statistically significant change in vehicle emissions, the expected number of crashes along the corridor would fall by 2.5%, and the expected number of fatal crashes in a ten-year period would fall by 1.1%.[24]

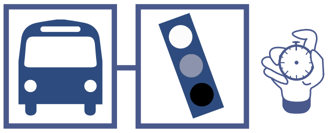
Anaheim, California, implemented the SCOOT adaptive signal control system within a three-square-mile area of the city containing four major event centers. Notably, this implementation required the SCOOT system to use existing mid-block vehicle detectors rather than detectors at the preferred locations near upstream intersections. A before-and-after evaluation of five test routes through the area found that the change in travel times ranged from a decrease of 10% to an increase of 15%. More circuitous routes involving more of the SCOOT system saw travel time changes from a 2% reduction up to an increase of 6%. The relative performance against the baseline system was better when there were no events at the centers being studied.[25]

[23] Peck, C. *et al.* 1999.

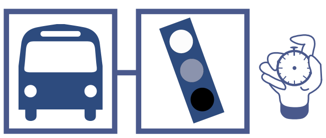
[24] Jensen, M., *et al. Metropolitan Model Deployment Initiative Seattle Evaluation Report: Final Draft.* Federal Highway Administration Report (FHWA-OP-00-020). Washington, DC: May 2000.

[25] McNally, M.G., *et al. Evaluation of the Anaheim Advanced Traffic Control System Field Operational Test: Executive Summary.* California PATH Research Report (Report No. UCB-ITS-PRR-99-18). Berkeley, CA: July 1999.

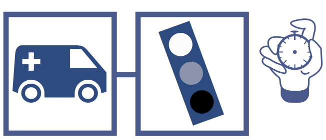
These results indicate inconsistent performance of the SCOOT system with vehicle detectors in non-standard locations. Also, as implemented in Anaheim, the system appears to have more difficulty adapting to the extreme variations in traffic volume that occur during major events than the more minor variations present in daily operation.



A study at the busiest intersection along a transit route in Eindhoven, the Netherlands, investigated the impact of several transit signal priority strategies on the delay experienced by buses and private vehicle traffic. The study found that average total vehicular delay experienced during the three busiest hours at the intersection increased by 40 seconds per vehicle under absolute priority. There was no significant change in delay with the buses operating under conditional priority, which only provides a green signal for buses running behind schedule. This pattern held true for all of the surveyed hours, with absolute priority causing large delays to other traffic, while conditional priority caused little, if any, additional delay. Buses experienced an average of 27 seconds of delay without priority. This figure dropped to 3 seconds per bus with absolute priority. During conditional priority, the bus delay fell between these values. Ninety percent of all buses received zero-delay service under absolute priority. Only 74% of the late buses experienced zero-delay service under conditional priority, indicating a need to improve the system's determination of a vehicle's on-time status.[26] These results indicate that additional control of on-time schedule performance provided to transit operators by conditional priority causes little additional delay to other traffic.



A second study in Eindhoven investigated the impact of the signal priority system on the deviation of transit vehicles from schedule. Field measurements of vehicle schedule adherence before and after a major intersection found a 28-second difference in the change in average schedule deviation as vehicles traversed the intersection. Vehicles traveling through the intersection under conditional priority achieved a 17-second improvement in the average absolute value of schedule deviation, while vehicles traveling without the benefit of conditional priority generally increased the average value of schedule deviation by 11 seconds. Simulation to investigate the impact of various priority strategies along a four-stop hypothetical transit route also indicated that conditional priority had a positive impact on schedule reliability as measured through deviations from scheduled running times.[27] The improvements in schedule reliability for buses at the intersection studied and along the simulated route indicate the enhanced control of on-time schedule performance that conditional signal priority can provide to transit operators.



A simulation of emergency vehicle signal preemption at three intersections near a suburban hospital outside Washington, DC found that the average travel times of other vehicles using the intersections increased a minimal, though statistically significant, 2.4% when signals were preempted for emergency vehicles.[28]

Studies at intersections in Los Angeles, California; Rochester, New York; and Phoenix, Arizona; indicate that automated pedestrian detection at traffic signals can improve safety. In general, there was an 81% decrease in the number of pedestrians crossing during a DON'T WALK with the addition of automated detection to intersections with operational push buttons. Conflicts encountered by pedestrians during the first half of the crossing were reduced 89% while conflicts for the second half were reduced 42%. Conflicts associated with right-turning vehicles were reduced 40%. All other conflicts were reduced 76%. Most of these reductions are attributed to reliable detection and signal extension for pedestrians in the process of crossing, not those waiting at the curb to

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[26] Furth, Peter G. and Theo H.J. Muller. "Conditional Bus Priority at Signalized Intersections." 79th Annual Meeting of the Transportation Research Board. Washington, DC. 9-13 January 2000.

[27] Muller, Theo and Peter Furth. "Integrating Bus Service Planning with Analysis, Operational Control, and Performance Monitoring." ITS America 2000 Annual Meeting. Boston, Massachusetts. 1-4 May 2000.

[28] Bullock, Darcy, J. Morales, B. Sanderson. *Evaluation of Emergency Vehicle Signal Preemption on the Route 7 Virginia Corridor.* Federal Highway Administration Report (Publication No. FHWA-RD-99-070). Washington, DC: July 1999.

cross. In Los Angeles, using automated detection only with the push-button taped over, there was a 7% to 17% increase in conflicts, likely due to pedestrians not realizing that the signal was automatically detecting their presence.[29]

Floating-car studies of the coordination of traffic signals across two jurisdictions in the Phoenix, Arizona, metropolitan area found a 6.2% increase in vehicle speeds, 1.6% reduction in fuel consumption, a 1.2% increase in CO emissions and no significant change in HC or NO_X emissions, and a reduction in the crash risk along the mainline of 6.7%. The field trial and floating-car data collection, included coordination of signal cycle lengths for 8 of the 21 signals along the corridor. Simulation studies of traffic along the entire corridor indicated that the benefits experienced by test vehicles at the coordinated intersections could be counteracted by delays experienced at earlier signals along the corridor. Simulation of signal coordination along the full length of the corridor indicated potential benefits of a 21% reduction in AM peak delay. Results for independent optimizations without coordination indicated a potential for a 16% reduction in AM peak delay.[30]

Three European projects investigated the impacts of public transit priority systems. Each of the projects demonstrated significant delay or travel time reductions for transit vehicles. Travel time reductions ranged from 5 to 15% in the QUARTET PLUS and TABASCO projects, with field trials in Toulouse, France; Turin, Italy; Gothenburg, Sweden; and Munich, Germany. The project in Valencia, Spain, found a 30% reduction in delay for vehicles already behind schedule. These reductions led to improvements in operating efficiency, which in turn provide significant cost reductions for operators.[31]

After implementing traffic signal priority for a light-rail transit (LRT) line along an urban arterial in Toronto, Canada, system operators were able to remove one vehicle from service and maintain the same level of service to passengers along the corridor, reducing operating expenses. The system operators have some concern over the operation of the system at LRT stops just prior to signalized intersections and have also received complaints regarding increases in pedestrian delay due to the signal priority system.[32]

A transit priority system implemented on a bus line along an urban arterial in Vancouver, British Columbia, has reduced the variability of travel time experienced by buses along the route by 29% in the AM peak and 59% during the PM peak. The system uses conditional priority permitting transit vehicles to obtain signal priority if they are behind schedule as the vehicle approaches the intersection.[33]

The automated red-light enforcement system in New York, N.Y. began operation in 1993 with enforcement at 15 intersections; by 1998, 30 intersections were included in the program.[34] A 1997 Urban Transportation Monitor article cited a 20% reduction in violations over the life of the program.[35]

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[29] Hughes, Ronald, H. Huang, & C. Zeger. "ITS and Pedestrian Safety at Signalized Intersections." *ITS Quarterly*. Vol. VII, No. 2. Washington DC: ITS America, Spring/Summer 1999.

[30] Zimmerman 2000.

[31] *Telematics Applications Programme - Transport Areas' Results (4th Funding Programme)*. European Commission Report. July 2000. [http://www.trentel.org/transport/frame1.htm]

[32] Cima, Bart, *et al.* "Transit Signal Priority: A Comparison of Recent and Future Implementations." ITE 2000 Annual Meeting. Nashville, Tennessee. 6-10 August 2000.

[33] Cima 2000.

[34] Institute of Transportation Engineers. *Automated Enforcement in Transportation*. ITE Report (Publication No. IR-100). Washington, DC: ITE, December 1999.

[35] "Cameras Reduce Red Light Running Violations by 20-30%." *The Urban Transportation Monitor*. May 23, 1997.

Howard County, Maryland, deployed red-light enforcement cameras at two intersections during a demonstration project. During the demonstration project, violators received warning notices in the mail. There was a 23% reduction in the number of violations per day at the two intersections after the public information campaign and mailing of violation notices commenced.[36] More recent reports from Howard County indicate that the program is successful. One intersection experienced 15 collisions during the year prior to implementation of a camera and eight collisions in the year following the installation. While the result was recorded too soon after implementation to be statistically significant, it may indicate a positive impact on safety at the intersections. Driver behavior has changed significantly at all intersections in Howard County where the cameras have been installed. The red light violation rate has dropped approximately 53% across all intersections with enforcement systems.[37]

Between the first and sixth months of operation of red light enforcement cameras in San Francisco, California, the ratio of violating vehicles to the total number of vehicles using the monitored approach decreased by 42%. San Francisco also implemented a public awareness campaign about the problem of red-light running at the time the automated enforcement program began.[38]

Oxnard, California, implemented an automated enforcement program very similar to the one implemented in San Francisco and also began a corresponding public awareness program. The enforcement program in Oxnard also achieved a 42% reduction in violations after only several months.[39]

Victoria, Australia, began its red-light enforcement program in 1983 and in 1999 the program included 35 cameras rotated among 132 sites around the Melbourne metropolitan area. A 1988 study found a 30% reduction in right-angle crashes due to the program and a 10.4% reduction in casualties from crashes.[40] A second study, in 1995, found that the number of red-light violations had been reduced between 35% and 60%, right-angle crashes decreased 32%, right-angle turning crashes decreased by 25%, and rear-end crashes decreased by 30.8%; however, rear-end turning crashes increased by 28.2%.[41]

In the first year of operations, crashes caused by running red lights were reduced 9% at camera-monitored intersections in the city of Charlotte, North Carolina. The system has resulted in a violation reduction of 75%. Charlotte believes that giving the program a name and an extensive marketing program has been a major factor in the success of the system.[42]

A 1999 survey of drivers in five U.S. cities that employ red-light running enforcement cameras and five cities that do not use the cameras found that drivers in both groups of cities strongly favor the use of enforcement cameras. In cities currently using the cameras, 80% of drivers approved of their use, while in cities that do not have enforcement cameras, 76% of drivers were in favor of the systems.[43]

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[36] ITE 1999.

[37] Hansen, Lt. Glenn. "Can We Increase the Capability of Red Light Cameras?" *ITS World.* January/February 2000.

[38] ITE 1999.

[39] ITE 1999.

[40] Victoria Traffic Camera Office. Website, [http://home.vicnet.net.au/~tco/index.htm]. Melbourne, Australia: TCO, 1999. cited in ITE 1999.

[41] Coleman, Janet A. et al. *FHWA Study tour for Speed Management and Enforcement Technology.* Federal Highway Administration Report (FHWA-PL-96-006). Washington, DC: February 1996. *cited in* ITE 1999.

[42] "Branding is the Name of the Game in Enforcement." *ITS International.* May/June 2000. pp. 66-67.

[43] Retting, Richard A. "Reducing Red Light Running Crashes: A Research Perspective." 2000 ITE Annual Meeting. Nashville, Tennessee. 6-10 August 2000.

2.2 FREEWAY MANAGEMENT SYSTEMS

There are three major ITS functions that make up freeway management systems. Two of these are the monitoring and control of freeway operations. Monitoring and surveillance can be used to implement control and management strategies such as ramp metering rates and variable speed limits based on observed freeway conditions. The third function consists of displaying or providing information to the motorist. Motorists may receive this information in several ways, including Dynamic Message Signs (DMS), Highway Advisory Radio (HAR), In-vehicle Signing (IVS), or specialized information transmitted only to a specific set of vehicles. Other methods of providing traveler information are discussed in Section 2.9 of this report.

Freeway Management Systems

- Traffic Surveillance
  - Incident Detection
- Traffic Control
  - Lane Control
    - Speed Limits
    - Lane Use
  - Freeway Entrance
    - Ramp Metering
- Information Display
  - Dynamic Message Signs
  - Highway Advisory Radio
  - Specialized Information
    - Ramp Rollover
    - Downhill
  - In-Vehicle Signing
- Public Safety
  - Enforcement

Figure 2-9: Taxonomy for Freeway Management Systems

Automated enforcement is also used to improve safety by increasing compliance with speed limits and reducing aggressive driving. Figure 2-9 shows the classification of benefits data for freeway management systems.

For a summary of freeway management systems deployment in 78 of the largest U.S. cities, refer to www.itsdeployment.its.dot.gov.

2.2.1 Summary of Freeway Management Impacts

Data collected for freeway management systems have shown improvements to safety, reductions in travel time and delay, increased throughput, and flow improvements. Although each of these measures contains data points, only a few contain enough data for comparison and analysis. Much of the collected data have been related to ramp metering. Ramp metering has shown significant reductions in crashes, crash rates, and increased mainline travel speed. Table 2-1 outlines much of the ramp metering results collected and is compiled from data presented in previous benefits reports along with the new data highlighted in Section 2.2.2.

Location	Number of Meters	Freeway Coverage (km)	Crash Reduction	Secondary Crash Reduction	Crash Rate Reduction	Increased Speed	Reduced Travel Time	Delay Reduction	Increased Throughput Capacity	Demand Increase	Increased Traffic Volume
National Survey			15-50%			16-62%	48.0%		8-22%	17-25%	
Seattle, WA					62.0%						10-100%
St. Paul, Minnesota						60%		11-93 hours	30.0%	2.9-7.2%	
Portland, OR	58		43%			60%	39.1%			25.0%	
Minneapolis/St. Paul, MN	6	8	24%		38.0%	16%					
Minneapolis, MN	39	27	27%		38.0%	30%				32.0%	
Minneapolis/St. Paul, MN*	430	338	21%			8%	22.0%		16.3%		9.9%
Seattle, WA	22				39.0%	20%	52.3%			86.0%	
Denver, CO	5		50%							18.5%	
Detroit, MI	28		50%			8%				12.5%	
Austin, TX	3	4.2				60%				7.9%	
Long Island, NY						9%					
Long Island, NY	70	207	15%			13%					
Amsterdam			35%	46%	23.0%						
German Autobahn			29%		20.0%						
Glasgow, Scotland									5.0%		

* Figures from the 2000 Minneapolis/St. Paul evaluation converted as needed from impact of ramp metering shutdown to impact of ramp metering operation.

Table 2-1: Summary of Ramp Metering Impacts

There are several interesting points to note from the table. First, there are three different evaluations of the ramp meters in the Minneapolis region. The difference between these studies is that the second one examined more than six times the number of meters and over three times the number of freeway kilometers as the first, yet both studies show similar results in crash and crash rate reductions. The most recent study, completed in February 2001, assesses the impact of the entire ramp metering system and also measured a similar crash reduction percentage. The variety of travel speed improvements between the studies is likely due to differences in the operating conditions of the different study areas under investigation. For example, speed improvements might be very significant in bottleneck areas, but modest at less congested interchanges.

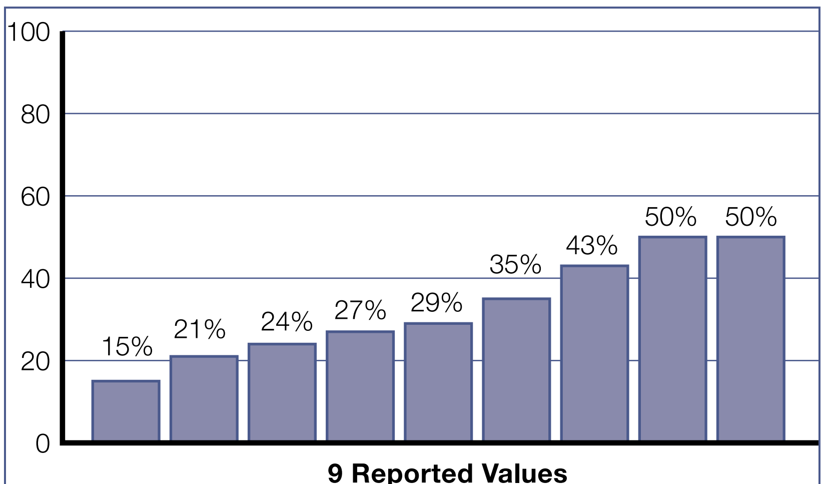

Figure 2-10: Percent Crash Reduction Due to Ramp Metering

Figure 2-10 summarizes the measured values for the percent reduction in crashes due to ramp metering of freeways in metropolitan areas. Ramp metering can reduce crashes by reducing the probability of sideswipes in merge areas. Also reduced are rear-end collisions that occur as vehicles slow to allow others to merge, or because vehicles on the

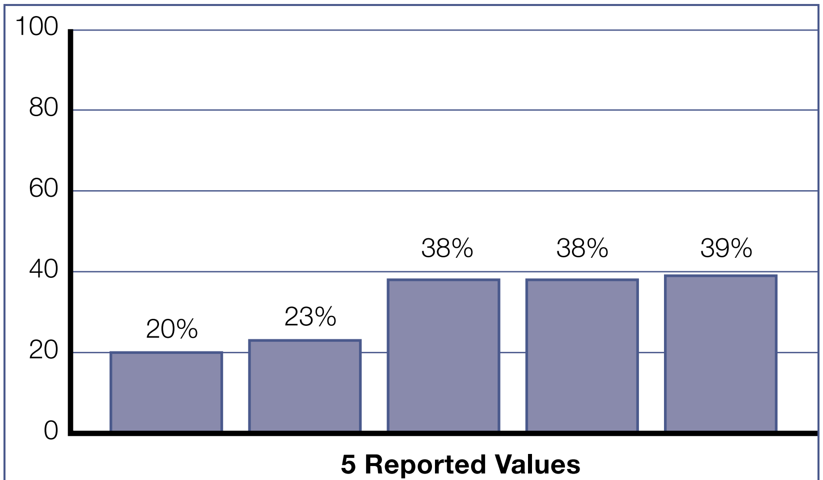

Figure 2-11: Percent Reduction in Crash Rates Due to Ramp Metering

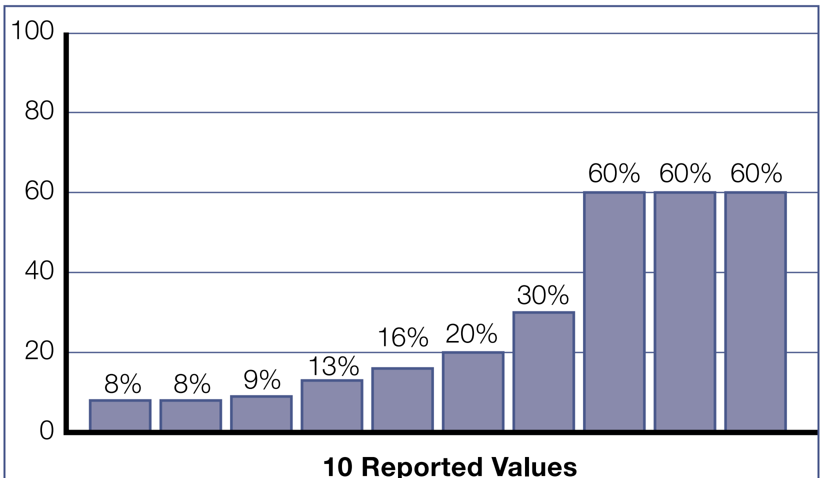

Figure 2-12: Percent Increases in Speed Due to Ramp Metering

ramp cannot merge. These reductions occur in both the mainline lanes as well as on ramps. Values of crash reductions reported range from 15% to 50%. Figure 2-11 illustrates the data reflecting reduction in crash rates, which range from 20% to 39%.

Ramp metering also has a positive impact on freeway speeds as summarized in Figure 2-12. These increases in speed imply significant travel time or delay savings. The range of speed increase is from 8% to 60%. This large range may be due to the differences in flow rates, geometric design of the freeway, number of meters, ramp spacing, or the length of freeway being measured. The figure also shows that the data appear to be grouped around low (8% to 16%) and high (60%) thresholds.

2.2.2 Summary of Most Recent Evaluations

A recent study performed for the Minnesota Department of Transportation (Mn/DOT) revealed the impacts of shutting down the extensive ramp metering system on Minneapolis-St. Paul area freeways for a six-week evaluation period. The study analyzed data collected along four test corridors chosen to represent typical freeway configurations and conditions across the region. The study collected a variety of data using several data collection techniques, including probe vehicles operating during peak periods, traffic volume counts from existing traffic detectors and temporary installations, crash statistics, and traveler surveys. Results from the evaluation indicate the generally positive impact of ramp meters:

- A 9% reduction in freeway volume without ramp meters, and a 14% reduction in peak period throughput (VMT).
- An average 22% decrease in freeway travel times with the meters on. The increase in travel times without the system more than offsets the elimination of ramp delays. Meters result in an annual systemwide savings of 25,121 hours.

- A 7% reduction in freeway speeds without meters.
- A 26% increase in crashes without meters.

Market research data collection results showed a number of changes in attitudes among area travelers that occurred once meters were shut down.

- Most survey respondents believed that traffic conditions worsened.
- Support for modifying the metering system, such as using faster cycle times, having shorter operating hours, and using fewer meters, increased from 55% to 69% of respondents.

Analysis of the benefits and costs of the ramp metering system showed that when the costs of the entire congestion management system (including changeable message signs, traveler information, and other components) are factored in, the benefit/cost ratio for ramp metering is 5:1. When ramp meter benefits are compared to only those costs directly associated with ramp metering, the benefit/cost ratio is 15:1.[44]

A computer simulation study estimated the impact of a freeway management system on incident-related congestion in Fargo, North Dakota. Results of the investigation revealed an 8% decrease in network travel times and an 8% increase in speeds with the installation of dynamic message signs to notify travelers of alternative routes around incidents. The study also investigated the integration of the freeway management system with an adaptive signal control system on adjacent arterial roadways to accommodate diverted traffic, which resulted in an 18% reduction in travel times and a 21% increase in vehicle speeds during incident conditions.[45]

A study to examine the safety impacts and public opinion of the pilot Aggressive Driver Imaging and Enforcement (ADIE) program along the Capital Beltway in Montgomery and Prince George's Counties, Maryland, was conducted in 1998. The study used motorist surveys and speed measurements to determine the effectiveness of the imaging and enforcement system and a related media campaign carried out in November 1997. The system began operation in January 1998. The ADIE system consisted of a specially trained police officer using several ITS technologies mounted in a dedicated police vehicle positioned at appropriate locations along the Beltway. The system allowed the officer to identify aggressive drivers and trigger an automated camera that photographed both the entire vehicle and the license plate. Warnings were mailed to offenders, but no penalties were assessed during the pilot program. Before-and-after surveys were distributed to residents in the vicinity of the Beltway, Commercial Vehicle companies operating on the Beltway, and truck drivers at a rest area near the I-95 and I-495 Interchange in Maryland. Approximately 4,000 copies of the survey were distributed in April 1997 and again after the system began operation, with approximately 1,000 surveys returned each time. Survey results indicated that the media campaign was effective in increasing motorists' awareness of the aggressive driving problem, with the number of respondents indicating that aggressive driving was a problem increasing from 19% to 54%. Prior to implementation, 82% of survey respondents favored using video technology for traffic enforcement, while 86% favored its use afterwards. The study analyzed speed data from automatic recording stations at three locations along the Beltway to assess the impact of the system on vehicle speeds. There was a significant reduction in the number

[44] Cambridge Systematics, Inc. *Twin Cities Ramp Meter Evaluation.* Prepared for Minnesota Department of Transportation. February 1, 2001.

[45] Birst, Shawn and Ayman Smadi. "An Evaluation of ITS for Incident Management in Second-Tier Cities: A Fargo, ND Case Study." ITE 2000 Annual Meeting. Nashville, Tennessee. 6-10 August 2000.

of vehicles exceeding 60 mph (the Beltway speed limit is 55 mph) in March 1998 when compared to March 1997. Two of the three recording stations showed decreases while one revealed an increase in the number of vehicles traveling at more than 60 mph. Due to the incomplete development of the system, related technical problems hindering its application, and the short duration of the study period, overall safety impacts such as any reduction in the number of crashes could not be assessed.[46]

The traffic management system for Highway 401 in Metropolitan Toronto is known as COMPASS. COMPASS was developed to provide safe and efficient travel on 42 km of the highway. It consists of loop detectors to determine traffic speed, volume, and density along with closed circuit television (CCTV) cameras monitoring the highway. Incident conditions and delay are monitored along the highway. Information is then sent to dynamic message signs, the media, fax machines, and radio stations for delivery to travelers. The benefits of the system include a cost savings of over $10 million per year from reduced crash, travel time, and vehicle operation costs. Incident duration has been reduced from an average 86 minutes to 30 minutes, while average incident-related delay is reduced by 537 vehicle hours per incident systemwide. This results in over 300,000 vehicle-hours of delay saved each year. By displaying messages on the dynamic message signs, 200 crashes per year are also saved. Average speeds have also improved between 7% and 19%.[47]

[46] Daniel Consultants, Inc. *Aggressive Driver Imaging and Enforcement: Evaluation Report - Impact of Media Campaign and Effects on Safety and Productivity*. Report prepared for Science Applications International Corporation. September 11, 1998.

[47] Institute of Transportation Engineers. *1996 ITS Tour Report: Eastern North America & 1996 ITS World Congress.* ITE Report. Washington, DC: 1997.

2.3 TRANSIT MANAGEMENT SYSTEMS

Advanced Public Transportation Systems (APTS) include a number of ITS applications that can help transit agencies increase the safety and operational efficiency of the nation's transit systems. Remote monitoring of transit vehicle status and passenger activity helps to provide additional safety and security to passengers. Transit ITS services also assist operators in maintaining vehicle fleets. Vehicle self-diagnostics can alert mechanics of unexpected mechanical problems as well as routine maintenance needs. Automated vehicle location (AVL) and computer aided dispatch (CAD) can improve scheduling activities and schedule adherence. Figure 2-13 shows the taxonomy for benefits of transit management systems described in this section. Transit signal priority and electronic fare payment, discussed in sections 2.1 and 2.7, respectively, also provide significant benefits to transit operations.

Transit management systems have demonstrated that they are capable of reducing travel time both by improving the operation of the vehicles and the overall operation of the transportation network. Transit management systems improve schedule adherence and the dissemination of schedule and route information to passengers, resulting in a reduction in passenger wait time and improvement in transfer coordination. Also, APTS applications reduce the cost of system operations by improving staff productivity and the utilization of facilities and equipment.

Transit Management Systems

- Transit Management
  - Maintenance
  - Automated Vehicle Location
  - ParaTransit
    - Computer Aided Dispatch
- Transit Information
  - Display - Audio/Visual
    - Traveler Information

Figure 2-13: Taxonomy of Transit Management Systems

For a summary of transit management systems deployment in 78 of the largest U.S. cities, refer to www.itsdeployment.its.dot.gov.

2.3.1 Summary of Transit Management System Impacts

Combined CAD/AVL systems are some of the most widely deployed APTS applications.[48] Analysis of these systems has begun to reveal their quantifiable impacts on schedule reliability. The unique conditions faced in each application of CAD/AVL and the different performance metrics used in evaluating them, make summary assessments of the systems difficult. Figure 2-14 contains three reported values of the impact of these systems on the on-time performance of the transit systems that implemented them. Results in the figure are from evaluations of implementations in Portland, Oregon;[49] Kansas City, Missouri;[50] and Baltimore, Maryland.[51] Regardless of the performance measures used, many system evaluations indicate positive impacts on schedule reliability and operational efficiency. In addition to improvements in on-time performance, CAD/AVL systems allow agencies to gain the most from their vehicle resources, providing valuable information for operational control strategies that can reduce the number of vehicles necessary to provide the required level of service to transit passengers.

Passenger surveys reveal high levels of customer satisfaction with implemented APTS applications. Transit patrons appreciate the benefits of improved communication of transit route and schedule information through a variety of information dissemination technologies. The various surveillance technologies used in APTS also improve the safety and security of transit systems.

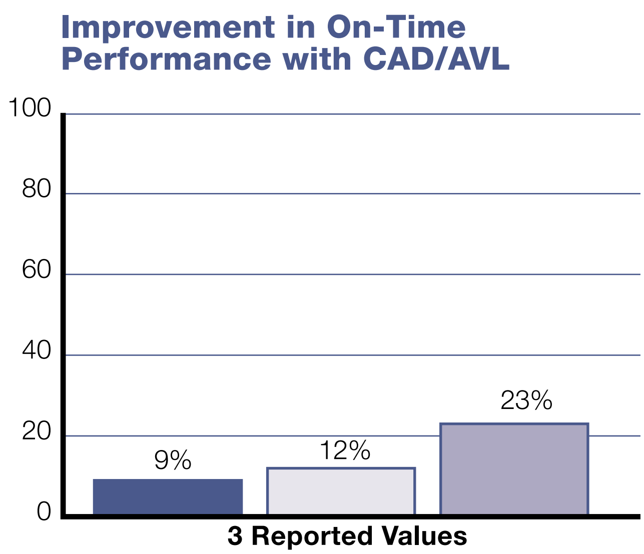

Figure 2-14: Improvement in On-Time Performance with CAD/AVL

2.3.2 Summary of Most Recent Evaluations

Metro Online, a website providing route and schedule information for the Seattle area bus system, provides a valuable service to its users. Many users indicated, in a survey, that they had been long-term users of this ITS service. Several recommended potential improvements to the site, including improvements to the route planning and transfer sections of the site.[52]

Customer satisfaction was also high for Transit Watch, a system that provides actual arrival and departure information for passengers at key transit centers in Seattle. Transit riders indicated that they would like to see the information available at places where travel decisions are made. While the system did not increase the satisfaction of existing riders with the transit system as a whole, new riders were pleased with the system, which may indicate that it could help the bus network retain new transit patrons.[53]

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[48] Casey, R., *et al. Advanced Public Transportation Systems: The State of the Art - Update – 96.* Federal Transit Administration Report. Washington, DC: January 1996.

[49] Strathman, James G., *et al.* "Service Reliability Impacts of Computer-Aided Dispatching and Automatic Vehicle Location Technology: A Tri-Met Case Study." *Transportation Quarterly.* Vol. 54 No. 3, Summer 2000. pp. 85-100.

[50] Giugno, M. *Milwaukee County Transit System: Status Report.* July 1995.

[51] "Intelligent Time Savers, Life Savers." *ITS Update.* December 1997.

[52] Jensen, M., *et al.* 2000.

[53] Jensen, M., *et al.* 2000.

Since implementing an Automatic Vehicle Location (AVL) system, the Denver Regional Transportation District (RTD) has provided its transit customers with higher quality service. The RTD decreased the number of vehicles that arrived at stops early by 12% between 1992 and 1997. The number of passengers per vehicle that arrived at stops late decreased by 21%. Customer complaints decreased by 26% per 100,000 boardings, in part due to improved schedule adherence by RTD. Provision of a silent alarm feature with the AVL system has helped improve the safety of the transit system. Passenger assaults per 100,000 passengers decreased by 33% between 1992 and 1997.[54]

The Outreach paratransit transportation broker in San Jose, California, realized significant benefits after implementing a digital geographic database, an Automatic Vehicle Location system on a portion of the vehicles under contract to Outreach, and an automatic scheduling and routing system. Outreach benefited from increased ridership, better on-time performance, and a $500,000 reduction in operating costs during the first year of operation. A study of the system revealed an increase in the number of shared rides from 38% to 55% of all rides provided, a reduction in the size of the paratransit fleet from 200 to 130 vehicles, and a reduction in the cost per passenger mile from $4.88 to $3.72.[55]

Portland, Oregon's, Tri-Met System achieved a 9.4% improvement in on-time performance after implementing an AVL and CAD systems. The variability in the headways between buses decreased by 5% after implementation of the improvements. No significant change was measured in the average run times for buses along the routes, with run times remaining about 1% longer than their scheduled values. The average coefficient of variability for bus run times did improve by 18%, however, and no route experienced an increase in run time variability. These benefits indicated by the comparison of before and after data are consistent with the improved control available to transit supervisors after the implementation of the AVL and CAD systems. A modeling effort using the collected data to control for external impacts on bus run times determined that the impact of the AVL/CAD system was to improve running times by 3.4%. Increases in the average number of stops made, the scheduled headways of buses, and the average departure delay of buses beginning their routes counteracted this improvement. This indicates that the AVL/CAD system allowed the Tri-Met to accommodate these changing conditions without increasing bus run times.[56]

A demonstration system in Valencia, Spain, incorporated a dynamic bus scheduling system and a remote maintenance monitoring system. This system led to efficiency gains including a 35% reduction in the time it takes to create a bus schedule and a 10% improvement in the cost-effectiveness of schedules through reductions in waiting time. The maintenance system enabled a 20% to 30% reduction in the time required to detect and correct vehicle faults.[57]

A European study investigating the use of Travel Dispatch Centers for coordinating and managing paratransit services demonstrated significant cost savings over previous implementations. Accounting for implementation costs, the system resulted in a 2% to 3% annual decrease in costs to provide paratransit service, which compares favorably with the previous experiences of a 15% annual increase.[58]

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[54] Weatherford, Matt. *Assessment of the Denver Regional Transportation District Automatic Vehicle Location System.* U.S. Department of Transportation Report (DOT-VNTSC-FTA-00-04). Cambridge, MA: John A. Volpe National Transportation Center, August 2000.

[55] Taylor, Steven T. "Reaching Out with ITS." *ITS World.* March/April 1997. pp. 24-28.

[56] Strathman 2000.

[57] *Telematics Applications Programme* 2000.

[58] *Telematics Applications Programme* 2000.

A 1998 survey of transit riders in Ann Arbor, Michigan, assessed the impact of several transit safety and security enhancements including on-board video surveillance, emergency phones, video cameras at transit centers, enhanced lighting at transfer centers, and increased police presence. The surveillance systems were the safety enhancement most often noticed by respondents. The on-board cameras were noticed by 70% of the respondents and the transit center cameras by 63%. Additional police presence was noticed by 51% of respondents, while the increased lighting was noticed by 42%. Only 28% of those responding to the survey noticed the emergency phones installed at transfer centers. Respondents rated all improvements very highly when asked the degree to which each improved their sense of security.[59]

2.4 INCIDENT MANAGEMENT SYSTEMS

It is projected that by the year 2005, incident-related congestion will cost the U.S. public over $75 billion in lost productivity and will result in over 8.4 billion gallons of wasted fuel.[60] Incident management systems can reduce these effects by decreasing the time to detect incidents, reducing the time for responding vehicles to arrive, and by decreasing the time required to return the facility to normal conditions. Freeway service patrols, which began prior to the emergence of ITS technologies, but are being incorporated into traffic management centers, significantly reduce the time to clear incidents, especially minor incidents. It is generally understood that incident management systems are implemented concurrently with freeway management systems, but it is important to keep in mind that arterials can be included in incident management programs as well. Coverage of arterials by incident management programs is increasing, particularly in areas with well-established programs. The classification of benefits data for incident management systems is summarized in Figure 2-15.

For a summary of incident management systems deployment in 78 of the largest U.S. cities, refer to www.itsdeployment.its.dot.gov.

Incident Management Systems

- → Surveillance
- → Detection
- → Response
  - → Patrols

Figure 2-15: Taxonomy for Incident Management Systems

2.4.1 Summary of Incident Management Impacts

Table 2-2 summarizes much of the data collected for incident management impacts. Incident management programs have shown the potential to reduce the number of crashes and the time required for the detection and clearance of incidents. These programs show significant savings in the cost of congestion and are cost-effective. In addition, the public response to these programs has been very positive.

[59] Wallace, Richard R., *et al.* "Who Noticed, Who Cares? Passenger Reactions to Transit Safety Measures." T*ransportation Research Record No. 1666.* Washington, DC: Transportation Research Board, 1999. pp. 133-138.

[60] Booz Allen, and Hamilton. *Incident Management: Detection, Verification and Traffic Management.* Filed Operational Test Cross-Cutting Study. September 1998.

Location	Reduced Incident Clearance Time	Reduced Response Time	Crash Reduction	Secondary Crash Reduction	Reduced Crash Rates	Cost Savings/yr. ($ millions)	Delay Savings (hrs/yr.)	Percent Delay Savings	Fuel Savings (Gallons)
Brooklyn, NY	66.0%								
Philadelphia, PA			40.0%						
San Antonio, TX		20.0%	35.0%	30.0%	41.0%	1.65	255,500		2,600
Japan				50.0%					
Houston, TX						8.40	572,095		
Denver, CO						0.95	95,000		
Atlanta, GA							2,000,000	5.00%	
Minnesota						1.40			
Atlanta, GA	38.0%								
Georgia Navigator	23 min	30.0%				44.60	547,000		

Table 2-2: Summary of Incident Management Data

Figures 2-16 and 2-17 show the range of values reported for cost savings and delay savings. Both of these measures are a function of the study area and implementation methodology. Thus the results show a wide range of possible values.

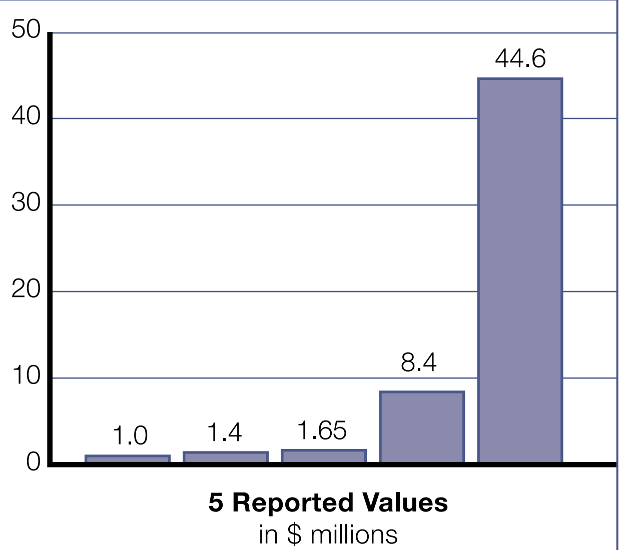


Figure 2-16: Reported Cost Savings Values for Incident Management

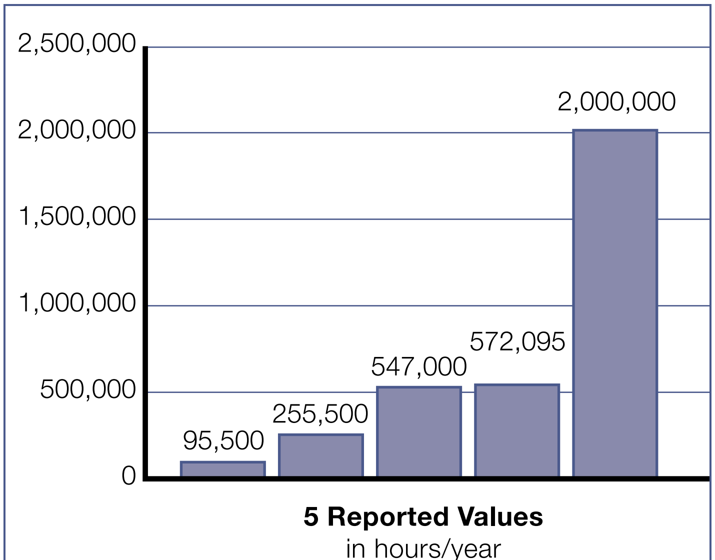


Figure 2-17: Reported Delay Savings Values for Incident Management

2.4.2 Summary of Most Recent Evaluations

Results from the evaluation of nine ITS implementation projects in the city of San Antonio, Texas, indicate that the most effective stand-alone implementation is incident management, which showed improvements in all impact measures assessed. DMS and arterial traffic signal control can provide additional improvement under many of these areas. For a particular corridor modeled during this study, optimum implementation of the integrated DMS and incident management result in a 5.7% decrease in delay, a 2.8% decrease in crashes, and a 1.2% decrease in fuel consumption annually. Integrated use of incident management, DMS and arterial traffic control can achieve an annual benefit of a 5.9% reduction in delay, a 2.0% decrease in crashes, and a 1.4% decrease in fuel consumption for travelers in the corridor. Focus group studies indicate that customers are satisfied with the DMS system, but do have some suggestions for improvement. Participants in the focus groups felt that DMS were a reliable source of traffic information, primarily when they are located close to the congestion or incident.[61]

Georgia's Intelligent Transportation System, "NAVIGATOR," includes several ITS elements. Elements include freeway management, incident management, transit management, electronic toll collection, electronic fare payment, and signal control. Operators can update dynamic message signs, ramp meters, the web site, and information kiosks quickly with a click of a mouse. Operators can also dispatch emergency response and change traffic signal timings. An evaluation of NAVIGATOR concentrated on the freeway and incident management system component and determined the following impacts:[62]

- Reduced response, identification, and dispatch time for incidents to two minutes (a 30% reduction).
- A 23-minute reduction in incident duration during 1997, resulting in cost savings of $44.6 million due to reduced delay time (did not include environmental benefits and benefits due to ramp metering during incidents).
- A 2.3:1 benefit/cost ratio for 1997 for the freeway and incident management components (based on a capital investment of $72 million for these components).
- Other benefits include air quality impact reductions, fuel consumption improvements, crash reduction, more efficient use of emergency services and more satisfied travelers.

Freeway service patrols have proven to be one of the most successful aspects of an incident management program for reducing incident detection time and duration. With a high benefit-cost ratio (ranging from 2:1 to 36.2:1), programs such as these are popular with the motoring public, politicians, and the agencies that support and operate them. Table 2-3 summarizes several benefit/cost ratios reported.[63]

[61] Carter, M. *et al. Metropolitan Model Deployment Initiative: San Antonio Evaluation Report (Final Draft).* FHWA Report (FHWA-OP-00-017). Washington, DC: May 2000.

[62] Presley, Michael, *et al. Calculating Benefits for NAVIGATOR: Georgia's Intelligent Transportation System.* Georgia Department of Transportation. September 1998.

[63] Fenno, David W., and Michael A. Ogden. "Freeway Services Patrols: A State of the Practice." 77th Annual Meeting of the Transportation Research Board. Washington, DC: January 1998.

Patrol Location	Patrol Name	Year Performed	B/C Ratings
Charlotte, NC	Incident Management Assistance Patrol	1993	3:1 to 7:1
Chicago, IL	Emergency Traffic Patrol	1990	17:1
Dallas, TX	Courtesy Patrol	1995	3.3:1 to 36.2:1
Denver, CO	Mile High Courtesy Patrol	1996	20:1 to 23:1
Detroit, MI	Freeway Courtesy Patrol	1995	14:1
Fresno, CA	Freeway Service Patrol	1995	12.5:1
Houston, TX	Motorist Assistance Program	1994	6.6:1 to 23.3:1
Los Angeles, CA	Metro Freeway Service Patrol	1993	11:1
Minneapolis, MN	Highway Helper	1995	5:1
New York & Westchester Co., NY	Highway Emergency Local Patrol	1995	23.5:1
Norfolk, VA	Safety Service Patrol	1995	2:1 to 2.5:1
Oakland, CA	Freeway Service Patrol	1991	3.5:1
Orange Co., CA	Freeway Service Patrol	1995	3:1
Riverside Co., CA	Freeway Service Patrol	1995	3:1
Sacramento, CA	Freeway Service Patrol	1995	5.5:1

(Adapted from Fenno and Ogden; see previous page)

Table 2-3: Results of Service Patrol Benefit-Cost Studies

2.5 EMERGENCY MANAGEMENT

Benefits of emergency management include those derived from improved notification, dispatch, and guidance of emergency or other response equipment when an incident occurs, as shown in Figure 2-18. These benefits are sometimes highly dependent on the related implementations of incident management systems, which often detect the need for emergency response to incidents on the transportation network. Applications of ITS in emergency management typically consist of automatic vehicle location, computer aided dispatch, fleet management, and vehicle guidance systems. Each of these systems can help decrease the response time of emergency vehicles to incident scenes and aid public safety agencies in improving their operational efficiency.

The U.S. Department of Transportation recently initiated an ITS Public Safety program. As this program guides the development of ITS applications for public safety agencies such as police, fire, and rescue departments, improved information on the benefits of ITS to emergency management should develop.

Emergency Management

- Emergency Management
  - Dispatch
    - Automated Vehicle Location
    - Fleet Management
- Emergency Vehicle
  - Guidance

Figure 2-18: Taxonomy of Emergency Management

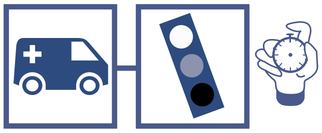
For a summary of emergency management systems deployment in 78 of the largest U.S. cities, refer to www.itsdeployment.its.dot.gov.

2.5.1 Summary of Emergency Management Impacts

Very few new data have been collected in the area of Emergency Management since the 1999 version of this report. Therefore, data highlighted in this section are from the 1999 report.

Albuquerque, New Mexico, uses a map-based computer-aided dispatch system in its ambulance fleet. The system allows the dispatch center to send ambulances to the exact location of an emergency and provide guidance on how to get there. As a result, the company's efficiency has increased by 10 to 15 percent.[64]

[64] Taylor, Steven T. "Helping Americans." *ITS World*. Jan/Feb 1997.



Palm Beach County, Florida, installed the Priority One signal preemption system. The system is used to connect the Global Positioning System (GPS) to its emergency vehicles. Prior to installation, it was predicted that the system could cut 20% from incident response time, depending on the intersection and time of day (as found by two Illinois towns using the system). As the vehicle approaches a traffic light, it transmits a signal interrupting the normal cycle, which allows the emergency vehicle to go through it without stopping. The GPS system will also allow dispatchers to figure out who is closer to an emergency. The cost is about $4000 per intersection and $2000 per vehicle.[65]

The Puget Sound Help Me (PuSHMe) Mayday System allowed a driver to immediately send a response center a notification and location of incidents along with the need for any assistance. The system includes two-way pagers and cellular telephones that transmit vehicle location, nature of the problem, and the priority level of the problem to a response center. The devices may also send automated signals when the driver may be incapable of manually initiating a signal. Ninety-five percent of drivers equipped with voice communications felt they were more secure, while just 70% of those with only data communications said that they were more secure with the system installed.[66]

[65] Shifrel, Scott. "Satellites Around Globe May Save Lives Right Here." *The Palm Beach Post*. June 1, 1997.

[66] Haselkorn, M., *et al. Evaluation of PuSHMe Mayday System*: Final Report. June 19, 1997.

2.6 ELECTRONIC TOLL COLLECTION

Electronic Toll Collection (ETC) is one of the ITS program areas where little new benefits information is required. Benefits due to impacts on the cost of toll administration, management, and collection have been demonstrated. Vehicle delay reduction and throughput at toll plazas have been proven to be very high. Therefore, many of the recent reports for applications of ETC have concentrated on the accuracy and improvements in vehicle identification. Technologies are now capable of identifying vehicles at mainline speeds and at a high rate of accuracy. As a result, throughput is maximized, and delay that would occur at toll plazas is substantially reduced. There are also several efforts planned or underway to integrate these systems with other possible electronic payment systems, such as parking, transit fare payment, and drive-through window payment.

For a summary of electronic toll collection deployment in 78 of the largest U.S. cities, refer to www.itsdeployment.its.dot.gov.

2.6.1 Summary of Most Recent Evaluations

The evaluation of air quality benefits from implementing automatic vehicle identification (AVI) technology for electronic toll collection (ETC) has demonstrated positive results.

Electronic Toll Collection
- Toll Administration
- Toll Collection
- Vehicle

Figure 2-19: Taxonomy of Electronic Toll Collection

Located in Orlando, Florida, the Orlando-Orange County Expressway Authority (OOCEA) operates 11 mainline toll plazas. The busiest, the Holland East Toll Plaza, includes 14 toll lanes, nine of which are used for peak direction travel. A before-after study on the Express Pass (E-PASS) implementation of AVI-based ETC at the toll plaza was conducted to evaluate the reduction in vehicle emissions. Specifically, the reductions in Carbon Monoxide (CO), Hydrocarbons (HC), and Nitrogen Oxides (NO_X) were evaluated at the toll plaza. Data for the before AVI study were collected from August 1994 to October 1994. Arrival, departure, and speed data were collected during the peak morning hour (7-8 AM) for 14 days across all nine lanes in the westbound direction at the plaza. The after study data were collected from July 1996 to August 1996 during the peak morning hour (7-8 AM) in the westbound direction for 10 days. During this phase of the study, two dedicated lanes were configured for AVI/ETC operations. A comparison of before and after data revealed that the total average number of vehicles using the Holland East Toll Plaza during the peak hour increased by an average of 30% (1270 vehicles). Also, the average number of E-PASS users in the "after" study during the peak hour compared to the total volume is 40%. This is significant when considering that there were no E-PASS users in the "before" study. Using the MOBILE5a emission model and collected data, it was shown that even with the increased volumes at the Holland East Toll Plaza, vehicle emissions were reduced. The model estimated an overall average reduction in Carbon Monoxide by 7.29% (5.21 kg) and HC by 7.19% (0.40 kg), but NO_X increased by 33.77% (2.21 kg). Two additional scenarios were run to control for the growth in volumes on the results. The results remained consistent with the before-after study but demonstrated larger benefits.[67]

A cost-benefit analysis was undertaken as part of an Electronic Toll and Traffic Management (ETTM) feasibility study for Florida's Turnpike. Tamiami Plaza, the most heavily utilized of all the Turnpike mainline toll plazas, was selected for the study. For the 10% ETTM participation alternative, the benefit-to-cost (B/C) ratio was 2.03:1. For 30% ETTM, the B/C ratio was 2.29:1, and for 50% ETTM, the B/C ratio was 3.07:1.[68]

A report published in July 2000 summarizes the evaluation results for many types of ITS projects implemented in Europe between 1994 and 1998, including road pricing facilitated by electronic toll collection. Impact analysis of electronic toll collection in urban areas found up to a 17% reduction in traffic due to a road-pricing scheme. Most of the population was found to be against road pricing schemes, but if the programs were accompanied by reductions in vehicle and fuel taxes, acceptability rises to 61%.[69] These impacts are due to a road-pricing scheme facilitated by electronic toll collection, which could also be implemented without ETC, likely with a higher operating cost.

An assessment of the impact of a value-pricing program for two toll bridges in Lee County, Florida, was evaluated. The program allows motorists to pay a 50% discounted bridge toll during designated hours just outside the typical AM and PM peak periods. Only those drivers participating in the electronic prepayment program were eligible for the reduced tolls, as they were collected automatically via in-vehicle transponders mounted on the vehicle's windshield. A traveler survey of Lee County residents and collection of vehicle volume data at the toll plazas are the basis for the results presented in the study. The program began in August 1998. The analysis indicated that there was a significant shift in travelers away from the peak (full toll) periods to the non-peak (discounted toll) periods by those drivers who possessed the necessary transponders. A random telephone survey of 400 motorists in the county took place several months after the program began operation, between November 30 and December 5, 1998. Of the 193 travelers who had transponders in their vehicles, 38 (20%) responded that they had made changes in their travel due to the new program. Analysis indicated that travelers who modified their travel plans were more likely to be retired or working part-time. The survey results indicated that commuters were less likely to modify their schedules as a result of variable pricing than those with other trip purposes.[70] These impacts are also due to a road-pricing scheme facilitated by electronic toll collection, which could also be implemented without ETC, but probably with higher operating costs.

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[67] Klondzinski, J.G., *et al.* "Impacts of Electronic Toll Collection on Vehicle Emissions." 77th Annual Meeting of the Transportation Research Board. Washington, DC. January 1998.

[68] Pietrzyk, Mike, *et al.* "Cost-Benefit Analysis of Electronic Toll and Traffic Management." Proceedings of the IVHS America 1992 Annual Meeting, Volume I. 1992.

[69] *Telematics Applications Programme* 2000.

[70] Burris, Mark and Ashley Yelds. "Using ETC to Provide Variable Tolling: Some Real-World Results." ITS America 2000 Annual Meeting. Boston, Massachusetts. 1-4 May 2000.

2.7 ELECTRONIC FARE PAYMENT

Electronic fare payment is another one of the ITS program areas where little new benefits information has been required to justify implementation. Electronic fare payment tests, which address customer convenience and security, are ongoing in both bus and rail systems. Results indicate increased convenience to the customer, and significant cost savings in the administrative and money handling processes of the service providers. In some cases, it has also been reported that electronic fare payment can increase transit ridership.

For a summary of electronic fare payment deployment in 78 of the largest U.S. cities, refer to www.itsdeployment.its.dot.gov.

2.7.1 Summary of Most Recent Evaluations

A report published in July 2000 summarized the evaluation results for several ITS projects implemented in Europe between 1994 and 1998. Three projects discussed demonstrated the coordinated use of a smart card as a payment system for public transit, canteens, libraries, swimming pools, and/or other city services. User acceptance and satisfaction with these systems was very high, ranging from 71% to 87%.[71]

Other benefits reported for using electronic fare payment include:[72]

- Ventura County, California: Smart card system will save an estimated $9.5 million per year in reduced fare evasion; $5 million in reduced data collection costs, and $990,000 be eliminating transfer slips.
- New York City: Metro Card system will save an estimated $70 million per year in fare evasion, resulting in increased revenues of $34 million from merchant fees and revenue float, $140 million from unused value on the cards, and $49 million from increased ridership.
- New Jersey: estimated savings of $2.7 million in reduced handling costs of fare media, increased revenues of 12% after automated fare collection implementation.

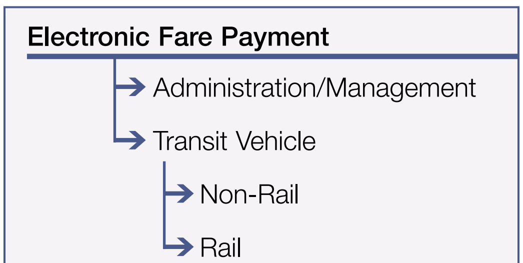


Figure 2-20: Taxonomy of Electronic Fare Payment

[71] *Telematics Applications Programme* 2000.

[72] *APTS Benefits*. Federal Transit Administration, November 1995.

2.8 HIGHWAY-RAIL INTERSECTIONS

The number of crashes that occur at highway-rail intersections (HRIs) on a yearly basis indicates the need for improvements at HRIs. In addition, the occasional spectacular crash including school buses or hazardous materials attracts national attention. However, the number of crashes occurring at HRIs has continued to decline over the last several years. As of January 2001, preliminary statistics show that from January to October 2000 2,776 HRI incidents were reported. This number is down 4.5% from that of the same period in 1999 (almost 14% from the same time period for 1997). The number of fatalities at HRIs increased from 331 to 351 (6%) between the two time periods. The general trend has been a decrease in HRI fatalities since 1997. HRI incident rates, calculated as the number of incidents multiplied by 1,000,000 then divided by the total number of train miles, has also shown a downward trend (18.8% since 1997).[73] It should be noted that these reductions are not related to ITS implementations. Instead they may be due to aggressive educational programs, such as "Operation Lifesaver" and the extensive use of the media to promote railroad safety issues over the last several years, as well as the physical reduction in the number of HRIs. The goal of the HRI user service is to further improve safety at these crossings and to improve the coordination between rail operations and traffic management functions.

Several operational tests involving coordinating traffic signals and notifying vehicles of approaching trains at intersections are currently being developed and implemented. A few pilot projects have produced results, but are insufficient to develop overall conclusions. Several other projects are being planned or are now in progress and are expected to produce quantitative data on benefits. Figure 2-21 illustrates the classification of benefits data for highway-rail intersections.

For a summary of highway-rail intersection systems deployment in 78 of the largest U.S. cities, refer to www.itsdeployment.its.dot.gov.

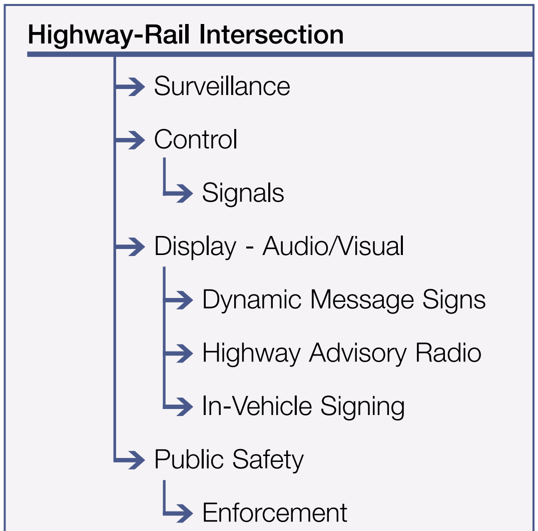
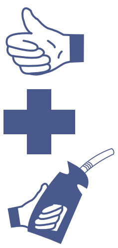


Figure 2-21: Taxonomy for Highway-Rail Intersections

[73] Federal Rail Administration, Office of Safety.

2.8.1 Summary of Most Recent Evaluations

Minnesota DOT investigated the effectiveness of an in-vehicle train crossing warning system for school buses in Glencoe County. Transmitters mounted at five rail crossings transmitted warning signals to school buses in the vicinity of the crossings. The system notified drivers of both the presence of the crossing and whether or not a train was approaching. The evaluation of the project consisted of a questionnaire distributed to drivers and train operators. Drivers felt that the system enhanced awareness of the crossings and approaching trains; however, there were no significant changes in driver behavior. The drivers' confidence in the system's reliability was evenly divided.[74]



To reduce train horn noise at heavily used highway-rail grade crossings in Ames, Iowa, an automated horn system to warn motorists and pedestrians was installed in September 1998. Working in conjunction with existing gates and lights, two horns at each intersection are aligned to provide a more directed audible warning to the road and eliminate the need for the train horn under most circumstances. The evaluation examined the changes in noise levels in the area before and after installation of the automated horn system, and the opinions of residents, motorists, and locomotive engineers regarding the system. Results indicate that the area impacted by a noise level greater than 80 decibels decreased by 97% with the implementation of the automated system, from 171 acres to less than six acres. A mail-in resident survey taken two months before and two months after implementation determined that area residents were very satisfied with the system. 77% of residents indicated that the train horns had a "negative" or "very negative" impact on their quality of life before the automated system began operation. After implementation, 82% of residents responded that the automated horn was "no problem." The project also surveyed the locomotive engineers seven months after the automated horns began operation. Ninety-two percent of engineers indicated that the overall safety at the crossings was "about the same" or "safer" after the system was installed.[75]

[74] *APTS Benefits* 1995.

[75] Gent, Steve J., *et al. Evaluation of an Automated Horn Warning System at Three Highway-Railroad Grade Crossings in Ames, Iowa.* Iowa Department of Transportation Report. undated.

2.9 REGIONAL MULTIMODAL TRAVELER INFORMATION

Providing traveler information regarding several modes of travel can be beneficial to both the traveler and service providers. Several transit agencies have started using traveler information kiosks and web sites to provide schedules, expected arrival times, expected trip times, and route planning services to patrons. Also, several traffic management centers are providing current traffic conditions and expected travel times using similar approaches. These services allow users to make a more informed decision for trip departures, routes, and mode of travel, especially in bad weather. They have been shown to increase transit usage, and may help to reduce congestion when travelers choose to defer or postpone trips, or to select alternate routes. Information on impacts of traveler information systems are separated into those which provide pre-trip and en-route information, as shown in Figure 2-22.

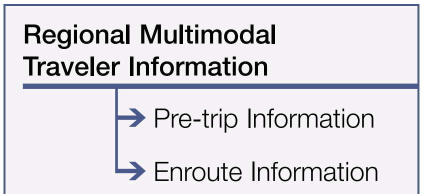


Figure 2-22: Taxonomy for Regional Multimodal Traveler Information

For a summary of regional multimodal traveler information systems deployment in 78 of the largest U.S. cities, refer to www.itsdeployment.its.dot.gov.

2.9.1 Summary of Multimodal Traveler Information System Impacts

Evaluation of implemented traveler information systems reveals that the systems are well received by those who make use of them. Field tests providing traveler information through a variety of in-vehicle and portable devices have received widespread support from project participants. The number of travelers using the information systems generally represents a small portion of the total travelers in a region. Consequently, the evaluated systems have little, if any, impact on travel times across the regional transportation network. Individual users of the systems do perceive significant benefit from them and are generally satisfied with the service.

2.9.2 Summary of Most Recent Evaluations

The Advanced Regional Traffic Interactive Management and Information System (ARTIMIS) is a regional traffic management system provided by: the Kentucky Transportation Cabinet; Ohio Department of Transportation; FHWA; Ohio-Kentucky-Indiana Regional Council of Governments; and the City of Cincinnati. The system serves the Northern Kentucky and Cincinnati metropolitan areas. It contains an advanced transportation management system and an advanced traveler information system. In June 1995, a telephone information service began providing real-time traffic and travel condition information by specific route or route segment. Sources of up-to-date traffic information include video cameras, radar detectors, inductive loops, aircraft, service patrols, and drivers acting as probes. In a survey conducted in February and March 1999, ARTIMIS users rated the service very high in accuracy and ease of use. More than 99% of those surveyed said they benefited by avoiding traffic problems, saving time, reducing frustration, and arriving at destinations on time.[76]

[76] Clemons, J., L. Aultman-Hall, & S. Bowling. *ARTIMIS Telephone Travel Information Service: Current Use Patterns and User Satisfaction*. Kentucky Transportation Center, University of Kentucky, Department of Engineering. Lexington, KY: June 1999.

The customer satisfaction evaluation undertaken as a part of the Seattle Metropolitan Model Deployment Initiative (MMDI) determined, through focus groups, mail-in questionnaires, and web-based surveys, the response of Seattle area travelers to the various ITS improvements undertaken during the project. Overall, the three traveler information projects evaluated for customer satisfaction received high ratings from those travelers who made use of the systems. While the number of travelers influenced by the different systems varied widely, those who relied on each individual system generally found them to be useful. The Washington State Department of Transportation (WSDOT) traveler information web site received very favorable ratings from participants in an online survey accessible through the site. The web site used data from freeway loop detectors and video feeds to publish freeway segment travel speeds and incident data. Responses indicated that the site was frequently used for trips to and from work or school and that route changes were a significant response to information obtained from the site. Participants also indicated the benefit of reducing the stress of their journey. It is important to note that this was a voluntary survey, and that the responses of those who participated cannot be extended to represent all users of the web site. Data on the number of user sessions on the web site each day reflected a very large spike in usage during a winter weather event in December. This provides evidence of the importance of these types of systems during severe weather.[77]

The Seattle MMDI also implemented a traffic information television channel, known as Traffic TV. A focus group study and mailed questionnaire indicated that frequent users of the Traffic TV service rated it very highly, often using it to change travel routes for a particular journey. The survey also indicated that many of the users discovered the service while changing channels on their TV sets, indicating a low public awareness of the service.[78]

The Fastline system, designed to provide pre-trip and en-route traveler information in the Seattle area through Personal Digital Assistants (PDAs), experienced very low usage during the MMDI project. The lack of a significant marketing campaign and the limited number of PDAs supported by the software limited the market penetration of the service. Limited evidence of those travelers who did make use of this system indicated that they did change their behavior based on the information received.[79]

Additions and improvements to elements of San Antonio's traveler information system occurred during the MMDI, including new traveler information kiosks, improvements to the internet web site, and the installation of in-vehicle navigation (IVN) devices in vehicles operated by public agencies in the area. The kiosks provide information on incidents and congestion on the freeway network, transit schedules and fares, as well as navigational assistance. The web site provides freeway traffic information including incident locations, and links to transit schedule and fare information. The IVN devices provide navigational assistance, incorporating information on congestion, incidents, and railroad crossing status when planning trips.

Evaluation of the kiosks by a qualified expert indicated that the devices had several functional problems and were unlikely to be used often by travelers. Based on these results, the study did not perform further evaluation on the system impacts of the kiosks or customer satisfaction with them.

The web site evaluation indicates that usage of the site increased at a rate of 19% per year over the course of the nine-month evaluation period. Significant latent demand for the service was evidenced by dramatic increases in the

[77] Jensen, M., *et al.* 2000.

[78] Jensen, M., *et al.* 2000.

[79] Jensen, M., *et al.* 2000.

number of users accessing the site during two severe weather events over the evaluation period. Despite this growth, the relatively small number of travelers making use of the system led to no overall system impacts due to the web site. Modeling results indicate that individual travelers who use the web site prior to traveling along a particular corridor would receive annual benefits of a 5.4% reduction in delay, a 0.5 % reduction in crash rate, and a 1.8% reduction in fuel consumption.

The small number of publicly owned vehicles using the in-vehicle navigation (IVN) devices led to no system impact from these devices. Focus groups composed of drivers of vehicles equipped with the units indicated that the drivers most satisfied with the system were those who frequently drove different routes each day. Drivers often asked to drive to unfamiliar parts of the metropolitan area, such as paratransit drivers and police investigators, seemed to get the greatest benefit from the system. Public safety representatives did indicate that, with improvements to the method for entering destinations, the devices could be helpful in reducing response times of emergency vehicles. Modeling results indicate significant potential benefits for individuals using the devices. Over a one-year period a traveler using an IVN device could experience an 8.1% reduction in delay, a 4.6% reduction in the crash rate, and a 3% reduction in fuel consumption.[80]

The Seattle Wide-area Information for Travelers (SWIFT) Field Operational Test was an evaluation project of a large-scale advanced traveler information system. Deployed in the Seattle metropolitan area, SWIFT provided information on several transportation modes using three different devices. The devices included a wristwatch, an in-vehicle navigation system, and a portable PC-based system. Approximately 800 participants were used to evaluate the effectiveness and user acceptance of the three devices. The message watch received traffic information regarding user specified routes. The in-vehicle devices allowed users to request navigation instructions and provided traffic information and guidance along the selected route. Portable computers received information regarding traffic incidents, speed, congestion, and bus-location information. Users of the PC systems appeared to place a higher importance on the receipt of incident and congestion information and less on general information than users of other devices. In general, users of all three devices indicated that they found the information useful for making travel decisions. They also indicated a reduction in stress and travel time. Others changed routes based on provided information. Many users of the devices (especially Seiko Message Watch users) indicated that messages did not provide timely information. Some also questioned the accuracy of information displayed.[81]

A Finnish project found a high user acceptance of traveler information delivered via portable electronic devices sometimes called personal travel assistants (PTA). One-third of users reported changing mode based on information provided, and half changed route based on the information. Another project reported 40% stating they had changed mode based on information from the PTA, while 15% to 25% were willing to start their journey earlier.[82]

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[80] Carter, *et al.* 2000.

[81] Perez, William and Bruce Wetherby. *Seattle Wide-area Information For Travelers (SWIFT): Evaluation Summary*. Prepared for Washington State Department of Transportation by Science Application International Corporation, McLean, VA. January 5, 1999.

[82] *Telematics Applications Programme* 2000.

Evaluations of a series of European projects have provided information on the impacts of a variety of traveler information systems:[83]

Six projects provided information via public access terminals or fixed information terminals. User acceptance of the devices was high; cited projects report 79% to 95% of users finding the systems easy to use.

Internet information provided during six of the projects also had a high level of user acceptance, with 65% to 75% of respondents indicating that the information was easy to use and understand.

Several projects implemented in-vehicle navigation (IVN) devices. The CLEOPATRA project in Turin, Italy, demonstrated timesavings of more than 10% for cars equipped with the IVN devices. Customer satisfaction measures ranged from 50% to 75% of users expressing satisfaction with the devices. It should be noted, however, that 20% of the test drivers in Rotterdam, the Netherlands, expressed concern over being distracted from the driving task.

Several European studies focused on the impacts of messages displayed on DMS and the effectiveness of different information strategies. A collaborative study among the various projects found that 30% to 90% of drivers noticed DMS information. In Piraeus, Greece, the route guidance system combined with an integrated traffic control strategy led to a 16% reduction in travel time.

The Phoenix MMDI assessed customer satisfaction with the publicly operated Trailmaster web site and the Traffic Check cable TV traffic information service. Both the web site and television channel provided information on travel conditions on Phoenix area roadways by integrating data from the freeway management system and the Arizona Department of Transportation (ADOT) Roadway Closure and Restriction System.

Analysis of web site usage statistics indicated that the number of visits to the traveler information web site increased steadily during the evaluation period at a rate of 50% per year; evaluators expected this trend to continue. Overall, usage levels for the Phoenix web site were significantly lower than those experienced in Seattle, where traffic congestion is a more significant problem. Two focus group studies revealed Phoenix area travelers felt that congestion levels were not high enough to warrant frequent use of the site. Users did find the site helpful in assessing delays due to construction. Participants felt that the addition of congestion information for arterial roadways would make the site more useful.

A telephone survey was conducted to assess the impact of the traveler information cable TV channel implemented through the MMDI. Thirty-five thousand cable subscribers in Tempe, Arizona, received the Traffic Check television service during the evaluation period. Seven percent of these subscribers responded to a postcard survey inquiring about their use of the traffic information channel. Phone interviews were conducted with 723 subscribers, approximately half of whom had used the Traffic Check channel.

The phone interviews yielded several interesting results regarding the usage and customer satisfaction with Traffic Check. Of the participants who commute regularly, 93% report listening to traffic radio broadcasts for traveler information, 77% used traffic reports on local television, 75% use DMS, and 48% report using Traffic Check.

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[83] *Telematics Applications Programme* 2000.

Survey results also indicate that pre-trip information in general may be less useful than en-route information; respondents typically indicated that information sources available en-route were most useful. Due to the small sample size, the authors of the evaluation report caution against extrapolating the survey results to a larger population.[84]

Mitretek Systems performed a three-step analysis of the effects of web-based traffic information and weather events on a mixed freeway/arterial network north of downtown Seattle. Analysis of Washington State's Department of Transportation (WSDOT's) traffic website usage data and observed weather data revealed that web site activity increased by 27% during a weather event and 69% during a snow event. This analysis also indicated that market penetration of the advanced traveler information system (ATIS) is not evenly distributed as originally assumed in the Seattle Metropolitan Model Deployment Initiative (MMDI) evaluation. A comparison analysis of non-uniform distribution results to MMDI baseline data found that for the "Freeway and Arterial" scenario, the total number of stops decreased by 6%, the adjusted travel time decreased by 1% percent, and the vehicle kilometers of travel did not appreciably change. The coefficient of variation for the "Freeway Only" scenarios decreased by a small but statistically significant 0.62 %, indicating that the travel time was more reliable. The results of a network analysis demonstrated that a non-uniform ATIS utilization rate related to severe weather has a small positive impact on roadway system efficiency.[85]

[84] Zimmerman 2000.

[85] Hardy, Matthew, *et al. Analyzing the Effects of Web-Based Traffic Information and Weather Events in the Seattle Puget Sound Region: Draft Report.* Mitretek Systems. October 2000.

2.10 INFORMATION MANAGEMENT

Data collected by ITS applications have great value as indications of the historical performance of a transportation system with regard to a variety of performance measures. In addition to supporting improvements in the operation of the ITS components, these data can also assist transportation planning, research, and safety management activities. The National ITS Program Plan released by the U.S. DOT in August 2000 describes ITS data archiving as addressing "the collection, storage and distribution of ITS data for transportation planning, administration, policy, operation, safety analyses, and research."[86] The recent addition of the Archived Data User Service (ADUS) and Archived Data Management System (ADMS) to the National ITS Architecture also indicates the value of retaining and analyzing data collected by ITS.

Operating agencies around the U.S. are in various stages of planning, implementing, and operating archived ITS data management systems. As these systems become a part of routine transportation planning, research, and operations activities, examples of their effectiveness will become available.

2.11 IMPACTS OF OTHER ITS APPLICATIONS IN METROPOLITAN AREAS

As the implementation of ITS in metropolitan areas continues, many implementing organizations are realizing that ITS applications initially designed for rural areas can also apply to situations faced in metropolitan areas. Examples of these applications include travel and tourism services, particularly systems providing information on travel services such as hotels and restaurants, and road weather management systems. Road weather management systems provide support to transportation agencies in collecting and disseminating information on road surface and weather conditions and managing weather-related maintenance activities, such as snow and ice removal during winter storms. These ITS applications can be beneficial in metropolitan as well as rural areas, and evaluations of urban applications of these systems are beginning to demonstrate positive impacts.

2.11.1 Summary of Most Recent Evaluations

An automated motorist warning system (AMWS) in the city of Ft. Lauderdale, Florida warns motorists of the presence of wet pavement on a freeway ramp at an urban interchange. Comparing vehicle speed data from an evaluation period of six weeks prior to the activation of the AMWS and nine weeks following the activation reveals that, after the system was activated, average vehicle speeds were 10.2 mph (16.4 km/h) lower during heavy rain and 4.6 mph (7.4 km/h) lower during periods of light rain.[87]

[86] U.S. DOT ITS Joint Program Office. *The National Intelligent Transportation Systems Program Plan: Five Year Horizon*. Federal Highway Administration Report (FHWA-OP-00-008). August 2000.

[87] Pietrzyk, Michael C. "Are Simplistic Weather-Related Motorist Warning Systems 'All Wet'?" ITE 2000 Annual Meeting. Nashville, Tennessee. 6-10 August 2000.

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