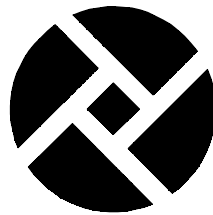


Intelligent Transportation Systems Applications for Airports

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June 2001

Introduction

This paper provides an overview of Intelligent Transportation System (ITS) applications, and how they can benefit operations and customer service at Portland International Airport (PDX).

ITS is defined as the application of advanced sensor, computer, electronics and communication technologies to maximize the efficiency and safety of transportation infrastructure. Over the past twenty years, state and local transportation agencies have applied ITS technologies to improve freeway, surface street, and transit operations. Many of the technologies deployed in ITS applications have their roots in other industries. For example, closed-circuit television (CCTV) surveillance was originally applied in the security industry. ITS adapted CCTV cameras to monitor traffic flow, gather information on crashes, and communicate conditions to the public.

Similar to the migration of CCTV camera technology from security to transportation, ITS technologies are being applied in new ways. Most recently, airports have found ITS useful in improving a variety of landside operations including parking lot management, curbside management, and tracking commercial vehicles. This has resulted in an improved customer experience at the airport.

Purpose

This paper describes typical ITS technologies that have been widely deployed in the United States and overseas, on freeways and in the public transit sector. Rather than providing a comprehensive view, it focuses on ITS technologies that may be beneficially applied to PDX landside operations.

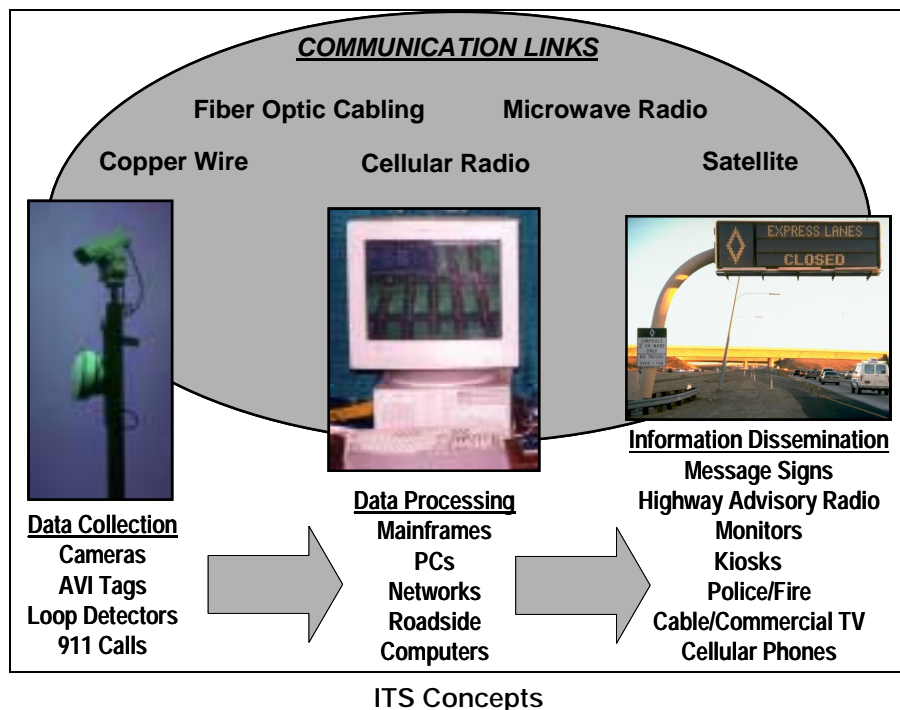
Descriptions of airport ITS applications are also included. Although ITS components have been installed at numerous airports (including PDX), there do not appear to be any comprehensive ITS applications at U.S. airports to date. However, several airport operators (e.g., Los Angeles World Airports, Maryland Aviation Administration, Massachusetts Port Authority, and the Port Authority of New York and New Jersey) are in the process of planning, designing, or implementing comprehensive ITS systems. The description of airport ITS included here focuses on applications that are pertinent to PDX landside operations.

Intelligent Transportation Systems: An Overview

This section defines concepts that support ITS functions. It also provides a description of ITS technologies that have been deployed on freeways and public transit sectors in the United States and overseas.

ITS Functions

ITS is based on three unique but interrelated functions: data collection, data processing, and information dissemination. These functions, their typical components, and their inter-relationships are illustrated below.



Data collection involves gathering information from numerous sources including field devices (e.g., cameras, vehicle detectors), transportation service providers (e.g., transit agencies, police and fire), and other sources (e.g., commercial television, radio, and other media). For example, if an accident occurred on I-205 and NE Airport Way, information about the accident could be collected from CCTV cameras monitoring the area, or emergency responders such as the police and Oregon DOT's (ODOT) safety service patrol (COMET). Details about the incident could also be provided to a 911 dispatcher by a passing motorist using a cellular phone.

Data processing involves making the data that has been collected usable to support a specific function or task. Taking the example of the accident on I-205, ODOT could take the information gathered from their responders and or the police, and process it for use by others such as travelers and operations staff at PDX.

Information dissemination is the act of making information available to end users, whether it is another transportation service provider that needs to make operational decisions (e.g., adjust traffic signal timings) or to travelers needing to make informed decisions about their trips. Using the same I-205 example, information about the accident and its impacts could be provided to travelers approaching and departing PDX, so that they could make travel decisions such as selecting alternate routes or using transit instead.

Typical ITS Applications (Non-Airport)

To date, ITS deployments have primarily focused on five functional areas. The following sections describe these service areas:

- Traffic Management
- Traveler Information
- Commercial Vehicle Operations
- Transit Management
- Electronic Toll and Traffic Management



Ramp Metering Station

Traffic Management

ITS traffic management benefits the public by improving traffic flow on freeways and arterial streets. This is achieved through traffic monitoring, communications, signal controls, and freeway management systems to manage the demand, operations, safety and security of the transportation system.



Closed Circuit Television Image from
Oregon DOT Traveler Information website Tripcheck.com

Enabling Technologies

Technologies that support traffic management include:

- ***Dynamic Message Signs (DMS)*** are a flexible and powerful means of communicating with motorists. They provide specific information regarding discrete events (such as weather-related closures), suggest alternate routes that are needed for avoiding construction or incidents that disrupt normal traffic operations, and warn motorists of closures resulting from unplanned events.
- ***Highway Advisory Radio (HAR)*** communicates information regarding specific events to drivers via their AM radio receivers. Information may include weather-related closures, alternate routes for avoiding construction or incidents that disrupt normal traffic operations, or closures resulting from unplanned events. HAR provides the opportunity to disseminate longer, more detailed messages than DMS is capable of providing.

- **Closed Circuit Television (CCTV)** enables operators to remotely observe traffic conditions so that operational decisions (e.g., activating DMS to divert traffic away from an accident) can be made based on the observed conditions. To support travel decisions, images from CCTV cameras can also be provided to travelers through numerous sources such as broadcast and cable television and the Internet. An additional function of CCTV is to visually verify incidents that have been detected through other processes such as a call from a passing motorist using a cellular telephone. This can enable more effective incident response.
- **Ramp Metering** monitors and limits the number of vehicles entering the freeway over a given time interval, so that demand does not exceed capacity.



Message sign providing traffic information

Observed Benefits

The following benefits have been observed in non-airport applications through the implementation of various traffic management elements:

- As part of the first phase of San Antonio's TransGuide system a digital communications network, DMS, lane-control signals, vehicle loop detectors, and CCTV were installed to support operations along 26 miles of freeway in the downtown area. This resulted in a 35% total reduction in accidents, 30% reduction in secondary accidents (e.g., rear-end accidents that occur in traffic back-ups), and a 40% reduction in accidents that occur during inclement weather.

- A six-year study in Seattle, Washington concluded that a ramp metering/freeway management system resulted in a 62% decrease in accident rates.
- With the implementation of vehicle detectors and CCTV cameras, the Maryland Chesapeake Highway Advisories Routing Traffic (CHART) program has shown a benefit/cost ratio of 5.6:1. Most of these benefits resulted from a 5% reduction (2 million vehicle-hours per year) in delay associated with non-recurrent congestion (e.g., accidents).
- The Gowanus Expressway/Prospect Expressway rehabilitation project in Brooklyn, New York has been implemented with an incident detection system, 20 CCTV cameras, highway advisory radios, DMS, and a construction information hotline. With this system the average time it takes to clear an accident has been reduced to 31 minutes from nearly 1.5 hours (a 66% reduction).
- Use of an Integrated Corridor Traffic Management/Ramp Metering System, in concert with an arterial signal control system in Minneapolis, Minnesota has resulted in a 30% greater throughput of vehicles and an increase of freeway speeds of almost 20 miles per hour. Ramp meters also resulted in a net decrease of vehicle delay of between 11 and 93.1 vehicle hours during peak periods for the seven ramp metering stations studied.

Although these benefits are significant, the ITS technologies deployed were on highway systems that were heavily congested on a daily basis. The extent of benefits may be less on roadways that are operating with less congestion.

Traveler Information

Traveler information systems provide information on both highway and transit systems. This is achieved by providing transportation network performance data to travelers, in both pre-trip and real-time modes.

Enabling Technologies

Technologies that support the provision of traveler information include:

- ***Broadcast and cable television:*** Real-time traffic information offered over broadcast and cable television can be helpful to commuters at businesses and hotel facilities and to other travelers without Internet access. Information that can be provided includes traffic flow maps, bridge or mountain pass conditions, weather maps, and real-time surveillance video.
- ***Commercial radio*** broadcasts are an ideal means of providing traffic information during normal operations and emergency situations. This enables travelers to make decisions based on the prevailing conditions, and guides them during emergency closures.
- ***Kiosks*** are generally placed in locations with high pedestrian traffic such as shopping malls, office lobbies and transit stations to provide real-time traveler information. They are designed to be user-friendly and are equipped with features such as video, touch-screens, and sound. In some cases they provide printers for dispensing hardcopies of maps, and telephones for speaking with an operator.

- **Automated trip itineraries planning systems** provide transit travelers with the ability to interactively plan trips. Some systems around the country provide the capability to develop itineraries across numerous transit operators within the same region. These systems are typically accessed via the Internet and telephone.
- **Web pages** provide real-time traveler information, including video images, color-coded maps representing traffic conditions, and warnings such as closures and weather conditions.
- **Audio-text telephone service** provides traveler information over hard-wire and wireless telephone connection. Typically, this system is menu-driven so the traveler can obtain information specific to their individual needs and specific routes.
- **Cellular phones** can provide access to audio-text and live operator service. General Motors' *Onstar* service provides callers with concierge services from a live operator, including directions and emergency roadside services.
- **In-vehicle devices** provide travelers with navigational assistance and real-time traffic information through devices that are either original equipment or an after-market feature.

Many of these traveler information technologies could also be used to disseminate flight status information to airport patrons.



“Flow Map” from Washington State DOT
Traveler Information website

Observed Benefits

Benefits that have been observed in non-airport environments from the implementation of various elements of a traveler information system include:

- Surveys in Seattle, Washington and Boston, Massachusetts metropolitan areas indicate that when provided with traveler information, 50% of all travelers change routes, and 45% change the times that they travel. Additionally, an estimated 5-10% of travelers will change travel mode based on the availability of accurate information.
- The Los Angeles Smart Traveler project has deployed a small number of information kiosks in locations such as offices lobbies, and shopping plazas. Requests for a freeway map constituted 83% of all requests. Over 50% of the inquiries included requests for MTA bus and train information.

Commercial Vehicle Operations

ITS technologies that support commercial vehicle operations increase motor carrier safety and productivity by improving and targeting inspections, and reducing paperwork through electronic transactions, weigh-in-motion and automatic vehicle technologies. These systems also support activities related to roadside safety operations, freight and fleet management, and vehicle operations.

Enabling Technologies

Technologies that support commercial vehicle operations in a non-airport environment include:

- Commercial off-the-shelf (COTS) software packages, such as Computer Aided Dispatch (CAD)/AVL to support vehicle locating functions
- Communications networks
- Electronic data interchange platforms
- Electronic funds transfer systems
- Shipment identification technologies including bar code readers, optical character recognition, and radio frequency identification (RFID) systems

Observed Benefits

Observed benefits of commercial vehicle operations applications of ITS include:

- The HELP/Crescent project on the west coast evaluated four technologies for the screening of transponder-equipped vehicles. Based on the outcomes, projected benefits for a state government include:
 - \$1.7 million reduction in costs incurred as a result of hazardous materials incidents
 - \$0.5 to \$1.8 million annually in the reduction of tax evasion
 - \$5.6 million in savings in infrastructure repair resulting from detecting overweight loads
 - \$169,000 reduction in operating costs for weigh stations
 - \$156,000 to \$781,000 reduction in costs incurred as a result of accidents

Transit Management

When applied to transit operations, ITS provides the ability to remotely monitor vehicle status, passenger activity and vehicle location. Transit ITS also helps to assist operators maintain fleets of vehicles.



Transit shelter equipped to provide
real-time bus arrival times

Enabling Technologies

Technologies that support transit management functions include:

- ***Automatic Vehicle Location (AVL) systems*** enable bus dispatchers to know the location of buses at all times. Location data can then be processed to provide travelers with trip itineraries and real-time vehicle arrival times, so that a passenger waiting at a transit stop knows when the next train or bus will be arriving at that location. AVL can also be used to locate transit drivers/operators in an emergency situation.
- ***Automated passenger counters*** provide transit operators with the ability to collect real time and historical data that is tied to route production. In turn, this data can be used to adjust routes to meet the needs of the traveling public.
- ***In-vehicle annunciation*** provides audio and visual presentations in the vehicle about next-stop information. These help transit operators provide clearly understood information to passengers and comply with ADA requirements.
- ***Electronic fare collection*** provides transit riders with the ability to use fare cards instead of coins and tokens to pay for transit fares. This helps reduce the need to collect, count, and distribute coin and currency collected from passengers, making operations more cost-efficient.
- ***Signal priority*** extends the green time on a traffic signal, enabling buses to pass through an intersection and maintain schedules.

Observed Benefits

The benefits observed from the implementation of transit management systems in a non-airport environment include:

- Through the use of Computer Aided Dispatch System (CAD)/Automatic Vehicle Location Systems, the Kansas City Area Transportation Authority of Kansas City, Missouri reduced up to 10% of the equipment required to provide service on some routes. Savings achieved through this system implementation enabled the transit service provider to pay for the system in two years. The system improved on-time performance by 12% in the first year of operation.
- The Milwaukee Transit System reported a 40% reduction in off-schedule buses since implementing a Global Positioning System (GPS)-based AVL system on all of its vehicles (543 buses and 60 support vehicles)
- The Mass Transit Administration in Baltimore, Maryland reported a 23% improvement in on-time performance by equipping vehicles with AVL.

Electronic Toll and Traffic Management

Electronic toll and traffic management uses Automatic Vehicle Identification (AVI) to electronically collect tolls. This allows drivers to pay tolls with fewer delays at tollbooths.

Enabling Technologies

Enabling technologies that support the functions of electronic toll and traffic management include:

- RFID systems: These are commonly referred to as AVI systems. There are several types of RFID and communication technologies available, including: (1) vehicle-mounted transponders or toll tags that transmit a unique signal, (2) antennas mounted above travel lanes, (3) readers connected to each antenna that transmit the signals received by the antenna to a central computer system, and (4) central or host computers used to store and process signals.

Observed Benefits

Examples of benefits observed from the implementation of electronic toll collection in a non-airport environment include:

- The Odawara Toll gate in Japan saw a difference of 11 seconds in the time a conventional toll collection takes, compared with an electronic toll collection-equipped car.
- On the Tappan Zee Bridge toll plaza in New York State, a manual toll lane can accommodate 400-500 vehicles per hour, whereas an electronic toll-collection lane can accommodate up to 1000 vehicles per hour.

How Does ITS Relate to Operations at PDX?

The following paragraphs describe potential airport ITS applications, with emphasis on those that have the potential to enhance roadway safety and efficiency, improve customer service, and promote more efficient operations at PDX. The ITS applications described are based on needs that have been identified to date. The benefits reflect those that have observed from previous ITS deployments at other airport locations.

Parking Access and Revenue Controls

PDX is in the process of implementing a new parking access and revenue control system. In addition to the benefits that this new system will provide, there are other potential features that may further improve parking operations.



Sign providing parking space availability information by level
source: Leigh Fisher Associates

Enabling Technologies

Examples of ITS applications that could reduce entry and exit delays and enhance customer service include:

- ***Parking passes for frequent travelers or corporations:*** Other airport operators have issued or sold "access cards" that allow parking patrons to enter and exit designated parking facilities. These cards, which typically are composed of AVI transponders or proximity cards, reduce the time required by patrons to enter and exit parking facilities. In communities with major toll roads or toll bridges that have electronic toll collection, the same AVI tags used on the toll facilities can be used to enter and exit an airport parking facility. These applications require the integration of separate equipment into the exit plaza lanes, a mechanism for distributing transponders to parking patrons, software integration with the parking access and revenue control system, and a clearance house or back office operation to set up, maintain, debit and replenish transponder accounts.

- **Cash-less entry and exit systems:** In addition to access cards, new parking controls permit the use of electronic purses (or smart cards), debit cards, credit card-in/credit card-out access systems, and License Plate Recognition or Optical Character Recognition systems (using infrared or visual cameras) or systems that capture an image of the entire rear of front end of the vehicle. In addition, Pay-on-Foot parking systems can be used to reduce customer delays at the exit plaza.
- **Parking directional systems or “smart garages”:** Available parking control systems provide space-by-space occupancy counts and can direct parking patrons to empty spaces located in specific parking garage or lots, on specific levels, or to individual spaces. These systems can be independent of a parking access and revenue control system.
- **Parking reservation systems:** Several vendors offer parking reservation systems for valet or self-parking operations, which allow patrons to reserve and guarantee spaces using their telephone or a website.



Advanced parking directional system sign

source: Leigh Fisher Associates

Examples of Airport Applications

Airports that have implemented the systems described above include:

- Denver, Hartsfield-Atlanta and Seattle-Tacoma International airports: AVI-based frequent parker tags are being (or were previously) used.
- Transponders issued by toll bridge or turnpike operators can be used to enter and exit and pay for airport parking at Dallas/Fort Worth International, LaGuardia, Kennedy International, and Newark International airports.
- U.S. airports with advanced parking directional systems include Baltimore/Washington, Houston Intercontinental, and Raleigh-Durham International, with test or pilot applications being considered at other U.S. airports. Several European airports, including Hanover, Frankfurt, Munich and Zurich have sophisticated directional systems.

- Numerous airports (e.g., Denver, San Francisco, and Tampa) use parking access and revenue control systems to support business and management planning, by developing and monitoring long-term trends in parking activity, revenues, and certain types of transactions and the relationship between these trends and airline passenger data. This data can be used to forecast future performance (e.g., determine implications on space requirements and revenues resulting from potential parking rate changes) and to support airport business and management decisions.

Commercial Vehicle Management Systems

Airport applications of commercial vehicle management systems are typically based on proximity cards (such as those used at PDX), or more frequently on vehicle-mounted AVI transponders. These transponders allow airport management to monitor commercial vehicle activity and provide a reliable basis for charging access fees calculated on a per-trip basis, or overtime (or dwell time) charges. The systems can also be used to discourage excessive trips or to penalize operators that exceed prescribed limits. AVI systems do not require drivers to open windows to use the proximity cards and can provide additional functions such as supporting taxicab dispatching or shuttle bus tracking systems.

Enabling Technologies

Examples of ITS applications that enhance the efficiency of commercial vehicle operations include:

- **Monitoring and controlling commercial vehicle activity:** The enabling technologies now used by most airport operators are RFID-based AVI systems. There are a limited number of vendors supplying AVI equipment for airport applications, but these vendors provide both battery-powered transponders, and transponders powered by radio signals emitted by the antennas (i.e., passive transponders). The key hardware components of the system are the transponders (or tags), overhead antenna, readers, host computer and workstations. Airport operators can select from off-the-shelf or customized software, reporting and communication functions. This software can be used to support planning activities, such as trend analysis of volumes by vehicle class by day or hour or operator.
- **Driver control:** Airport-issued commercial vehicle driver permits or licenses can be combined with AVI tags or other technologies to assist airport operators in controlling or monitoring drivers operating vehicles on the commercial lanes, or desiring access to the hold lots.
- **Taxicab and limousine dispatching:** Transponders mounted on taxicabs and limousines can be used to detect when these vehicles enter the hold lot, to dispatch or signal the drivers to proceed to commercial lanes or passenger pick up areas, and to collect fees from the operators.
- **Shuttle bus tracking:** Various technologies, including vehicle-mounted AVI or Global Positioning Systems (GPS) can be used to monitor the location of shuttle buses. This data can be used to provide estimated arrival time to waiting passengers, or assist dispatchers in controlling bus headways and operations.

- **Driver and Operator Management Systems:** Database management systems can be used to gather, sort, and present data describing the status of operators (e.g., insurance coverage and expiration, vehicle permits and VIN), driver (e.g., points, penalties, or status of commercial drivers license and expiration date) and provide this data to designated users. It would also be possible to share information electronically with cooperating state agencies.

Examples of Airport Applications

Airports that have implemented AVI-based commercial vehicle management systems and the observed benefits include:

- More than 20 airports use AVI systems to monitor commercial vehicle activity and calculate access fees. These systems provide reliable and accurate data to support commercial billing, track commercial vehicle activity and trends, and monitor the performance of individual operators. Examples of these airports include those serving Albuquerque, Burbank, Dallas/Fort Worth, Denver, Houston Intercontinental, Los Angeles, Minneapolis, Oakland, Orlando, Ontario Orange County (John Wayne Airport), Pittsburgh, San Francisco, San Jose, Salt Lake City, Seattle, and Washington, D.C.
- Several airports use AVI systems to monitor dwell times or excessive trips (or circuits), thereby limiting the length of time a commercial vehicle is permitted to remain at the curbside area or commercial lane. Examples of these airports include Los Angeles (excessive circuits), Albuquerque, Houston, Orlando, and Pittsburgh (dwell times), Los Angeles and San Francisco (excess trips). Other airport operators have installed or are planning to install these systems including the airports serving Atlanta, Honolulu, Philadelphia, and Raleigh-Durham.
- Minneapolis-St. Paul and Boston-Logan International Airports use AVI technology to manage and dispatch taxicabs. This technology provides positive controls on dispatching, driver sequence, and allows the elimination of the previous paper ticket dispatching assignments that were often abused by taxicab drivers. It also provides records that identify short-haul taxi trips, which are usually allowed priority upon their return to the airport, based on their time away from the airport.
- AVI-based shuttle bus tracking systems are in use at John F. Kennedy and Miami International airports. The operators of Phoenix-Skyharbor International Airport are evaluating the GPS and AVI systems for shuttle bus operations.

Traveler Information Systems

Traveler information systems provide travelers with real-time (roadway conditions) and static (transit schedules) information for both highway and transit systems. The provision of both pre-trip and en-route traveler information can enhance customer service for those traveling to and from PDX. A significant advantage of employing this strategy at PDX is that a large amount of traveler information is already being generated regionally both by Tri-Met and ODOT.



Traveler information kiosk at
Seattle-Tacoma International Airport

Enabling Technologies

Enabling technologies available to distribute traveler information include:

- **Kiosks:** Kiosks located in the terminal near baggage claim could enable travelers to receive information on a variety of transportation services and prevailing traffic conditions as they leave the airport. The existing kiosks in the terminal could be enhanced to provide additional information that is readily available through ODOT and other sources.
- **Highway Advisory Radios:** It is possible to provide real-time data on parking conditions, roadway or traffic conditions, or airline operations via a live broadcast.
- **Personal Digital Assistants:** Personal digital assistants (PDAs) are hand-held devices that could potentially provide real-time information to passengers to assist in planning their trip to PDX. Information could include traffic conditions and parking availability and guidance. Most likely, this media would be used by the private sector in bundling airport-related information with other types of information (traffic, sports, weather, stocks) provided to PDA owners.

- **Traveler Information Monitors:** Traveler information monitors could potentially be located in the terminal near baggage claim or in the parking garage, to provide deplaning passengers with real-time traffic conditions.
- **Websites** - The provision of pre-trip traveler information via an Internet website is potentially very beneficial. As mentioned previously there is a variety of traveler information available regionally.



Trip-planning kiosk

Examples of Airport Applications

Airports that have implemented ITS-based traveler information systems include:

- The Port of Seattle, in cooperation with the Washington State DOT, installed kiosks at Seattle-Tacoma International Airport along the primary paths to and from public parking and rental car ready/return areas. These kiosks provide video monitors displaying real-time information concerning traffic operations (e.g., travel speeds) on the regional roadway network.
- At Dallas/Fort Worth Airport, passengers on American Airlines are provided with real-time information on flight arrival and departure gates via a Highway Advisory Radio and a toll-free telephone number.
- At Nashville International Airport motorists parked in the short-term parking lot are provided with airline arrival and departure time information.
- Numerous airports have websites (e.g., *flysfo.com*) that provide travel directions or links to travel direction websites (e.g., the *sjc.org* link to Yahoo driving directions). Some provide estimated travel times.

Traffic Operations and Management Systems

Potential ITS traffic operations and management elements for airport applications are described below. The primary focus of these systems is enhanced roadway network surveillance and the active management of traffic flows, using dynamic message signs or other devices.

Enabling Technologies

Enabling technologies available to support traffic operations and management include:

- **Dynamic Message Signs** provide parking and other information to travelers entering and exiting the airport.
- **Closed Circuit Television (CCTV)** provides an opportunity to visually observe and monitor traffic conditions on roadways accessing the airport.
- **Enhanced Vehicle Detection Systems:** Installation of detection devices, when connected to the data collection and processing software will allow operators to monitor and verify congestion on the airport roadways.

Examples of Airport Applications

Los Angeles International is the best example of a U.S. airport that has implemented ITS-based traffic operations and management systems. A comprehensive system integrating most of the elements described above is being implemented.

Los Angeles World Airport (LAWA) has completed a Traffic Operations Center (TOC) at the Los Angeles International Airport, containing 13 CCTV cameras that monitor the entire Airport roadway system and key intersections along the primary arterial access routes. TOC staff (Airport and City of Los Angeles DOT staff) can also access traffic volume data that is gathered through the use of pavement-mounted vehicle detectors and AVI systems. Using this data, staff can (1) activate alternative signal-timing plans, (2) coordinate the deployment and actions of Airport police and traffic control officers, and (3) activate dynamic message signs located on the primary entrance roadways. The TOC also contains a Highway Advisory Radio broadcasting booth, which will be used for live broadcasts of real-time traffic information. LAWA's future plans include expanding the traffic management and control systems in the TOC to provide (1) expert (or automated) control of traffic signal systems, (2) bus arrival time displays, and (3) real-time parking and traffic information through the Airport's website and other communication systems.

Although other airports (including those serving Newark and Boston) are considering similar ITS-based traffic operations and management control systems, the system at Los Angeles International Airport is the most advanced.

Considerations for PDX

This paper has provided a brief overview of ITS concepts and applications, the functions provided by ITS deployments, and benefits experienced with various deployments. Although to date there are few examples of comprehensive applications of ITS deployments at airports, the benefits experienced with deployments on regional and local transportation systems suggest that ITS systems can enhance the PDX travelers' trip in a variety of ways and enhance Airport operations.

Subsequent papers will describe potential solutions and projects, in response to identified needs at PDX. Preliminary interviews with airport staff have revealed several potential ITS airport applications, which are described below.

Parking Management

Parking decks at PDX are often full, and drivers entering the airport do not know which decks are full until they enter the parking garages. This results in additional time spent circulating around the parking decks to locate available spaces. PDX's parking management system provides PDX staff with information on parking availability by deck. This information could be provided to drivers entering the airport via Dynamic Message Signs (DMS) or Highway Advisory Radio (HAR).

Commercial Vehicle Management

Implementing Automatic Vehicle Identification (AVI) could enhance taxi and limousine dispatching at PDX. As mentioned previously, these systems can be used to detect when vehicles enter the hold lot, dispatch or signal the drivers to proceed to commercial lanes or passenger pick up areas, and collect fees from the operators.

In addition, PDX would benefit from the development and implementation of a database management system that would gather, sort, and present data on the status of operators and drivers and provide this data to designated users.

Traveler Information

Enhancing traveler information services would be a relatively simple implementation of ITS technologies, provided that the needed data (video images) is currently being collected by ODOT and can easily be made available to PDX for dissemination to travelers. An additional benefit is that the monitors would be readily accessible for use by multiple customers at any one time. The Port has already recognized the benefits of linking to other transportation service providers' websites, as demonstrated by the current link to Tri-Met. Additional pre-trip information could potentially be made available to travelers with links to ODOT's *tripcheck.com*, which provides real-time traffic conditions for the Portland Metropolitan Area and statewide.

Traffic Operations and Management

Traffic operations and management can be enhanced by presenting travelers with parking information, including the availability of spaces in the garage or surface lots, and directions or guide signs leading to these facilities. For inbound motorists, the optimal placement for DMS would be on NE Airport Way. DMS signs along Airport Way could provide outbound motorists information on traffic conditions for the surrounding freeway system, or guide them to alternate routes.

Enhancing vehicle detection systems will allow operators to monitor and verify congestion on NE Airport Way and airport drives. Additionally, data collected from these systems could be placed in a central traffic data collection and processing system, which could enable the data to be used in the future for planning purposes.

Closed Circuit Television (CCTV) could provide an opportunity to visually observe and monitor traffic conditions on NE Airport Way, the at-grade highway-rail intersection on NE 82nd, and the parking exit plaza. This would enable PDX management to make operational decisions based on the prevailing conditions, whether it is an accident or a queue at the toll plaza.

This is a preliminary list of potential short-term ITS applications that could be implemented at PDX. A longer term vision will be developed based on current and future needs that may be addressed using ITS. The ITS vision will be translated to a program of projects. By looking at the longer term, opportunities to coordinate between projects and share infrastructure and information can be explored, in order to ensure that the deployments are as efficient as possible.

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