Draft Technical Report

Deployment of Intelligent Transportation Systems (ITS) A Summary of Progress: 1997-2007

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Table of Contents

List of Figures

List of Tables

Executive Summary

Background

This report presents selected results of the ITS Deployment Tracking surveys conducted between 1996 and 2007. This report was prepared to describe how advanced technology is impacting our ability to address urban transportation challenges**.** Beginning in 1997, the Intelligent Transportation Systems (ITS) Metropolitan Deployment Tracking project has systematically gathered data to measure the level of ITS deployment within 78 of our nation's largest metropolitan areas as well as statewide and rural deployment in each state. Within each metropolitan area, agencies involved with freeway, arterial, and transit management as well as public safety (law enforcement and fire/rescue/emergency medical), and toll collection were surveyed to track deployment progress. Each of the 50 state departments of transportation was surveyed to gather information on statewide and rural ITS deployment. The most recent survey was conducted in 2007 when more than 2,100 surveys were distributed to state and local transportation agencies located in nearly all states. Almost 90% of the surveys were returned. Detailed results from the 2007 survey and all previous national surveys are available on-line at http://www.itsdeployment.its.dot.gov . The web site also provides access to survey results in the form of downloadable reports and fact sheets.

Traffic congestion, air and noise pollution, greenhouse gas emissions, transportation related crashes and fatalities as well as increasing costs are among the growing list of challenges which threaten the efficiency, safety, security, and productivity of the Nation's surface transportation system. All forecasts show that the demand for surface transportation services – Vehicle Miles of Travel (VMT) and freight movement – will continue to grow while the supply of transportation infrastructure will remain relatively static. In addition, transportation funding is falling short of the addressing these needs through traditional policy responses. Since jurisdictions lack the resources and ability to build their way out of congestion agencies are turning toward "smart" infrastructure solutions to improve the management of surface transportation assets

Organization of Report

This report summarizes data collection results according to the following broad functions since these functions provide a link between a technology and the capability the technology is designed to support:

***Monitoring Transportation System Conditions* -** ITS technologies provide transportation agencies with the ability to monitor travel conditions through real-time collection of traffic conditions using a variety of field sensors and closed circuit television (CCTV) cameras.

***Managing Infrastructure and Assets* -** The deployment of ITS technologies improves the way agencies manage surface transportation assets. Traffic responsive traffic signal systems are now in place. Freeways are actively managed through strategies such as ramp metering and high occupancy vehicle (HOV) lanes. Transit vehicles are scheduled and routed in real-time and in response to passenger demand.

Informing Travelers - As a result of deployment progress over the last decade, travelers have access to a range of pre-trip and en-route information. Web sites to assist travelers in planning trips and monitoring travel conditions are now deployed. In addition, dynamic message signs (DMS) are deployed which provide travelers with messages regarding travel conditions while they are en-route. Transit agencies have developed trip planning tools that assist travelers in planning trips and completing financial transactions.

Automating Financial Transactions - ITS technologies are assisting in the automation of financial transactions. Toll agencies now have the ability to automate toll collection which reduces toll collection costs, increases accuracy, and enhances traveler convenience. Transit patrons can now used “Smart” cards and other media to pay fares. This eliminates the need for exact chance and reduces the costs associated with fare collection.

Improving Safety and Security - ITS surveillance technology is used to monitor safety and security conditions on bridges, tunnels, and roadways. Speed management and red-light running cameras are deployed to increase safety for road users. Transit properties have deployed cameras and other devices to monitor vehicles and stations.

Integration-Numerous agencies have integrated systems to leverage capability. The construction of a Traffic Management Centers (TMCs) provides many agencies with a capability to link together surveillance and response assets along with traveler information resources.

Selected Conclusions

Monitoring Transportation System Conditions

- Overall, the deployment of surveillance systems has shown the greatest progress from 1997 to 2007, and trends indicate that growth in deployment will continue into the future for these technologies.

- Real-time monitoring of surface transportation system conditions has expanded over the period 1997 to 2007. For example, nearly 45% of freeway miles in the Nation’s 78 Largest Metropolitan Area were under electronic surveillance in 2007. This represents a nearly threefold increase over the level of deployment in 1997.

- Approximately 35% of freeway miles in these areas were under electronic surveillance by Closed Circuit Television (CCTV) in 2007. CCTV coverage provides agencies with the ability to more quickly and accurately identify vehicle incidents and crashes.

- Nearly 62% of all fixed-route buses were equipped with Automated Vehicle Location (AVL), a nearly threefold increase over 1997.

Managing Infrastructure and Assets

- The data gathered by monitoring systems are used by transportation agencies to manage operations. While deployment of these systems has increased over the last ten years, in many cases the trends for new adoption have flattened out. For some traffic control systems, such as ramp metering or lane control, the data indicate that those metropolitan areas that will adopt them have already adopted them, well short of even a majority of the 78 largest metropolitan areas that were surveyed.

- In 2007, nearly 55% of all traffic signals in 78 of the Nation's Largest Metropolitan Areas were under centralized or closed loop control. About 25% of traffic signals provided for the capability for emergency vehicles to preempt signal timing.

- In 1997, approximately 30% of freeway miles in these areas were covered by a service patrol. This has increased to 54% of miles in 2007

- In 2007, 62% of all paratransit vehicles in these areas operated under computer aided dispatch. This increase represented a threefold increase from 1997 levels of deployment for computer aided dispatch.

Informing Travelers

- Transportation agencies have deployed a rich set of traveler information media to support pre-trip and en-route information dissemination. Transit agencies have made a significant investment in providing travelers with sources of static information concerning schedules, routes, and fares, as well as dynamic information concerning schedule adherence and actual vehicle arrival times.

- In 2007, virtually all of the Nation's 78 Largest Metropolitan Areas offer a web site containing traveler information from less than half of areas in 1997.

- Dynamic Message Signs (DMS) on freeways are deployed in nearly all of these metropolitan areas up from about half of these areas in 1997.

- A total of 39 states reported having a statewide web site supporting traveler related information in 2007. Numerous sites contained information about road closures, work zone/construction, and traffic incidents.

Automating Financial Transactions

- Technologies that automate financial transactions for transportation agencies save money, improve accuracy, and provide an additional source of information on toll road traffic conditions or transit ridership. Deployment of these systems has expanded to virtually universal coverage.

- In 2007, approximately 85% of all toll lanes operated in the Nation's 78 Largest Metropolitan Areas were equipped with Electronic Toll Collection (ETC) capability. In 1997, approximately 36% of lanes were equipped with ETC capability.

- In 2007, approximately 70% of fixed route buses in these areas were equipped with magnetic strip readers and 33% were equipped to read Smart cards.

Improving Safety and Security

- ITS technology has been deployed to support a wide variety of safety and security applications including surveillance, automated enforcement, and support for emergency response operations.
- A decade ago there was no capability to manage emergency vehicle assets. In 2007, 65% of metropolitan areas feature an emergency vehicle tracking system.
- In 2007, over 80% of emergency management vehicles were equipped with computer aided dispatch in the Nation's 78 Largest Metropolitan areas, nearly double the level in 1997.
- Approximately 39% of freeway centerline miles in these areas were covered by real-time data collection monitored for security purposes in 2007.
- Nearly 51% of all fixed route buses were equipped with audio or visual surveillance to enhance security in 2007.

Integration

- The interagency sharing of operational data in real time is one of the cornerstone concepts for the national ITS program. The level of integration among ITS technologies and services has continued to increase. However, the level of integration is falling short of the potential. The data indicate that some data collected by agencies is not shared in real-time with other agencies to the extent possible.

<u>Next Steps</u>

A similar deployment tracking national survey is planned for 2010. This survey will provide and update to historical trend data as well as provide the opportunity to examine the deployment progress of new initiatives and gather data in greater depth concerning specific deployment issues.

1 Introduction

This report presents selected results of the 2007 ITS Deployment Tracking survey and describes how advanced technology is impacting our ability to address urban transportation challenges**.** Beginning in 1997, the Intelligent Transportation Systems (ITS) Metropolitan Deployment Tracking project has systematically gathered data to measure the level of ITS deployment within 78 of our nation's largest metropolitan areas as well as statewide and rural deployment in each state. Within each metropolitan area, agencies involved with freeway, arterial, and transit management as well as public safety (law enforcement and fire/rescue/emergency medical), and toll collection were surveyed to track deployment progress. Each of the 50 state departments of transportation was surveyed to gather information on statewide and rural ITS deployment. The most recent survey was conducted in 2007 when more than 2,100 surveys were distributed to state and local transportation agencies located in nearly all states. Almost 90% of the surveys were returned. Detailed results from the 2007 survey and all previous national surveys are available on-line at http://www.itsdeployment.its.dot.gov . The web site also provides access to survey results in the form of downloadable reports and fact sheets.

The first part of this report describes the challenges that ITS services and technologies are addressing. These problems include growing traffic congestion, transportation safety and security, increasing transportation agency operating costs, as well as the need to encourage alternative travel modes to the single occupant automobile. Following this discussion, the report provides an overview of deployment tracking results from 1997 to 2007. The results are divided into major functional areas describing how advanced technology is transforming the capabilities of agencies to manage the surface transportation system and improving the use of the system by travelers.

The remainder of the report describes the deployment of technologies to support transportation agencies in key functional areas. The second section covers technologies used to monitor transportation system conditions. The third section is devoted to technologies used to manage infrastructure. This is followed by the fourth section that outlines the level of technology used to disseminate traveler information. The fifth section outlines the level of deployment of technology used to automate financial transactions. The sixth section describes the level of deployment of technologies designed to improve safety and security. The final section of the report describes how ITS technology supports interagency integration.

1.1 Transportation Challenges

Traffic congestion, air and noise pollution, greenhouse gas emissions, transportation related crashes and fatalities as well as increasing costs are among the growing list of challenges which threaten the efficiency, safety, security, and productivity of the Nation's surface transportation system. All forecasts show that the demand for surface transportation services – in vehicle miles of travel (VMT) and freight movement – will continue to grow while the supply of transportation infrastructure will remain relatively static. In addition, transportation funding is falling short of addressing these needs through traditional policy responses. Since jurisdictions lack the resources and ability to "build their way out of congestion" agencies are turning toward "smart" infrastructure solutions to improve the management of surface transportation assets. For example, over the past decade:[1]

- A combination of ITS technologies in Detroit, Michigan—including advanced traveler information systems, highway advisory radio, ramp metering, and variable message signs—increased average vehicle speeds by 8.7 kilometers per hour (5.4 mph), decreased trip times by 4.6 minutes, and reduced commuter delay by 22 percent.
- Studies at traffic management centers demonstrate ramp metering systems reduce accidents by between 15 and 50 percent.
- In Pennsylvania, the I-95 Traffic and Incident Management System (TIMS) reduced highway incident closure time by 55 percent.
- The Advanced Regional Traffic Interactive Management & Information System serving Cincinnati and Northern Kentucky estimates that use of traveler information reduced fatalities 3.2 percent.
- The New Jersey Turnpike Authority reports that their EZ Pass system reduces toll station traffic delay by 85 percent.
- Users of the Advanced Traveler Information Service in the Washington, DC region were able to reduce the frequency of early and late arrivals by 56 and 52 percent respectively.

The deployment tracking data presented in subsequent sections of these report provide a national view of ITS adoption over the past decade. Numerous state and local agencies have invested in advanced technologies to address the complex problems they face. As explained in the next section, the implementation of ITS technologies offers the potential to meet growing surface transportation demand by enhancing the capability to actively manage the surface transportation system.

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[1] Source: "Traffic Congestion Factoids." http://www.fhwa.dot.gov/congestion/factoids.htm

1.2 Advanced Technology is Transforming Transportation Management and Operations

The deployment of Intelligent Transportation System (ITS) technologies can greatly improve a transportation agency's capability to actively manage the surface transportation system. These technologies enable an agency to monitor conditions, manage infrastructure and assets, inform travelers, improve safety and security, automate financial transactions, and integrate operations. For purposes of describing deployment, this report summarizes deployment activities according to the broad functions they support. This categorization is adopted since it provides a link between a technology and the capability which a technology is designed to support and provides a better appreciation of the benefits associated with deploying a technology. The following paragraphs provide a summary of these functions.

Monitoring Transportation System Conditions

ITS technologies provide transportation agencies with the ability to monitor travel conditions through real-time monitoring of traffic conditions using a variety of field sensors and closed circuit television (CCTV) cameras. The availability of real-time data means that agency staff can more rapidly identify and respond to events that impede traffic flow or endanger the safety of the traveling public. In addition, the monitoring of real-time conditions allows agencies to develop traveler information services that are used by the public to make travel related decisions such as when, where, and how to travel. Surveillance systems are in place to monitor the safety and security of roadways and public transit facilities. These systems provide agencies with the ability to identify potential threats and to formulate effective response strategies in the event of an incident.

Managing Infrastructure and Assets

The deployment of ITS technologies is also improving the way agencies are managing surface transportation assets. Traffic signal systems that are responsive to changing travel demands are now in place. Freeways can be actively managed by implementing strategies such as ramp metering and high occupancy vehicle (HOV) lanes that are responsive to traffic demand. Transit vehicles can be scheduled and routed in real-time and in response to passenger demand.

Informing Travelers

As a result of deployment progress over the last decade, travelers have access to a range of pre-trip and en-route information. Web sites have been developed to assist travelers in planning trips and monitoring travel conditions. Dynamic message signs (DMS) are deployed which provide travelers with messages regarding travel conditions while they are en-route. Transit agencies have developed trip planning tools that assist travelers in planning trips and completing financial transactions.

Automating Financial Transactions

ITS technologies are assisting in the automation of financial transactions. Toll agencies now have the ability to automate toll collection which reduces toll collection costs, increases accuracy, and enhances traveler convenience. Transit patrons can now used "Smart" cards and other media to pay fares. This eliminates the need for exact chance and reduces the costs associated with fare collection.

Improving Safety and Security

ITS surveillance technology is used to monitor safety and security conditions on bridges, tunnels, and roadways. Speed management and red-light running cameras have been deployed to increase safety for road users. Transit properties have deployed cameras and other devices to monitor vehicles and stations.

Integrating Systems

Numerous agencies have integrated systems to leverage capability. The construction of a Traffic Management Centers (TMCs) provides many agencies with a capability to link together surveillance and response assets along with traveler information resources.

The remaining sections of this report describe the level of deployment of ITS technologies. Emphasis is placed on deployment within 78 of the largest metropolitan areas. However, statistics are provided describing the level of statewide deployment of selected technologies. The data gathering effort indicates that significant deployment progress has been made across a range of technologies and geographic areas.

2 Monitoring Transportation System Conditions

This section describes the deployment of technologies used to monitor transportation system operating conditions. Section 2.1 describes the growth in capability to monitor real-time traffic conditions. Section 2.2 outlines trends in deployment of technologies to detect traffic incidents. Finally, Section 2.3 discusses technologies that have been deployed to monitor transit vehicle location and performance.

ITS technologies enable real-time monitoring of:

- Traffic Conditions
- Traffic Incidents and Crashes
- Transit Vehicle Location and Performance

2.1 Traffic Conditions

The deployment of cameras and advanced sensor technology such as inductive loops and acoustic detectors, provides transportation agencies with the capability to monitor urban traffic conditions in real-time. As will be shown in the next section, live pictures provided by cameras assist staff in quickly identifying and characterizing incidents and coordinating incident response. Using real-time data characterizing the volume, speed, and density of the traffic stream, agency staff is able to: 1) identify and respond to traffic incidents, 2) inform the traveling public of congestion levels and 3) employ traffic management strategies such as ramp metering, congestion pricing, and high occupancy vehicle lanes to improve operating performance.

The past decade has witnessed a dramatic increase in deployment of traffic surveillance technologies on urban freeways. As presented in Figure 1, in 1997 approximately 15% of the freeway miles in the 78 largest metropolitan areas were under electronic surveillance. Technologies deployed included loop detectors, video image processing, as well as radar detectors. By 2007, the extent of coverage in these areas increased essentially threefold to nearly 45% of the freeway miles. The increased presence of real-time data collection technologies has provided agencies with an expanded capability to identify potential congestion problems and to more quickly respond. Growing deployment of these technologies has also provided agencies with the ability to inform travelers of changing conditions to assist in trip planning and to understand the current status of the transportation system.

Real-time monitoring of traffic conditions on arterials has also rapidly expanded over the period 1997 to 2007. As presented in Figure 1, the percentage of signalized intersections under electronic surveillance has increased steadily to 40% by 2007. The increase in surveillance capabilities along arterials provides agencies with the capability to inform travelers regarding changing conditions, and to coordinate traffic management strategies. The steady growth in coverage of these systems on both freeways and arterials is unmatched by any other category of ITS technology. The real-time data gathered from these systems support a wide variety of ITS applications.

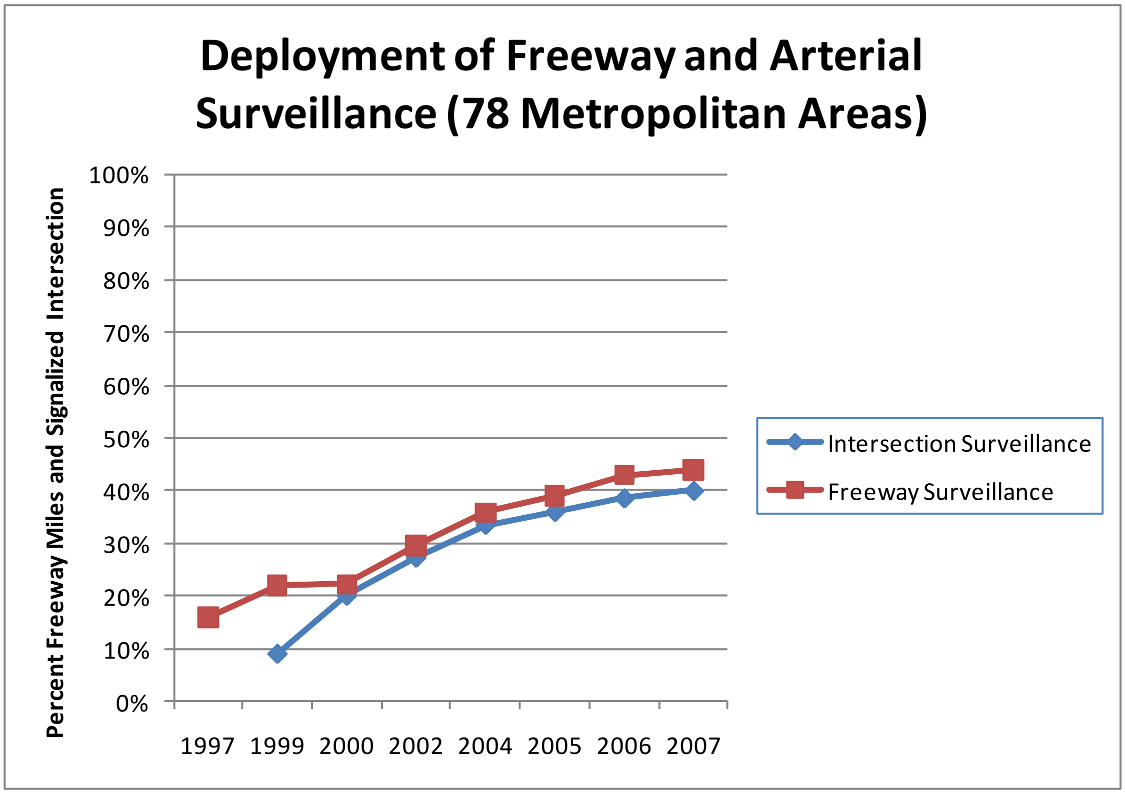


Figure 1: Trends for Deployment of Surveillance Systems 1997-2007

2.2 Traffic Incident and Crashes

A number of technologies have been deployed to assist in detecting and evaluating incidents on freeways and arterials. The most important of these is closed-circuit television (CCTV) cameras, which provide highway agencies and emergency responders with the ability to locate and characterize incidents in order to prepare an appropriate response. In addition, information regarding the location and potential delay impacts associated with an incident is provided to the traveling public so they make appropriate trip decisions. Other technologies that have been widely deployed include incident detection algorithms and free cellular phone calls to a dedicated number.

As presented in Figure 2, deployment of CCTV cameras on freeways and arterials has steadily increased. Data collected over the last decade indicates that 35% of the freeway miles in these areas were under surveillance by CCTV cameras in 2007, a nearly fivefold increase over ten years. In 2007, approximately 6% of arterial mileage in these areas was under surveillance by CCTV cameras in 2007, a substantial increase over the 1997 coverage.

In addition to CCTV cameras, trend data on two other important methods to detect traffic incidents have been collected: incident detection algorithms and free cellular phone calls to a dedicated number to report incidents. In 2007, approximately 15% of the freeway miles in these areas were covered by an incident detection algorithm (arterial coverage, not shown, exists but is less than one percent). In addition, in 2007 30% of the freeway miles were covered by a free cellular phone call to a dedicated number, with the coverage on arterials being about half of that. The deployment trends indicate that deployment of CCTV coverage on both freeways and arterials is increasing steadily, while the other technologies have leveled off or are decreasing.

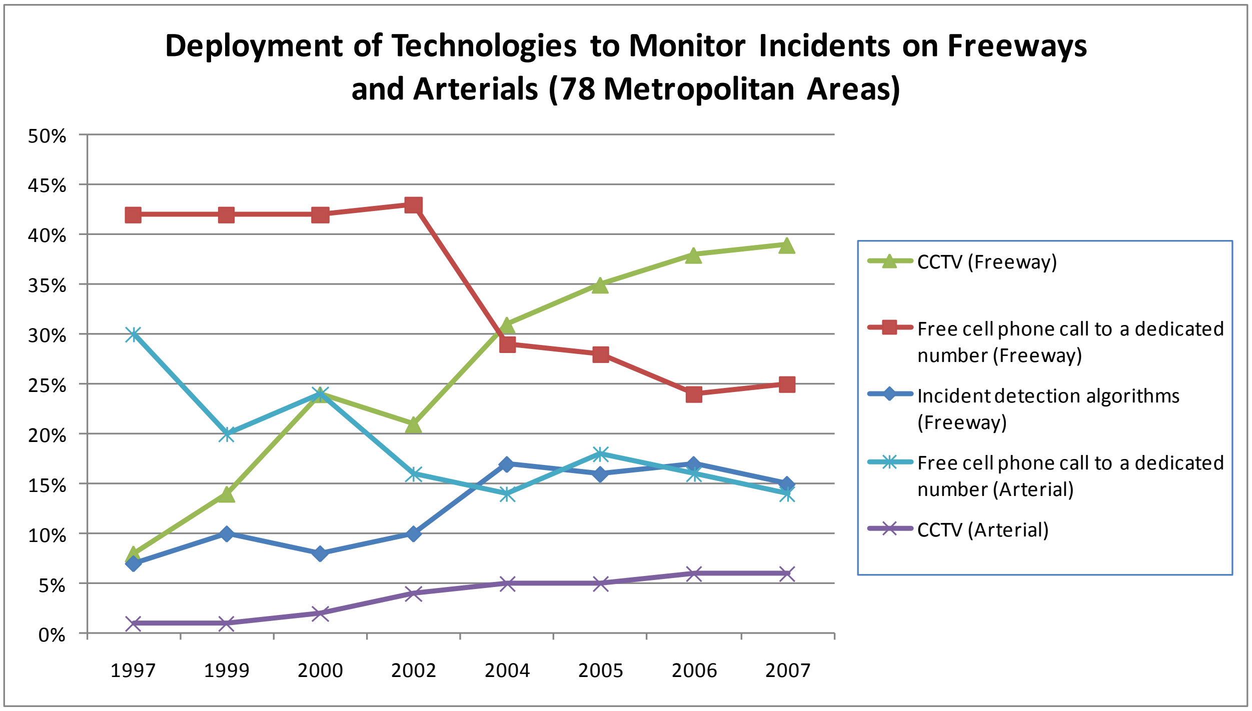


Figure 2: Trends for Deployment of Incident Monitoring Systems 1997-2007

In addition to the systems in the previous section, a variety of surveillance and detection technologies have been adopted in metropolitan areas to monitor incidents, however, trend data are not available. Table 1 outlines results from the 2007 national survey for adoption of various technologies to detect incidents on freeways and arterials. The most commonly reported method is the use of traveler reports, which has been adopted by almost all metropolitan areas surveyed. Call boxes remain an important source as well. Information from enhanced 911 systems is included as an incident detection system in a significant number of metropolitan areas, while use of advanced crash notification systems is lightly deployed.

Incident Detection Methods		
Technology	**Description**	**Number of Metropolitan Areas**
Traveler Reported	Number of metropolitan areas that use traveler reported information to detect incidents on freeways	57
	Number of metropolitan areas that use traveler reported information to detect incidents on arterials	52
Call Boxes	Number of Metropolitan areas employing call boxes on freeways	19
Wireless/E911	Number of metropolitan areas that deploy wireless enhanced 911 systems on freeways	17
	Number of metropolitan areas that deploy wireless enhanced 911 systems on arterials	8
Mayday/ACN	Number of metropolitan areas that deploy Mayday or Advanced Crash Notification systems on freeways	2
	Number of metropolitan areas that deploy Mayday or Advanced Crash Notification systems on arterials	0

Table 1: Adoption of Incident Detection Methods

2.3 Transit Vehicle Location and Performance

Transit agencies employ sophisticated technology to monitor fleets and improve maintenance. Automated vehicle location (AVL) technology provides a transit operator with the capability to monitor the location of transit vehicles in real-time. Vehicle location information is used to design and refine vehicle schedules and monitor route performance. In addition, with the proper technology, riders are able to monitor vehicle locations for the purpose of informing themselves regarding potential delays. Transit agencies also employ technology to support remote monitoring of vehicle components to assist in fleet maintenance.

Figure 3 summarizes the ten-year progress of transit agencies in the Nation's 78 of the largest metropolitan areas in deploying these technologies. Deployment of AVL has expanded steadily to the point that in 2007, 62% of all vehicles used on fixed-route bus serve were equipped with AVL technology, nearly a threefold increase over 1997. The use of remote systems to monitor the condition of key vehicle components has also expanded by a factor of three, from 10% of the fixed route bus fleet in 1997 to more than 30% in 2007.   Deployment trends indicate the expansion in coverage of both transit fleet monitoring technologies will continue in the future.

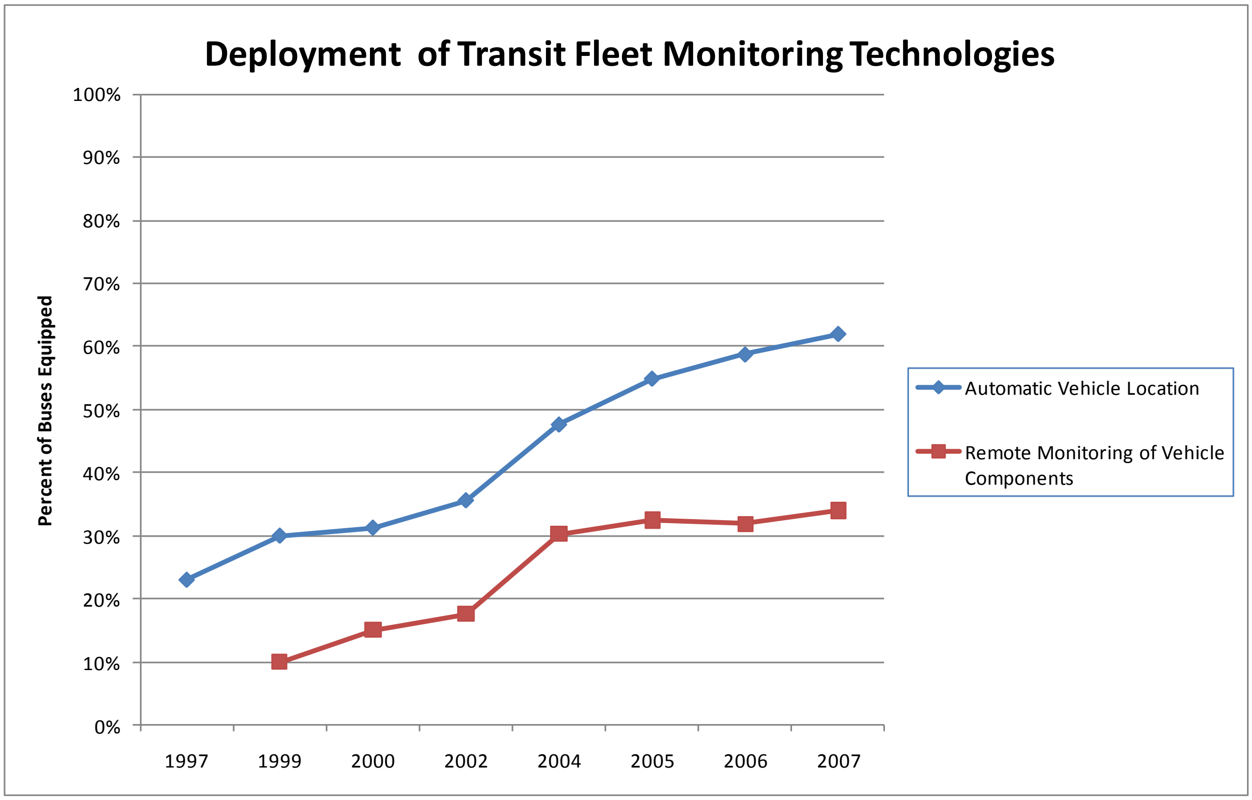


Figure 3: Trends for Deployment of Transit Fleet Monitoring Systems 1997-2007

Fleet management systems improve transit reliability through implementation of Automated Vehicle Location (AVL) and Computer Aided Dispatch (CAD) systems which can reduce passenger wait times. These systems may also be implemented with in-vehicle self-diagnostic equipment to automatically alert maintenance personnel of potential problems.

Transit Fleet Management Systems			
Technology	**Description**	**Percent of Fleet Equipped**	**Number of Metropolitan Areas**
Monitoring Location	Fixed route buses equipped with Automated Vehicle Location (AVL)	65%	54
	Demand responsive vehicles equipped with AVL	62%	44
Maintenance	Fixed route buses with real-time monitoring of vehicle components	44%	36
	Demand responsive vehicles with real-time monitoring of vehicle components	39%	21

Table 2: Deployment of Transit Fleet Management Systems

3 Managing Infrastructure and Assets

ITS technologies assist agencies in managing:

- Traffic Signals and Arterial Streets
- Parking Management
- Freeway Ramp Meters and Lane Control Systems
- Incident Management and Response Assets
- Transit Fleets
- Transportation Management Centers

One of the major impacts of the information gathered by the monitoring systems outlined in the previous section is to support expanded operational capability for transportation agencies. The deployment of a range of advanced technologies provides transportation agencies with expanded capability to manage highway system infrastructure and public transit assets. Among other things, this capability has reduced response time to clear incidents, enhanced the responsiveness of traffic signal timing, and improved transit fleet management. These expanded capabilities have meant that travelers have experienced a reduction in incident related congestion, a reduction in delay associated with traffic signal inefficiencies, and an improvement in transit service coverage, scheduling, and responsiveness.

This section will cover several aspects of the improvement in managing infrastructure and assets from deployment of ITS technology. Section 3.1 covers improvements to arterial management, through a variety of methods including traffic signal operations and other methodologies and lane control. Section 3.2 covers adoption of parking management systems. Section 3.3 discusses enhancements to freeway operation through ramp metering and various types of lane control and special event management. Section 3.4 covers incident management improvements through service patrols and systems to assist in clearance and recovery of incidents. Section 3.5 covers transit operations, including fleet management tools and demand management systems. Section 3.6 covers functions being performed by transportation management centers.

3.1 Traffic Signals and Arterial Streets

Advancements in traffic signal technology has resulted in capability to improve traffic signal coordination and responsiveness through centralized control. Sensors deployed at approaches to signalized intersections detect the presence of vehicles to determine the volume and speed of approaching traffic. Computer technologies are then applied to adjust traffic signalization in response to demand to minimize vehicle delay and maximize vehicle throughput. Centralized control provided by a master computer is used to coordinate numerous traffic signals along a corridor or within an entire grid network of signalized intersections.

Deployment of these technologies on arterials of 78 of the largest metropolitan areas to improve operations is well established and is shown in Figure 4. In 2007, approximately 55% of all signals in these areas were under centralized or closed loop control. Another category of operational improvements involves coordination with public safety and transit agencies to deploy systems on the infrastructure and vehicles to provide traffic signal preemption for public safety vehicles responding to an emergency and priority to transit vehicles when needed to meet schedule. About one fourth of signalized intersections provided the capability for emergency vehicles to preempt signal timing. Deployment of systems supporting priority for transit is much less well established and involves about 2% of signals. Both closed loop and emergency vehicle preemption systems are experiencing steady growth in coverage.

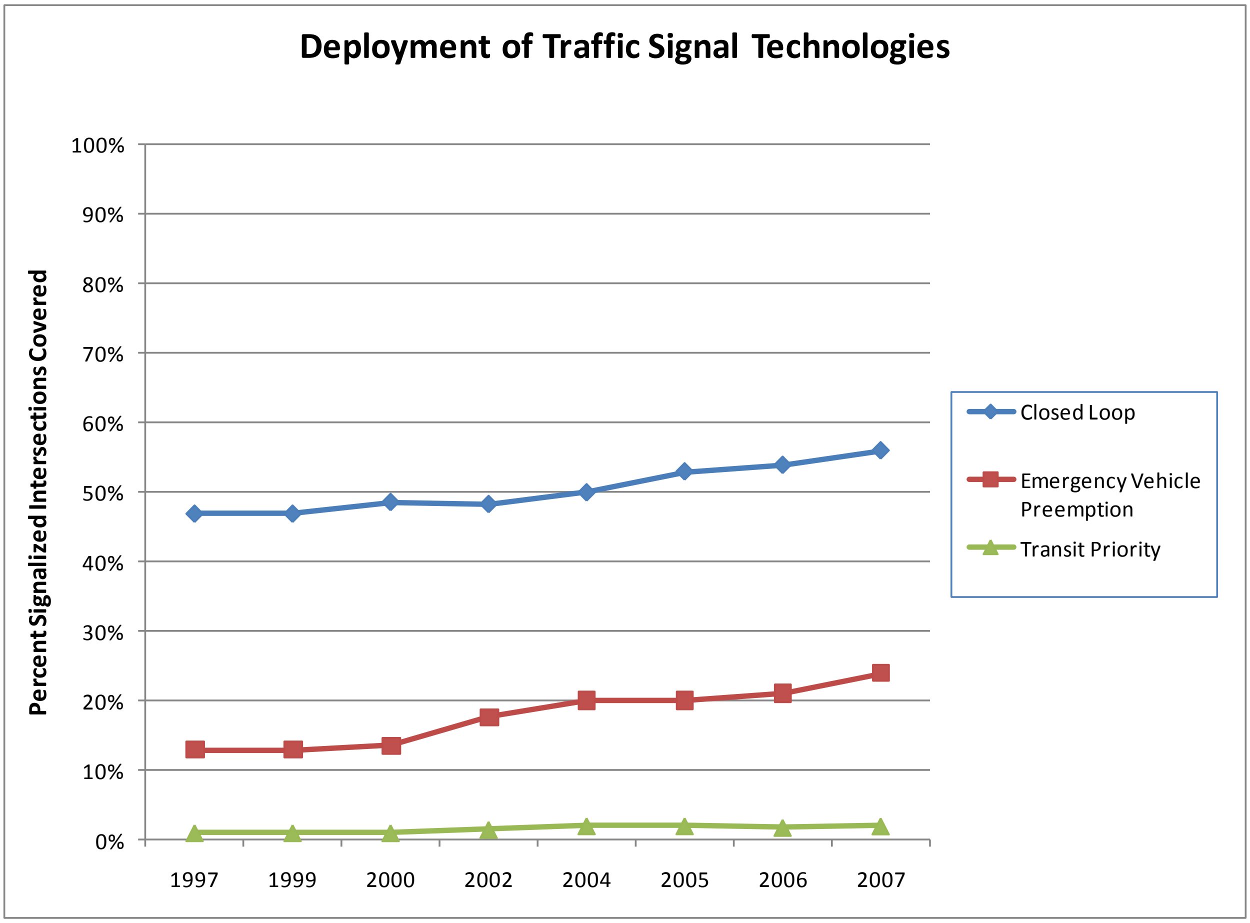


Figure 4: Trends for Deployment of Traffic Signal Technologies 1997-2007

Traffic control measures on arterials optimize travel speeds and improve safety of bicyclists and pedestrians and smooth traffic flow during special events. Information on adoption of these technologies is shown in Table 3 below. The adoption of closed loop or centralized control and emergency vehicle preemption, although limited in coverage as shown above, are virtually universally adopted among the 78 largest metropolitan areas. Deployment of bicycle or pedestrian systems is widely adopted, as is the use of special event systems to help managed special event traffic. Priority for transit vehicles, while having limited coverage of signalized intersections, is deployed in more than one third of the metropolitan areas surveyed, and the same comment applies to adoption of adaptive signal control. A small number of metropolitan areas have adopted variable speed limits as an arterial control methodology.

Adoption of Arterial Traffic Control Technologies		
Technology	**Description**	**Number of Metropolitan Areas**
Advanced Signal Systems	Signalized intersections operated under closed loop or central system control	73
Emergency Vehicle Preemption	Signalized intersections that allow for signal preemption for emergency vehicle	70
Bicycle & Pedestrians	Deployment of bicycle or pedestrian systems (e.g., pedestrian detectors, pedestrian activated lighted crosswalks, specialized pedestrian signals such as 'countdown' WALK/DON'T WALK signals and bicycle-actuated signals)	65
Special Events	Deployment of special event systems (e.g., traffic signal operating plans, temporary lane restrictions, traveler guidance, or other measures)	66
Transit Signal Priority	Signalized intersections that allow signal priority for transit vehicles	33
Adaptive Signal Control	Signalized intersections under real-time traffic adaptive control using SCOOT/SCATS or other similar advanced software	27
Variable Speed Limits	Deployment of variable speed systems on arterials	7

Table 3: Adoption of Arterial Traffic Control Technologies

Arterial lane management applications can promote the most effective use of available capacity during emergency evacuations, incidents, construction, and a variety of other traffic and/or weather conditions. Table 4 below shows the number of metropolitan areas that have adopted various lane management technologies on arterials. Reversible flow lanes and emergency evacuation lanes are the most widely adopted lane management techniques. Lane control with lane closure capability and high occupancy vehicles is less widely adopted.

Arterial Lane Management Technologies		
Technology	**Description**	**Number of Metropolitan Areas**
Reversible Flow Lanes	Arterial reversible lane centerline miles equipped with automated lane management technologies	11

Arterial Lane Management Technologies		
Technology	**Description**	**Number of Metropolitan Areas**
Emergency Evacuation	Arterial roadway equipped with lane management measures to support emergency evacuations	7
Lane Control	Arterial roadway equipped with lane control signs supported by technologies to allow temporary closure	5
HOV Facilities	Arterial High Occupancy Vehicle (HOV) centerline miles equipped with automated lane management technologies	3

Table 4: Adoption of Lane Management Technologies on Arterials

3.2 Parking Management Systems

Parking management systems with information dissemination capabilities, most commonly deployed in urban centers or at modal transfer points such as airports, monitor the availability of parking and disseminate the information to drivers, reducing traveler frustration and congestion associated with searching for parking. Table 5 shows the number of metropolitan areas that have adopted parking management technologies. A total of 12 out of 78 metropolitan areas have deployed parking management data collection systems and parking data dissemination systems.

Parking Management Systems		
Technology	**Description**	**Number of Metropolitan Areas**
Data Collection	Parking management data collection systems that monitor the availability of parking	12
Information Dissemination	Parking management systems that disseminate parking availability information to drivers	12

Table 5: Adoption of Arterial Parking Management Technologies

3.3 Freeway Ramp Meters and Lane Control Systems

The principle methods for direct control of freeway traffic are ramp metering and lane control. Traffic control measures on freeway entrance ramps, such as ramp meters, can use sensor data to optimize freeway travel speeds and ramp meter wait times. Lane management applications can promote the most effective use of available capacity on freeways to encourage the use of high-occupancy commute modes. Figure 5 shows the trend for adoption of these two freeway management technologies on 78 of the largest metropolitan areas. The trend for both indicates that adoption of these technologies is leveling off at about 25 of the 78 metropolitan areas. However, Figure 6 shows that while no new metropolitan areas are adopting ramp metering, those that have adopted it are steadily increasing the coverage. These data show that while ramp metering may not be appropriate for every large metropolitan area, where it has been deployed, it has been successful and continues to gather increased support from local freeway management agencies and city governments.

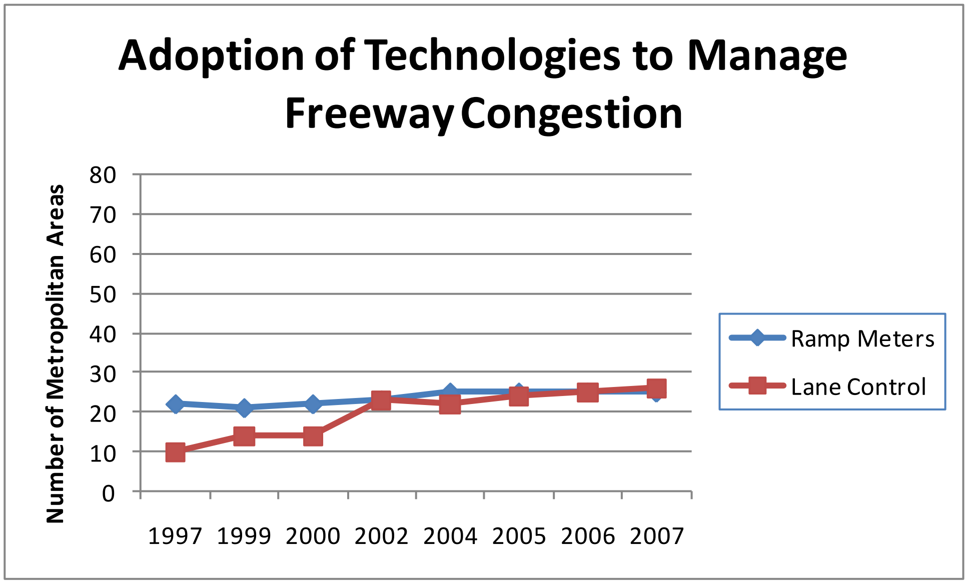


Figure 5: Trends for Adoption of Freeway Ramp Metering and Lane Control 1997-2007

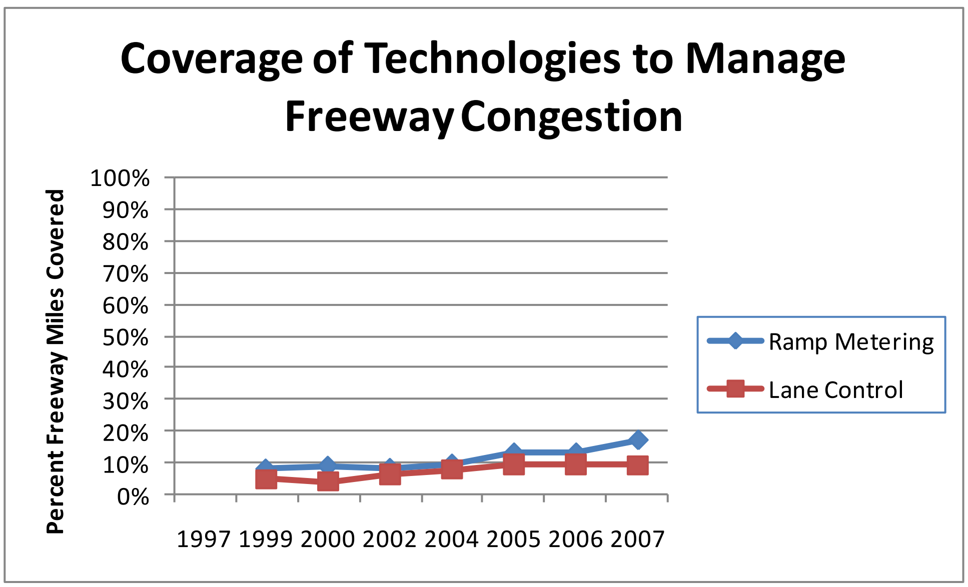


Figure 6: Trends for Deployment of Freeway Ramp Metering and Lane Control 1997-2007

A variety of lane management methodologies have been adopted by metropolitan areas on freeways to meet specific needs. Table 6 below lists the number of metropolitan areas reporting the adoption of various lane management technologies on freeways. Four systems are most widely adopted: high occupancy vehicle lanes, lane closure systems, reversible flow lanes, and emergency evacuation lanes.

Freeway Lane Management Systems		
Technology	**Description**	**Number of Metropolitan Areas**
HOV Facilities	Freeway High Occupancy Vehicle (HOV) centerline miles equipped with automated lane management technologies	13
Lane Closure	Freeway equipped with lane control signs supported by technologies to allow temporary closure	11
Reversible Flow Lanes	Freeway reversible lane centerline miles equipped with automated lane management technologies	10
Emergency Evacuation	Freeway equipped with lane management measures to support emergency evacuations	9
Variable Speed Limits	Freeway equipped with variable speed limit technologies	5
Pricing	Freeway under congestion pricing and equipped with technologies to support congestion pricing strategies	5

Table 6: Adoption of Lane Management Technologies on Freeways

3.4 Incident Management and Response Assets

Over the past decade, the deployment of incident identification technologies has been paralleled by a greatly expanded incident response capability. By reducing the time required to clear incidents, surface transportation and emergency response agencies can open travel lane to traffic quicker thereby reducing the delay impacts associated with incident management. Real-time communication among agencies enabled by Intelligent Transportation System (ITS) technologies enables coordination of response resources.

Roving service patrols provide one of the most effective incident response methods. Since 1997, the Nation's 78 of the largest metropolitan areas have seen an increase in the number and coverage of freeway service patrols. As presented in Figure 7, in 1997, approximately 30% of freeway miles in these areas were covered by a service patrol, coverage which had increased to 54% by 2007. While deployment of service patrols on arterials has experienced steady growth from 1997 to about 14% in 2007, coverage lags significantly behind freeways.

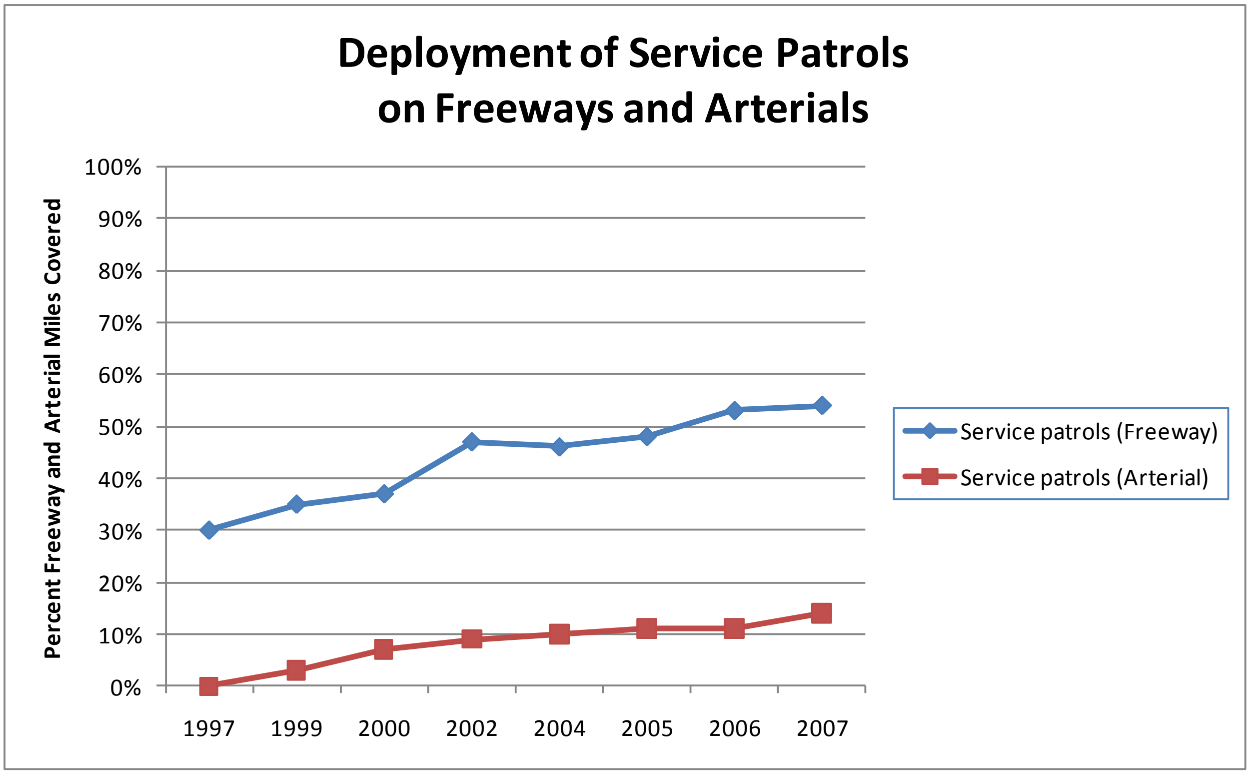


Figure 7: Trends for Deployment of Service Patrols on Freeways and Arterials 1997-2007

ITS technologies are deployed on freeways and arterials to speed the investigation of incident scenes and help ensure the safety of incident responders and provide for the safe travel of vehicles around the incident site. Table 7 shows the rate of adoption of clearance and recovery systems on freeways and arterials. The use of temporary traffic control devices and technology to aid in data collection at incident scenes on both freeways and arterials is well established.

Incident Clearance and Recovery Systems			
Technology	**Description**	**Number of Metropolitan Areas Freeway**	**Number of Metropolitan Areas Arterial**
Temporary Traffic Control	Deployment of temporary traffic control devices, such as portable message signs and lane control signs, to help ensure the safety of freeway incident scenes	58	59
Data Gathering	Using video imaging to assist with data collection at incident scenes to speed the reopening of travel lanes	29	33

Table 7: Adoption of Incident Clearance and Recovery Systems

3.5 Transit Fleets

Transit agencies have a large investment in rolling stock. ITS technologies have been applied to improve the fleet management capabilities of agencies offering a range of public services including both fixed route and demand responsive transit. As presented in Figure 8, deployment of ITS technologies to improve transit fleet operations has grown steadily since 1997. These include computer aided dispatch (CAD) and traffic signal priority capabilities. In 2007, 62%% of paratransit vehicles were under CAD, an increase over 1997 of a factor of three. This technology provides the capability to change routes and schedules in response to demand in real-time thereby increasing vehicle productivity, and is experiencing rapid expansion in deployment. Buses equipped with traffic signal priority have the capability to override signal timing when needed to improve schedule adherence when operating with similarly equipped traffic signals. Deployment has expanded from nearly zero to about 11% of the fixed route fleet in 78 of the largest metropolitan areas.

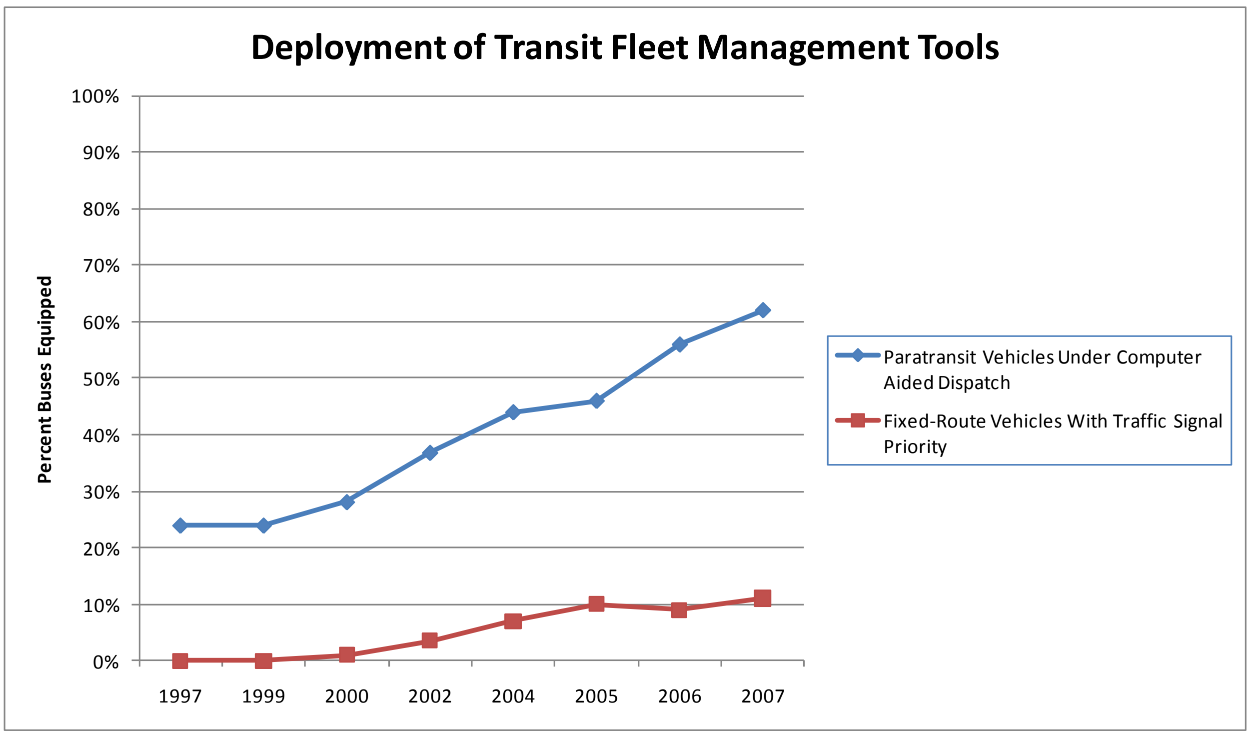


Figure 8: Trends for Deployment of Transit Fleet Management Tools 1997-2007

Transportation demand management service, such as planning, ride sharing/matching, dynamic routing/scheduling, and service coordination, increase public access to transit resources where coverage is limited. Table 8 below shows the results from the 2007 survey. These results show that all four travel demand systems are well established, with three of the four adopted by transit agencies in 36 or more metropolitan areas.

Transportation Demand Management Systems		
Technology	**Description**	**Number of Metropolitan Areas**
Planning	Using data from technologies such as AVL/CAD systems and automatic passenger counter systems to assist in planning	56
Service Coordination	Using vehicle monitoring and communication technologies to facilitate the coordination of passenger transfers between vehicle or transit systems	44
Ride Sharing /Matching	Providing ride sharing and carpool matching services	36
Dynamic Routing /Scheduling	Using AVL combined with dispatching and reservation technologies to provide flexible routing and scheduling	21

Table 8: Adoption of Transportation Demand Management Systems

3.6 Transportation Management Centers (TMC)

Transportation management centers support real-time integration and coordination among various traffic management agencies. Figure 9 below shows the percent of freeway and arterial TMCs that perform particular functions. While the two types of TMC are similar in emphasis on detection, verification and monitoring of incidents, information dissemination to the public and other agencies, as well as network surveillance, they have significant differences in the functions they carry out. Arterial agencies emphasize corridor management and traffic signal control, as might be expected, but also network surveillance and special event traffic management. Freeway TMCs, on the other hand, are much more likely to support en route traveler information, incident management dispatch, and environmental monitoring.

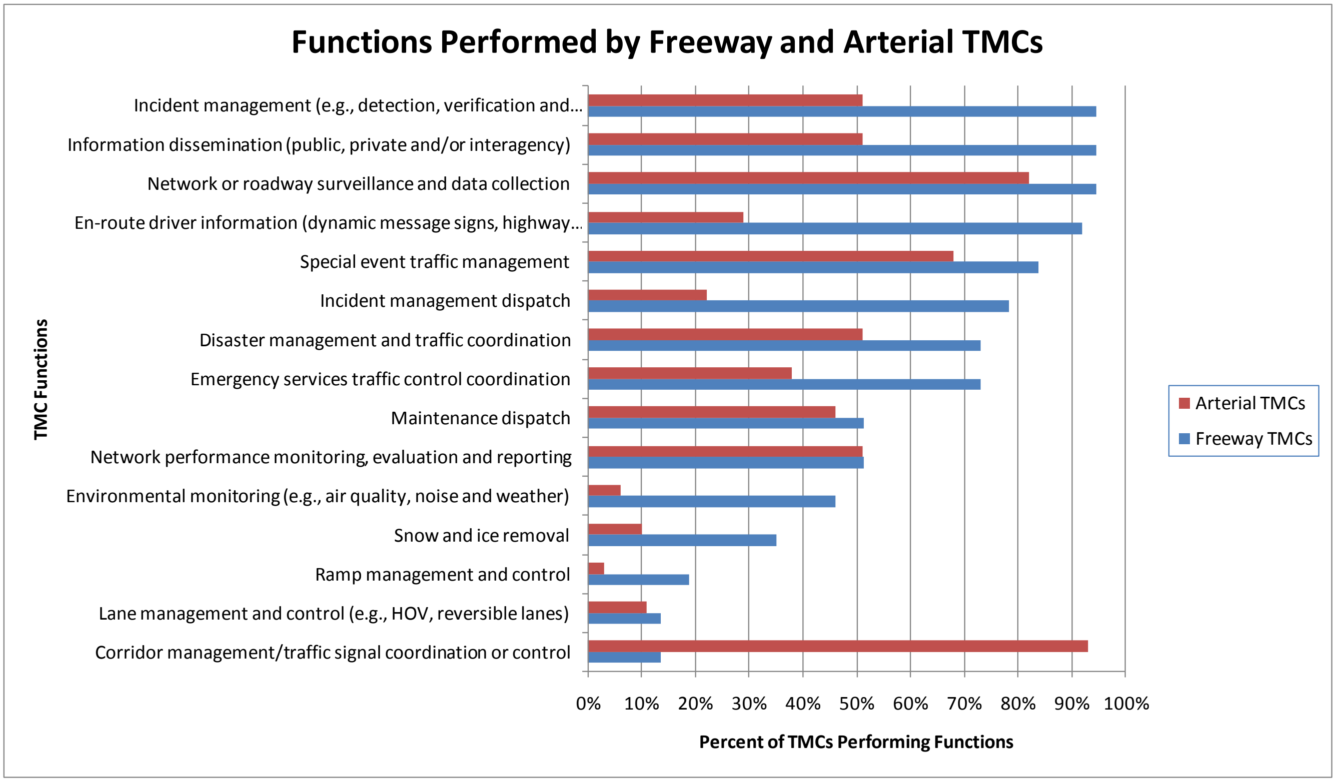


Figure 9: Functions Performed by Freeway and Arterial TMCs

4 Informing Travelers

One of the major transformations in transportation is the use of technology to provide travelers information that can be used for pre-trip planning and to support travelers en route to their destination. This capability to support traveler decision-making springs largely from the effort devoted to gathering information on traffic conditions outlined above and illustrates how investment in ITS can serve multiple functions. Pre-trip planning can involve using information concerning current traffic conditions to decide on a particular route or to make a transportation mode choice. En route, travelers are provided real-time information on congestion from different sources covering a variety of topics, including incidents, weather, special events, or road closures, and can make routing decisions to avoid delays. The impact on the traveling public is profound. Visitors in an unfamiliar area can make good choices like an experienced local traveler. Regular commuters can make a choice between various possible routes and modes based on real-time information on conditions. Traffic management agencies are able to reduce the impact of congestion by providing travelers with alternate routings. Statewide web sites provide specialized tourist and traveler information. Transit agencies have deployed a rich set of tools to keep travelers informed of static information such as routes and fares, and dynamic information on arrival times schedule adherence.

> ITS technologies are used to provide travelers with a range of information including:
>
> - Pre-Trip Information
> - En-Route Information
> - Tourism and Events Information
> - Statewide Traveler Information
> - Transit Traveler Information

This discussion of deployment of traveler information technology will be broken out into a number of specialized areas. Section 4.1 will cover technologies devoted to providing pre-trip information, while Section 4.2 will cover en-route technologies and message types. Section 4.3 covers tourist services. Section 4.4 covers statewide web sites and the types of messages they display. Section 4.5 covers transit information systems, including the media used, and display of dynamic information in vehicles and facilities.

4.1 Pre-Trip Information

Figure 10 shows the trends for adoption of various traveler information media in 78 of the largest metropolitan areas from 1997 to 2007. The fastest growing media involve the internet. The use of web sites is the most widely adopted media, with adoption growing rapidly from less than half of the metropolitan areas in 1997 from to virtually all metropolitan areas in 2007. Email is the next most popular, showing rapid expansion in 2007. Automated telephone delivery is also widely deployed and also shows a rapidly growing trend for deployment. The use of pagers and fax are also similar in deployment, reported by about half of the metropolitan areas, although with opposite trends—the number of metropolitan areas providing service for pagers is increasing, while those providing faxed information is decreasing. The use of dedicated TV showed an uptick in 2006 to nearly 30 metropolitan areas, while the use of kiosks has shown almost no growth in recent years and was reported by 12 metropolitan areas in 2007.

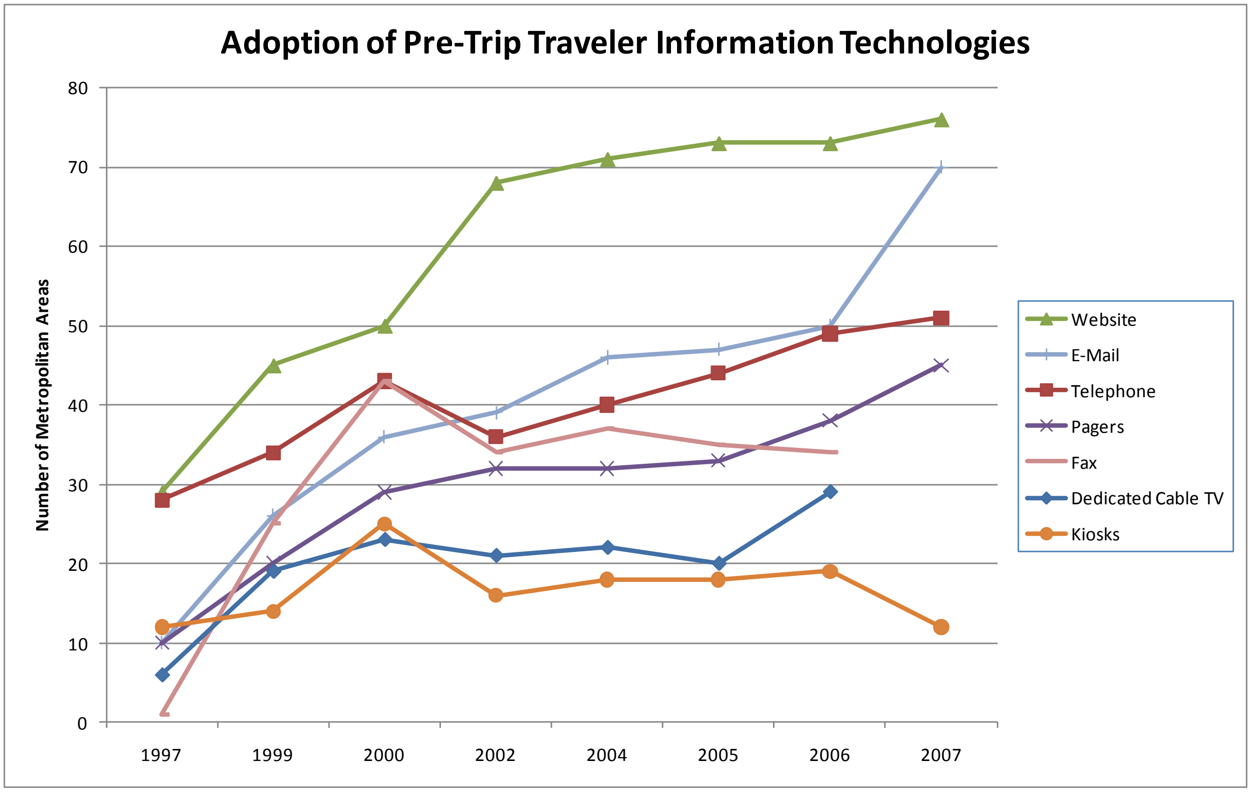


Figure 10: Trends for Adoption of Pre-Trip Traveler Information Systems 1997-2007

4.2 En-route Information

A variety of technologies are employed to provide en-route information to travelers on both freeways and arterials. The two most widely adopted technologies for disseminating en-route information are dynamic message signs (DMS) and highway advisory radio (HAR). Figure 11 shows the trends for adoption of these technologies by metropolitan areas for both freeway and arterial roadways. In both cases, adoption of HAR is about three fourths that of DMS, with adoption of DMS on freeways being virtually universal. Adoption in all cases has increased at about the same rate, with arterial adoption being a little more than half that of freeway adoption consistently.

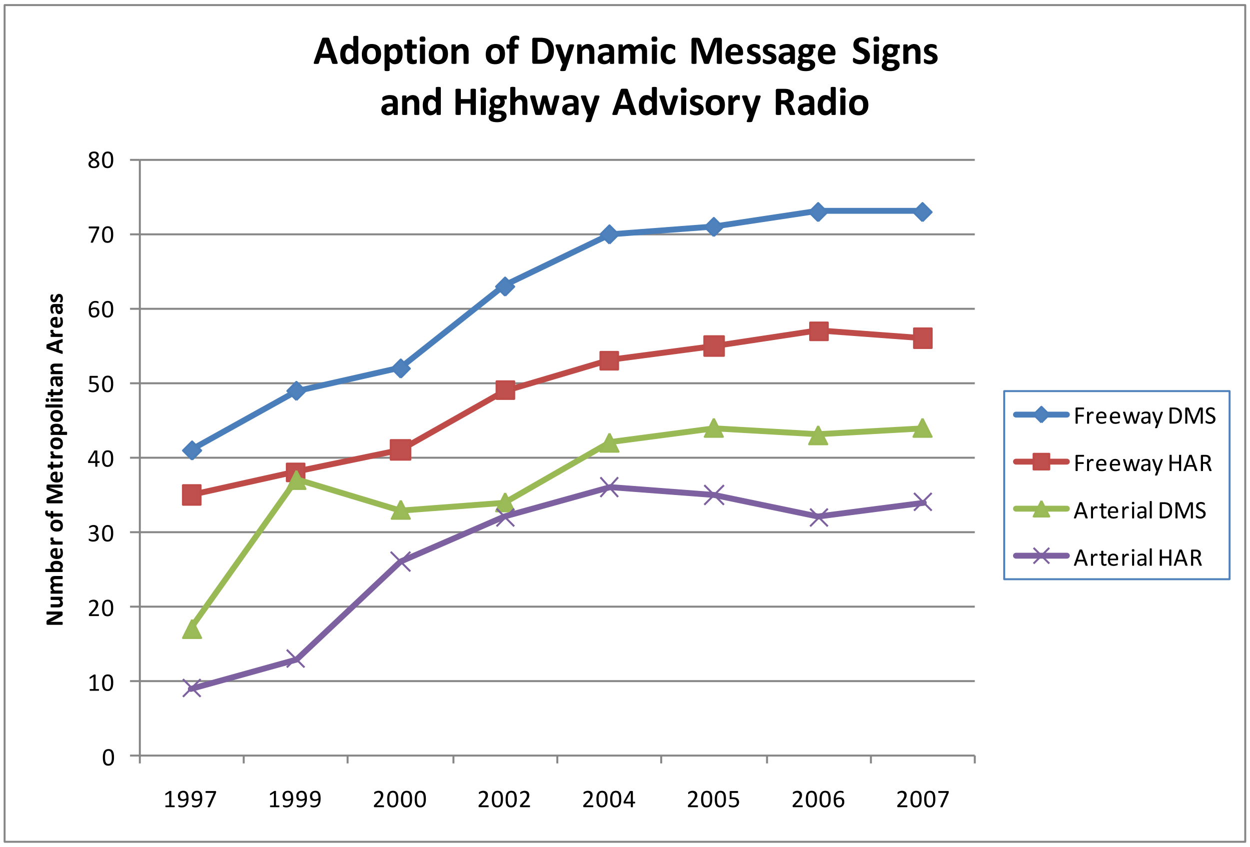


Figure 11: Trends for Adoption of DMS and HAR on Freeways and Arterials 1997-2007

These media are used to disseminate a wide variety of en-route messages. Figure 12 shows the types of messages disseminated on dynamic message signs (DMS), broken out by freeway and arterial deployment. The results are displayed based on the percentage of metropolitan areas that reported dissemination of the various message types on freeway and arterial DMS (data are based on 2006 results). The three most commonly disseminated message types involve incident information, Amber alerts, and maintenance and construction sites. Next in importance are special events that impact travel, congestion, and diversion information. Included in a significant number of metropolitan areas are messages not necessarily limited to travel, such as public service announcements, local special events, and driver safety campaign messages.

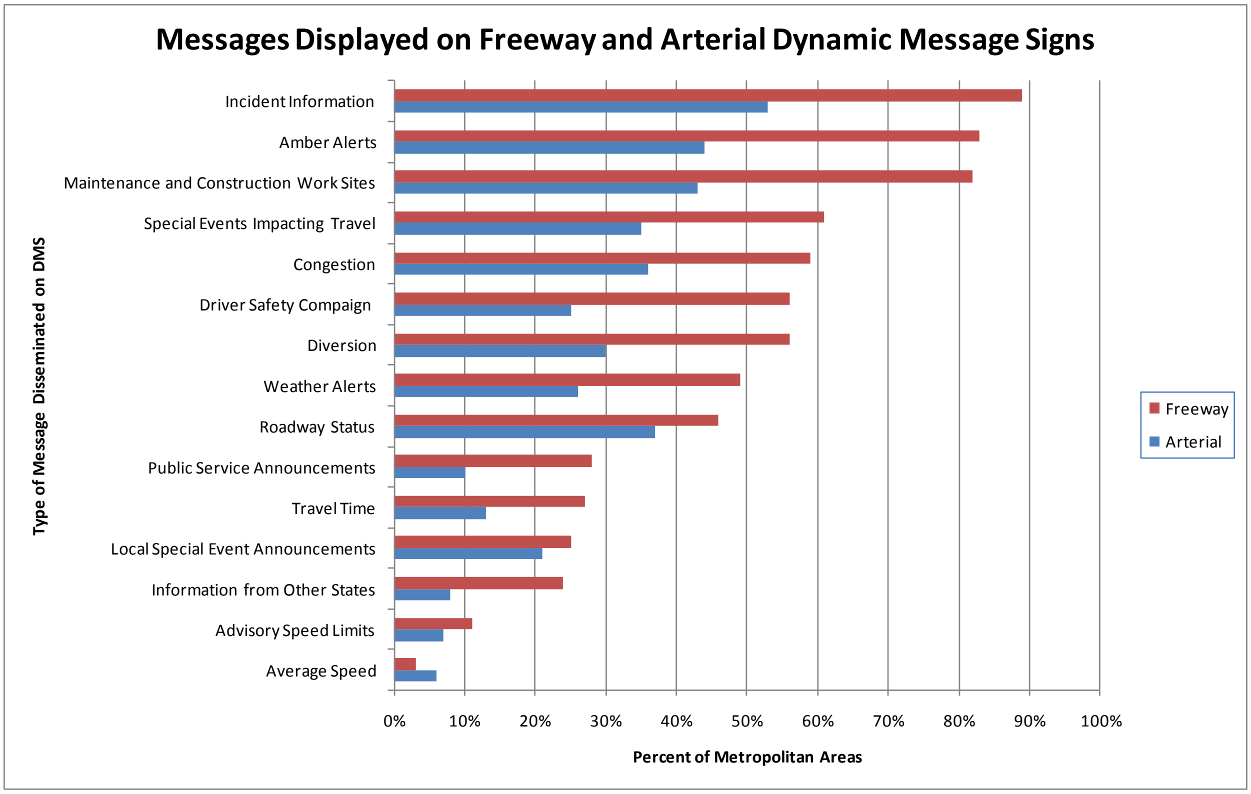


Figure 12: Types of En-Route Information Disseminated by Dynamic Message Signs

4.3 Tourism & Events

Tourism and event-related travel information systems focus on the needs of travelers in areas unfamiliar to them or when traveling to major events such as sporting events or concerts. These services address issues of mobility and traveler convenience. Information provided can include electronic yellow pages as well as transit and parking availability. Table 9 shows data for adoption of tourism information systems by metropolitan areas.

Tourism Information Systems		
Technology	**Description**	**Number of Metropolitan Areas**
Travel Services	Tourism information traveler systems that focus on the needs (i.e., electronic yellow pages, incorporating lodging reservations systems and directions to points of interest) of travelers in areas unfamiliar to them	9
Electronic Payment	Electronic payment systems (i.e., magnetic stripe cards, smart cards, or similar technologies) to facilitate traveler's payment for travel and other services at tourist destinations	9
Advanced Parking	Parking management systems that provide availability status and directional guidance posted on dynamic message signs at major tourism destinations	7

Table 9: Adoption of Tourism Information Systems

4.4 *Statewide Reporting of Traveler Information*

In the 2007 survey, 39 states reported having a statewide web site supporting travel services. Figure 13 shows that the two most commonly reported types of information provided by these sites were road closures and work zones. Next were incidents and CCTV images; followed closely by weather information, road surface conditions, and detours. Many of the web sites included tourism information: special events; maps; and a smaller number of states web sites providing information on points of interest, directions, hotel accommodations, and restaurants (not shown).

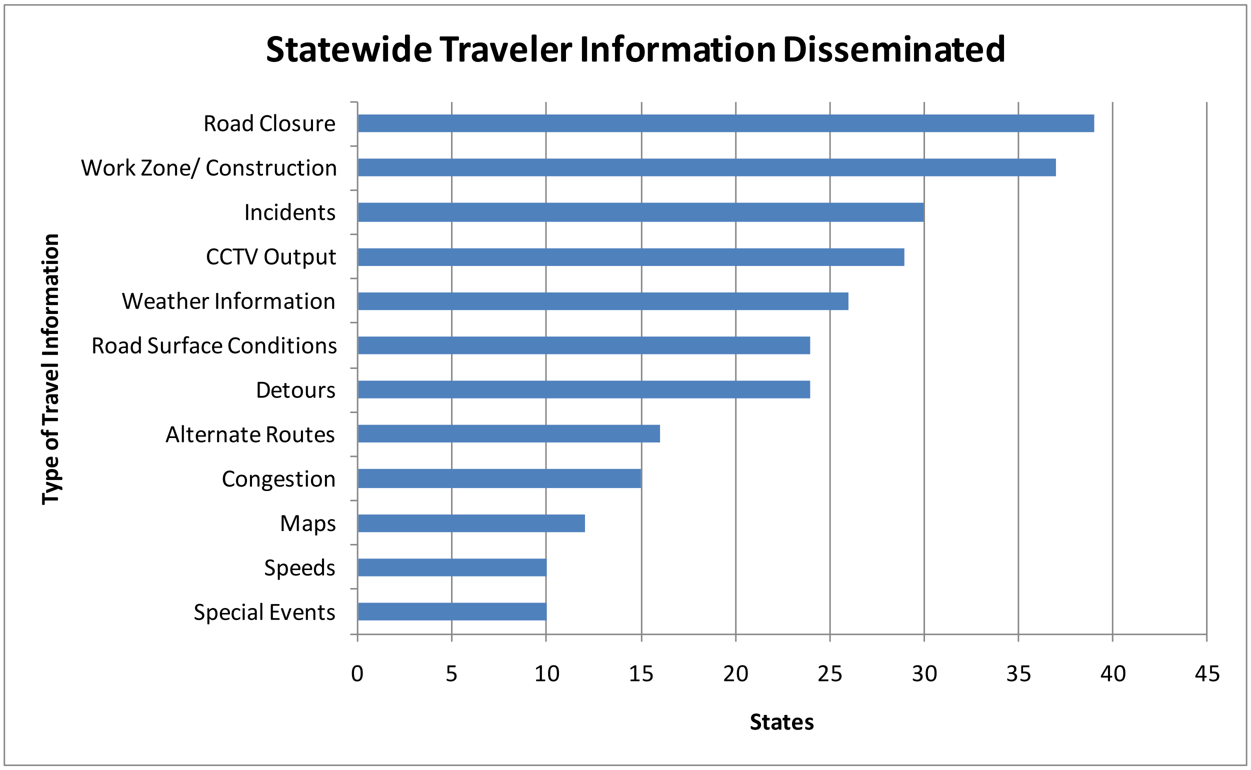


Figure 13: Information Disseminated by Statewide Traveler Information Web Sites

4.5 *Transit Traveler Information*

Transit agencies have made a significant investment in various types of information media to provide static and dynamic information for riders to assist in trip planning. In addition, a sophisticated set of tools has been deployed to provide riders at facilities and on transit vehicles with real-time dynamic information.

4.5.1 Media for Dissemination of Transit Information

The use of traveler information systems by transit agencies is well established. Virtually all agencies have web sites providing information on routes and schedules. To accommodate their users, transit agencies disseminate information through additional media ranging from email to kiosks. As shown in Figure 14, the most common type of information shared is static data concerning planned routes, schedules, and fares, which supports pre-trip planning. In many metropolitan areas, however, transit agencies are taking advantage of vehicle tracking capability to provide travelers with dynamic information concerning schedule adherence or actual arrival and departure times. Web sites and email are the most commonly reported media for the transmission of both types of information. Kiosks are much more in use by transit agencies than other transportation management agencies and kiosks are a significantly used media, as are automatic phone systems. This rich set of information dissemination tools has a significant impact on traveler decision-making, allowing them to quickly evaluate the use of transit in place of taking a private vehicle in planning a trip. Users of the transit system can use this information can serve to allow passengers to confirm scheduling information, improve transfer coordination, and reduce wait times.

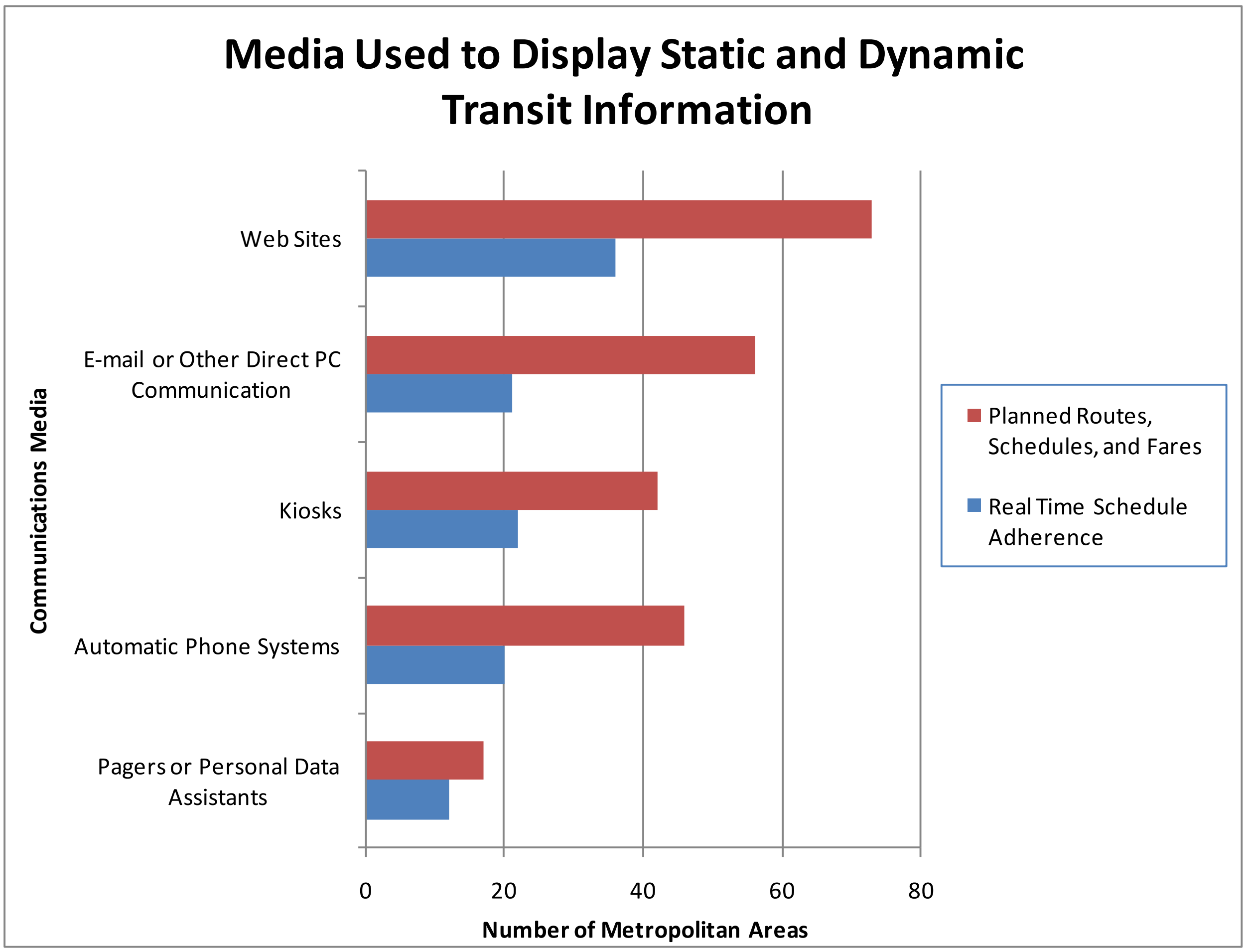


Figure 14: Media Used to Display Static and Dynamic Transit Information

4.5.2 Dissemination of Dynamic Information in Vehicles and Stations

An additional service provided by many transit agencies is to display dynamic information on schedule adherence to travelers in transit vehicles and stations. Electronic transit status information signs at bus stops help passengers manage time, and on-board systems such as next-stop audio annunciators help passengers in unfamiliar areas reach their destinations. Table 10 shows information on deployment and adoption of methods to disseminate dynamic information by transit agencies.

Systems to Display Dynamic Transit Information			
Technology	**Description**	**Percent of Fleet or Facilities Equipped**	**Number of Metropolitan Areas**
In-Vehicle Display	Fixed route buses that electronically display automated or dynamic traveler information (e.g., schedule and system information) to the public	44%	24
	Light rail vehicles that electronically display automated or dynamic traveler information (e.g., schedule and system information) to the public	27%	5
In-Facility Display	Bus depots that electronically display automated or dynamic traveler information (e.g., schedule and system information) to the public	26%	18
	Rail stations that electronically display automated or dynamic traveler information (e.g., schedule and system information) to the public	27%	19

Table 10: Systems to Display Dynamic Transit Information

5 Automating Financial Transactions

Transportation agencies and travelers now rely upon technology to reduce financial transaction time and costs and improve convenience. Historically, cash based financial transactions have been used to pay for transit fares and highway, bridge, or tunnel tolls.

ITS technology enables the following financial transitions:

- Toll Collection
- Transit Fare Payment

5.1 Electronic Toll Collection

Toll agencies have realized the benefits of introducing electronic toll collection to their travelers. Electronic toll collection (ETC) reduces delay associated with stopping to pay tolls since drivers may proceed through a toll barrier without stopping. In addition, electronic toll collection allows agencies to collect revenue without having to manage money and coins.

Figure 15 shows that between 1997 and 2007 a significant rise in the percentage of toll collection lanes with ETC capability. In 1997, approximately 36% of lanes were equipped with ETC capability. By 2007, this has increased to 85% of toll lanes. Figure 15 also shows a similar growth in the percentage of toll plazas equipped with ETC capability.

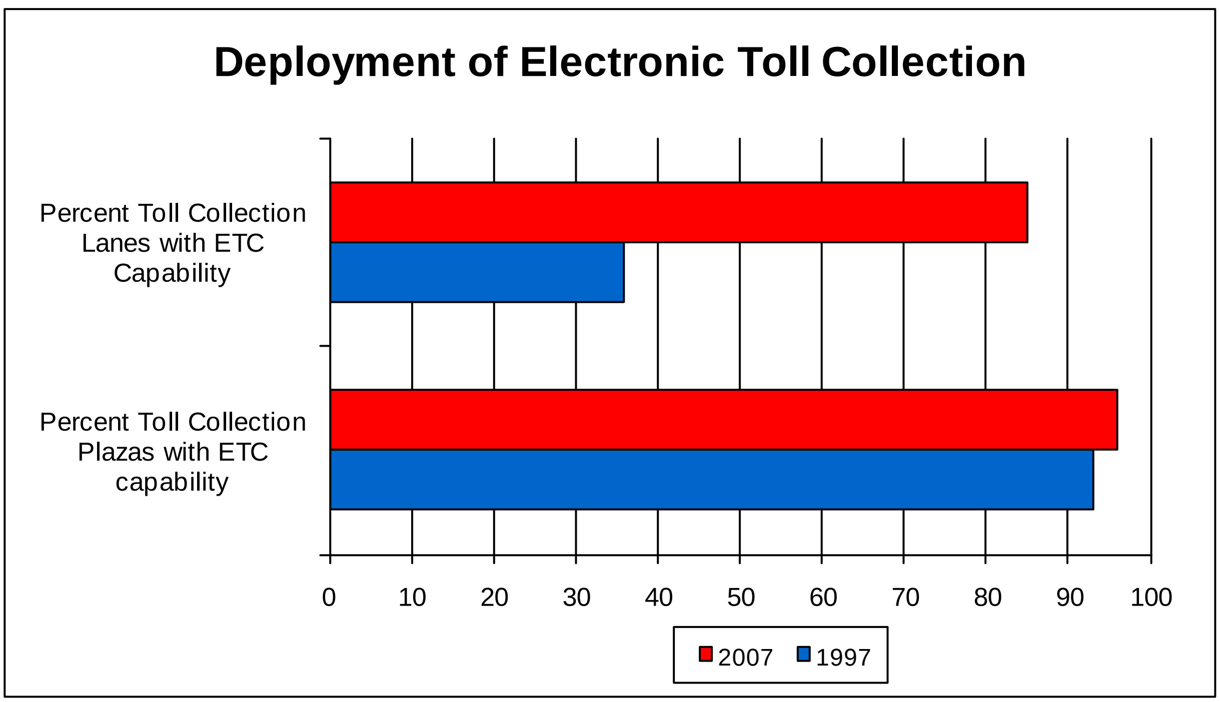


Figure 15: Trends for Deployment of Electronic Toll Collection 1997-2007

5.2 Electronic Fare Payment

Public transit operators have deployed electronic fare payment technology to provide payment convenience to riders. Rather than having to produce exact change, riders can use an electronic fare payment media to purchase services. Electronic payment also reduces the cost of managing financial transactions to operators.

Figure 16 shows that electronic fare payment has become a mainstay of fare collection on fixed route buses. In 2007, approximately 70% of fixed route buses were equipped with magnetic strip readers and 33% were equipped to read smart cards.

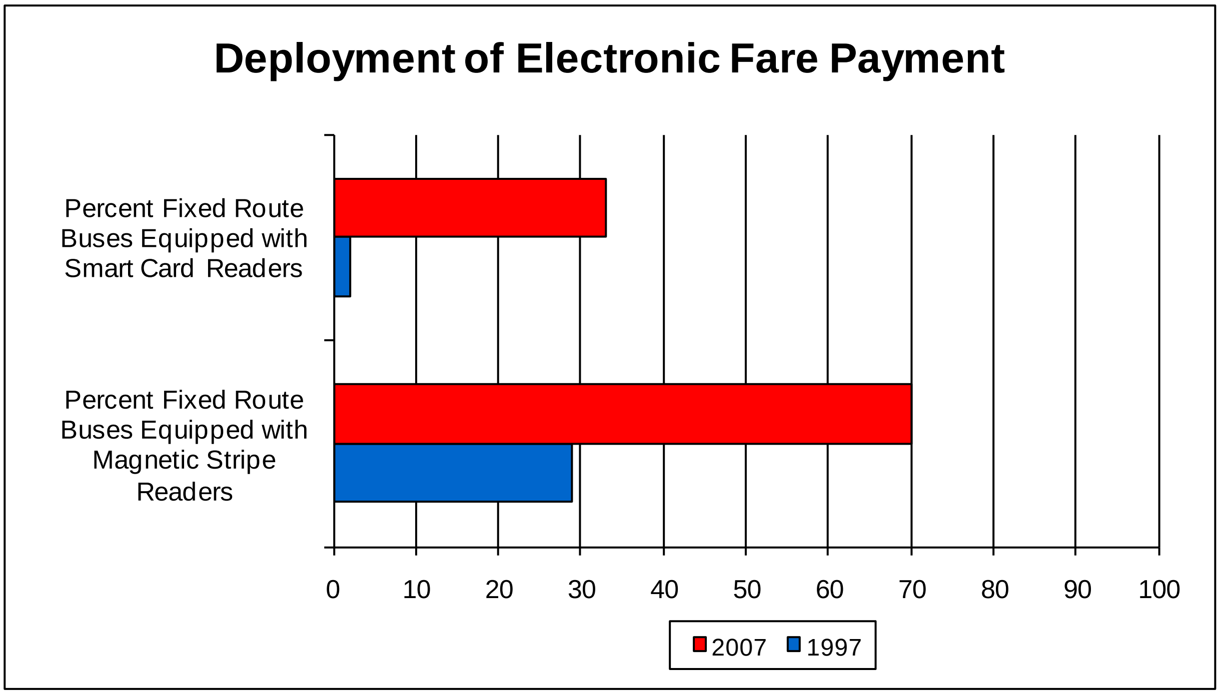


Figure 16: Trends for Deployment of Electronic Fare Payment 1997-2007

6 Improving Safety and Security

Deployment of ITS technology has had a major impact in improving safety and security. A wide variety of technologies are used to enhance security for travelers. Sophisticated and complex systems deployed in metropolitan areas as well as remote rural sites can detect when vehicles are operating unsafely and provide automated warnings to specific vehicles. Other ITS systems can aid traffic enforcement by detecting and identifying violators. Public safety agencies are heavy users of technology to vastly improve response to incidents and medical emergencies. Surveillance cameras are being widely deployed to enhance security at rest stops and other locations.

A range of ITS technologies assist in improving safety and security by assisting in:

- Responding to Emergency Situations
- Hazardous Materials Management
- Automating Enforcement
- Improving Transportation System Security

ITS technology has been deployed extensively to improve safety and security. Section 6.1 covers systems that aid in responding to emergency situations, including public safety fleet management technologies, systems aiding mobilization and response, and emergency medical services. Section 6.2 covers hazardous materials management systems. Section 6.3 covers statewide/rural deployment of crash prevention and safety systems. Section 6.4 covers automated enforcement systems, while section 6.5 outlines the use of surveillance systems to improve transportation security on highways and transit.

6.1 Responding to Emergency Situations

Figure 17 shows deployment trends for three key ITS technologies associated with emergency management from 1997 to 2007 in 78 of the largest metropolitan areas. The most widely deployed technology is computer aided dispatch, which covered over 80% of emergency management vehicles by 2007, nearly double the level of deployment in 1997. Deployment of vehicle navigation has increased from almost no deployment in 1997 to one fourth of emergency management vehicles in 2007. The deployment of emergency management vehicles equipped to operate with traffic signals supporting preemption has increased steadily over the period to about 7% of the emergency vehicle fleet.

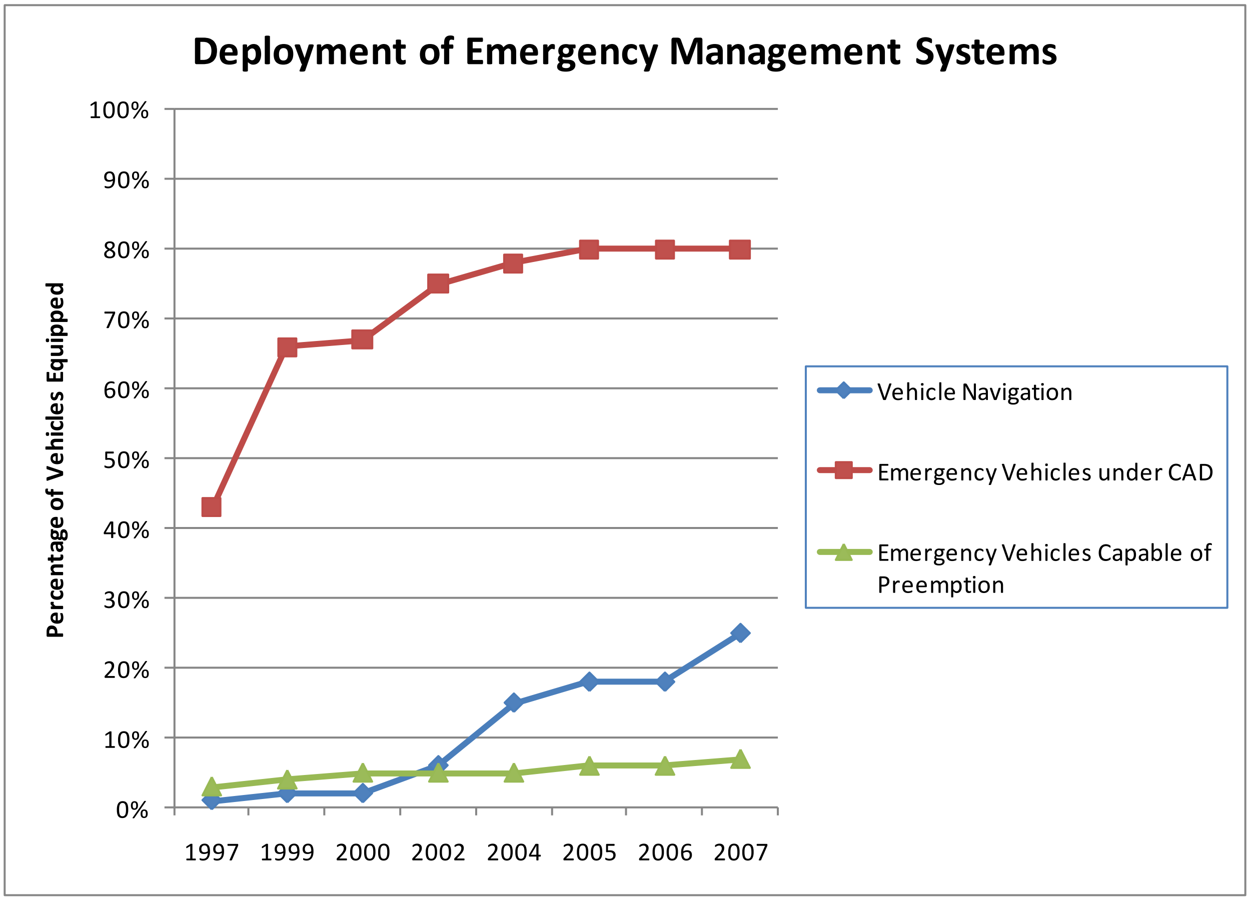


Figure 17: Trends for Deployment of Emergency Management Systems 1997-2007

6.1.1 Mobilization & Response

Deployment of technology is having a profound impact on emergency response. The variety of sensors deployed on the transportation infrastructure can help provide an early warning system to detect large-scale emergencies, including natural disasters and technological and man-made disasters. In the event of a large-scale emergency, ITS applications can assist with response management through services such as the tracking of emergency vehicle fleets using automated vehicle location (AVL) technology and two-way communications between emergency vehicles and dispatchers. Evacuation operations often require a coordinated emergency response involving multiple agencies, various emergency centers, and numerous response plans. Integration of public safety agencies with traffic and transit management systems enables emergency information to be shared between public and private agencies and the traveling public. This communication and cooperation also enables the use of the variety of ITS information dissemination capabilities to provide emergency traveler information. Table 11 shows the number of metropolitan areas in which public safety agencies have adopted various emergency mobilization and response technologies. Adoption data are broken out by agency type: law enforcement and fire/rescue. Systems supporting dispatch, detection, investigation, and evacuation management are very widely adopted.

Emergency Mobilization and Response Systems			
Technology	**Description**	**Number of Metropolitan Areas Law Enforcement**	**Number of Metropolitan Areas Fire/Rescue**
Dispatch	Automatic vehicle location and computer aided dispatch to locate and assign responders to incidents	76	70
Detection	Monitoring early warning alerting and advisory systems to identify emergencies	71	60
Investigation	Technologies (e.g., total station, surveying equipment, laser, close range photogrammetry, or forensic mapping) to speed the investigation of incident scenes	68	N/A
Evacuation Management	Integrated ITS and communications technology to coordinate evacuation management with different agencies, including traffic management and transit	65	34
Response	Use of response routing systems by emergency responders to assist in identifying the quickest safe route to incident locations	49	34
	Emergency response vehicles with traffic signal preemption capability	29	55
Emergency Information	A dedicated emergency traveler information system	29	12

Table 11: Adoption of Emergency Mobilization and Response Systems

6.1.2 Emergency Medical Services

Advanced Automated Collision Notification (ACN) and telemedicine address the detection of and response to incidents such as vehicle collisions or other incidents requiring emergency responders. In rural areas, response time for emergency medical services is greater than in metropolitan areas, resulting in more severe consequences for those in need of medical assistance and greater need for information. Advanced ACN systems can notify emergency personnel and provide them with valuable information on the crash, including location, crash characteristics, and possible relevant medical information regarding the vehicle occupants. An alternative source of incident information is for public safety agencies to have access to data from commercial systems, such as OnStar. Telemedicine systems provide a link between responding ambulances and emergency medical facilities, enabling doctors to advise emergency medical personnel regarding treatment of patients en route to the hospital. Information in these systems can be transmitted via data links and voice. Table 12 shows the number of metropolitan areas in which law enforcement and fire/rescue agencies have adopted these emergency medical technologies. The deployment of telemedicine systems on ambulances is widespread, while a significant number of metropolitan areas have access to public and commercial collision alerting systems.

Emergency Medical Systems			
Technology	**Description**	**Number of Metropolitan Areas Law Enforcement**	**Number of Metropolitan Areas Fire/Rescue**
Telemedicine	Ambulances equipped with telemedicine capability	N/A	44
Automated Collision Notification (ACN)	Public safety agencies have access to Automatic Collision Notification (ACN) data	14	5
Commercial Alerting Systems	Public safety agencies with access to data from commercial systems (e.g., OnStar)	10	3
Advanced ACN	Public safety agencies have access to Advanced ACN	2	0

Table 12: Adoption of Emergency Medical Systems

6.2 Hazardous Materials Management

ITS applications associated with hazardous materials (HAZMAT) shipment can accomplish four major functions intended to provide safe and secure transport of hazardous materials by road. Vehicle-mounted hardware provides the capability to track HAZMAT shipments and support notification of management centers when a shipment deviates from its intended route. Roadside detectors can monitor for the presence of hazardous shipments in sensitive areas and, if electronic tag information is available on the detected vehicle, confirm that the shipment is on the expected route. Driver authentication technology can confirm that the individual operating a HAZMAT vehicle is authorized to do so and report operation by unexpected drivers to public safety entities. ITS can also provide assistance to commercial vehicle operations via electronic route planning services, ensuring compliance with HAZMAT shipment restrictions along planned travel routes. Of these, the use of driver authentication technology is most widely deployed. Table 13 shows the number of metropolitan areas in which law enforcement and fire/rescue agencies have adopted these technologies. The most widely adopted of these HAZMAT management systems is the use of driver authentication technology by law enforcement agencies.

HAZMAT Management Systems			
Technology	**Description**	**Number of Metropolitan Areas Law Enforcement**	**Number of Metropolitan Areas Fire/Rescue**
Driver Authentication	Driver authentication technology to confirm that the individual operating a HAZMAT vehicle is authorized to do so	19	3
Detection	Roadside detectors to monitor for the presence of hazardous shipments in sensitive areas	6	2
Tracking	Vehicle-mounted hardware to track HAZMAT shipment to detect when a shipment deviates from its intended route	4	1
Route Planning	Technology to provide assistance to commercial vehicle operators via electronic route planning services	5	1

Table 13: Adoption of HAZMAT Management Systems

6.3 Statewide Crash Prevention and Safety Systems

A variety of different types of crash prevention and safety systems have been deployed statewide in rural locations, based on a 2007 survey of each of the 50 state departments of transportation. These systems are deployed rural settings to address specific safety issues at spot locations. Operation in remote sites requires sophistication in the use of automation to ensure the effectiveness of systems operating in a stand-alone mode. Road geometry warning systems can provide automated alert to specific vehicles operating in an unsafe manner approaching curves, downhill grades, ramps, and low overhead clearance situations. Highway-rail warning systems provide warnings to vehicles of approaching trains. Intersection warning systems monitor traffic approaching on crossing roads and provide warnings. Pedestrian safety systems warn vehicles of the presence of pedestrians in cross walks, while bicycle warning systems similarly provide warnings of their presence in tunnels or narrow bridges. Finally, animal warning systems detect the presence of animals and provide warnings to approaching vehicles. Table 14 shows results from a survey of each of the 50 state departments of transportation concerning statewide or rural deployment. The various road geometry and warning systems are the most widely deployed, followed by highway rail crossing and pedestrian safety systems.

Statewide Crash Prevention and Safety Systems		
Technology	**Description**	**Number of States**
Road Geometry Warning Systems	Automated overheight/overwidth warning systems that use roadside detectors and electronic warning signs to warn drivers of vehicles that are too tall or wide to pass under bridges or through tunnels	23
	Automated warnings of excessive speeds approaching freeway ramps	11
	Automated warnings for vehicles approaching too fast for curves on highways	11
	Automated warnings for vehicles approaching downhill grades	6
Highway-Rail Crossing Systems	Use of sensors to detect and warn vehicles of approaching trains at highway-rail crossings statewide and in rural areas	16
Pedestrian Safety	Automated systems to protect pedestrians by alerting drivers as pedestrians enter crosswalks	15
Animal Warning Systems	Automated systems that detect large animals approaching the roadway and provide warnings to travelers	8
Intersection Collision Warning	Automated sensors to monitor traffic approaching dangerous intersections and warn vehicles of approaching cross traffic	7
Bicycle Warning Systems	Use of detectors and electronic warning signs to identify bicycle traffic and notify drivers to improve safety on narrow bridges and tunnels	4

Table 14: Adoption of Statewide Crash Prevention and Safety Systems

6.4 Automated Enforcement Systems

Automated enforcement systems, such as speed enforcement and stop/yield enforcement, improve safety, reduce aggressive driving, and assist in the enforcement of traffic signal and speed compliance. Table 15 shows that these systems are well established on arterials.

Automated Enforcement Systems			
Technology	**Description**	**Number of Metropolitan Areas Freeway**	**Number of Metropolitan Areas Arterial**
Speed Enforcement	Automated speed enforcement technologies	5	25
Stop/Yield Enforcement	Signalized intersections with automated photo red light running enforcement	N/A	31

Table 15: Adoption of Automated Enforcement Systems

6.5 Improving Transportation System Security

Highway agencies and transit operations are concerned about maintaining safe and secure facilities. Closed-circuit television (CCTV) provides highway and transit agencies with the capability to observe assets in order to identify potential security threats.

6.5.1 Enhancing Highway Security

Surveillance cameras have been deployed on both freeways and arterials to provide added security. Table 16 shows that deployment on freeways is well established, while deployment on arterials is limited, although it has been adopted by a majority of metropolitan areas.

Highway Security Systems			
Technology	**Description**	**Percent Miles Covered**	**Number of Metropolitan Areas**
Freeway Security Surveillance	Freeway centerline miles covered by real-time traffic data collection monitored for security purposes	39%	53
Arterial Security Surveillance	Arterial centerline miles covered by real-time traffic data collection monitored for security purposes	1%	45

Table 16: Deployment of Highway Security Systems

6.5.2 Transit Security Systems

Advanced software and communications enable data as well as voice to be transferred between transit management centers and transit vehicles for increased safety and security, improved transit operations, and more efficient fleet operations. Transit management centers can monitor in-vehicle and in-terminal surveillance systems to improve quality or service and improve the safety and security of passengers and operators. Table 17 shows that deployment of transit surveillance systems is widespread, with more than half of the fixed route buses being equipped. Deployment at facilities such as bus stops, bus depots, and rail stations is also well established.

Transit Security Systems			
Technology	**Description**	**Percent Fleet or Facilities Equipped**	**Number of Metropolitan Areas**
In-Vehicle Surveillance	Fixed route buses with audio or video surveillance to enhance security	51%	63
	Demand responsive buses with audio or video surveillance to enhance security	18%	33
	Light rail vehicles with audio or video surveillance to enhance security	46%	11
Facility Surveillance	Bus depots with audio or video surveillance to enhance security.	34%	39
	Rail stations with audio or video surveillance to enhance security.	23%	23
	Bus stops with audio or video surveillance to enhance security	1%	15

Table 17: Deployment of Transit Security Systems

7 Integration

From the inception of the national ITS program, the use of technology in support of real-time interagency integration to form a unified regional traffic control system has been a central concept. Individual agencies routinely generate information that is used for purposes internal to that component which can have a significantly increased impact if shared. For example, a traffic signal agency may use sensors to monitor traffic conditions to revise signal timing in response to changes in conditions. Other agencies can make use of this information in formulating their own control strategies, for example when transit agencies alter routes and schedules based on real-time information on arterial traffic conditions, or freeway agencies alter ramp metering or diversion recommendations based on the same information. The same information can be shared with travelers to support pre-trip and en-route decision-making.

Figure 18 portrays the national summary indicators for integration. ITS integration is measured using 34 links that have been defined within the ITS infrastructure. These links are both inter-component (e.g., the sharing of arterial and freeway traffic condition information between freeway and arterial management agencies) and intra-component (e.g., the sharing of traffic signal timing information between arterial management agencies). Interagency integration can be defined by a set a links, which are described in Appendix 1. The measure of integration is the simple calculation of the number of agencies that participate in integration compared to the total number of agencies that possibly could (see Appendix 2 for a fuller explanation).

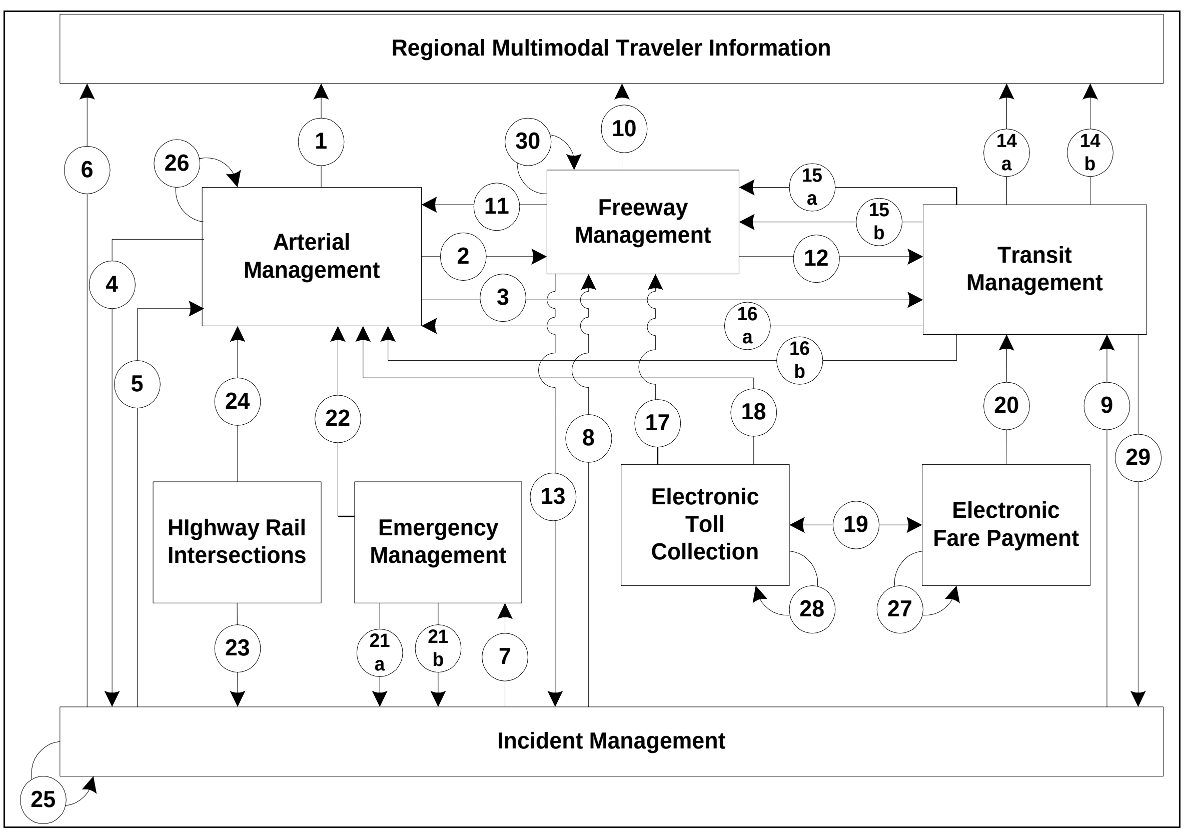


Figure 18: Integration Links

In order to make the discussion of individual links clearer, links have been grouped into four broad categories: (1) Traffic Management Integration, (2) Traveler Information Integration, (3) Transit Management Integration, and (4) Emergency Response Integration. The relative amount of integration is indicated by the shading in the circles associated with each integration link in Figures 19 to 22.

7.1 Traffic Management Integration

Traffic Management Integration enables the implementation of coordinated traffic management strategies among operating agencies responsible for Freeway Management, Incident Management, and Arterial Management within a metropolitan area.

Figure 19 presents an overview of the integration links that define Traffic Management Integration. Freeway management and incident management are well integrated. Other interagency integration is more limited, however. In particular, integration between freeway, arterial, and transit management is quite limited.

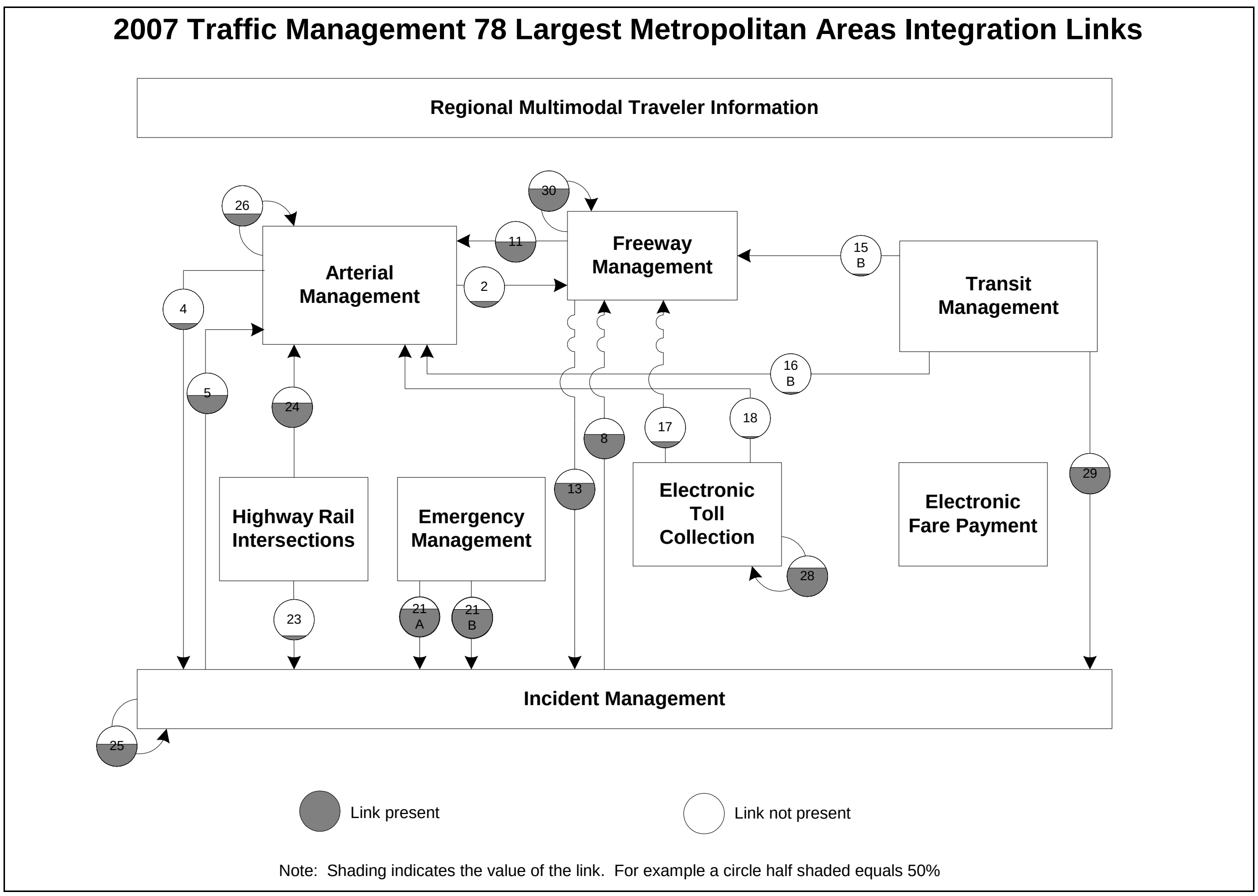


Figure 19: Traffic Management Integration Links

7.2 Traveler Information Integration

The collection, processing, and distribution of timely information related to the performance of the transportation system is a by-product of integrating selected metropolitan ITS components. Information gathered by Freeway Management, Incident Management, Arterial Management, and Transit Management components is fused to create a region-wide traveler information database. Information in the database is then transferred to various media for display to travelers. Travelers receiving this information can make better-informed decisions regarding if, when, where, and how to travel, which may lead to an increase in travel efficiency and a reduction in travel congestion and delay. Figure 20 presents an overview of the integration links that define Traveler Information Integration. Arterial management information is only rarely made available to travelers. On the other hand, transit information, particularly schedule information, is widely available. Information on incidents is also widely disseminated.

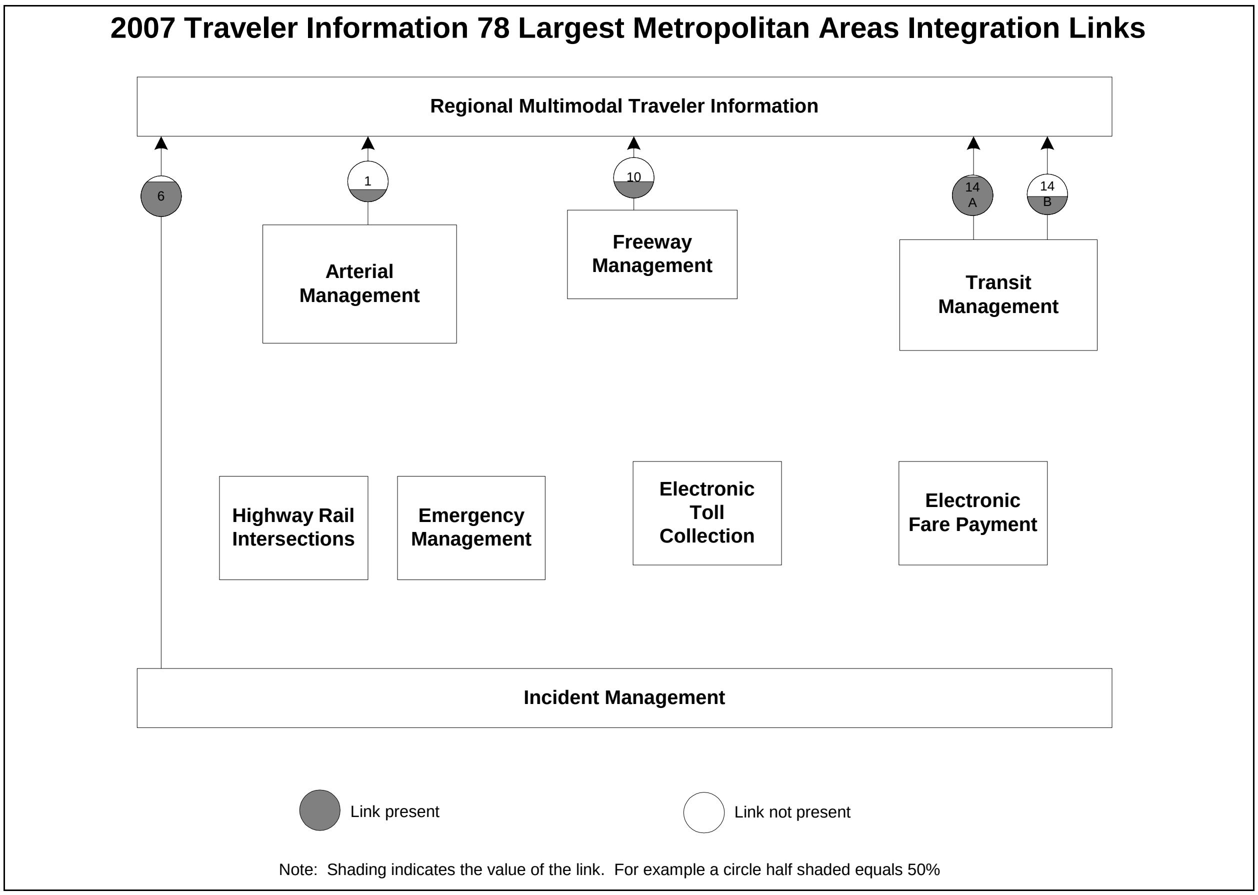


Figure 20: Traveler Information Integration Links

7.3 Transit Management Integration

Transit Management Integration provides public transit operators with information and control capabilities to better manage transit system on-time performance. Transit Management Integration also exploits the use of EFP media to improve the efficiency of route planning and financial management. Figure 21 presents an overview of the integration links that define Transit Management Integration. Overall, transit agencies are not well integrated into the ITS information infrastructure.

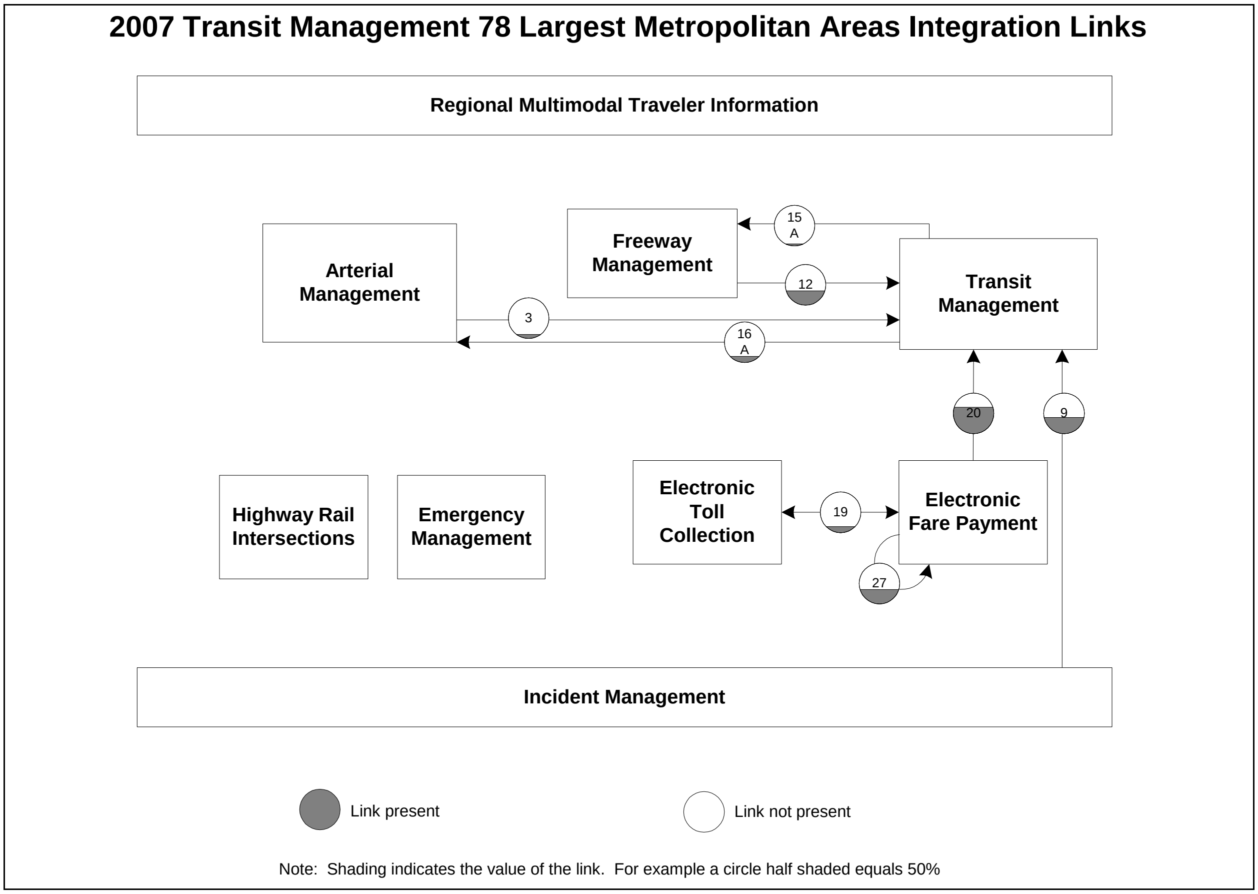


Figure 21: Transit Management Integration Links

7.4 Emergency Response Integration

Emergency Response Integration increases emergency response capabilities through improved incident notification from Incident Management and traffic signal preemption provided by Arterial Management. Figure 22 presents an overview of the integration links that define Emergency Response Integration.

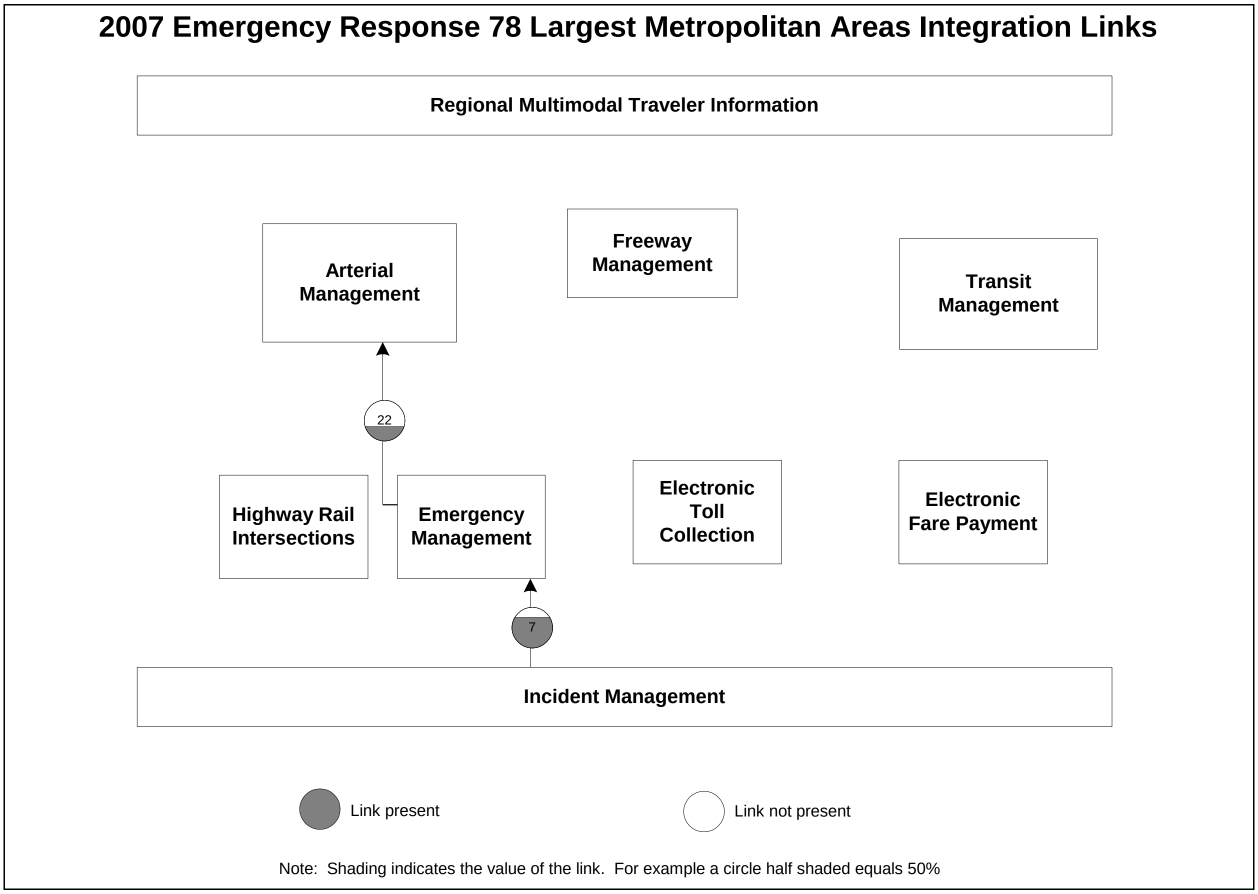


Figure 22: Emergency Response Integration Links

8 Future Research issues

A number of issues emerge from an analysis of deployment tracking results that may impact the continued growth of ITS deployment and, looking ahead, the IntelliDrive program. These issues may be fruitful areas for further research.

- Use of commercial data sources. Will agencies be more likely to purchase data vs. purchasing sensors to meet new Federal rules regarding traveler information? Is there a Federal role in overcoming hesitancy in purchasing data by states? Do agencies need to be provided help to buy data they need vs. what is available (how do we make agencies smart consumers)?

- Using new capabilities offered by technology. How do we take advantage of better information that will be available in a fully deployed IntelliDrive environment? How might the operation of freeways as well as traffic signals change in an environment of accurate real-time information on vehicle location, speed, type, and even planned route?

- Commitment to operations. Are local agencies committed to actively operating the transportation system? The deployment trends for technologies involved with active control of freeway traffic--ramp metering, lane control—show almost no growth in adoption by metropolitan areas over the last few years. This appears to indicate a lack of commitment to an active role in operations by freeway managers.

- Cultural issues. Are travelers comfortable for automated systems envisioned as part of the IntelliDrive program? One example is the limited deployment of red light running detection systems. In many communities, citizens are unhappy with automated ticketing in which there is no possibility of disputing the call. Furthermore, citizens are skeptical of for-profit firms being involved with enforcement, and they think that profits, rather than safety is the main goal of the deployment. The result is that even though local law enforcement reports improvements in safety through reduction of crashes, these systems are unpopular. Do local agencies need assistance in 'selling' technology?

- Integration. Why are agencies not more tightly integrated? One of the central concepts of the ITS program has been that technology will allow agencies to tightly integrate operations to support regional traffic management. Deployment tracking data show that integration lags deployment. More agencies collect data than share data with other agencies. While there are a number of technical issues that make real-time integration a challenge, the significant effort that has been put into overcoming barriers through efforts like the development of ITS standards, message sets, and data dictionaries. Instead, institutional issues seem to be the main barrier to further integration. The full potential of an IntelliDrive infrastructure will not be realized without a firm commitment by agencies to coordinate actions and integrate systems.

- Measuring performance. What is the role of performance measures and performance goals or guidelines in making decisions to deploy ITS technology? Would development of federal goals or guidelines for performance of transportation agencies lead to more uniform deployment of technology? Would this action be effective in promoting a uniform level of service to travelers nationwide?

- Procurement of technology. Many agencies report problems with the acquisition of technology. Lack of familiarity with important technical issues during procurement of technology often creates operational problems as well as difficulty with interoperability and supportability. Anecdotal accounts from state and local points of contact indicate that these issues impede making a decision to deploy. Is there a Federal role in assisting state and local agencies in procuring ITS technology?

- Transit technology. Which types of transit properties have implemented Traffic Signal Priority? Does implementation vary by size of operator? What is the nature of cooperation required between transit operators and transit operators to implement these systems?

- Metropolitan Area Characteristics. How does metropolitan area size impact the level of deployment that has been observed? The rate of population growth may have an impact as well. How do characteristics of the transportation network impact deployment? For example, ramp configuration impacts the feasibility of ramp metering. Metropolitan areas differ in their reliance on arterials compared to freeways and may have corresponding differences in needs for ITS technology.

- Funding. How are local agencies funding the deployment of technology? Can we relate the use of Congestion Mitigation and Air Quality funds to the level of deployment? In other words, are agencies relying on CMAQ money to fund ITS to reduce emissions?

APPENDIX 1: INTEGRATION LINK DESCRIPTIONS

Link	Description	Purpose
1	Arterial Management to Regional Multimodal Traveler Information	Arterial travel time, speed, and condition information are displayed by Regional Multimodal Traveler Information media.
2	Arterial Management to Freeway Management	Freeway Management Center monitors arterial travel times, speeds, and conditions using data provided from Traffic Signal Control in order to adjust ramp meter timing, lane control or HAR in response to changes in real-time conditions on a parallel arterial.
3	Arterial Management to Transit Management	Transit Management adjusts transit routes and schedules in response to arterial travel times, speeds, and conditions information collected as part of Traffic Signal Control.
4	Arterial Management to Incident Management	Incident Management monitors real-time arterial travel times, speeds, and conditions using data provided from Traffic Signal Control to detect arterial incidents and manage incident response activities.
5	Incident Management to Arterial Management	Traffic Signal Control monitors incident severity, location, and type information collected by Incident Management to adjust traffic signal timing or information provided to travelers in response to incident management activities.
6	Incident Management to Regional Multimodal Traveler Information	Incident location, severity, and type information are displayed by Regional Multimodal Traveler Information media.
7	Incident Management to Emergency Management	Incident severity, location, and type data collected as part of Incident Management are used to notify Emergency Management for incident response.
8	Incident Management to Freeway Management	Incident severity, location, and type data collected by Incident Management are monitored by Freeway Management for the purpose of adjusting ramp meter timing, lane control or HAR messages in response to freeway or arterial incidents.

Link	Description	Purpose
9	Incident Management to Transit Management	Transit Management adjusts transit routes and schedules in response to incident severity, location, and type data collected as part of Incident Management.
10	Freeway Management to Regional Multimodal Traveler Information	Freeway travel time, speed, and condition information are displayed by Regional Multimodal Traveler Information media.
11	Freeway Management to Arterial Management	Freeway travel time, speeds, and conditions data collected by Freeway Management are used by Traffic Signal Control to adjust arterial traffic signal timing or arterial VMS messages in response to changing freeway conditions.
12	Freeway Management to Transit Management	Transit Management adjusts transit routes and schedules in response to freeway travel times, speeds, and conditions information collected as part of Freeway Management.
13	Freeway Management to Incident Management	Incident Management monitors freeway travel time, speed, and condition data collected by Freeway Management to detect incidents or manage incident response.
14a	Transit Management to Regional Multimodal Traveler Information (static route information)	Transit routes, schedules, and fare information are displayed on Regional Multimodal Traveler Information media.
14b	Transit Management to Regional Multimodal Traveler Information (schedule adherence information)	Transit schedule adherence information is displayed on Regional Multimodal Traveler Information media.
15a	Transit Management to Freeway Management	Freeway ramp meters are adjusted in response to receipt of transit vehicle pre-emption signal.
15b	Transit Management to Freeway Management (transit vehicle probes)	Transit vehicles equipped as probes are monitored by Freeway Management for the purpose of determining freeway travel speeds or travel times.
16a	Transit Management to Arterial Management	Traffic signals are adjusted in response to receipt of transit vehicle pre-emption signal.
16b	Transit Management to Arterial Management (transit vehicle probes)	Transit vehicles equipped as probes are monitored by Traffic Signal Control for the purpose of determining arterial speeds or travel times.
17	Electronic Toll Collection to Freeway Management (ETC equipped probes)	Vehicles equipped with electronic toll collection (ETC) tags are monitored by Freeway Management for the purpose of determining freeway travel speeds or travel times.

Link	Description	Purpose
18	Electronic Toll Collection to Arterial Management (ETC equipped probes)	Vehicles equipped with electronic toll collection (ETC) tags are monitored by Traffic Signal Control for the purpose of determining arterial travel speeds or travel times.
19	Electronic Fare Payment and Electronic Toll Collection	Transit operators accept ETC- issued tags to pay for transit fares.
20	Electronic Fare Payment to Transit Management	Rider ship details collected as part of Electronic Fare Payment are used in transit service planning by Transit Management.
21a	Emergency Management to Incident Management (incident notification)	Incident Management is notified of incident location, severity, and type by Emergency Management for the purpose of identifying incidents on freeways or arterials.
21b	Emergency Management to Incident Management (incident clearance)	Incident Management is notified of incident clearance activities by Emergency Management for the purpose of managing incident response on freeways or arterials.
22	Emergency Management to Arterial Management	Emergency Management vehicles are equipped with traffic signal priority capability.
23	Highway-rail intersections to Incident Management (crossing status)	Incident Management is notified of crossing blockages by Highway-rail intersection for the purpose of managing incident response.
24	Highway-rail intersections to Arterial Management (crossing status)	Highway-rail intersection and Traffic Signal Control are interconnected for the purpose of adjusting traffic signal timing in response to train crossing.
25	Incident Management intra-component	Agencies participating in formal working agreements or incident management plans coordinate incident detection, verification, and response.
26	Arterial Management intra-component	Agencies operating traffic signals along common corridors sharing information and possibly control of traffic signals to maintain progression on arterial routes.
27	Electronic Fare Payment intra-component.	Operators of different public transit services share common electronic fare payment media.
28	Electronic Toll Collection intra-component	Electronic Toll Collection agencies share a common toll tag for the purpose of facilitating “seam less” toll transactions.
29	Transit Management to Incident Management (incident reporting)	Transit agency operators or dispatchers report traffic incidents (e.g. stalled vehicles, crashes) as part of an organized regional incident management program.

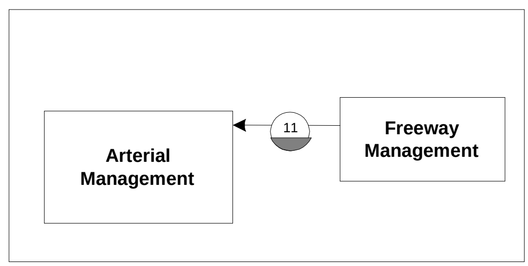
Link	Description	Purpose
30	Freeway Management intra-component	Freeway travel time, speeds, and conditions data collected by Freeway Management agencies are used by other Freeway Management agencies in response to changing freeway conditions for the purpose of adjusting ramp meter timing, lane control or HAR messages in response to freeway or arterial incidents.

APPENDIX 2: HOW TO READ INTEGRATION CHARTS

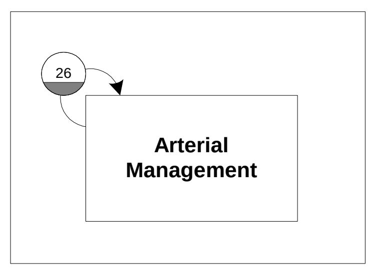
Figure 18 portrays the national summary indicators for integration. Indicators were developed to measure the level of integration between infrastructure components using a set of defined links (both inter- and intra-component).

A total of 34 individual integration links were specified. Each integration link has been assigned a number and an origin/destination path from one ITS infrastructure component to another. Both inter- and intra-agency links are considered.

For example, the number "11" identifies the integration of information from the Freeway Management component to the Arterial Management component. Each link represents the real-time sharing of information flowing in a particular direction. In the example, freeway management agencies within a metropolitan area share information gathered on traffic conditions with arterial management agencies to improve coordination of traffic control.



Another type of integration link defines the integration of agencies in the same infrastructure component. In this example, at least one arterial management agency in a metropolitan area shares information on signal timing with another to support regionally coordinated signal control. The extent of integration is reported in the diagram for each link through the level of shading in the circle.



The measurement of integration associated with each of the links is agency-based. The calculation is simple and is an expression of the number of agencies that share data divided by the total number of agencies that possibly could. Therefore, for each of the integration links, a percentage integration score, ranging from zero to one hundred, is assigned. The circle is shaded accordingly to reflect this percentage. As with the deployment indicators, this rating system is based on the maximum possible integration without consideration of whether it is needed in every case.