Intelligent
Transportation
Systems (ITS)

National ITS Architecture Transit Guidelines

Executive Summary

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Prepared for

U.S. Department of Transportation

Prepared by

PB Farradyne Inc.

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1 INTRODUCTION

"If you are interested in improving transit service, increasing ridership, assisting transit operators, and reducing operating costs, you should read this booklet."

How would you like to make your transit system safer and more attractive to customers? How would you like to use your transit resources more efficiently? By incorporating Intelligent Transportation Systems (ITS) into your transit system and applying the National ITS Architecture, this can become a reality. If you are interested in improving transit service, increasing ridership, assisting transit operators, and reducing operating costs, you should read this booklet.

This booklet is intended for transit board members and senior management. It provides general information on ITS and the National ITS Architecture with respect to transit, and highlights the benefits of each Section 2 briefly discusses the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), which led to the National ITS Program and the National ITS Architecture. Section 3 provides an overview of ITS, examples of ITS applications for transit, benefits of transit ITS, and examples of where these benefits have accrued. Section 4 discusses the National ITS Architecture, its benefits, and its importance.

If you are interested in additional information on ITS and the National ITS Architecture with respect to transit, refer to the supplemental publication, *National ITS Architecture Transit Guidelines Technical* Edition. The Technical Edition is written for transit project management and staff. It provides firm guidance and recommended practices for developing and deploying transit ITS applications, and useful information (lessons learned) from transit agencies that have deployed ITS systems. The Technical Edition also explains how to apply the National ITS Architecture when developing and deploying transit ITS applications.

2 ISTEA

Traffic congestion has become a major problem in many urban areas in the United States. Congestion results in lost productivity, additional accidents, Increased fuel usage and air pollution, and less leisure time.

"... the construction of more roadways and roadway lanes was no longer feasible or credible in many areas as the primary solution to traffic congestion."

For many years, state highway departments and localities responded to traffic congestion problems by simply and effectively building more roadways and roadway lanes. In the 1980's, transportation planners began facing greater public concerns about land use, highway safety, environmental sensitivity, and transportation efficiency In addition, government budgets were shrinking. Construction of additional lanes to handle increasing traffic loads became more expensive due to higher land and roadway construction costs As a result, the construction of more roadways and roadway lanes was no longer feasible or credible in many areas as the primary solution to traffic congestion.

These concerns and problems led to passage of ISTEA, which signifies the completion of the Interstate Highway

Program. The primary purpose of ISTEA is "... to develop a National Intermodal Transportation System that is economically efficient, environmentally sound, provides the foundation for the Nation to compete in the global economy and will move people and goods in an energy efficient manner."

Provisions of ISTEA that promote and relate to transit include the following:

- State and local governments are given more flexibility in determining transportation solutions, whether transit or highways.
- Multimodal and intermodal transportation systems are promoted.
- ISTEA provides highway and transit funding flexibility, identical matching shares, additional use of the trust fund, and an expanded research program.
- Transit capital improvements are eligible for funding under the Surface Transportation Program (STP) and National Highway System (NHS).
- Private sector funding for transportation improvements is allowed and encouraged.
- New technologies, such as ITS, are funded and strongly encouraged.

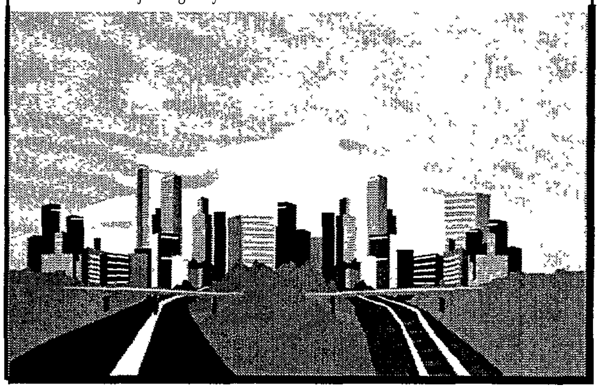
3 INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

ITS makes transportation systems "more efficient and customer service-oriented".

ITS offers an alternative to traditional measures in addressing transportation problems and needs. It applies advanced technologies to transportation systems to make them more efficient and customer service-oriented. In addition to reducing traffic congestion, ITS helps transportation operators by improving transportation system management, increasing system efficiency, and reducing operating costs ITS also increases safety, comfort, and convenience, making transportatron systems more attractive to customers, thus increasing the potential for additional ridership and revenue

ITS applications existed prior to ISTEA. Examples include bus electronic destination signs, bus tracking systems, and electronic fare boxes. However, ISTEA led to the creation of a formal ITS program.

Intelligent Transportation Systems
-more than just highways

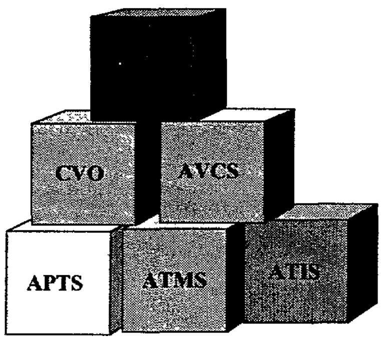


The goals of ITS, as stated in the National ITS Program plan, echo the goals of ISTEA:

- Improve the safety of the Nation's surface transportation system
- Increase the operational efficiency of the Nation's surface transportation system
- Reduce energy and environmental costs associated with traffic congestron
- Enhance present and future productivity

- Enhance the personal mobility and the convenience and comfort of the surface transportation system
- Create an environment in which the development and deployment of ITS can flourish

ITS consists of six major components, or classifications, some of which overlap. The major ITS components are:



- Advanced Public Transportation Systems (APTS)
- Advanced Transportation Management Systems (ATMS)
- Advance Traveler Information Systems (ATIS)
- Commercial Vehicle Operations (CVO)
- Advance Vehicle Control Systems (AVCS)
- Advanced Rural Transportation Systems (ARTS)

3.1 Transit ITS Examples

"Transit ITS applications range from . . . video cameras (for in-vehicle and in-terminal surveillance), to... transit vehicle tracking. "

There are many ITS applications for transit. Transit ITS applications range from basic electronic devices, such as video cameras (for in-vehicle and in-terminal surveillance), to major systems, such as transit vehicle tracking. Transit ITS applications typically fall into the APTS classification, but may also fall under classifications such as ATMS, ATIS and AVCS. The terms "transit ITS" and "APTS" are often used inter-changeably.

Transit ITS applications are often categorized broadly under four different sets of services or technologies. The categories are fleet management, traveler information, electronic fare payment, and transportation demand management. Examples of transit ITS applications, under their respective categories, include the following:

Fleet Management

- Transit management centers
- Transit vehicle tracking
- Transit operations software (for fixed-route bus, paratransit, and rail)
- Geographic Information Systems (GIS)
- Automatic Passenger Counters (APC)
- Traffic signal preferential treatment
- Vehicle diagnostics
- Collision avoidance

Traveler Information

- Pre-trip and en-route transit information
- In-terminal/wayside information systems
- In-vehicle information systems (automatic annunciation)
- Multimodal traveler information

Electronic Fare Payment

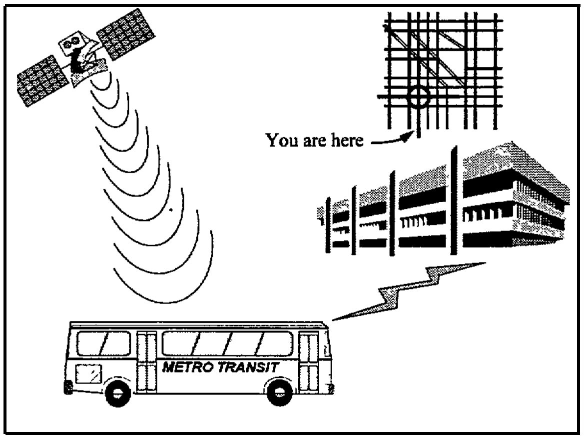
- Automated fare payment systems
- Multi-operator integrated fare systems

Transportation Demand Management

- Real-time ridesharing
- Mobility manager
- High Occupancy Vehicle (HOV) facility operations

A few of these transit ITS applications are briefly discussed below

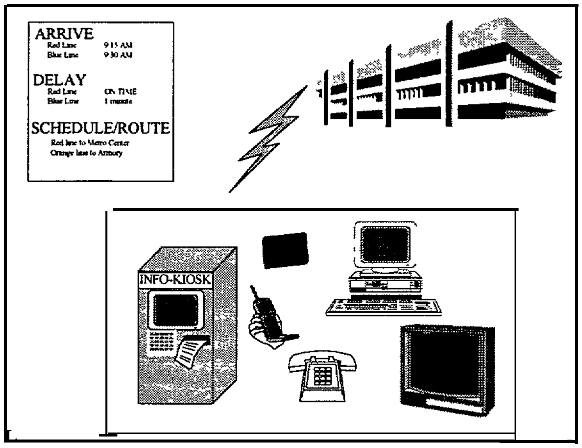
Transit Vehicle Tracking



Transit vehicle tracking systems determine the real-time location of transit vehicles and transmit the locations to the dispatch center where they appear on a computerized map. Transit vehicle tracking employs Automatic Vehicle Location (AVL) and Computer-Aided Dispatch (CAD) technologies. There are several different technologies that are used to perform the AVL function. These include the Global Positioning System (GPS), signpost/odometer, dead-reckoning, and a combination of these. GPS is the most commonly used AVL technology.

Vehicle location information may be used for a number of purposes. These include correcting deviations in service (on-time performance), improving operations and planning (scheduling and run-cutting), providing input to traveler information systems, and locating vehicles in times of emergencies or crises (e.g., crimes in progress, medical emergencies). Transit vehicle tracking systems are being used by several transit agencies in the United States. Over the past four years, their use has increased more than 200 percent. As of December 1996, there are approximately 58 transit vehicle tracking systems in operation, under installation, or being planned.

Pre-Trip Transit Information



Pre-trip information is information provided to the traveler prior to his or her departure. For transit, pre-trip information may Include transit routes, schedules, fares, and other pertinent information. The most common media employed are touch-tone telephones and human operators. Other systems use the Internet, pagers, personal communications devices, cable television, and kiosks. Although currently not available,it is anticipated that interactive television will be used to provide pre-trip information in the future.

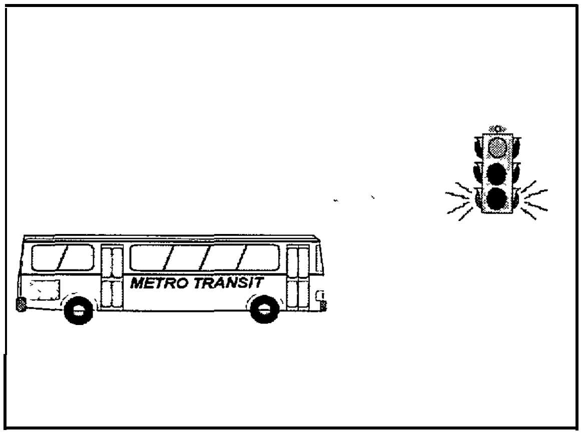
Automated Fare Payment Systems

Automated fare payment systems allow passengers to pay for their transit trips electronically, using a card instead of directly using cash. They employ electronic communication, data processing, and data storage technologies. Automated fare payment systems allow a common fare card to be used for multiple transit modes and provide the means for multiple operators to honor the same card. They enable automated accounting of transfers and simplify ridership data collection.

Several types of automated fare payment systems/methods exist or are proposed by transit agencies. They include transit passes, stored-value fare cards, fare systems based on passenger accounts, multi-use electronic purses, and cashless purchase systems. Transit agencies may use one or a combination of these systems/methods. Two types of media (technology) are most widely used or being pursued by transit agencies for these fare payment systems/methods. The first type is a magnetic stripe card. The second type is a smart card which contains an imbedded integrated circuit.

Transit passes, which are valid for a specific period of time, reduce the number of monetary transactions to one per issuing period. Stored-value fare cards contain value worth more than one transit fare. Each time the fare card is used, the cost of the trip is deducted from the card. Passenger account fare systems currently do not exist, but are possrble. If such systems existed, a customer would be charged automatically each time he or she received transit service, and would be billed instantly (like debit cards) or periodically (like credit cards). Fare systems based on passenger accounts would be advantageous for paratransit operations. Multi-use electronic coin purse systems use cards that contain stored value, like stored-value fare cards. However, multi-use electronic coin purse cards can be used for transit trips and small purchases from cooperating merchants. In cashless purchase fare systems, fare media (transit tickets) are purchased with a bank card or credit card. These systems eliminate the need for customers to carry cash to pay for transit service.

Traffic Signal Preferential Treatment



Traffic signal preferential treatment allows buses and light rail vehicles to have limited control over traffic signals. These systems grant preference to a transit vehicle by allowing the vehicle to preempt a traffic signal upon its approach. This gives transit vehicles a mobile advantage over passenger and commercial vehicles, and reduces transit trip times.

Two methods are used for signal preemption. The first employs a special transmitter on the transit vehicle and a companion receiver located at or near the signalized intersection. As the vehicle approaches the signal, the receiver identifies the vehicle from its transmission and either holds the light green or changes it to green until the vehicle passes through the intersection. The second method ties the transit agency's AVL system with the traffic signal system. As the transit vehicle approaches the traffic signal, the AVL system provides the traffic signal the proper cue to grant the transit vehicle preference.

3.2 Transit ITS Benefits

"First, ITS improves transit efficiency and thus helps to reduce operating costs . .."

Why invest scarce resources in deploying ITS? Because, ITS can provide numerous benefits to transit. First, ITS improves transit efficiency and thus helps to reduce operating costs in the following ways:

- Automatic vehicle diagnostics, which can be interfaced with AVL systems, reduce the number of major breakdowns by reporting potential vehicle problems before serious damage occurs, and extends the life of vehicles by providing input for vehicle maintenance scheduling.
- Transit vehicle tracking and traffic signal preferential treatment systems provide more efficient and on-time operations, making transit more attractive to passengers and thus increasing the potential for additional ridership and revenue. Traffic signal preferential treatment also reduces run times, which allows transit agencies to serve routes with fewer buses while retaining frequency, or serve routes with the same number of buses while increasing frequency. Traffic signal preferential treatment helps transit to compete better with the automobile. By pre-empting traffic signals at intersections, buses and light rail vehicles are allowed to reduce trip times.
- Transit operations software and GIS increase the accuracy and speed of dispatching, provide route and schedule optimization, and provide coordination between modes (e.g., fixed-route bus with paratransit).
- Automated fare payment systems increase fare collection throughput and reduce delays at fare gates. In addition, automated fare payment systems can reduce costs associated with maintenance and cash handling costs.
- Automatic data collection systems (e.g., automatic passenger counters), transit operations software, and GIS help improve transit planning and management.
- Automatic data collection systems and in-vehicle video surveillance systems keep fraudulent claims down in accident cases involving transit vehicles In addition, in-vehicle video surveillance systems act as a deterrent to vandalism.

" Second, ITS increases safety, comfort, and convenience for passengers, and thus increases attractiveness to customers..."

Second, ITS increases safety, comfort, and convenience for passengers, and thus increases attractiveness to customers in the following ways:

- Traveler information systems provide travelers useful and desired transit information (e.g., routes, schedules, fares, parking availability) conveniently through a variety of media. Transit vehicle tracking provides a tool for supplying passengers with real-time route and schedule information.

- In-vehicle information systems, such as next-stop audio and visual annunciators, make transit easier for the transit novice, visually impaired, and hearing impaired to use, and assist passengers in identifying stops during periods of poor visibility.
- Automated fare payment systems make fare payment more convenient for passengers.
- Video surveillance systems increase safety and security by deterring violent or criminal activity in transit vehicles and facilities. Surveillance systems and silent alarms aid in rescue efforts if these activities occur.
- Transit vehicle tracking decreases response time in cases of medical and security emergencies since the dispatcher knows immediately where to send help.
- AVCS, such as on-vehicle collision avoidance devices (future technology), will reduce transit vehicle collisions, improving safety and reducing costs and insurance claims.

“Third, ITS assists transit operations managers and vehicle operators... thus helping them to perform a better job...”

Third, ITS assists transit operations managers and vehicle operators by automating many of their labor-intensive duties. ITS makes their jobs easier and allows them to focus on important issues, thus helping them to perform a better job in the following ways

- Transit operations software and GIS assist dispatchers by automating and optimizing route and schedule information, and minimizing operator interfaces for many functions.
- Automated fare payment systems relieve drivers of the fare collection task.
- Automatic passenger counters and next-stop annunciators allow vehicle operators to concentrate on driving. Next-stop annunciators also satisfy requirements of the Americans With Disabilities Act (ADA).
- Several ITS applications improve vehicle operator safety, such as those discussed above for transit passengers.

"Fourth, ITS promotes an intermodal transportation system and helps transit compete with the automobile.”

Fourth, ITS promotes an intermodal transportation system and helps transit compete with the automobile.

- ITS helps transit to maintain or perhaps even increase its share of the transportation market, by creating an environment for an intermodal transportation system and by making transit more efficient and attractive to travelers.

ITS is being, and will continue to be, applied to highways, roads, and automobiles, making auto travel more desirable than ever. Without the application of ITS to transit, transit will continue to lose ridership to the automobile.

3.3 Transit ITS Success Stories

Two common concerns within the transit industry about ITS include the cost of ITS and whether ITS will have a significantly favorable effect on operations. Some early documented results show quantifiable benefits of transit ITS technologies. These results will help dispel many of the concerns transit agencies have about ITS.

Some of the results are presented below and grouped according to the particular ITS application. As ITS applications mature, additional results will be available. It should be noted that, like any new technology or system, problems initially exist and that these problems are worked out as the technology or system evolves and matures.

Transit Vehicle Tracking

- The Maryland Mass Transit Administration reported a 23 percent improvement in on-time performance by AVL-equipped buses.
- The Kansas City Area Transportation Authority reported a 12 percent improvement in schedule adherence after the first year of AVL operations. The analysis of actual run times on all routes over an extended period of time allowed a reduction in the scheduled run time for several routes, with fewer buses operating on those routes and no reduction in service to the customer. The result was a savings in both operating expense and capital expense, which allowed Kansas City to amortize their AVL investment in two years.
- Preliminary data from Milwaukee show a 28 percent decrease in the number of late buses. "Late" is defined as being greater than one minute behind schedule.
- AVL/CAD systems have helped reduce response times in cases of medical and security emergencies. The fact that a dispatcher can pinpoint a vehicle at all times and is able to advise the police of the nature of the problem, has produced a reduction in response time from over 10 minutes to less than 2 minutes. A dispatcher in Denver believes that their AVL/CAD system has literally saved the lives of some passengers.

Pre-TripTransit Information

- Although few quantifiable results of advanced traveler information systems exist, many transit agencies believe that this ITS component is desirable and even necessary. Many transit agencies feel that transit information is necessary to be competitive with other modes in today's information-rich environment.

Automated Fare Payment Systems

- New Jersey Transit reported a 12 percent increase in revenue since the introduction of its automated fare payment system.
- Automated fare payment systems can reduce fare evasion and short-changing that occur in cash payment and handling systems. Ventura County, California projects a savings of up to $95 million per year due to the reduction in this factor alone
- Automated fare payment systems produce revenues due to interest on the "float" or unused portion of the card. A transit agency retains the total value of the card until it is actually used New York City Transit estimates a yearly revenue gain of millions of dollars from the float when its metro card system is fully implemented.

Transit Operations Software

- The Winston-Salem Transit Authority evaluated their computer-aided dispatch and scheduling system for a paratransit fleet of 17 buses. While the client list grew from 1,000 customers to 2,000 customers over a six-month period and vehicle-miles per passenger-trip grew five percent, operating expense dropped two percent per passenger-trip and nine percent per vehicle-mile. These improvements occurred at the same time as service improvements, including establishment of same day reservations which grew to account for 10 percent of trips, and a decrease in passenger wait time of over 50 percent.

Traffic Signal Preferential Treatment

- Bus travel time in Portland, Oregon was reduced by between five percent and eight percent by allowing buses to either extend green time or shorten red time by only a few seconds. This ITS application results in faster service for passengers, and allows the use of fewer vehicles to serve a route or increase service frequency for a route.

4 NATIONAL ITS ARCHITECTURE

"Like the Federal interstate Highway System, the National ITS Architecture is a blueprint that provides a top-down approach for developing a seamless transportation system..."

Individual ITS applications provide incremental benefits and improvements to the current transportation system. When tied together to form an integrated system (both integrated transit system and integrated multimodal system), ITS delivers much greater benefits and improvements. The National ITS Architecture was developed to do just that, in addition to providing a number of other important functions.

The National ITS Architecture provides a framework for state and regional transportation agencies to develop and implement integrated and interoperable, multimodal, Intelligent Transportation Systems. Like the Federal Interstate Highway System, the National ITS Architecture is a blueprint that provides a top-down approach for developing a seamless transportation system, in this case an Intelligent Transportation System, with consistent character across the United States. The National ITS Architecture fosters a logical and organized approach to ITS deployment that will ease implementation of ITS applications and save transportation agencies implementation, operations, and maintenance costs.

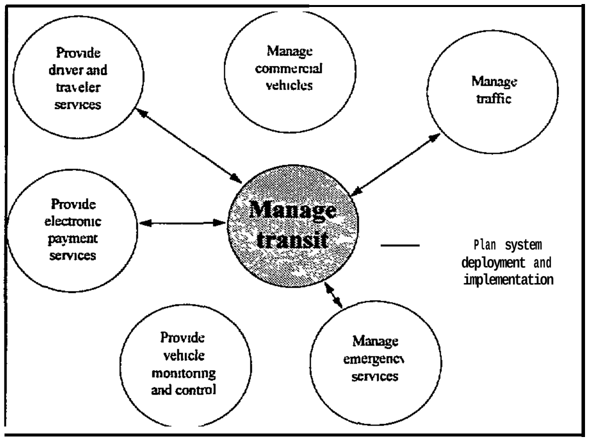
There are specific benefits to be gained in the transit community through informed application of the National ITS Architecture methodology, knowledge base, and tools. The major benefits of the National ITS Architecture are discussed below in Section 4.1. Development of the National ITS Architecture was completed recently (July 1996) thus data on benefits are not yet available.

4.1 National ITS Architecture Benefits

"The National ITS Architecture guides regions in developing integrated and compatible, multimodal Intelligent Transportation Systems that provide even more benefits to customers and transportation agencies."

Using the National ITS Architecture increases the benefits provided by ITS. The National ITS Architecture guides transportation agencies in interconnecting individual ITS applications, such as transit vehicle tracking systems and passenger information systems. Individually these applications provide their own benefits Together, due to synergy, they provide additional benefits. For example, operating alone, a transit vehicle tracking system provides a transit agency the real-time location of its vehicles and a passenger information system provides travelers static route and schedule information. When these applications are connected, they provide real-time transit vehicle route and schedule information to travelers.

The National ITS Architecture guides regions in developing integrated and compatible, multimodal Intelligent Transportation Systems that provide even more benefits to customers and transportation agencies. For example, when traffic information, collected by a transportation agency, is disseminated to the public, travelers may want to switch to transit prior to or during their trip. Thus, congestion on the highway is reduced, transit ridership increases, and travelers reach their destinations sooner and under less stressful conditions. Also, information provided to transit agencies from other transportation agencies (e g., traffic and incident information) helps transit to operate more effectively. For example, a transit agency may use traffic or incident information it obtains from a traffic management center and incident management center to temporarily reroute its vehicles around a major incident. The National ITS Architecture identifies interfaces such as these where transportation data are exchanged. The following figure shows those processes that exchange data with the manage transit process.



The Eight Main Processes within ITS

"The National ITS Architecture offers a great deal of guidance and a wealth of information on the development and implementation of ITS. It is recommended that transit organizations use the fruits of the National ITS Architecture in their efforts to apply ITS technologies to transit."

The National ITS Architecture provides other major benefits as it.

- identifies where standards are needed for system interoperability (interfaces and products) and prioritizes the development of these standards. Transit agencies have expressed that a tremendous need for ITS standards exists. The standards development effort has recently started and will take several years to complete. It is recommended that the transit community get involved in the development of those standards that relate to transit.
- is an open-ended framework that allows ITS applications (both transit and traffic) to be added when desired or as needed.
- promotes modular, off-the-shelf products that support open-ended Intelligent Transportation Systems. In other words, use of the National ITS Architecture discourages dead-end,

closed, and expensive proprietary systems. This reduces costs. Transit agencies have stated that they discourage proprietary systems and desire open systems.

- provides assistance for procurement and implementation by providing product cost estimates and identifying criteria to evaluate system performance.
- promotes lower-priced ITS equipment and components due to economies of scale and competition through multiple vendors.
- identifies new funding sources by strongly encouraging private sector participation in ITS. For example, Information Service Providers (ISPs) that disseminate traveler information are likely to be privately owned and operated.
- assists agencies in developing a strategy for phased ITS deployment.
- builds upon the existing transportation and communications infrastructure. In some cases, however, current communications infrastructure may need to be upgraded to allow for improvements in quality or additional capacity.
- provides confidence for transportation agencies and elected officials of the success of ITS by providing a well-thought-out plan for the implementation of an interoperable, intermodal, Intelligent Transportation System.

The National ITS Architecture offers a great deal of guidance and a wealth of information on the development and implementation of ITS. It is recommended that transit organizations use the fruits of the National ITS Architecture in their efforts to apply ITS technologies to transit.

4.2 How to Find Out More About ITS and the National ITS Architecture

To find more information on ITS and the National ITS Architecture with respect to transit, refer to the publication, *National ITS Architecture Transit Guidelines Technical* Edition. Additional information on ITS and the National ITS Architecture can be obtained from:

- World-Wide Web at:
  - http://www.its.dot.gov
  - http://www,rockwell.com/itsarch
  - http://www.fta.dot.gov/library/technology/APTS/t_its. htm
  - http://www.fta.dot.govlfta/library/planning/lVHS/ivhs.html
  - http://www itsa.org
- ITS Joint Program Office, (HVH-1), Federal Highway Administration, U S. Department of Transportation, 400 Seventh Street SW, Washington, DC 20590, phone: 202-366-9536, fax: 202-366-3302
  - the 16 National ITS Architecture documents are available for a fee (documents may be purchased as a set or individually)
  - other documents that may be of interest and obtained from the Joint Program Office include *The National Architecture for ITS: A Framework for Integrated Transportation in to the 21st Century,* and *Building the ITI: Putting the National Architecture into Action*
- Office of Mobility Innovation, (TRI-1O), Federal Transit Administration, U.S. Department of Transportation, 400 Seventh Street SW, Washington, DC 20590; phone: 202-366-4995
- ITS America, 400 Virginia Avenue SW, Suite 800, Washington, DC 20024; phone: (202) 484-4847

- PB Farradyne Inc , Attn. ITS Planning, 3200 Tower Oaks Blvd., Rockville, MD 20852; phone: 301-816-2760, Internet: transitguide@farradyne.com

REFERENCES

Casey, Robert F., Lawrence N. Labell, Ross Holmstrom, Joseph A. LoVecchio, Carold L.. Schweiger, Terrence Sheehan. 1996. Advanced Public Transportation Systems: The State of the Art Update '96. Washington, D.C.: U.S. Department of Transportation, Federal Transit Adminrstration. FTA-MA-26-7007-96-1.

Goeddel, Dennis. 1996. Benefits Assessment of Advanced Public Transportation Svstems Cambridge, Massachusetts: US. Department of Transportation, John A. Volpe Transportation Systems Center. DOT-VNTSC-FTA-96-7.

Jones, William S. 1995. "ITS Technologies in Public Transit: Deployment & Benefits." Washington, D.C.: U.S. Department of Transportation, ITS Joint Program Office. Photocopied.

MITRE Corporation, The. 1996. Intelligent Transportation Infrastructure Benefits: Expected and Experienced. Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration. FHWA-JPO-96-008.

Mitretek Systems. 1996. Key Findings From The Intelligent Transportation System (ITS) Program: What Have We Learned?. Washington, D.C.: U.S Department of Transportation, Federal Highway Administration. FHWA-JPO-96-0036.

Roberts, Donald L., and Dwight E. Shank. 1995. Assessment of ITS Benefits — Early Results. McLean, Virginia, The MITRE Corporation. MP 95WOOOO192.

U.S. Department of Transportation. 1996. Department of Transportation's Intelligent Transportation Systems (ITS) Projects. Washington, D.C.: U.S. Department of Transportation, Intelligent Transportation Systems Joint program Office. FHWA-JPO-96-003.

________ 1992. Intermodal Surface Transportation Efficiency Act of 1991, A Summary. Washington, D.C.: U.S. Department of Transportatron. FHWA-PL-92-008.

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