Lesson 1. Public Transportation Operations Page 2

ITS Applications in Transit Management and Operations

Lesson 1 Objectives Page 3

After completing this lesson, you will be able to:

- List the objectives of PTO systems
- Understand how PTO systems fit within the National ITS Architecture
- Describe some of the technologies used in public transportation operations

Go ahead and begin the lesson.

Introduction to Public Transportation Operations Page 4

ITS user services, technologies and applications are currently employed in public transportation operations in the U.S., Europe, and the Pacific Rim countries. Public transportation operations (PTO) includes many activities, two of which are as follows:

- **Fleet management**
- **Passenger security**

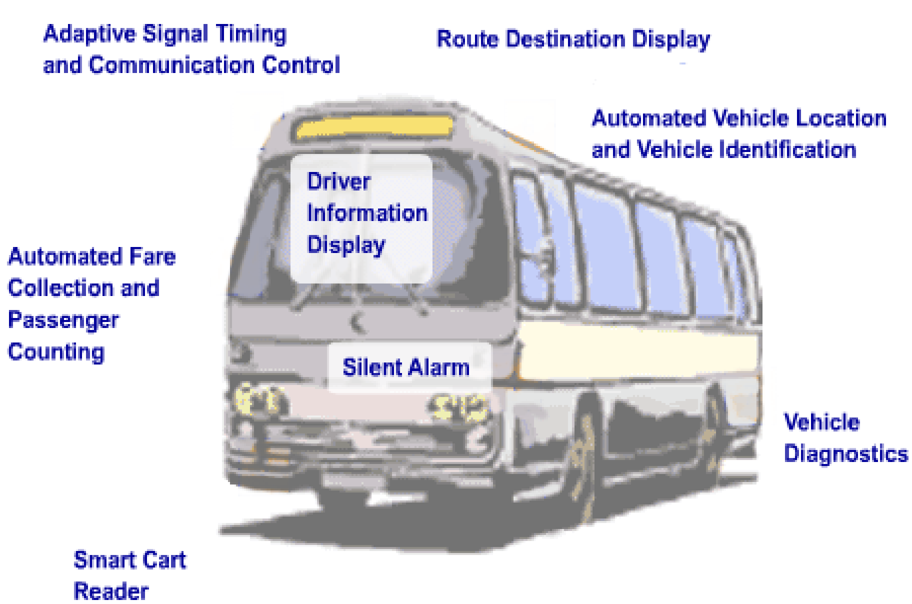
The objective of a PTO system is to perform management functions in order to improve transit service effectiveness, operating efficiency, and passenger safety.

Let us now take a look at the technologies used in the deployment of systems for public transportation operations.

ITS Applications in Transit Management and Operations

Public Transportation Operations Technologies Page 5

▸ *Click on a component name to read its definition:*



Public Transportation Operations Technologies (cont'd) Page 6

Fleet management and operations involves the use of wire and wireless communication systems, geographic information systems, computer-based vehicle tracking systems, and other advanced information technologies.

In this section, we will discuss the following technologies:

- **Advanced Communication Systems (ACS)**
- **Automatic Vehicle Location (AVL) Systems**
- **In-Vehicle Diagnostic (IVD) Systems**
- **Transit Operations Software (TOS)**
- **Fixed-Route Bus CAD Systems**
- **Paratransit CAD (PCAD) Systems**
- **Automatic Passenger Counters (APC)**

ITS Applications in Transit Management and Operations

Advanced Communications Systems (ACS) Page 7

Advanced Communications Systems are innovative solutions to accommodate the increased communication requirements of ITS technologies.

Requirements:	Transmit data and voice
Technologies:	Wireless (2-way radio, RF MDT)
Anticipated Benefits:	- Ease the strain on the agency communication network - Accommodate increased telecommunications needs

ACS: An Illustrative Example Page 8

The **Potomac Rappahanock Omni-Link Paratransit Service Advanced Communication Systems** include the following components:

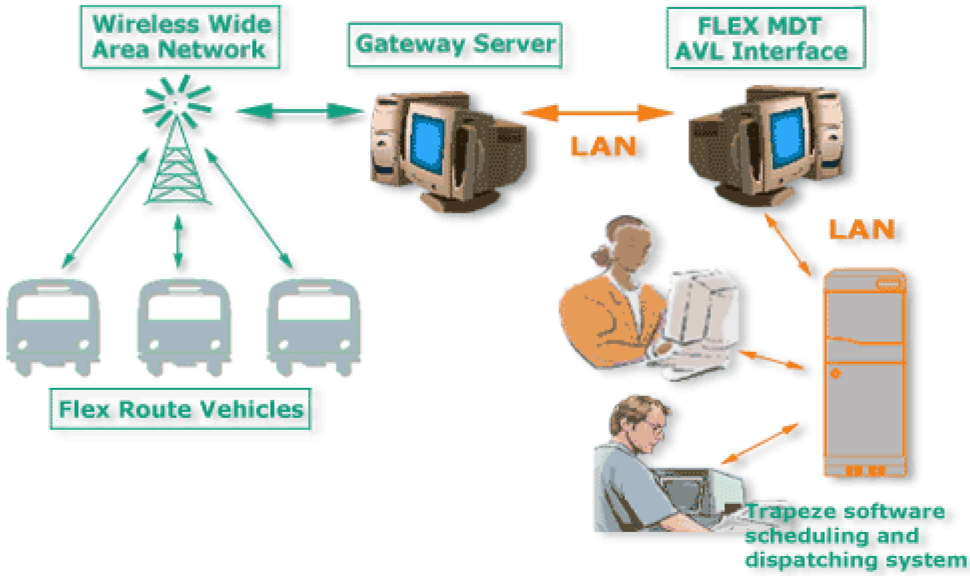
- Mobile data terminals
- Automated vehicle location technologies
- Scheduling/dispatching software - the Trapeze dispatching system schedules the routes and is used by the dispatchers to monitor the activities of the operators.

The gateway is a communications program with two major functions:

1. The program interfaces with the Trapeze scheduling and dispatching system.

2. The program also controls the radio transmissions to and from the MDT units on-board the vehicles.

ACS: An Illustrative Example (cont'd) Page 9



Source: ARINC Proposal

Data to be exchanged between the vehicles and the dispatch center are transmitted in much the same way that the bus location data are transmitted from the vehicles to the gateway system at the dispatch center. However, the information from the dispatcher must first pass through the FLEX MDT/AVL Interface before reaching the gateway server.

The dispatching system transmits the operator's manifest to the vehicle MDT which displays it on its screen. When the operator reaches the destination, a transaction of the completed trip is transmitted to the dispatch center; the scheduling system is then automatically updated. Messages between the dispatch center and the vehicles can be transmitted in the same manner.

ITS Applications in Transit Management and Operations

Test Your Knowledge: ACS Page 10

Question 1. The two main objectives of Advanced Communications Systems, or ACS, are to:

- Ease the strain on the agency's network
- Increase the speed of communications
- Both

Correct. ACS aims to reduce the strain on the agency's communications network by using wireless communications to exchange data between the vehicles and the transit operations centers.

The second objective of ACS is to help accommodate the increased telecommunications requirements of ITS technologies.

Question 2. Advanced Communications Systems are implemented via wireless communications (2-way radio and RF MDT).

- True
- False

Automatic Vehicle Location (AVL) System Requirements Page 11

AVL systems are used to monitor vehicles, track the real-time location of vehicles and transmit it to a central location in order to:

- Make corrections to deviations in service for paratransit
- Serve as input into passenger information system
- Detect emergencies

Click on NEXTBus to see how AVL systems contribute to passenger information systems.

AVL System Technologies Page 12

AVL systems use the following technologies:

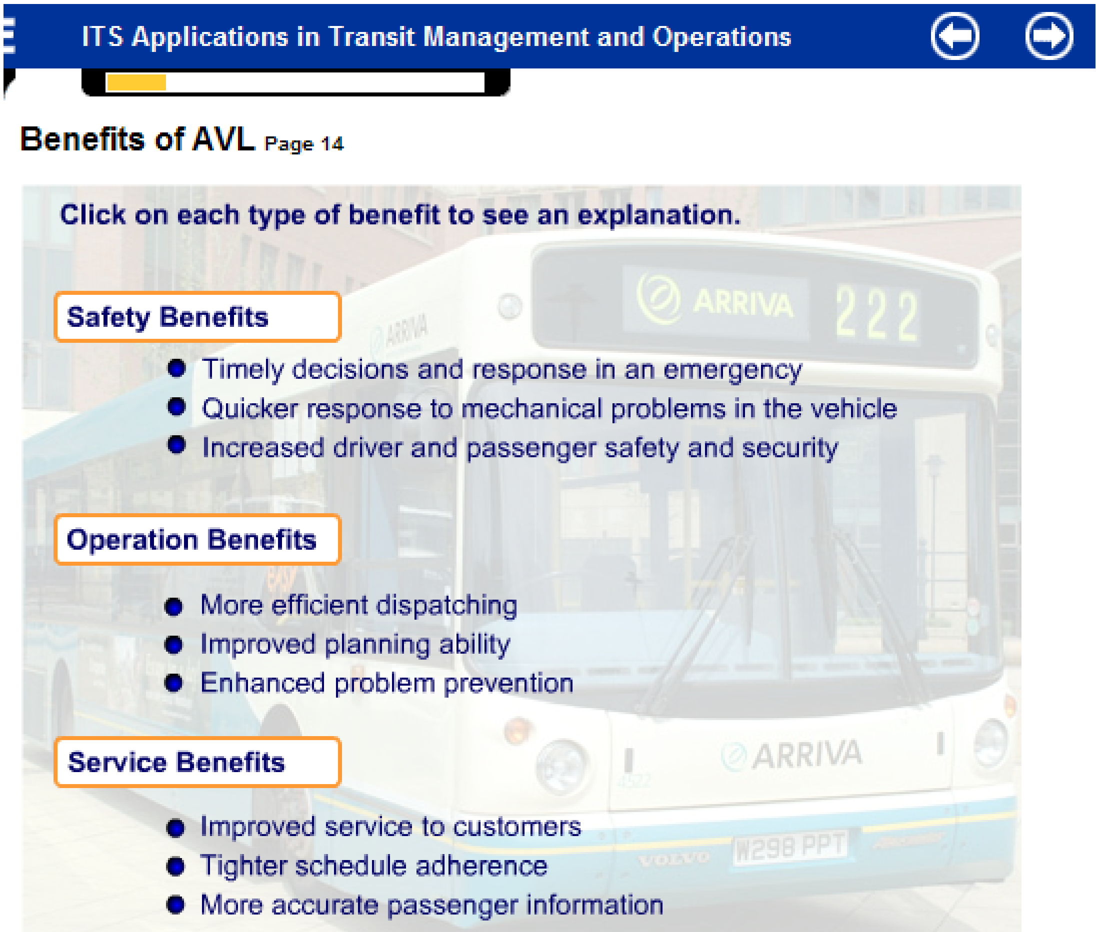
GPS - determines the location of vehicles by using signals transmitted from a network of 26 satellites to vehicles equipped with onboard GPS receivers. Coverage area includes all of North America.

Signpost and Odometer - radio beacons placed along the route send a low power signal with a unique ID code to buses passing by. When polled, buses transmit the most recent signpost ID, as well as the mileage traveled since passing the signpost (using the odometer).

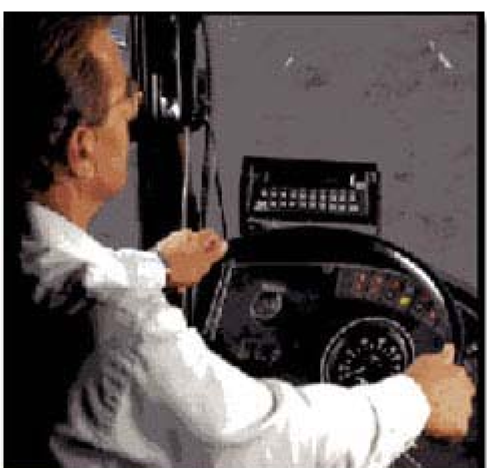
Radio navigation/Location - the location of the vehicle is determined by obtaining the bearing of the moving vehicle with reference to two or more fixed radio stations which are of a known distance apart.

Dead Reckoning - measures the vehicle's acceleration and direction. Using a known starting point as a reference, the dead reckoning unit uses odometer and compass inputs to determine vehicle position from the starting point.

Note that a combination of GPS and Dead Reckoning with map matching is considered to be the most accurate technology for locating a vehicle.



In-Vehicle Diagnostic (IVD) Systems Page 15



Diagnostic systems identify out-of-parameter conditions, warn the operator as required, place the component in a safe operating condition if possible, and record the fault in memory for future review.

Typically, the system receives signals from the throttle pedal, vehicle speed sensor, turbo boost sensor, air temperature sensor, fluid temperature, and oil pressure sensors, among others.

For more information on IVD, you can download **Understanding and Applying Advanced On-Board Bus Electronics**, available from the FTA in PDF format (120 pages). *(See Teacher Talk for the full reference.)*

ITS Applications in Transit Management and Operations

IVD Systems (cont'd) Page 16

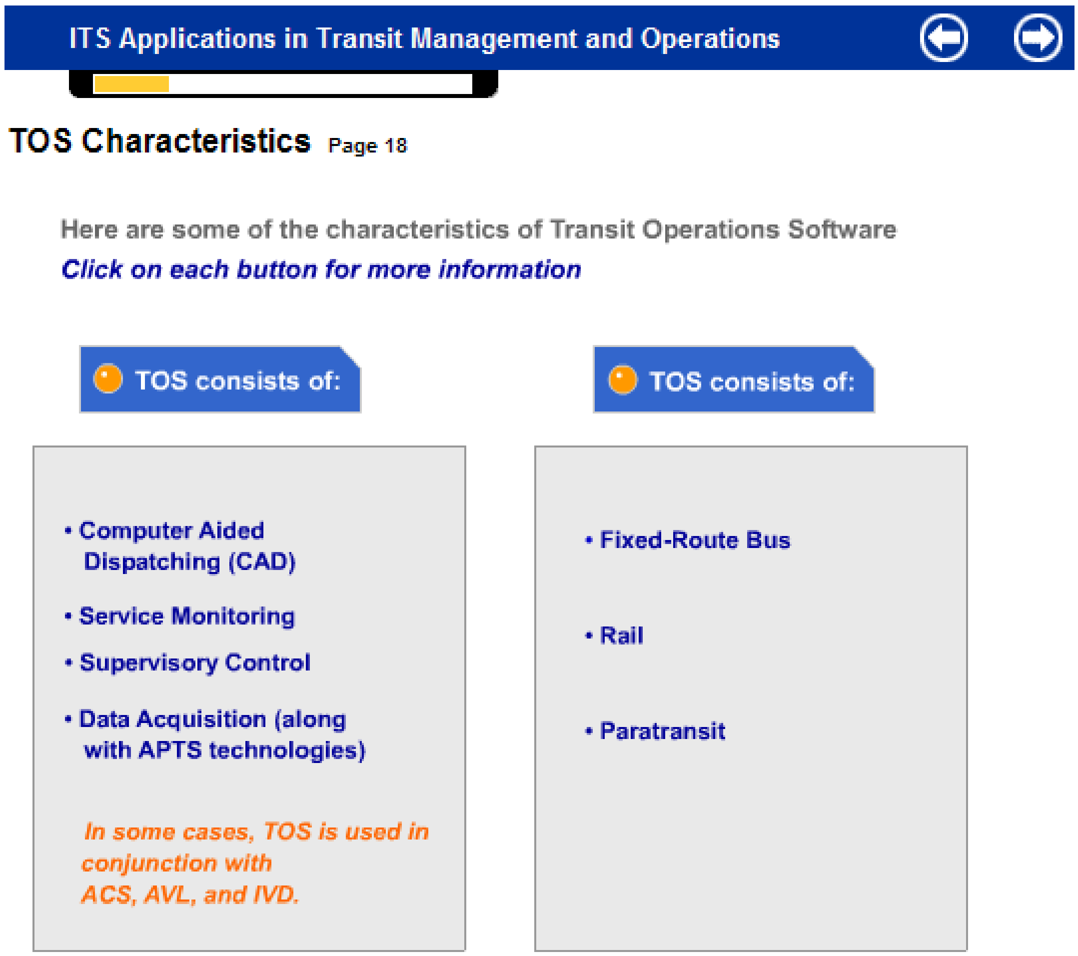
IVD Systems have the following characteristics:

Requirements:	- Performs continuous measurement of vehicle components (e.g. oil pressure, engine temperature, electrical system, tire pressure). - Any out of tolerance conditions are passed to dispatcher in real time without driver intervention.
Technologies:	- In cab diagnostic/fuel economy display - AVL linkage - Automatic data link at bus maintenance bays (e.g bus ID, odometer readings)
Anticipated Benefits:	- Quicker notification of mechanical problems - More rapid response to service diagnostics - Decrease in costly repairs due to early detection of potential problems

Transit Operations Software (TOS) Page 17

MARTA's Bus Communication Center, Atlanta GA.

- TOS can automate, streamline, and integrate many transit functions and modes.
- TOS identifies incidents and assists in managing response and service restoration effectively.
- TOS helps provide reliable service to the customer, improves the efficiency of operations for the agency, and enhances safety for vehicle operators and customers.



Fixed-Route Bus CAD Systems Page 19

- CAD software manages communications due to increase in data transmission that results from AVL, APC, and other APTS technologies.
- CAD software reduces the amount of voice traffic and prioritizes the importance of both voice and digital transmissions.

Computer Aided Dispatch Screen

Fixed-Route Bus CAD Systems (cont'd) Page 20

Dispatcher's Console

[Source: "Denver RTD Computer Aided Dispatch/Automatic Vehicle Location System", Report DOT-FHWA-TRI-II-99-29, September 1999]

- CAD systems help track the on-time status of each vehicle in a fleet, thus helping operators, dispatchers, and customers by providing updates on the location of vehicle.
- CAD systems help reduce bus bunching.

Paratransit CAD (PCAD) Systems Page 21

PCAD software can be used to assign customers to demand-responsive vehicles.
These vehicles operate in shared ride mode.

Technologies

- Telecommunications consisting of 2-way data and voice communication
- GPS base station
- Mapping software

Anticipated Benefits

- Improves scheduling and dispatching
- Increases productivity
- Information can be integrated into other agency functions

Automatic Passenger Counter (APC) Systems Page 22

Automatic Passenger Counter Systems

Automatic Passenger Counter Systems (APC) count the number of people boarding or alighting a vehicle.

These systems can be installed in the 2 main types of buses (steps or low floor).

Automatic Passenger Counter (APC) Systems Page 22

Automatic Passenger Counter Systems

APC uses the following technologies:

- Infrared beams, placed across the passenger's path to register passenger activity (boarding or leaving the bus)
- Treadle mats, which react to the pressure of a passenger's foot as he/she steps on it
- AVL system linkage, used to link passenger activity with specific route stops

Treadle switch

Automatic Passenger Counter (APC) Systems Page 22

Automatic Passenger Counter Systems

APC provides the following benefits:

- Lower data collection costs
- Shorter time necessary to process the collected data
- Improved service planning
- Increased type and range of data available

Moreover, APC data collection has proven to be more accurate than the data collected manually in several instances.

APC System Components Page 23

In the offline mode, the data are stored on the vehicle and downloaded at the garage.

In the real-time mode, wireless communication systems send the data to a central computer at the garage or transit center.

Roll your mouse over each APC System Component for a description:

Electronic Payment Systems (EPS) Page 24

Since this topic is addressed at length in our next module, we will only say a few words about Electronic Payment Systems, which are found increasingly in public transit systems. Magnetic striped cards have been in use for a few years on transit systems. Many agencies are now turning to Smart Cards as a payment option.

As of today, most EPS on transit have been designed for rapid rail systems. However, commuter rail and light rail are also beginning to adopt EPS as the need for seamless regional transportation arises.

Fewer efforts have been made to implement EPS on motorbus systems. The major challenges associated with EPS on motorbus systems result from relatively high EPS capital costs and necessity to install EPS validation and authorization equipment on individual vehicles.

EPS Technologies Page 25

EPS uses the following technologies:

- Smart Cards: In contrast to magnetic striped cards with limited security features and memory, smart cards include electronic encryption of the information on the card and a Personal Identification Number (PIN).

  Smart Cards can store up to 20-30 Kbits of data in their memory.

- Communications: depending on the type of card used, data are transmitted to the host via an antenna or metal contacts.
- Terminals and readers take three forms: Insertion-type (swipe card) readers, motorized-type readers, and radio-frequency readers.

EPS Challenges Page 26

EPS for transit attempts to solve a number of issues, from the viewpoints of both the agency and the customer.

Transportation agencies are confronted with these problems:

- Costs and liability associated with cash collection
- Inaccurate data collection and reporting
- Intermodal coordination
- Flexibility in fare policy implementation
- Reduction of fare evasion and fraud

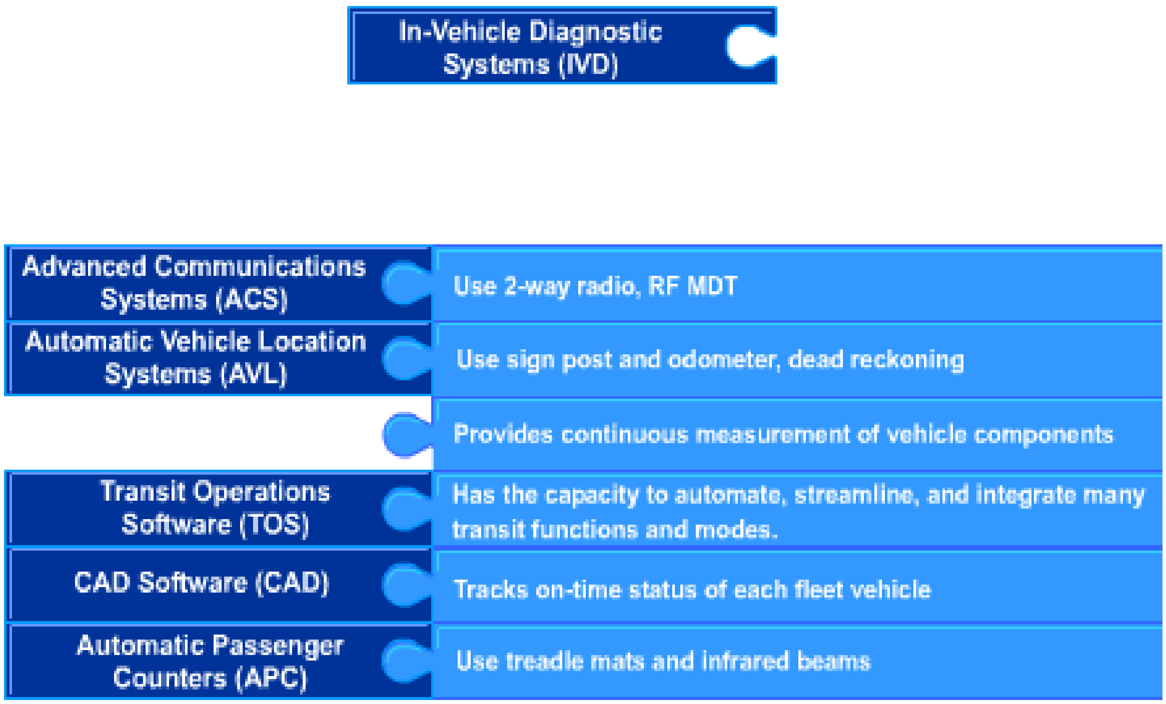
Customers complain about the following:

- Problems associated with need to have exact change
- Difficulties associated with intermodal transfer and multiple fares
- Need for a single payment medium accepted by various transit agencies

You will find detailed information on EPS in the next module, **Electronic Payment Systems**.

Test Your Knowledge: Technologies Puzzle Page 27

Take the "pieces" from the top and drag them next to the property they match.



Relationship to the National ITS Architecture Page 28

As we reach the end of this section, let us consider briefly the National ITS Architecture and its relationship with Public Transportation Operations.

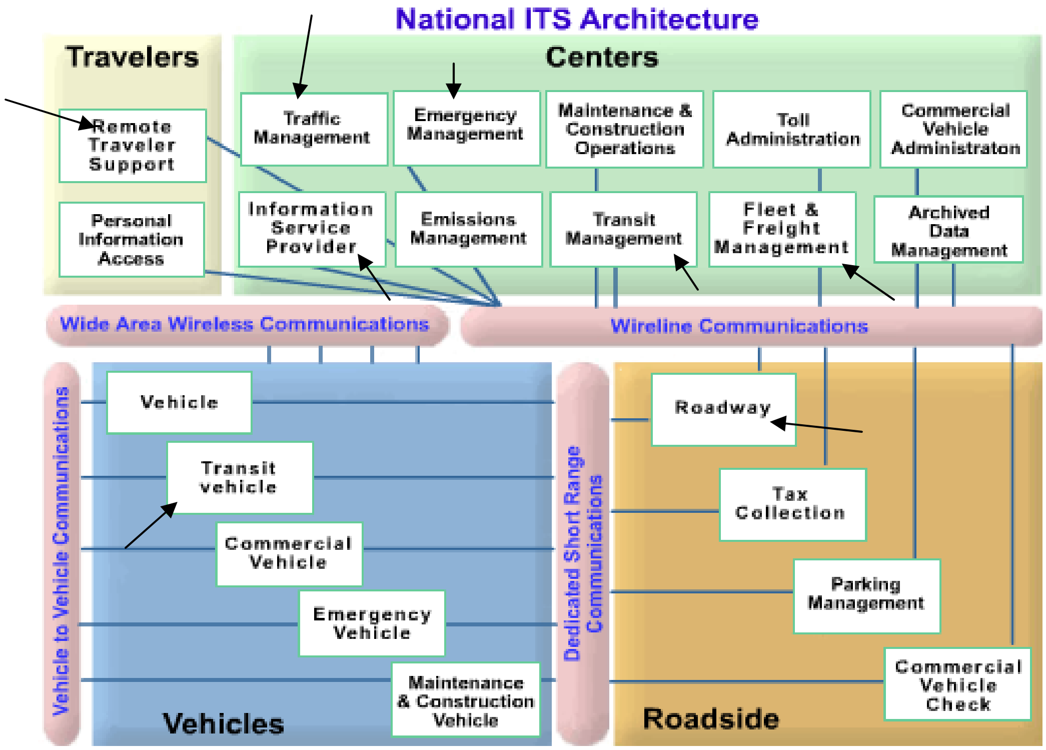
One of the purposes for the development of a national ITS system architecture is to provide a framework to facilitate the planning, design, and implementation of ITS technologies and solutions. Central to this national system architecture are the subsystems associated with the management and operations of transit facilities and services and the need of transit travelers.

The National Architecture is illustrated on the next screen. The graphic represents the physical architecture in terms of the transportation layer (i.e. the subsystems) and the communications layer (the 4 types of communications), to help you understand how the system provides the required functionality.

The subsystems concerned with PTO systems will appear as you roll your mouse over the diagram.

Relationship to the National ITS Architecture (cont'd) Page 29

► Roll your mouse over the diagram to see how PTO systems are related to the National ITS Architecture.



ITS Applications in Transit Management and Operations

Lesson 1 Objectives Review Page 30

Now that you have completed the lesson, you should be able to:

1 List the objectives of PTO

In this lesson, we saw that the objectives of the PTO System include:

- Improving transit service effectiveness
- Increasing operating efficiency
- Enhancing passenger safety

Continue

ITS Applications in Transit Management and Operations

Lesson 1 Objectives Review Page 30

Now that you have completed the lesson, you should be able to:

1 List the objectives of PTO

2 Understand how PTO fit within the National ITS Architecture

The subsystems associated with management/operations of transit services and needs of transit travelers are a vital part of the National ITSArchitecture:

- Remote Traveler Support
- Emergency Management
- Information Service Provider
- Transit Vehicle
- Traffic Management
- Transit Management
- Fleet and Freight Management
- Roadway

Continue

Lesson 1 Objectives Review Page 30

Now that you have completed the lesson, you should be able to:

1 List the objectives of PTO

2 Understand how PTO fit within the National ITS Architecture

3 Describe some of the technologies used in PTO

- Advanced Communication Systems (ACS)
- Automated Vehicle Location Systems (AVL)
- In-Vehicle Diagnostic Systems (IVD)
- Transit Operations Software (TOS)
- Fixed-Route Bus CAD Systems (CAD)
- Paratransit CAD Systems (PCAD)
- Automated Passenger Counters (APC)
- Electronic Payment Systems (EPS)

Continue

Lesson 1 Quiz Page 31

The Internet is a key component of Advanced Communications Systems (ACS) employed for Public Transportation Operations (PTO).

○ True
◉ False

Correct.
Good job!

While the Internet is a main component of many ATIS and other ITS application, it is not a main component in Advanced Communication Systems. As presented in the module, main ACS components include 2-way radio and RF MDT.

Lesson 1 Quiz Page 31

Typically, Transit Operations Software (TOS) consists of:

○ a. Computer-aided dispatching
○ b. Service monitoring
○ c. Supervisory control
○ d. Data acquisition modules
◉ e. All of the above
○ f. All but c

Correct.
Good job!

Typically Transit Operating Software consists of computer-aided dispatching, service monitoring, supervisory control, and data acquisition.

Lesson 1 Quiz Page 31

Paratransit CAD software can be used to assign customers to demand responsive vehicles, which are operating in shared-ride mode.

- ◉ True
- ○ False

Correct. Good job!

The use of CAD software eliminates the need to assign passengers with a labor-intensive manual approach.

Lesson 1 Quiz Page 31

Which of the following is NOT an anticipated Automatic Vehicle Location (AVL) system benefit?

- ○ Quicker response to mechanical problems in the vehicle
- ○ Increased driver and passenger safety and security
- ○ Improved schedule adherence
- ◉ Shorter vehicle boarding times
- ○ Increased dispatching efficiency

Correct. Good job!

All the choices listed above, except for shorter vehicle boarding times, are anticipated Automatic Vehicle Location (AVL) system benefits.

Lesson 2. ITS Applications in Public Transportation Operations Page 32

In this lesson, we will take a look at these PTO deployments:

- **Winston Salem Transit, NC**

- **Santa Clara County, CA**

- **Montgomery County, MD**

Lesson 2 Objectives Page 33

After completing this lesson, you will be able to:

- Discuss the background of the applications in Winston Salem, Santa Clara County, and Montgomery County.
- Identify some of the components used in these applications
- Assess the effectiveness of the strategies adopted

Case Study: Winston-Salem Transit, N.C. Page 34

Started as part of the Winston-Salem Mobility Manager operational test project, Winston-Salem Transit, or WSTA, uses advanced technologies to improve transportation options for the young, elderly, disabled, and others who are unable to use "fixed-route" transit.

WSTA now operates 22 paratransit vehicles through Trans-AID. Hardware and software components of the system include:

- Implemented computer aided dispatch and scheduling
- Mobile data terminals
- AVL technology

Case Study: Winston-Salem Transit, N.C. (cont'd) Page 35

The Winston-Salem Transit Authority in Winston-Salem evaluated the effects of computer-aided dispatch and scheduling system in the operation of a 17-bus fleet.

Measures of Effectiveness:

- Operating expenses decreased by 8.5% per vehicle mile and by 2.4% per passenger trip.
- Customer satisfaction increased by 17.5%.
- Passenger waiting time decreased by 50%.

For more information on this and other Winston-Salem Transit projects, read the [1994 Technical Assistance Report (FTA #8)](), or visit the [WSTA site]().

Case Study: Santa Clara County, CA Page 36

The SMART Paratransit Project began in April 1994 and was completed in 1996, under the direction of a non-profit organization called "OUTREACH". The project, funded by Cal Trans and the FTA, and co-sponsored by the Santa Clara Valley Transportation Authority, aimed to accommodate the increases in paratransit demand required for full ADA compliance by January 1997.

The SMART paratransit system includes these components:

- A digital geographic database, including detailed information such as city and street names, block-by-block address ranges, traffic flow characteristics, and major facilities. The database covers the entire Santa Clara area.
- Automated scheduling and routing software, which schedules clients to appropriate vehicles according to a variety of parameters (pick-up and drop-off times, individualized client loading times, equipment and seating availability of a vehicle, and any other special client needs or equipment), and produces optimum daily routes.
- Turn-key GPS-based AVL System for 40 paratransit vehicles (capable of expanding to up to 1,000 vehicles). This system integrates communications handling equipment with mobile radios and base station radios to provide current vehicle position information.

Case Study: Santa Clara County, CA (cont'd) Page 37

Two independent evaluation studies were planned by the funding entities, CalTrans and the FTA. U.C. Berkeley, Institute of Transportation Studies, conducted the first study and submitted the findings to CalTrans. The second study, contracted by the FTA, was conducted by Cambridge Systematics.

Measures of Effectiveness:

- There was an annual savings in the total cost of $488,325 during the first year of operation of the automated trip scheduling system.
- Shared rides increased from 38% to 55%.
- The fleet size decreased from 200 vehicles to 130.

For more information, visit the [Santa Clara County SMART Paratransit]()

Demonstration Project web site.

Case Study: Montgomery County, MD Page 38

Montgomery County operates a mass transit system known as "Ride On" and consisting of 218 buses. The Ride On fleet provides over 17 million trips per year and it connects to the Washington D.C area Metrobus and Metrorail system. In 1997, Ride On buses were equipped with Global Positioning System (GPS)-based Automatic Vehicle Location (AVL) equipment. Real-time information is now available about the location of the buses, their average speeds along the routes, and bus delays.

The major objective of the application is to improve the transit schedules and the on-time performance of the county's bus system. The components of the system include:

- Global positioning system
- AVL
- CAD system, three channel (2 voice channels,1 data channel) radio system

Case Study: Montgomery County, MD (cont'd) Page 39

The Ride On system is further distinguished by two features:

1. It initiates a "health check" for each vehicle every five minutes.
2. A silent emergency alarm allows the operators to covertly inform dispatch personnel of an emergency or life-threatening situations.

Measures of Effectiveness:

- Travel Time - potential decrease of 15-18%
- Fleet Size - potential decrease of 4-13%
- On-time performance - potential increase of 11-28%
- Incident Response Time - potential decrease of 40-50%

For more information, visit the Montgomery County Ride On web site.

General information on the ATMS program of the county is also available online at the Montgomery County Department of Public Works web site.

Test Your Knowledge: Implementations Page 40

QUESTIONS	
► Of the three case-studies presented in this lesson, which one was NOT focused on paratransit?	Santa Clara, CA
	Winston-Salem, NC
	✔ Montgomery County, MD
	Correct. The Montgomery County application had as a major objective to improve the transit schedules and the on-time performance of the County's bus system.
► The Santa Clara implementation resulted in a large increase in shared rides as well as a sizable reduction of the vehicle fleet.	✔ True
	False
	Correct. In this case-study, the number of shared rides increased from 55% to 78%, while the fleet was reduced from 200 to 130 vehicles.

Lesson 2 Objectives Review Page 41

Now that you have completed the lesson, you should be able to:

1 Describe the backgrounds and objectives of the applications in Winston-Salem, Santa Clara County and Montgomery County.

- The Winston-Salem Trans-Aid project began as part of the Winston-Salem Mobility Manager operational test. The main objective of this application is to improve transportation options for the young, elderly, disabled, and other users who are unable to use "fixed-route" transit.
- The Santa Clara County SMART Paratransit Project was initiated by OUTREACH, funded by Cal Trans and the FTA, and co-sponsored by the Santa Clara Valley Transportation Authority. One of the project's objectives was to accommodate the increases in paratransit demand for full ADA compliance by January 1997.
- The Montgomery County "Ride On" fleet consists of 218 buses providing 17 million trips per year, and connecting to the Washington D.C area Metrobus and Metrorail system. The main objective of the application is to improve the transit schedules and the on-time performance of the County's bus system.

Continue

Lesson 2 Objectives Review Page 41

Now that you have completed the lesson, you should be able to:

1. Describe the backgrounds and objectives of the applications in Winston-Salem, Santa Clara County and Montgomery County.
2. Identify some of the components used in these applications
   - The Winston-Salem Transit system included computer- aided dispatch and scheduling, mobile data terminals and AVL technology.
   - In Santa Clara County, the SMART Paratransit system includes a digital geographic database, automated scheduling and routing software, and GPS-based AVL.
   - The Montgomery County Ride-On system includes GPS-based AVL, and a CAD system.

Continue

Lesson 2 Objectives Review Page 41

Now that you have completed the lesson, you should be able to:

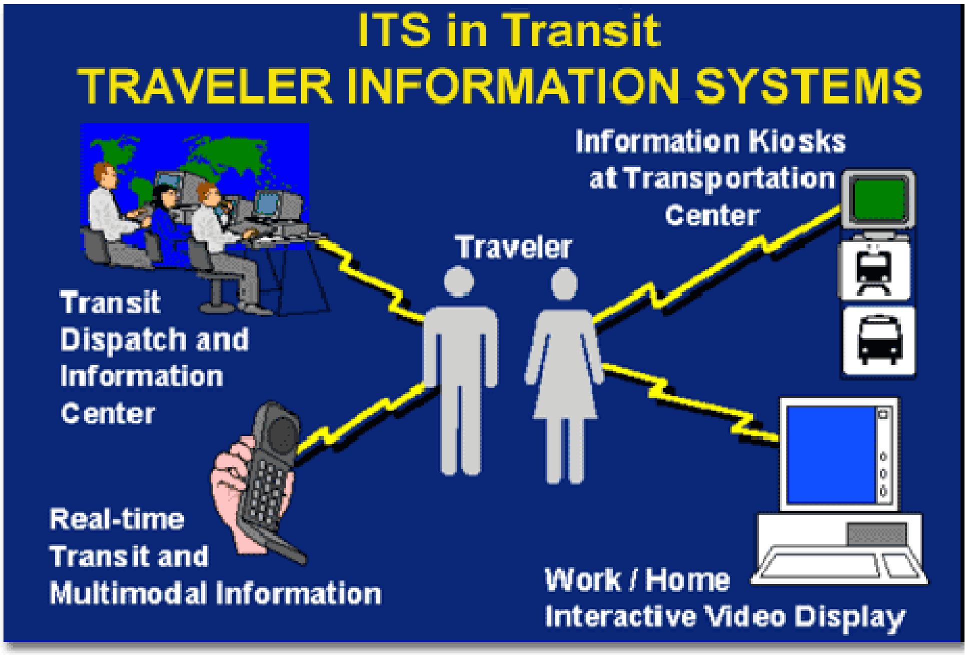
1. Describe the backgrounds and objectives of the applications in Winston-Salem, Santa Clara County and Montgomery County.
2. Identify some of the components used in these applications
3. Assess the effectiveness of the strategies adopted

   The measures of effectiveness given in the lesson showed the three applications were successful in the following respects:

   - In Winston-Salem, customer satisfaction increased while operating expenses and passenger waiting time diminished.
   - In Santa Clara County, operating costs and fleet size decreased while shared rides went from 38 to 55%.
   - Finally, in Montgomery County, fleet size and travel time are expected to diminish, with a noticeable increase in incident response time and on-time performance expected to occur.

Continue

Lesson 3. Advanced Traveler Information Systems (ATIS) for Transit Page 42



Lesson 3 Objectives Page 43

After completing this lesson, you will be able to:

- Define the objectives and benefits of ATIS for transit
- Explain how ATIS for transit fits within the National ITS Architecture
- Describe the technologies and components used in ATIS for transit

ATIS for Transit: Background Page 44

Traveler information systems provide information to help travelers make travel decisions prior to their departure and/or during their trip. While some traveler information systems are designed to assist only transit patrons, other systems are more comprehensive and provide information on other modes as well.

A traveler information system may be either static or dynamic. For instance, scheduled bus arrival times stored in a database may be available from a touch screen computer in a hotel lobby (static system); or, the computer may provide actual bus arrival times obtained through the use of an automated vehicle location (AVL) system which tracks transit vehicles in real time.

For instance, WMATA's Rideguide provides itinerary planning and real-time transit information to Washington Metro patrons.

ATIS Objectives Page 45

The primary objective of traveler information systems are:

- To improve traveler convenience
- To reduce traveler frustration
- To increase safety and security

We will now look at the way in which ATIS for Transit can fulfill these objectives.

ATIS Benefits Page 46

Ease and convenience of travel is one of the major benefits of traveler information systems. For instance, transit patrons can determine at work, perhaps via the Internet, whether their commuter train is leaving on schedule. Should the train be delayed, they can then decide to stay at work later or perhaps run an errand before getting to the train station.

ATIS systems have also helped improve **passenger safety and security** in two ways:

1. The availability of information on schedule adherence means that patrons can avoid waiting an extended period of time at a remote bus stop location.
2. Traveler information systems facilitate communications between bus and train operators and dispatchers. Thus, it is now easier to report or monitor potential passenger problems on transit vehicles or in terminal areas.

ATIS Benefits (cont'd) Page 47

Increased overall ridership and revenues are also cited as long-term benefits of transit traveler information systems. Convenience and ready availability of information have contributed to increases in trip frequency of current riders, as well as attracting new patrons.

One underlying assumption is that transit should become more competitive as the use of ATIS systems, coupled with other transit improvements, yield enhancements in all facets of transit: service quality, convenience, safety, and security.

Check it out!

Additional information on ATIS and access to ATIS-related documents are available from the Traveler Information Systems page on the FTA site.

ATIS Components Page 48

Click each item for more information:

Traveler Information Systems Components:

- Pretrip information sources
- Pretrip access mechanisms
- Enroute information sources
- Enroute access mechanisms

Traveler Information System Tools:

- Kiosks
- Closed-circuit television monitors
- Cable television
- Telephones
- Dynamic or variable message signs (DMS/VMS)
- PCs on the Internet

ATIS Requirements Page 49

- **Tracking locations of vehicles** is a requirement in dynamic traveler information systems; for example, telling a passenger that a bus is running 10 minutes behind schedule requires that the bus be tracked in real time.
- **Maintaining a database of routes and schedules** is necessary for the comparison of predicted (ETA/ETD) and scheduled arrival time.
- **Communications from information source to user**, for example, the estimated time of arrival information may be provided to a rider en-route at a bus stop or terminal.
- **Interface/display subsystem** provides the rider with information in an understandable format.

Test Your Knowledge: ATIS Page 50

Question 1. The benefits from ATIS for individual travelers include:

- Enhanced safety
- Less stress
- Both

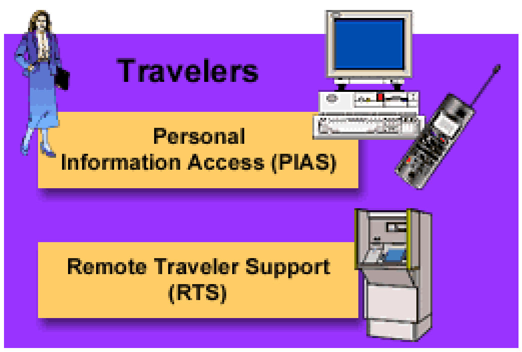
Correct. Benefits from ATIS include both enhanced passenger safety and reduced stress.

Question 2. ATIS information can be provided to travelers through the telephone.

- True
- False

ATIS and the National ITS Architecture Page 51

Traveler information systems for transit incorporate aspects related primarily to two of the 33 ITS User Services included in the National ITS Architecture:

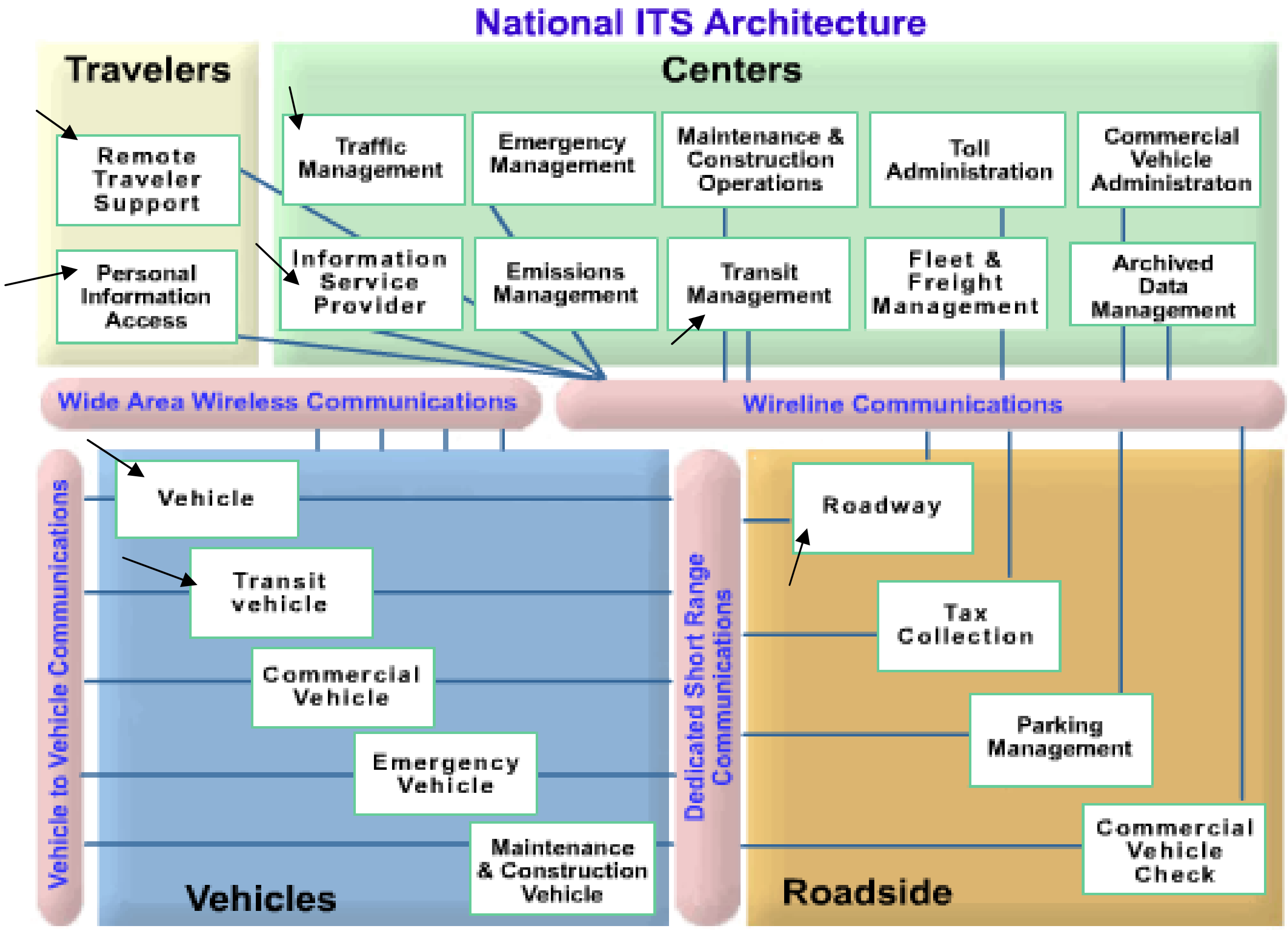


1. The En-route traveler information user service, which is provided during the trip either in the transit vehicle or at the transit/station/stop.
2. The Pre-trip traveler information user service, made available prior to departure to assist in the selection of a mode, route, and/or departure time.

The relationship of ATIS for transit to the other components of the National ITS Architecture is illustrated on the next screen.

ATIS and the National ITS Architecture (cont'd) Page 52

► Roll your mouse over the diagram to see how PTO systems are related to the National ITS Architecture.



ATIS and the National ITS Architecture (cont'd) Page 53

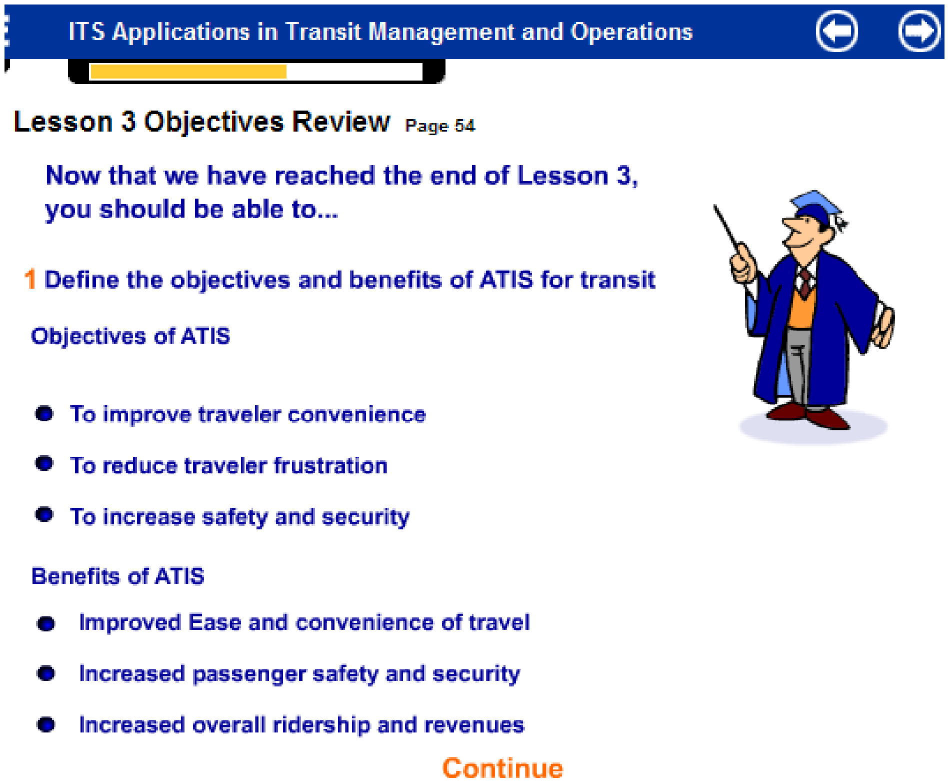
As shown on the previous screen, several transportation subsystems (e.g. traffic and transit management centers, vehicle) in the National ITS Architecture can be employed to provide information regarding transit and other modes.

For example, the transit management center might communicate with transit vehicles via a short-range communication system. With the aid of an AVL system, it can provide travelers with actual vehicle locations and/or estimated vehicle arrival times, parking availability, and

A traffic management center can provide information on real-time roadway traffic conditions with the use of similar communication

other information via the telephone, variable message signs, kiosks, and PCs with Internet connections.

systems and devices.



ITS Applications in Transit Management and Operations

Lesson 3 Objectives Review Page 54

Now that we have reached the end of Lesson 3, you should be able to...

1 Define the objectives and benefits of ATIS for transit

2 **Understand how ATIS for transit fits within the National ITS Architecture**

Traveler information systems for transit incorporate aspects related primarily to the Pre-trip and En-route traveler information user services. ATIS for transit is also related to the following subsystems:

- Remote Traveler Support
- Traffic Management
- Personal Information Access
- Transit Management
- Information Service Provider
- Vehicle
- Transit Vehicle
- Roadway

Continue

Lesson 3 Objectives Review Page 54

Now that we have reached the end of Lesson 3, you should be able to...

1 Define the objectives and benefits of ATIS for transit

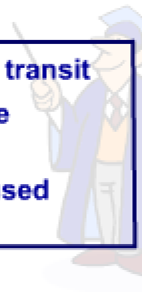
2 Understand how ATIS for transit fits within the National ITS Architecture

3 **Describe the technologies and components used in ATIS for transit**

ATIS information can be obtained before taking the trip (pre-trip) or during the trip (en-route). The information can be obtained through ATIS kiosks, CCTV, cable TV, telephone, PCs on the Internet, and dynamic or variable message signs (DMS or CMS) on the highways.

Lesson 3 Objectives Review Page 54

1. Define the objectives and benefits of ATIS for transit
2. Understand how ATIS for transit fits within the National ITS Architecture
3. Describe the technologies and components used in ATIS for transit



You are now ready to go on to Lesson 4, "Case Study: Seattle, WA, MDDI ". But before doing so, please take the short quiz presented on the next page.

Lesson 3 Quiz Page 55

The Internet is a main component of ATIS in transit.

- (●) True
- ( ) False

Correct.
Good job!

As illustrated in the Seattle ATIS transit application, the Internet is instrumental in the storage and dissemination of transit traveler information.

Lesson 3 Quiz Page 55

Which of the following is NOT an anticipated ATIS benefit?

- ( ) Improved traveling convenience for transit patrons
- ( ) Enhanced passenger safety and security
- (●) Improved transit fleet maintenance
- ( ) Increased overall ridership

Correct.
Good job!

Improved transit fleet maintenance is not an anticipated ATIS benefit since ATIS focuses on collection and dissemination of traveler information.

Lesson 3 Quiz Page 55

One of the major requirements of an ATIS system is to provide an estimated time of arrival information.

- ◉ True
- ○ False

Correct.
Good job!

Estimated time of arrival information provides passengers with useful information to plan their time accordingly.

Lesson 4. Case Study: Seattle MDDI Page 56

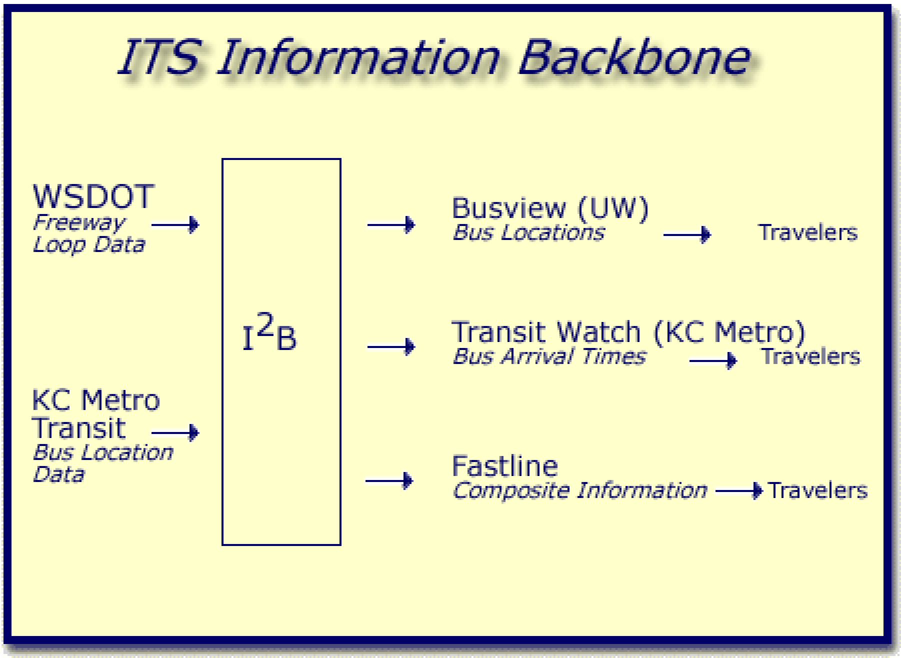
A traveler information system for transit has been designed as an integral part of the Seattle Metropolitan Model Deployment Initiative (MMDI), a comprehensive, multi-modal effort to implement a variety of ITS user services in the Seattle regional area.

The Seattle MMDI includes a partnership involving government, industry and academia. The major participants are the U.S. DOT, Washington State DOT (WSDOT), King County Metro, University of Washington (UW), and industry partners.

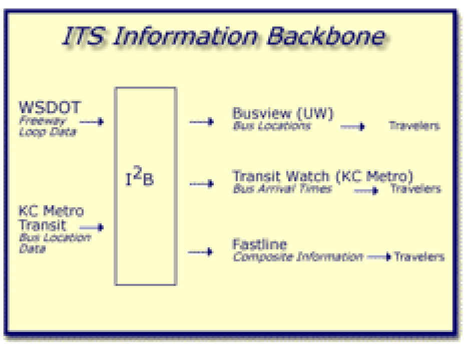
After completing this lesson, you will be able to:

Case Study: Seattle, WA Page 57

A distinguishing characteristic of the traveler information system in the Seattle MMDI is that it uses the Internet as a major communication medium between the transportation subsystems and the ITS information backbone (I^2B), as shown below.



Case Study: Seattle, WA (cont'd) Page 58



The I^{2}B is an information system design; it specifies how participants (e.g. WSDOT, KC Metro, University of Washington (UW), and private information service providers such as Fastline) organize information flows. These organizational flows consist of gathering, processing, and dissemination steps, from the source to the actual users.

From a functional standpoint, the I^{2}B acts as a collector and distributor of information. It receives information from contributors and redistributes this information to processors, who in turn process the information, add value, and provide the information to travelers.

The equipment components of the I^{2}B consist of a series of geographically distributed computers located at the UW, WSDOT, and KC Metro. The computers host processes that interact and collaborate with each other via the internet. The administration of the I^{2}B is performed by the UW, which also provides software tools for connecting to the I^{2}B.

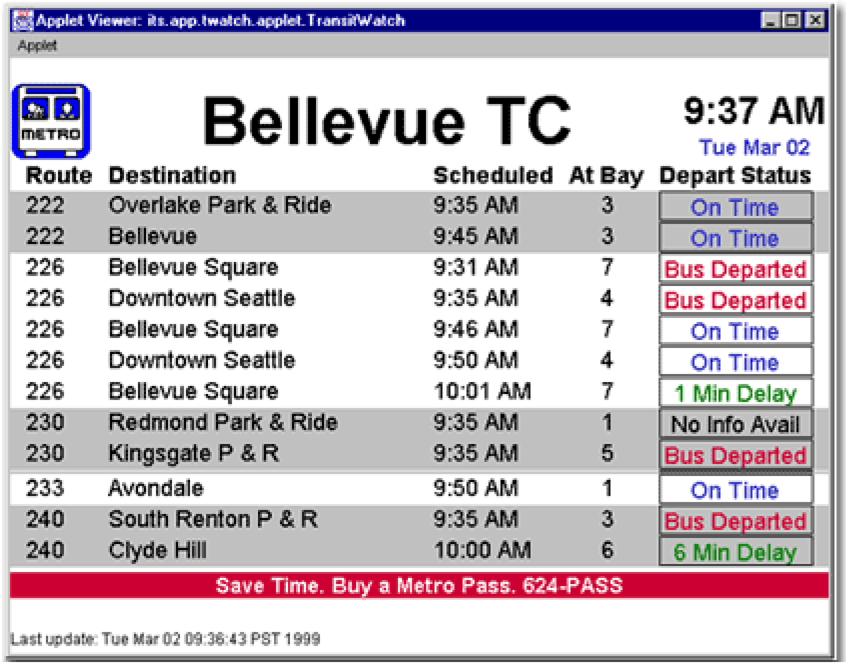
Case Study: Seattle, WA (cont'd) Page 59

UW also operates Busview, a service that uses the Internet to display KC Metro buses locations graphically. Travelers can connect to the Busview web site prior to their departure, click on a selected location of KC Metro's service area, and choose from icons representing route and bus numbers, direction of travel, and time elapsed since a bus last passed that location.

A sample of a Busview screen is shown on the next page.

Case Study: Seattle, WA (cont'd) **Page 60**

Case Study: Seattle, WA (cont'd) **Page 61**



UW and KC Metro also jointly operate Transit Watch, another transit specific software application accessible on the web, which displays estimated bus arrival times at key locations, as shown in the sample screen above.

Test Your Knowledge: Seattle Implementations Page 62

QUESTIONS

- **Seattle's "ITS Information Backbone" (I^2B):**
  - Collects information
  - ✗ Distributes information
  - ✓ Both collects and distributes information
  - Correct. The I2B receives information from contributors and redistributes this information to processors, who process it and provide it to travelers.

- **The Busview and Transit Watch applications obtain information from WSDOT and KC Metro Transit and relay it to travelers.**
  - ✗ True
  - ✓ False
  - Correct. Busview and Transit Watch obtain information from the ITS Information Backbone, process it, and relay it to travelers.

Lesson 4 Objectives Review Page 63

Now that we have reached the end of Lesson 4, you should be able to...

1 Describe the ITS Information Backbone, or I^2B

In this lesson, you have learned that the ITS Information Backbone collects information from its contributors and redistributes it to processors who, in turn, process the information, add value, and provide the information to travelers.

Lesson 4 Objectives Review Page 63

Now that we have reached the end of Lesson 4, you should be able to...

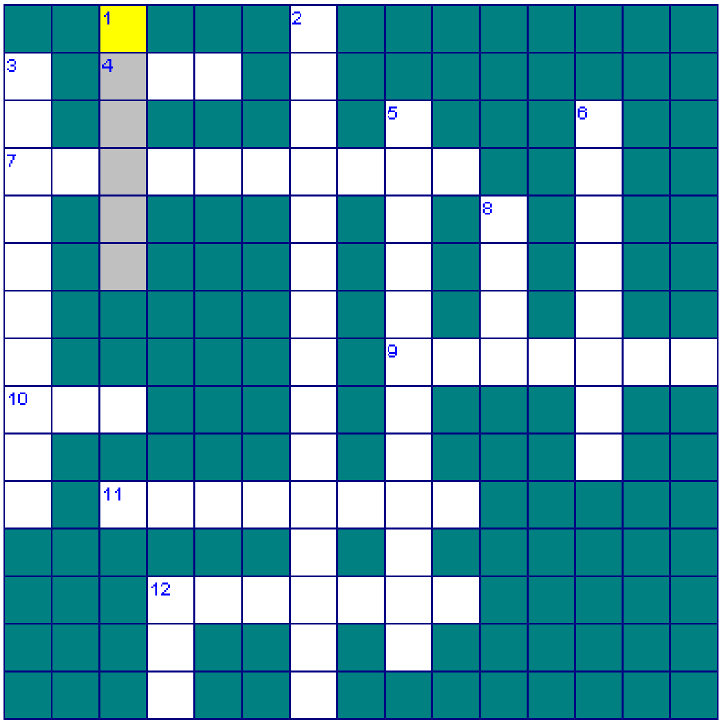
1 Describe the ITS Information Backbone, or I^2B

2 Discuss the BusView and Transit Watch applications

BusView is operated by the University of Washington. This service uses the Internet to display KC Metro buses locations graphically.

Transit Watch is operated jointly by the University of Washington and KC Metro. This application displays estimated bus arrival times at key locations through the Internet.

Crossword Puzzle Page 64



Crossword Compiler Software © A. Lewis 1999

Across

4. Used to track the real-time location of vehicles

7. Reacts to the pressure of a passenger's foot as he/she steps on it.

9. A Seattle service which uses the Internet to display buses locations graphically.

10. Automates, streamlines, and integrates many transit functions and modes.

Down

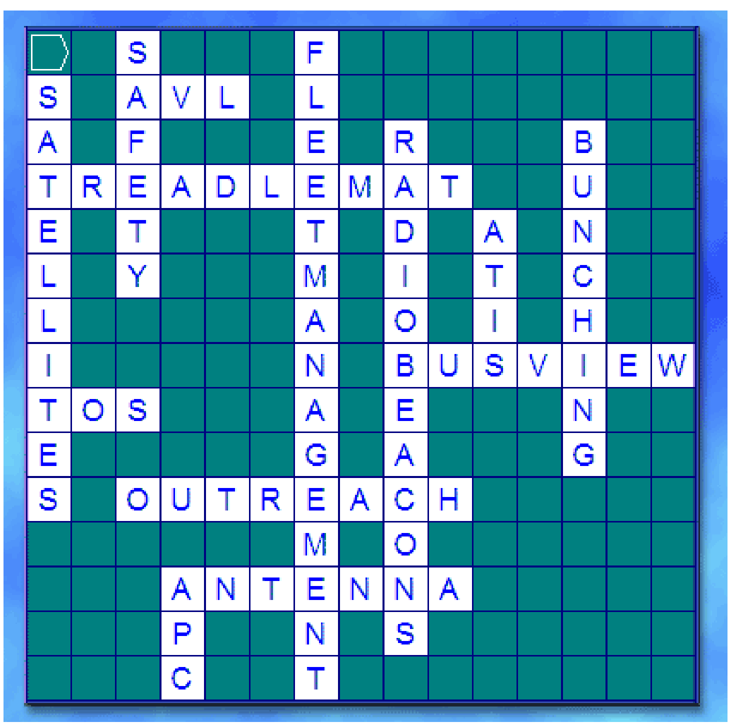
1. One of the benefits of ATIS and AVL

2. Important facet of Public Transportation Operations

3. There are 24 of these

5. Sometimes placed on telephone posts

6. Describes vehicles following each other too closely along the same route



Lesson 5. Traffic Signal Priority Strategies (TSPS) for Transit Page 66

Lesson 5 Objectives Page 67

After completing this lesson, you will be able to:

- List the objectives of TSPS
- Describe the requirements and benefits of TSPS
- Explain how TSPS fit within the National ITS Architecture
- Identify some of the technologies used for TSPS

TSPS for Transit: Background Page 68

Traffic Signal Priority is a strategy by which a particular set of vehicles is given preference at traffic signals, either any time they arrive at the intersection or only under certain conditions (e.g. on-time status, amount of traffic at opposing approaches).

*Although a transit vehicle does not warrant the same urgency as emergency vehicles, which always have priority, there are benefits in giving a bus priority at a traffic signal under the right conditions.**

Transponder Tag on Bus
[source: APTS: The State of the Art- Update 2000]

Traffic vehicles have been given priority at traffic signals for a long time. In early systems, the bus transmitted a request directly to the signal, and priority was given. Now, however, Traffic Signal Priority Systems take advantage of APTS technologies such as AVL and CAD.

**See Teacher Talk for source.*

TSPS Objectives

- A primary objective of TSPS in transit is to reduce vehicle running times for the purposes of increasing operational efficiency and maintaining scheduled times.
- Another objective is to control vehicle flow when vehicles along the same route are following one another too closely, a phenomenon referred to as bunching; bunching is a common problem in large urban areas along congested routes with short headways.

TSPS Requirements

- To provide extended green interval for MB
- To detect buses prior to the intersection and make appropriate changes, if necessary

TSPS for Transit: How Does It Work? Page 70

The bus transmits a sound or optical signal to the traffic signal controller to activate priority. The current green phase is extended, or the timing of the next green phase is moved up.

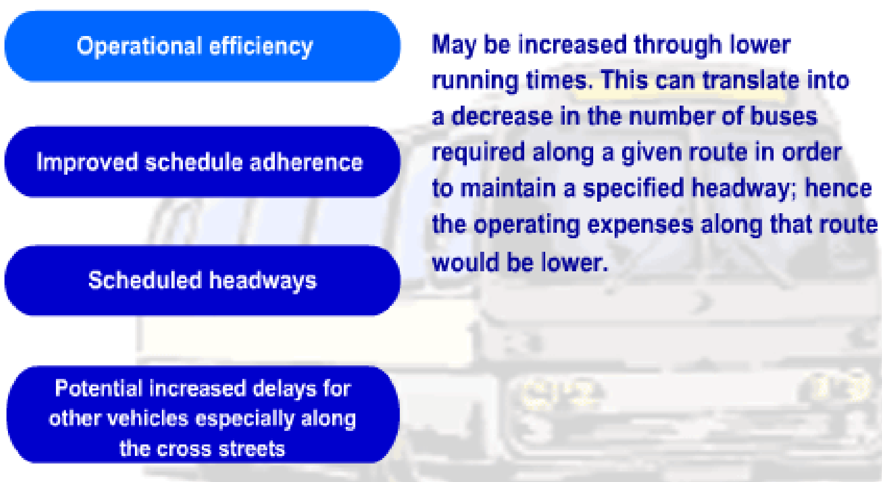
- TSPS for transit provide buses and light-rail vehicles with varying levels of control over traffic signals.
- This control may include the ability to extend the green phase and/or to truncate a red phase.
- TSPS may also provide priority treatment to emergency vehicles (e.g. fire, police, ambulance), usually in the form of an immediate green phase, often referred to as signal preemption.

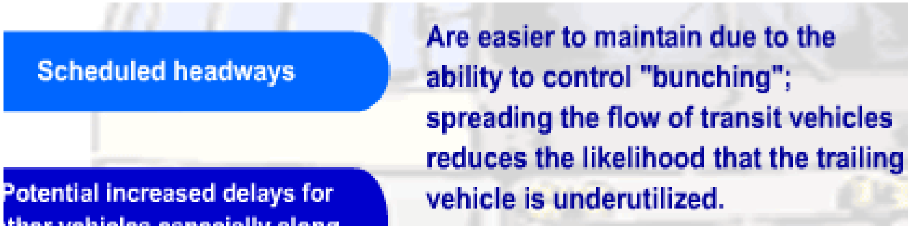
Signal Priority Antenna on Pole
[source: APTS: The State of the Art- Update 2000]

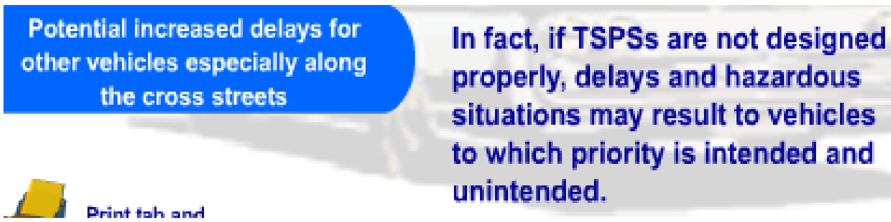
Benefits and Impact of TSPS Page 71

The application of TSPS for transit can increase vehicle operational efficiency, improve schedule adherence, and help maintain scheduled headways; however, it may also increase delays for other vehicles, especially along the cross streets.

Mouseover the tabs for an explanation:







TSPS and the National ITS Architecture Page 72

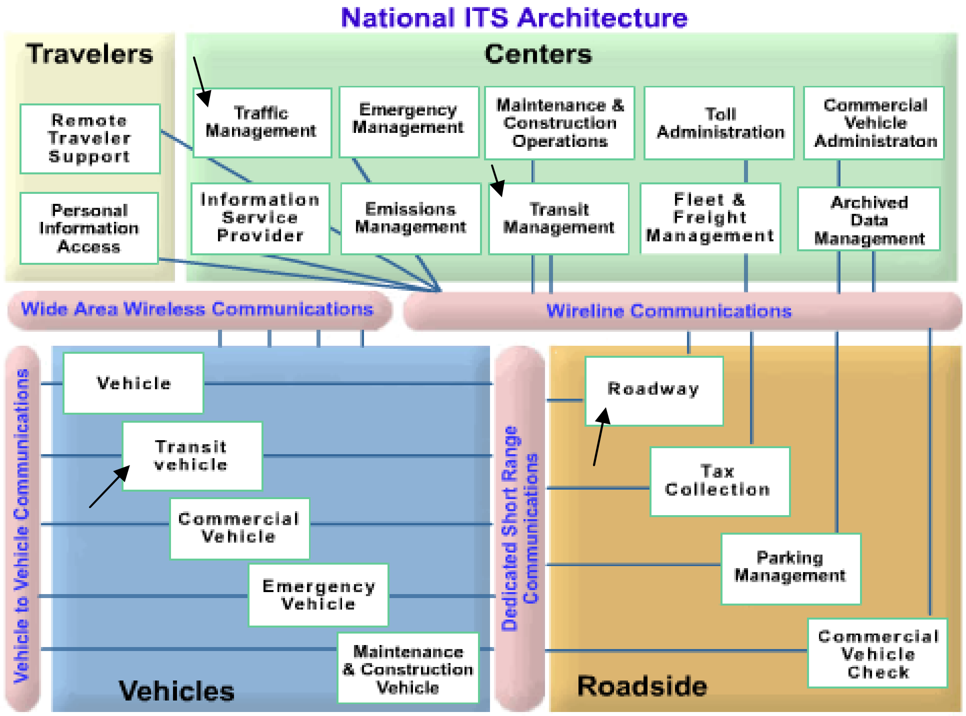
TSPS incorporate aspects related primarily to two of the 33 ITS User Services included in the National ITS Architecture:

1. The first, **Public Transportation Management**, is a user service supporting transit operational functions.
2. The second, **Traffic Control**, manages the movement of traffic including transit and other vehicles along roadways.

The relationship of TSPS to the other components of the National ITS Architecture is illustrated on the next screen.

TSPS and the National ITS Architecture (cont'd) Page 73

► Roll your mouse over the diagram to see how PTO systems are related to the National ITS Architecture.



TSPS and the National ITS Architecture (cont'd) Page 74

To illustrate the relationship between TSPS and the National ITS Architecture, consider the following examples.

Example 1:

1. Communicates via a wireless communication system with all fixed route buses to monitor their location
2. Processes location data with an automated vehicle location (AVL) system, and monitors bus routes
3. May send, if required, a message to the signal priority module on board the bus to enable the bus to communicate with the signal controller to request priority

Example 2:

1. The Traffic Signal Priority System includes a special transmitter on board the vehicle (i.e. vehicle subsystem).
2. The transmitter communicates via DSRC with local controller (i.e. roadside subsystem), requesting priority.
3. If a green phase exists at the time of request, it might be extended to allow the bus to clear the intersection. If a red phase exists, it will be terminated.

Lesson 5 Objectives Review Page 75

Now that we have reached the end of Lesson 5, you should be able to...

1 List the objectives of TSPS

- To maintain adherence to schedules
- To increase operating efficiency
- To control bus "bunching"

Lesson 5 Objectives Review Page 75

Now that we have reached the end of Lesson 5, you should be able to...

1 List the objectives of TSPS

2 Understand how TSPS fit within the National ITS Architecture

TSPS for transit incorporate aspects related primarily to the Public Transportation Management and Traffic Control user services. TSPS for transit are also associated with the following subsystems:

- Traffic Management
- Transit Management
- Transit Vehicle
- Roadway

Lesson 5 Objectives Review Page 75

Now that we have reached the end of Lesson 5, you should be able to...

1 List the objectives of TSPS

2 Understand how TSPS fit within the National ITS Architecture

3 Describe the requirements and benefits of TSPS

TSPS for transit must meet the following requirements:

- Increased operational efficiency
- Improved schedule adherence
- Easier-to-maintain scheduled headways

TSPS for transit offer the following benefits:

- To provide extended green interval
- To detect buses prior to the intersection and make appropriate changes

Lesson 5 Objectives Review Page 75

Now that we have reached the end of Lesson 5, you should be able to...

1 List the objectives of TSPS

2 Understand how TSPS fit within the National ITS Architecture

3 Describe the requirements and benefits of TSPS

4 Identify some of the technologies used for TSPS

Traffic Signal Priority Systems take advantage of APTS technologies such as Automated Vehicle Location (AVL), Computer-Aided Dispatching (CAD), and use wireless communication systems to monitor the location of fixed-route buses.

Lesson 5 Quiz Page 76

A major anticipated benefit of TSPS is that it will help drivers stay on schedule.

◉ True
○ False

Correct. Good job!

TSPS strategies, such as extending a green interval may lead to reductions in bus delay and thus improve schedule adherence.

Lesson 5 Quiz Page 76

An AVL system may be an essential component of TSPS.

◉ True
○ False

Correct. Good job!

Because some TSPSs are conditional upon the degree to which a bus is running late, the AVL system may be necessary; for example, the AVL may be used to acquire information regarding the actual location and time of the bus, to determine if i it is n fact running more than 10 minutes late.

Lesson 5 Quiz Page 76

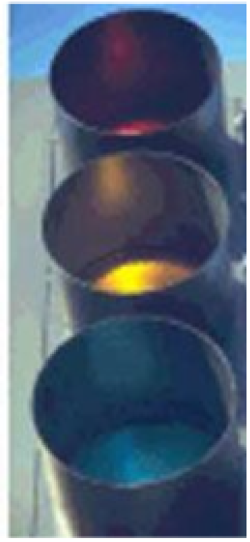
While it is recognized that TSPS may benefit transit riders, it may also negatively impact other travelers.

◉ True
○ False

Correct. Good job!

Delays may be encountered by auto travelers on the side streets intersecting the streets on which a bus is running. However, as , indicated in the module, typically such delays are small.

Lesson 6. Lessons Learned in TSPS Page 77



A number of case studies have been reported on TSPS experiences, from which a variety of lessons have been learned.

Let's now take a look at a few examples of TSPS deployment, and at the results they have yielded. We will briefly review systems implemented in:

- Charlotte, North Carolina
- King County, Washington
- Bremerton, Washington

Lesson 6 Objectives Page 78

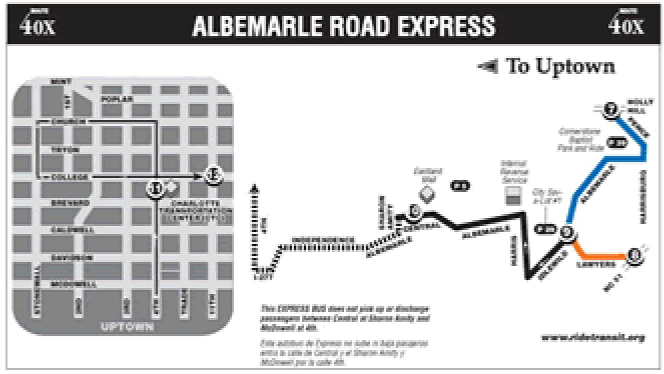
After completing this lesson, you will be able to discuss the Charlotte, King City, and Bremerton TSPS implementations with regard to the following characteristics:

- Hardware and software components
- Communications systems
- Measures of effectiveness

Case Study: Charlotte, NC Page 79

Background

In Charlotte, North Carolina, city officials implemented a TSPS strategy in 1985 along a major arterial for the purposes of improving the provision of express bus service (Bus Route 40X) providing access to downtown Charlotte. This TSPS is still in place.



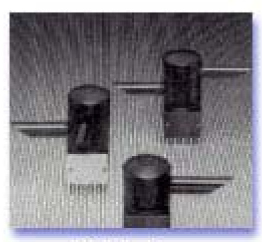
WEEKDAYS / DE LUNES A VIERNES						
Note	Pence & Holly Hill	Lawyers & hwy-51	Idlewild & Lawyers	Central & Eastland Mall	Charlotte Transportation Center	College & 11th
F	6:02a	------	6:16a	6:28a	6:52a	7:00a
F	------	6:15a	6:31a	6:43a	7:07a	7:15a
F	6:32a	------	6:46a	6:58a	7:22a	7:30a
F	------	6:45a	7:01a	7:13a	7:37a	7:45a
F	7:02a	------	7:16a	7:28a	7:52a	8:00a
F	------	7:15a	7:31a	7:43a	8:07a	8:15a
F	7:32a	------	7:46a	7:58a	8:22a	8:30a
F	------	7:45a	8:01a	8:13a	8:37a	8:45a
F	8:02a	------	8:16a	8:28a	8:52a	9:00a
	4:57p	------	------	------	5:27p	------
	------	5:20p	------	------	5:50p	------
	5:27p	------	------	------	5:57p	------
	------	5:50p	------	------	6:20p	------
	5:57p	------	------	------	6:27p	------
	------	6:20p	------	------	6:50p	------

Case Study: Charlotte, NC (cont'd) **Page 80**

- **Hardware:**
  - o 3M Opticom System
- **Software:**
  - o The green phase is extended or the red phase is truncated for express buses
  - o The system is in effect in the peak direction only
  - o No phases are skipped
  - o All non-priority phases get a minimum green
  - o The priority phase ends as soon as the bus clears the intersection
- **Communication Systems:**
  - o Infrared short range communication between bus emitter and intersection detector
  - o Wire communication between detector and phase selector in signal controller

3M Opticom System

Emitter



Detector

Case Study: Charlotte, NC (cont'd) **Page 81**

- **Measures of Effectiveness:**
  - o Average bus travel time reduced by four minutes
  - o Less wear and tear on braking systems due

It is also worth noting that this TSPS was

to reductions in stop and go flow

- Fewer rear-end collisions due to reductions in stop-and-go flow
- Decreases in idling time and thus in localized emissions
- Reductions in driver stress as a result of less lane changing
- Increase in ridership
- Improvements in traffic flow along arterial
- No major unacceptable delays reported on cross streets

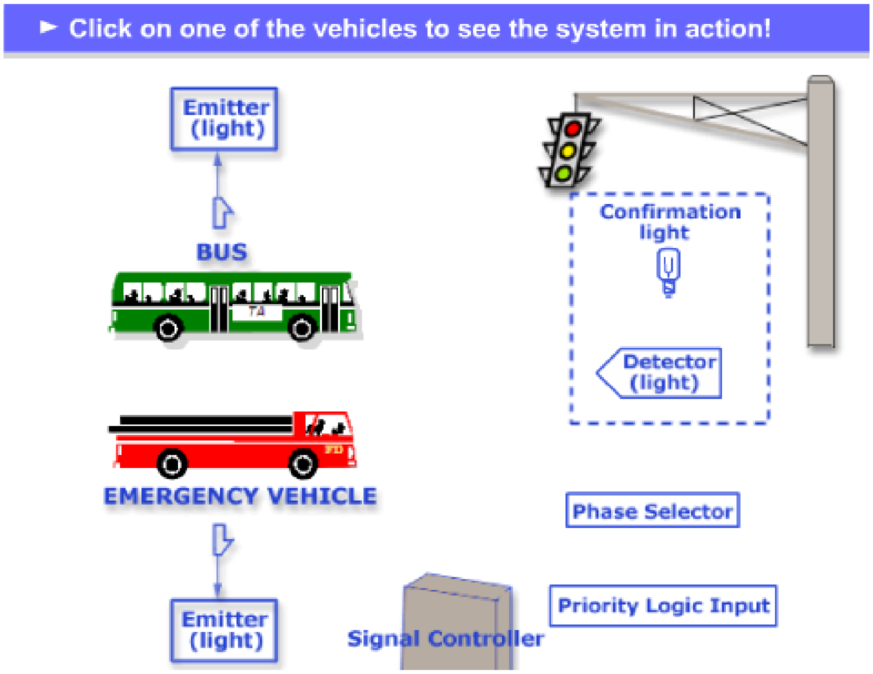
considered by local officials as a relatively easy strategy to plan and implement from an institutional standpoint because the City of Charlotte owns and maintains the traffic signals, and provides the bus service.

Case Study: Bremerton, WA Page 82

In Bremerton, a small scale TSPS on five vehicles on a 12-month trial basis in 1992-1993 was implemented by Kitsap transit, a local transit operator, in conjunction with the local transportation department. Based on the results of this trial, an area-wide TSPS strategy was adopted and implemented and is now in place at 60 intersections along both local and express bus routes.

Hardware	3M Opticon System
Software	Extended green/truncated red
	Phase skipping permitted
	All walk and yellow times unchanged
Communication Systems	Infrared short-range communication between bus emitter and intersection detector
	Wire communication between detector and phase selector in signal controller

Case Study: Bremerton, WA (cont'd) Page 83



Case Study: Bremerton, WA (cont'd) Page 84

According to an assessment of the trial conducted by the University of Washington, the TSPS yielded the following results (measures of effectiveness):

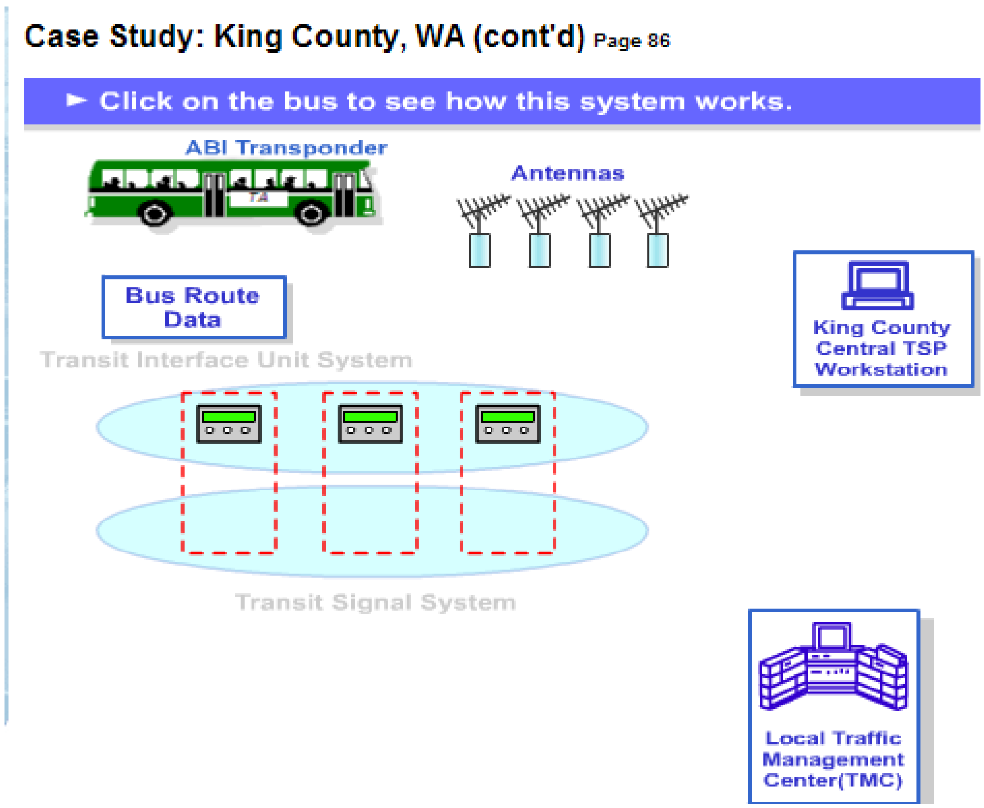
- Average bus travel time was reduced by 10%
- Express bus travel time decreased by as much as 16%
- Driver stress was lower; driver morale improved
- Decreased stop-and-go flow led to 20% increase in brake life
- No significant delays were experienced by cross streets traffic
- No major unacceptable delays were reported on cross streets

It was also estimated that on average 18-19 seconds were required to return to a normal cycle and that this TSPS may not work well with buses operating on headways of less than 15-30 minutes.

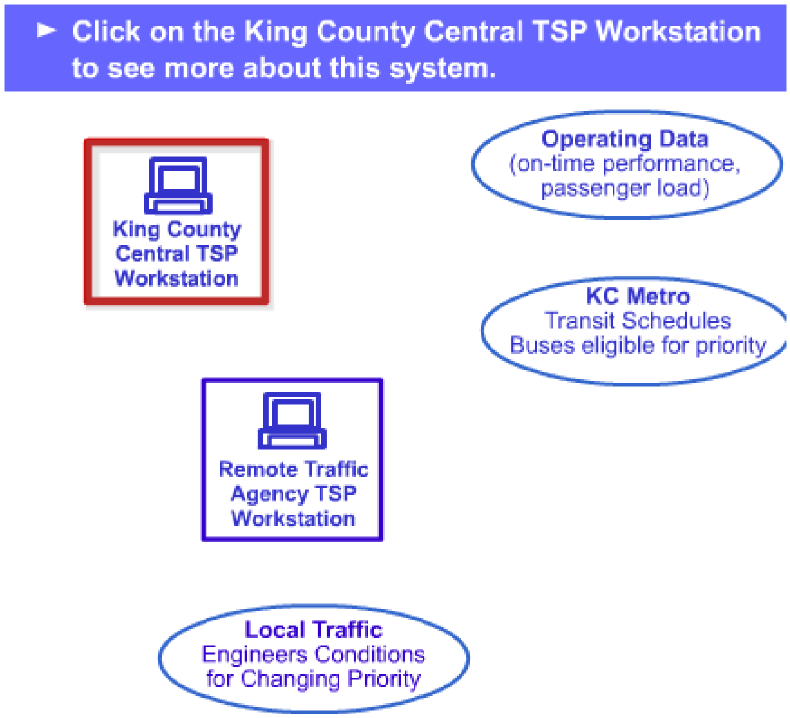
Case Study: King County, WA Page 85

One of the aims of the new *Intelligent Transportation Systems* program King County is building is the use of technology to reduce congestion and move vehicles and buses faster and more reliably along two major corridors. A transit signal priority system was installed on 210 buses in Seattle, Washington. This system complements the synchronized signal systems still under construction.

- **Hardware Components:**
  - Amtech RF (radio frequency) tag
  - Tag interface unit (TIU)
  - Pole-mounted Amtech log periodic antenna
  - Pole-mounted Amtech tag reader enclosure
- **Software Components:**
  - Extended green
- **Communication Systems:**
  - A reader at the roadside identifies the transponder tag on each bus and feeds information to a processor, which decides whether or not to grant priority.

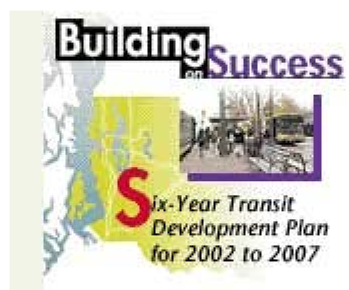


Case Study: King County, WA (cont'd) Page 87



Case Study: King County, WA (cont'd) Page 88

Measures of Effectiveness:



- Signal related stops decreased by 50%
- Average stopped delay reduced by 57%
- No average vehicle intersection delay
- Bus travel time reduced by 35%
- No side street delays

Check it out!

Information on King County's Six-Year Transit Development Plan (2002-2007) can be downloaded from the King County DOT web site (PDF format).

ITS Applications in Transit Management and Operations

Lesson 6 Objectives Review Page 89

Now that we have reached the end of Lesson 6, you should be able to...

Discuss the TSPS implementations in Charlotte, NC King County, WA and Bremerton, WA with respect to:

1 Hardware and software components

- **Hardware:**
  The Charlotte and Bremerton implementations both used the 3M Opticom System. In King County, the hardware (Amtech) included an RF tag, a tag interface unit, a pole-mounted periodic log antenna, and a tag reader enclosure.

- **Software:**
  The software set the parameters for green phase extension/red phase truncation for express or all buses, and emergency vehicles. The software also determined the length of the priority phase, whether phases were skipped, the direction (peak only or more) in which the system takes effect, and the effect on walk and yellow times.

ITS Applications in Transit Management and Operations

Lesson 6 Objectives Review Page 89

Now that we have reached the end of Lesson 6, you should be able to...

Discuss the TSPS implementations in Charlotte, NC King County, WA and Bremerton, WA with respect to:

1 Hardware and software components

2 Communication systems

- In Charlotte, NC, as well as Bremerton, WA, communication between the bus emitter and intersection detector occurs via short-range infrared; however, the detector and phase selector in signal controller are linked through wire communication.
- In King County, WA, a reader at the roadside identifies the transponder tag on each bus and communicates the information to a processor.

ITS Applications in Transit Management and Operations

Lesson 6 Objectives Review Page 89

Now that we have reached the end of Lesson 6, you should be able to...

Discuss the TSPS implementations in Charlotte, NC King County, WA and Bremerton, WA with respect to:

1. Hardware and software components
2. Communication systems
3. **Measures of effectiveness**

Significant reductions were obtained in:

- **Bus travel times**
- **Driver stress**
- **Wear and tear on the brake system**

Furthermore, in Charlotte, an increase in ridership was noted, along with:

- **Fewer rear end collisions due to reductions in stop and go flow**
- **Decreases in idling time and thus in localized emissions**

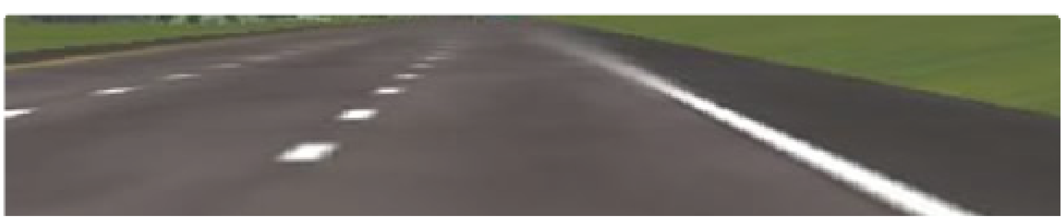
ITS Applications in Transit Management and Operations

Course Summary Page 90

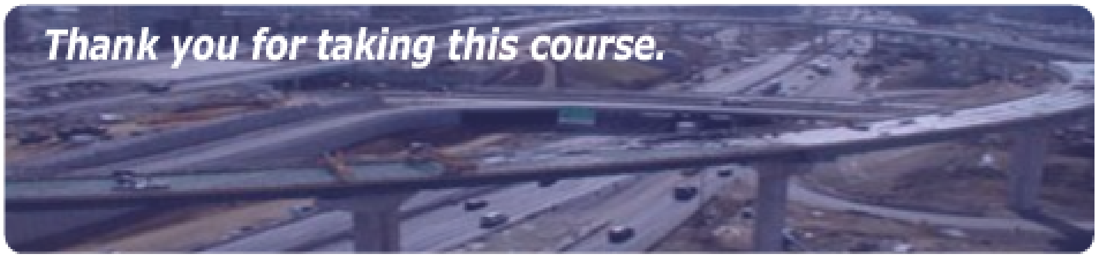
ITS applications are employed in several areas of transit management, including **Public Transportation Operations** (PTO), **Advanced Traveler Information Systems** (ATIS), and **Traffic Signal Priority Strategies** (TSPS). In each of these areas, a variety of technologies have been used to achieve the desired objectives.

PTO aims to improve transit service effectiveness, operating efficiency and passenger safety. PTO technologies include Advanced Communication Systems (ACS), Automatic Vehicle Location Systems (AVL), In-Vehicle Diagnostic Systems (IVD), Transit Operations Software (TOS), and Automatic Passenger Counters (APC).

Continue



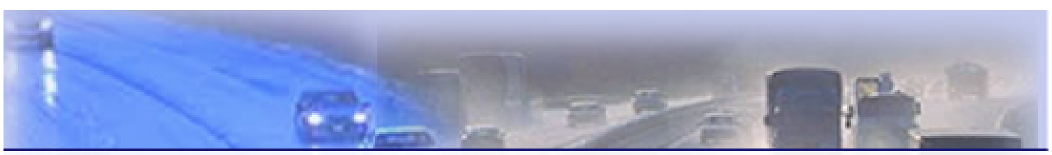
Course Summary Page 90



The second area we discussed was **ATIS**. ATIS aims to provide travelers with information to help them make travel decisions prior to their departure and/or during their trip. ATIS technologies include traveler information kiosks, closed-circuit television (CCTV) monitors, variable message signs (VMS), and traveler information portals on the Internet.

Finally, the area of **TSPS** is focused primarily on the reduction of transit vehicle running times and the increase of operational efficiency and adherence to scheduled times. TSPS technologies include various short-range wireless communication and automated vehicle location (AVL) systems. Eventually, other technologies may also include automated passenger counters.

Course Conclusion Page 91



What now?

You have now reached the end of the course. Please return to the CITE course server (ATutor) to take the final exam and complete the course survey, which are both available through the Tests & Surveys icon.

Then be sure to notify Denise Twisdale (mztwiz@umd.edu or 301-403-4592) that you have completed the course.

Module Objectives

- Distinguish between the positive and negative consequences of past and on-going experiences in the implementation of fleet management systems, passenger security systems, traveler information systems, and traffic signal priority strategies for transit and
- Explain the relationship between the key concepts and components of the national ITS systems architecture and the basic design of fleet management systems, traveler information systems, and traffic signal priority strategies for transit.
- Identify measures (or metrics) to assess the benefits and other impacts of traveler information systems and traffic signal priority strategies for transit.
- Illustrate the benefits and other impacts associated with the implementation of fleet management systems, traveler information systems, and traffic signal priority strategies for transit.
- Describe the objectives, limitations, and major factors associated with the development of fleet management systems, traveler information systems, and traffic signal priority strategies for transit.
- Explore the use of ITS applications in public transit in the areas of fleet management and operations, traveler information and transit priority.

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Module Requirements

- Adobe Flash and Shockwave players (Download from Links icon).
- Some familiarity with User Services and ITS Functions is necessary.