TRANSIT MANAGEMENT

FIFTY-SIX (56) PERCENT OF TRANSIT BUSES IN MAJOR METROPOLITAN AREAS ARE EQUIPPED WITH AVL TECHNOLOGIES.

TRANSIT

The transit industry in the United States consists of over 140,000 vehicles, 48 billion passenger miles of travel, and $8.5 billion in passenger fares. Over the past 10 years the transit industry has grown by over 20 percent—faster than either highway or air travel.[261]

Transit operations and fleet management ITS applications improve transit reliability through implementation of automated vehicle location (AVL) and computer-aided dispatch (CAD) systems which can reduce passenger wait times. The systems enhance security and improve incident management through improved vehicle-to-dispatch communications, enabling quicker response to aggressions, accidents and vehicle breakdowns. Speedy response to these types of incidents minimizes vehicle downtime and improves service reliability. Information on current vehicle location and schedule status can also support transit signal priority, which improves transit trip times and schedule adherence. Data records from AVL/CAD systems, along with automated passenger counters, are enabling a transition to improved transit planning and management strategies which rely on large quantities of data regarding system operations. This contrasts with many traditional management strategies which were developed to accommodate minimal data on system operations, limited by manual data collection requirements.[262] Vehicle monitoring technologies can allow transit vehicles to perform self-diagnostic tests and automatically alert maintenance personnel of potential problems, either immediately via AVL/CAD systems or through routine downloads at vehicle maintenance facilities.

Public access to bus location data and schedule status information is increasingly popular on transit agency Web sites. Passengers can confirm scheduling information, improve transfer coordination, and reduce wait times. In addition, electronic transit status information signs at bus stops help passengers manage their time, and on-board systems such as next-stop audio annunciators help passengers in unfamiliar areas reach their destinations.

Web-based multi-modal trip planners are in development, providing information on trip travel times by both automobile and public transportation services. The Federal Transit Administration is sponsoring development of such a system managed by the Regional Transportation Authority of Northeast Illinois. The system will enable Chicago area travelers to navigate an extensive network of bus and rail services, tollways, expressways, and major arterials. The concept of the Chicago area Web-based Multi-Modal Trip Planning System is to integrate driving itineraries, transit trip planners, and real-time monitoring systems to provide side-by-side comparisons of trip itineraries using transit, driving, or any combination of non-motorized modes such as biking and walking. The goal is to create a comprehensive decision support tool for choosing travel options that incorporate convenience, efficiency, and cost—from the traveler's perspective.

A growing role for ITS in the transit industry includes support for bus rapid transit (BRT). These transit lines typically supplement infrastructure-based improvements with transit ITS to provide service qualities approaching those of rail transit facilities. Infrastructure-based improvements to BRT lines include enhanced shelters, level boarding facilities, and priority treatments such as dedicated transit lanes or queue-jump lanes at congested intersections. ITS technologies typically deployed include transit signal priority and AVL/CAD for enhanced schedule performance, and improvements to traveler information that include in-vehicle annunciators and the provision of wayside arrival time information at major stops along the line.

TRANSIT MANAGEMENT CATEGORIES IN THE ITS KNOWLEDGE RESOURCES

Operations and Fleet Management

- Automatic Vehicle Location and Computer-Aided Dispatch
- Transit Signal Priority
- Maintenance
- Planning
- Service Coordination

Information Dissemination

- In-Vehicle Systems
- In-Terminal/Wayside
- Internet/Wireless/Phone

Transportation Demand Management

- Ride Sharing/Matching
- Dynamic Routing/Scheduling

Safety and Security

- In-Vehicle Surveillance
- Facility Surveillance
- Employee Credentialing
- Remote Disabling Systems

OTHER ITS KNOWLEDGE RESOURCE CATEGORIES RELATED TO TRANSIT MANAGEMENT

Refer to other chapters in this document.

Electronic Payment and Pricing

- Transit Fare Payment
- Multi-use Payment

Traveler Information

- Pre-Trip Information
- En Route Information

Information Management

- Data Archiving

Collision Avoidance

- Obstacle Detection
- Lane Change Assistance
- Lane Departure Warning
- Road Departure Warning
- Forward Collision Warning
- Rear Impact Warning

Driver Assistance

- Precision Docking
- Coupling/Decoupling

ITS applications can also support transportation demand management activities including carpooling and ridesharing services, and enable flexible, door-to-door paratransit service that is typically provided for disabled travelers. Computer databases and Internet technologies can facilitate ride sharing and carpool matching services to reduce peak period travel along major commuter routes. Paratransit services increase public access to transit resources where coverage is limited or provide service to those who cannot access standard service. ITS can improve these services through data collection technology and software supporting better coordination of service providers and scheduling of trips, or by supporting innovative strategies, such as route deviation or zone-based demand-responsive feeder service to fixed routes. These latter strategies enable transit systems to provide access for those living in close proximity to scheduled transit services but unable to reach them. Use of ITS technologies to support paratransit services represents another growing area of transit ITS deployment. Applications for human services transportation that improve scheduling and service coordination among multiple providers can be cost-effective and provide enhanced service to travelers. Several of these concepts are included in the Mobility Services for All Americans (MSAA) initiative discussed below.

Transit ITS services include a number of other ITS applications that can help transit agencies increase safety and security, as well as enhance the operational efficiency of the Nation's transit 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 in several cities have the ability to monitor in-vehicle and in-terminal surveillance systems to improve quality of service and improve the safety and security of passengers and operators.

Several ITS technologies discussed elsewhere in this document have significant impacts on public transit systems. Electronic fare payment systems offer significant potential for transit agencies to streamline cash-handling processes and the potential for simplifying traveler access to multiple transit systems in a region. Also of interest are advanced traveler information systems (ATIS), which can include transit information, as in the case of the multi-modal trip planner discussed above. ITS data archiving can provide important information for transit planning and management. Finally, several vehicle-based collision avoidance technologies have been tested on transit vehicles and show promise for lessening the likelihood of crashes involving transit vehicles.

In addition to the ITS technologies profiled in this chapter, two major ITS initiatives will impact the development of ITS technologies for transit: MSAA and Integrated Corridor Management (ICM).

The goal of the MSAA initiative is to improve transportation services and simplify access to employment, healthcare, education, and other community activities by means of the advanced technologies of ITS and through extending transportation service partnerships with consumers and human service providers at the Federal, State, and local levels. Several ITS technologies profiled in this chapter will be deployed in support of this initiative including integrated vehicle dispatching and scheduling, AVL, communication systems, electronic payment systems/financial tracking and billing systems, and ATIS.[263]

The purpose of the ICM initiative is to demonstrate that ITS technologies can be used to efficiently and proactively manage the movement of people and goods in major transportation corridors by facilitating integration of the management of all networks in a corridor. The results of the initiative will help to facilitate widespread use of ICM tools and strategies to improve mobility through integrated management of transportation assets. The ICM initiative will also demonstrate how proven and emerging ITS technologies can be used to coordinate the operations between separate corridor networks (including both transit and roadway facilities) to increase the effective use of the total transportation capacity of the corridor.[264]

Additional information on both of these initiatives is available at the ITS JPO's Web site: *www.its.dot.gov/msaa* and *www.its.dot.gov/icms*.

AVL/CAD SYSTEMS IMPROVED SCHEDULE ADHERENCE BY 9 TO 23 PERCENT IN 3 U.S. CITIES.

Findings

Benefits

Fleet management applications can improve both the experience of transit riders and the efficiency of transit operations by enabling more efficient planning, scheduling, and management of transit assets and resources. Transit agencies have reported reductions in fleet requirements ranging from two to five percent as a result of improved fleet utilization.[265] For large agencies even small percentage gains can represent large amounts of actual operating cost savings.[266] Deployment of AVL/CAD and scheduling software has enabled cost savings for paratransit providers through better planning of trips. An innovative application of these technologies has also demonstrated that agencies operating fixed routes can provide the option of demand-responsive services.

Improving schedule reliability improves travelers' experiences by reducing wait time anxiety and simplifying successful connections to other transit services. Data from transit systems in Portland, Oregon; Milwaukee, Wisconsin; and Baltimore, Maryland show that AVL/CAD systems have improved schedule adherence by 9 to 23 percent. The systems enable better monitoring of transit system status by transit dispatchers and allow appropriate responses to early arrivals, bus bunching, and other operational challenges as they arise.[267] Figure 8 shows the range of documented experiences with improvements in transit travel times after the implementation of transit signal priority, with improvements ranging from 1.5 to 15 percent.[268] Several studies show a range of measurements, typically representing measurements during peak periods and off-peak periods, or results for a variety of signal priority scenarios tested. Transit signal priority is often implemented on a conditional basis intended to help transit vehicles improve schedule performance by granting signal priority when vehicles are behind schedule. This practice can lead to a reduced need for recovery time in the scheduled trip and improve transit travel times. Archived data from AVL/CAD systems can also facilitate these types of schedule improvements.

Table 8 lists qualitative ratings for the impact of ITS applications for transit under each of the ITS goal areas identified by the U.S. DOT. These ratings demonstrate that each of the transit ITS applications have positive impacts on travelers' experiences. Applications supporting transit operations and fleet management provide substantial cost savings to transit operators, reduce transit vehicle emissions and energy consumption, and improve traveler mobility. Technologies supporting paratransit systems—listed under transportation demand management—have cost savings benefits for paratransit operators and improve customer experiences.

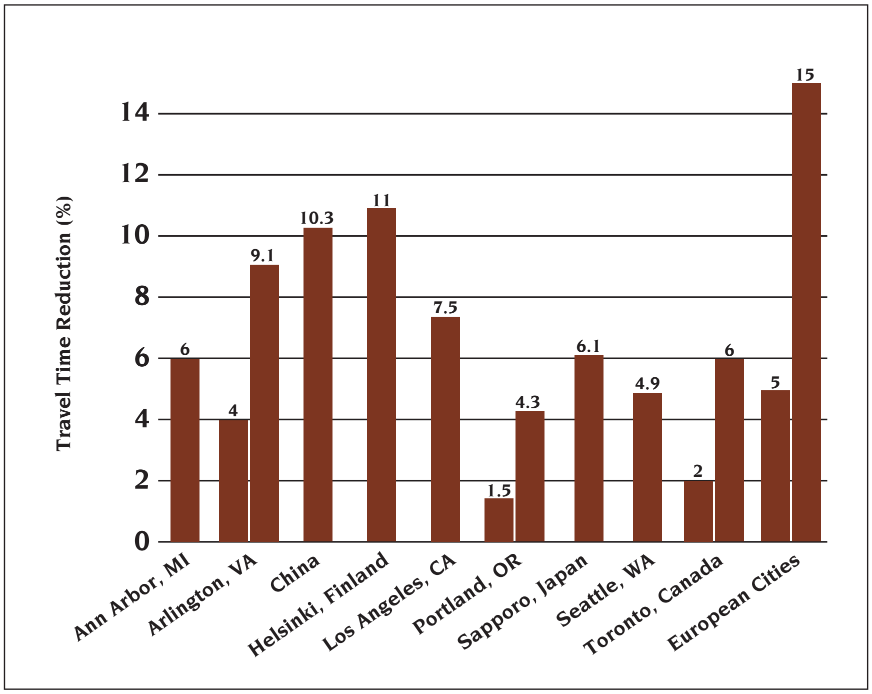

Figure 8 – Transit Travel Time Improvements with Transit Signal Priority

Table 8—Transit Management Benefits Summary	Safety	Mobility	Efficiency	Productivity	Energy and Environment	Customer Satisfaction
Operations and Fleet Management		●	✚	●	✚	●
Information Dissemination						●
Transportation Demand Management				●		✚
Safety and Security	✚					✚

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

CAPITAL COSTS FOR MOBILE DATA TERMINALS TYPICALLY RANGE BETWEEN $1,000 AND $4,000 PER UNIT.

Costs

Based on survey results from over 100 transit agencies and equipment suppliers, the trend in mobile data terminals (MDTs) is more functionality and lower unit, installation, maintenance, and repair costs. MDTs are multifunctional on-board devices that support two-way communication between the vehicle and the control center. The majority of MDTs are used to download driver manifests, collect driver data such as sign on/sign off and start run/end run, count passengers boarding and alighting, and to function as an emergency alarm. Capital costs for MDTs typically range between $1,000 and $4,000 per unit with installation costs frequently between $500 and $1,000.[269] In 2007, a comprehensive cost assessment of BRT components was conducted and found that on-board security systems typically cost approximately $10,000 per vehicle.[270]

Deployment

Figure 9 shows deployment trends for three key transit management technologies from 2000 to 2006, based on a survey of the country's 78 largest metropolitan areas. The use of AVL on fixed-route buses has expanded rapidly during this period, growing from 32 percent in 2000 to almost 60 percent in 2006. The percentage of demand-responsive paratransit vehicles under CAD has grown equally as fast. In 2006, 56 percent of demand-responsive paratransit vehicles operated under CAD. About one-third of fixed-route buses are equipped with sensors that monitor vehicle components in real time, although deployment of this technology has leveled off in the past few years.

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

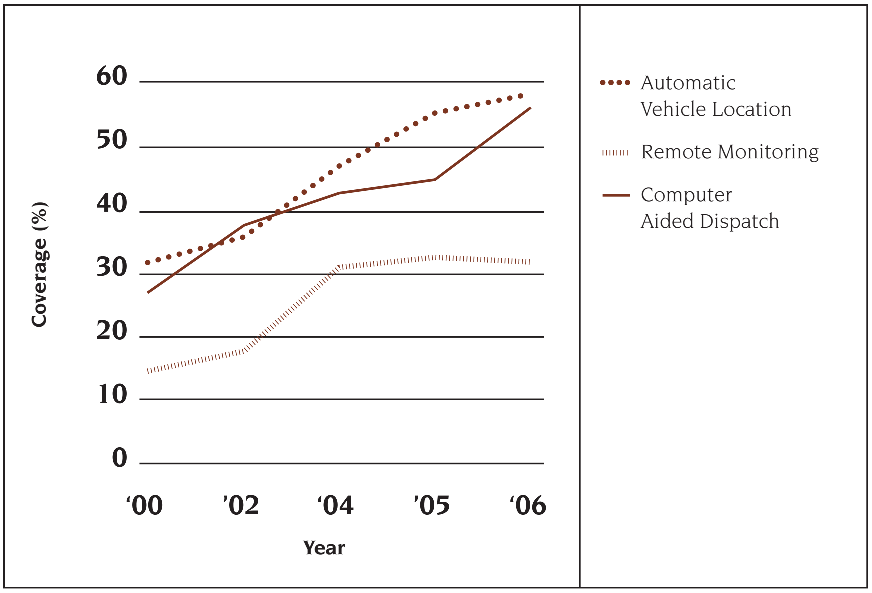

Figure 9 – Deployment Trends for Transit Management Technologies, 2000-2006

Selected Highlights from the ITS Knowledge Resources on Transit Management

Operations and Fleet Management

Transit operations and fleet management technologies improve transit reliability through implementation of AVL and CAD systems. These systems may also be implemented with in-vehicle self-diagnostic equipment to automatically alert maintenance personnel of potential problems. Automated passenger counters can provide additional data to support service planning. Service coordination, technologies can help assure connections between transit services at transfer points through a service commonly known as connection protection. Transit signal priority systems, through coordination with arterial management systems, can improve service quality and transit agency productivity.

Operations and Fleet Management	
Deployment	
The use of ITS to support fleet management has experienced wide acceptance among transit agencies in major metropolitan areas. More than half (56 percent) of fixed-route transit buses in the country's 108 largest metropolitan areas are equipped with AVL; 56 percent of demand-responsive paratransit vehicles operate under CAD; and 30 percent of fixed-route transit buses are equipped with technology to monitor vehicle components in real time. Thirty-nine (39) percent of transit agencies in these 108 metropolitan areas archive data on transit operations for later use.	
Benefits	
ITS Goals	**Selected Findings**
Mobility	***Summary Finding:*** Studies from transit systems in Portland, Oregon; Milwaukee, Wisconsin; and Baltimore, Maryland show that AVL/CAD systems have improved schedule adherence by 9 to 23 percent.[271]
Mobility	In Eindhoven, the Netherlands, on-board computers recorded daily transit performance. This information was used to plan minimum transit route times and increase schedule reliability.[272]
Efficiency	In Portland, Oregon, evaluation data show that AVL/CAD increased the effective capacity of the bus system by providing the same level of service to a greater number of travelers using the same equipment.[273]
Productivity	Analysis of archived bus travel time and passenger load data from the AVL/CAD system deployed in Portland, Oregon found that scheduled time on 81 of 104 routes could be shortened while the remaining 23 required additional time. Identified schedule changes could potentially yield $7 million in annual operating cost savings.[274]

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Operations and Fleet Management	
Benefits	
Customer Satisfaction	The Connection Protection system deployed by the Utah Transit Authority helped assure connections between higher frequency light rail transit service and lower frequency bus routes. The system resulted in a small, but not statistically significant, increase in the number of travelers satisfied with their travel experience: 87 percent with Connection Protection compared to 85 percent without it.[275]
Costs	
Unit Costs Data Examples (See Appendix A for more detail)	
Transit Management Center subsystem: • Upgrade for Automated Scheduling, Run Cutting, or Fare Payment: $19K-$39K • Integration for Automated Scheduling, Run Cutting, or Fare Payment: $219K-$486K Transit Center Labor: $100K-$400K (annually) • Transit Vehicle On-Board subsystem: • Cell-Based Communication Equipment: $0.14K-$0.23K • Global Positioning System (GPS)/Differential GPS (DGPS) for Vehicle Location: $0.5K-$2K • Trip Computer and Processor: $0.1K-$0.12K • Automatic Passenger Counting System: $0.98K-$9.8K	

Operations and Fleet Management
Costs
Sample Costs of ITS Deployments
Worldwide: Costs data were obtained from various BRT projects either underway or planned and made available to transit professionals and policy makers in planning and decision making related to implementing different components of BRT systems. The data are representative of BRT development costs. On-board performance monitoring systems typically cost approximately **$2,000 per vehicle** and AVL systems cost around **$8,000 per vehicle**.[276] **Montana:** The Billings METropolitan Special Transit, a paratransit service, spent approximately **$43,500** to add AVL technology to its fleet of 15 vehicles.[277] **Massachusetts:** The cost of the capital infrastructure for the Cape Cod Advanced Public Transit Systems—which included radio tower upgrades, local area network upgrades, 100 AVL/MDT units, and software upgrades—was **$634,582**. This cost roughly represents **$6,346 per unit** for 100 units. Given that the Cape Cod project was an early demonstration project, upgrades to the existing communications system were necessary. Such requirements and associated costs may not be required by other agencies deploying AVL/MDT capabilities.[278] **Michigan:** The Flint Mass Transportation Authority (MTA) developed a plan to deploy ITS technologies to improve effectiveness and efficiency of transit service in Genessee County. The MTA budgeted **$5,000 per bus** and **$1 million** for the central system to implement a county-wide AVL system. The total capital cost was **$1,750,000** for 150 vehicles with an estimated **$250,000** for annual operations and maintenance (O&M) cost. To collect detailed transit passenger ridership information, the Flint MTA planned to install automatic passenger counters on 10 MTA fixed-route vehicles and rotated the vehicles with counters amongst all fixed routes. The costs were estimated at **$50,000** (**$2,500 per vehicle**) and O&M at **$10,000 per year**. On-board diagnostics are planned for 100 vehicles to support more efficient maintenance operations and on-road trouble-shooting. Costs are estimated at **$200,000** for capital and **$20,000 annually** for O&M.[279]

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Operations and Fleet Management: Transit Signal Priority

Transit signal priority systems use sensors to detect approaching transit vehicles and alter traffic signal timing to improve transit performance. For example, some systems extend the duration of green signals for public transportation vehicles when necessary.

Operations and Fleet Management—Transit Signal Priority	
Deployment	
Two percent of signalized intersections in the country's 108 largest metropolitan areas are equipped with transit signal priority.	
Benefits	
ITS Goals	**Selected Findings**
Mobility	***Summary Finding:*** Experience in 13 cities in the U.S. and abroad show 1.5 to 15 percent improvement in bus travel time due to transit signal priority.[280] This range represents experience with a variety of transit service types under varying traffic conditions. Several studies show significant reductions in travel time variability, with a corresponding improvement in on-time performance.
Mobility	Transit signal priority implemented as part of the Metro Rapid BRT service in Los Angeles yielded travel time improvements of 7.5 percent and signal delay reduction of 36 and 33 percent on two test corridors. [281]
Productivity	In the central area of Chicago, a feasibility study indicated that driver assistance technologies and transit signal priority for BRT would be cost-effective for deployment on proposed busways.[282]
Energy and Environment	Simulation of a transit signal priority system along a heavily traveled corridor in Arlington County, Virginia found a two to three percent reduction in fuel consumed by buses across a number of priority scenarios.[283]
Customer Satisfaction	Surveys found that riders on Vancouver's 98 B-line BRT service, which implemented transit signal priority to improve schedule reliability, rated the service highly with regard to on-time performance and service reliability (an average of 8 points on a 10-point scale).[284]

Operations and Fleet Management—Transit Signal Priority
Costs
Unit Costs Data Examples (See Appendix A for more detail)
Roadside Control subsystem: • Signal Controller Upgrade for Signal Control: $2.4K-$6K • Roadside Signal Preemption/Priority: $5K-$6K Transit Vehicle On-Board subsystem: • Signal Preemption/Priority Emitter: $0.5K-$2.1K • Preemption/Priority Transponder: $0.07K Roadside Telecommunications subsystem: • Conduit Design and Installation—Corridor: $50K-$75K (per mile) • Fiber Optic Cable Installation: $20K-$52K (per mile)
Sample Costs of ITS Deployments
United States: The need to upgrade or replace traffic signal software and controllers are key cost drivers in transit signal priority projects. Costs can be under **$5,000 per intersection** if existing software and controller equipment can be used. The costs can rise to **$20,000 to $30,000** per intersection if software and control equipment are to be replaced.[285] **California:** Stage one of the Watt Avenue corridor in Sacramento, California consisted of deployment of a transit priority system using Type 2070 controllers for 20 intersections, priority emitters for 60 transit vehicles, 14 closed circuit television cameras, 1 weigh-in-motion station, 4 DMS, and associated communication infrastructure. The fiber optic communication infrastructure connects the field devices with the County Traffic Operations Center (TOC) and the County TOC to the Caltrans/California Highway Patrol Regional Transportation Management Center. The cost to implement stage one was estimated at **$1.5 million**.[286] **California:** The Los Angeles County Metropolitan Transportation Authority, in partnership with the City of Los Angeles DOT, conducted the Metro Rapid Demonstration Program, a BRT full-deployment feasibility project, along two major arterials. The two Metro Rapid lines—Wilshire-Whittier and Ventura—began operations on June 24, 2000. A critical element of the Metro Rapid Program is the transit signal priority system. This system serves to improve on-time performance, provides real-time next bus arrival information to passengers waiting at bus stations, and assists fleet management by recording travel time for each bus run. The system is deployed at approximately 211 intersections, covering 42.4 miles along both Metro Rapid lines. The total cost for the system was **$4,243,000,** which equates to approximately **$20,000 per intersection** or **$100,000 per mile**.[287]

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Information Dissemination

Information dissemination Web sites allow passengers to confirm scheduling information, improve transfer coordination, and reduce wait times. Electronic transit status information signs at bus stops help passengers manage their time and on-board systems such as next-stop audio annunciators help passengers in unfamiliar areas reach their destinations.

Information Dissemination	
Deployment	
The use of ITS technologies to provide real-time transit information remains limited to a small portion of transit agencies. Ten (10) percent of transit terminals in the country's 108 largest metropolitan areas have in-terminal information systems that provide real-time transit information. Transit agencies in 18 of these 108 metropolitan areas use automated telephone systems to disseminate real-time transit schedule adherence status or arrival and departure times to the public. Transit agencies in 6 of the country's 108 largest metropolitan areas use in-vehicle systems for providing information on routes, schedules, and fares.	
Benefits	
ITS Goals	**Selected Findings**
Customer Satisfaction	***Summary Finding:*** Evaluation data show that passengers who use real-time bus or tram departure information signs find them useful. At the Acadia National Park in Maine, 90 percent of visitors using the signs said they made travel easier.[288] Several surveys in Helsinki, Finland found 66 to 95 percent of travelers regarded similar signs useful.[289]
Customer Satisfaction	The ROUTES (Rail, Omnibus, Underground, Travel Enquiry System) computerized travel enquiry system used by the London Transport in England helped 13 percent of travelers change their travel modes to transit, which generated an estimated £1.3 million of additional revenue for bus companies, £1.2 million for the underground, and £1 million for railways.[290]

Information Dissemination
Costs
Unit Costs Data Examples (See Appendix A for more detail)
Transit Management Center subsystem: • Transit Center Hardware: $8K-$10K • Transit Center Software, Integration: $792K-$1671K • Transit Center Labor: $100K-$400K (annually) Transit Vehicle On-Board subsystem: • Cell-Based Communication Equipment: $0.14K-$0.23K • Global Positioning System (GPS)/Differential GPS (DGPS) for Vehicle Location: $0.5K-$2K • Trip Computer and Processor: $0.1K-$0.12K Remote Location subsystem: • Transit Status Information Sign: $4K-$8K
Sample Costs of ITS Deployments
Oregon: The Portland Tri-County Metropolitan Transportation District (TriMet) deployed a real-time traveler information system, Transit Tracker, beginning in 2001. Transit Tracker provides riders with a real-time estimate of the expected time the next transit vehicle will arrive. The system covers all light rail stops and each of TriMet's 7,700 bus stops. Information is available at all rail stations and 13 bus stops via phone and a dedicated Web site. A rough cost estimate for the field equipment (designing, purchasing, and installing the dynamic message signs (DMS) at 13 bus stops and all rail stations), servers, and Web development for Transit Tracker is **$1,075,000**. O&M costs for Transit Tracker are estimated to be roughly **$95,000 per year**.[291] **Michigan:** The Flint MTA identified the cost for an advanced traveler information system consisting of a fleet-wide on-board announcement system, real-time arrival-departure information, and a Web-based trip planner; **$1.5 million** is budgeted for capital cost with **$225,000 annually** for O&M cost.[292] **Worldwide:** In 2007, a comprehensive cost assessment of BRT components was conducted and found that on-board security systems typically cost approximately **$10,000 per vehicle**. On-board passenger information systems typically cost approximately **$4,000 per vehicle** and signs at BRT stations typically cost **$6,000 per sign**.[293]

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Transportation Demand Management

Transportation demand management services, such as ride sharing/matching and dynamic routing/scheduling, increase public access to transit service.

Transportation Demand Management	
Deployment	
A significant number of transit agencies in major metropolitan areas use ITS technologies to improve transportation demand management efforts. Twenty-five (25) percent of transit agencies in the country's 108 largest metropolitan areas offer ride sharing and carpool matching services; 17 percent use AVL and CAD to support dynamic routing and scheduling; and 29 percent use ITS technologies to coordinate passenger transfers between vehicles or between transit systems.	
Benefits	
ITS Goals	**Selected Findings**
Productivity	An evaluation of scheduling software for the paratransit service in Billings, Montana found that the break-even point for savings as a result of the software implementation was a three percent improvement in efficiency, while the evaluation found that the software enabled a seven percent increase in rides per hour of service and an increase in rides per mile of just over three percent.[294] Scheduling software enabled St. John's County in northeast Florida to reduce office staff from 9 to 4.5 full-time equivalents, despite a doubling of daily trips on the paratransit service, saving $58,000 per year.[295] Route-deviation service can be less expensive than pure demand-responsive paratransit service while providing the additional important benefit of providing easy access to traditional transit routes for some patrons requiring door-to-door service. Experience with the Omnilink system in Prince William County, Virginia suggests that with less than 20 passengers per hour, adding 10 minutes of recovery time allows accommodation of one or two deviations per hour for routes taking approximately 35 minutes to drive without deviations.[296]
Customer Satisfaction	Interviews with transit operators and dispatchers for the consolidated transit service in Lake Tahoe, California found operators were generally satisfied with the MDTs deployed for communicating with dispatch. Dispatchers indicated that the precise location of the vehicles provided by the AVL system was useful. Both felt the scheduling capabilities provided were less than optimal for such a small demand-responsive service (five vehicles), but that the technologies provided useful capabilities for future service expansion.[297]

LESSONS LEARNED

Adjust bus schedules to assure adequate time to accomplish rail-to-bus connections, given the risk of late train arrivals at connecting stations.

The Connection Protection system in Utah improves the reliability of transfers from the higher frequency light rail trains to the lower frequency bus services at connecting rail stations. Many transit agencies look to schedule adherence by their operators as a key performance indicator; hence, there is a built-in disincentive for bus operators to create delays by waiting for late arriving passengers.

- Coordinate bus schedules closely with rail schedules to maximize the likelihood of successful rail-to-bus connections.

Some of the bus operators in Utah commented that the rail and bus schedules are not adequately coordinated and adjusted to assure optimal connection time. The operators recommended making adjustments on the busiest routes first, as those are where the most problems are encountered.

Transit system managers need to examine the patterns of late train events at stations that service their bus routes and determine whether current bus schedules are adequately synchronized with the rail schedules. Adjustment strategies may include: extending the departure times from the stations serviced by rail, relative to the rail arrival schedules or building in additional recovery time at appropriate points on the bus route to allow operators to make up time and get back on schedule.[303]

Transportation Demand Management
Costs
Unit Costs Data Examples (See Appendix A for more detail)
Transit Management Center subsystem: • Transit Center Hardware: $8K-$10K • Transit Center Software, Integration: $792K-$1671K • Upgrade for Automated Scheduling, Run Cutting, or Fare Payment: $19K-$39K • Integration for Automated Scheduling, Run Cutting, or Fare Payment: $219K-$486K • Transit Center Labor: $100K-$400K (annually) Transit Vehicle On-Board subsystem: • Cell-Based Communication Equipment: $0.14K-$0.23K • Global Positioning System (GPS)/Differential GPS (DGPS) for Vehicle Location: $0.5K-$2K • Trip Computer and Processor: $0.1K-$0.12K • Automatic Passenger Counting System: $0.98K-$9.8K
Sample Costs of ITS Deployments
Montana: The Billings METropolitan Special Transit System—a paratransit service that operates within the Billings, Montana city limits—deployed a computer-aided scheduling and dispatching software system at a cost of **$83,575**. A software maintenance fee is charged at **$11,835 per year**.[298] **New Mexico:** Client Referral, Ridership, and Financial Tracking (CRRAFT), a Web-based system that integrates human services transportation with the daily operating procedures and administration of multiple rural transit agencies, cost about **$1 million** to implement.[299] Operating costs for CRRAFT are about **$95,000 annually**.[300] Building on the success of CRRAFT, the Alliance for Transportation Institute developed a plan and implemented smart card technology—the Intelligent, Coordinated Transit Smart Card Technology Project (ICTransit Card)—to provide cost-effective, seamless, and convenient transportation services in a rural setting. The cost of the ICTransit Card system is approximately **$635,700**.[301] Operating costs for the ICTransit Card system are about **$93,000 annually** with about $40,000 shared with the annual operations for CRRAFT.[302]

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Safety and Security

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. Transit management centers can monitor in-vehicle and in-terminal surveillance systems, sometimes including video, to improve quality or the safety and security of passengers and operators. Silent distress alarms enable drivers to notify dispatch of on-board security situations and remote disabling systems can prevent hijacking of transit vehicles.

Safety and Security	
Deployment	
ITS technologies are used by many metropolitan transit agencies to enhance transit safety and security. Forty-three (43) percent of transit buses in the country's 108 largest metropolitan areas are equipped with in-vehicle surveillance systems, either audio or video, and 31 percent of transit depots in these 108 metropolitan areas were equipped with facility surveillance. In contrast, remote disabling systems remain far less popular, with only 2 percent of transit buses in these 108 metropolitan areas equipped with remote disabling systems.	
Benefits	
ITS Goals	**Selected Findings**
Safety	In Denver, on-board silent alarms installed on Regional Transportation District buses contributed to a 33 percent reduction in bus passenger assaults between 1992 and 1997.[304]
Customer Satisfaction	The Ann Arbor, Michigan transit authority installed on-board camera systems to increase safety and security. The cameras were often noticed by passengers, but the system only provided a significant feeling of additional security when respondents were traveling at night. Respondents to a survey rated police presence as giving them the greatest sense of security, followed closely by increased lighting. Emergency phones and video cameras had less impact.[305]

LESSONS LEARNED

Enhance overall transit safety and security programs by implementing video assessment systems.

Transit management can achieve significant returns on most of its safety and security investments by deploying a video assessment system that leverages an agency's other safety and security assets. The primary advantage to video assessment systems is their ability to record and archive information for real-time and archival use.

For example, the New Jersey Transit (NJ Transit) video assessment system is effective because of the interdisciplinary, multi-agency, multi-jurisdictional way in which it is used. The functional requirements for the system were defined under the direction of the NJ Transit police chief, who worked closely with the head of the Information Technology Department who, in turn, specified the technical aspects of the system. The police chief culled requirements not only from transit operations, but from strong working relationships with the New Jersey State Police, Amtrak, New York City Metropolitan Transportation Authority, and the Port Authority of New York and New Jersey.[308]

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Safety and Security
Costs
Unit Costs Data Examples (See Appendix A for more detail)
Transit Management Center subsystem: • Video Monitors for Security System: \$2K-\$5K • Hardware for Security System: \$13K-\$19K • Labor for Security System: \$293K-\$359K (annually) Transit Vehicle On-Board subsystem: • Security Package: \$3.3K-\$6K Remote Location subsystem: • Closed Circuit Television (CCTV) Camera: \$2K-\$5K • Transit Status Information Sign: \$4K-\$8K
Sample Costs of ITS Deployments
United States: Based on the results of a high-level scan on the use and adoption of advanced technology by public transit agencies, a video monitoring system costs approximately **\$10,000 per vehicle**. However, the addition of other integrated systems such as automated passenger counters, event recorders, voice annunicators, and equipment health monitoring may only cost a few thousand dollars more.[306] **Michigan:** The Flint MTA budgeted **\$1,250,000** to deploy digital video systems fleet-wide (250 vehicles at an estimated cost of **\$5,000 per vehicle**). O&M costs were estimated at **\$175,000 per year**.[307]

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