
CHAPTER 1

Introduction

1.1 OFFICE OF TECHNOLOGY APPLICATIONS

The mission of the Office of Technology Applications (OTA) of the Federal Highway Administration (FHWA) is to ensure the timely identification and assessment of innovative research results, technology, and products, and the application of those that are determined to be of potential benefit to the highway community. The OTA works in all areas of highway technology, including asphalt and concrete pavements, structures, geotechnology, hydraulics, traffic operations and management, safety, and motor carriers. This office also includes activities related to the implementation of approximately 100 products from the Strategic Research Program (SHRP).

Technologies and products identified through the OTA's assessment are developed, implemented, and promoted with State and local agencies, private industry, universities, and others in the national and international highway communities. The OTA works closely with the FHWA program and field office staffs. In addition, the OTA is expanding its alliances with the State and local agencies, private industry, universities, and others to broaden the network through which technology can reach its users.

The organizational structure of OTA consists of the director of the Office of Technology Applications, who serves as the principle advisor to the Associate Administrator for Safety and System Applications and by extension, to the Federal Highway Administrator on all technology assessment and deployment, Local Technical Assistance Program, and SHRP implementation matters pertinent to the FHWA's objectives and programs. The director also participates fully in relevant FHWA policy determinations and directs all activities of the Office of Technology Applications.

The OTA's program, for the most part, is divided into four types of projects: application projects, demonstration projects, special projects, and test and evaluation projects. Technical activities are assigned to one of the categories depending on the stage that the technology is in and, if the technology is already developed, what technology transfer or marketing approach would be most useful in reaching a technology's intended users.

The OTA's organizational structure reflects the broad range of activities represented in the other FHWA offices. It consists of three divisions and the SHRP Implementation staff:

- Engineering Applications Division administers a program that includes technical areas such as asphalt and concrete pavements; bridge design, construction, management, and protection; geotechnology; and hydraulics.
- Safety and Advanced Transportation Division administers a program that includes technical areas such as safety, highway design, traffic operations and control, and motor carriers.
- Technology Management Division crosses all technical areas in its technology assessment role and works with the office of International Programs in its technology transfer contacts. It provides fiscal, management, and publication support to the OTA, and similar assistance to program offices in relation to the applications program. The division also administers the Local Technical Assistance Program for the FHWA.

- Strategic Highway Research Program Implementation Staff serves as the liaison when the SHRP technology is identified for transfer to its users.

As mentioned, the four categories of OTA program activities are demonstration projects, application projects, test and evaluation projects, and special projects.

- Demonstration Projects - Efforts to nationally promote a proven material, process, method, equipment item, or other feature that FHWA has targeted for adoption by the highway community.
- Application Projects - Individual efforts to assess, refine, or disseminate an emerging technology. Such efforts may include contracts, regional or national seminars or workshops, specifications, notebooks or pamphlets, instructional/how-to guides, open houses, and focused clearinghouses that are not part of demonstration or test and evaluation projects.
- Test and Evaluation Projects - Efforts to evaluate innovative or emerging technologies that have been identified as having a great potential for use nationwide.
- Special Projects - Evaluation efforts of industry and the FHWA, in conjunction with interested States, to evaluate a material, process, method, or other feature. An effort begins with a technology sharing meeting, progresses through a work plan and several control experiments (or operational tests) to a closeout evaluation. These special projects can lead to a demonstration, test and evaluation, or a combination of the two types of projects.

The OTA staff consists of approximately 45 persons, of whom about 36 are professionals and para-professional. The Advanced Transportation Technologies Team, which will manage this demonstration project, consists of a Team Leader, three highway engineers, three on-site engineering consultants, and one engineering technician.

Demonstration Project No. 105, Advanced Transportation Management Technologies

Technical assistance in the form of a demonstration project, Demonstration Project No. 105 (DP 105), will provide an opportunity for policy and decision makers from transportation agencies including State and local Departments of Transportation (DOTs), Departments of Public Works (DPWs), and Metropolitan Planning Organizations (MPOs) to become aware of the state-of-the-practice technologies available to assist them in corridor management.

DP 105 will make top State and local highway managers, planning policy makers, and administrators aware of the significant role of these corridor management technologies in controlling congestion and improving mobility and safety. This demonstration project will be an effective method of providing a timely transfer of technology. In addition, there is a need for providing adequate technical assistance to operate and maintain these systems.

DP 105 will focus on proven corridor management systems and will use information on existing and emerging technologies in the development of the educational and training material.

Public/private partnerships have been formed between the Federal government and private industry to identify, acquire, and display the available technologies in terms of hardware and software used with existing and emerging technologies.

The objectives of this demonstration project are:

1. To provide technology transfer on state-of-the-practice corridor management techniques/technologies to improve mobility and safety;
2. To develop an executive summary for top management, administrators, and planning policy makers to make them aware of the significant role of these corridor management systems in improving mobility and safety; and
3. To provide hands-on demonstrations on the state-of-the-practice hardware and software in corridor traffic management systems.

Through the use of a workshop and hands-on simulation, DP 105 will present a comprehensive examination of the various components of a transportation-management system. These components, listed below, include management and control strategies of both freeways and related surface streets as an integrated system. DP 105 will show how a corridor fits into the larger regional picture. It will demonstrate the complexity of the interconnection among the various components and sections (including freeways and surface streets) of the region. A change or modification to one component or any one section of the system will affect traffic operations in another. DP 105 will demonstrate the ability to handle and coordinate freeway and arterial networks representing an entire region subject to traffic-management control.

DP 105 will focus on the highway element of transportation-management systems consisting of rubber-tired vehicles only. This will include travel associated with the private automobile and other vehicle classifications, such as trucks and buses, on both freeways and surface streets.

DP 105 encompasses the state-of-the practice techniques/technologies in corridor or regional management. It includes the development of interactive instruction for presentations to State and local DOTs, DPWs, and MPOs. Participants will be provided with the opportunity to observe and participate in discussions and operation of the corridor-management techniques/technologies as they relate to rubber-tired vehicles only. These technologies must be marketed and in service in the United States. The technology has to be proven and be currently available off-the-shelf.

This demonstration project, DP 105, will utilize information available on existing transportation-management technologies and systems in use for the development of outreach and educational material for presentations.

DP 105 is one of five Federal Highway Administration Technology Transfer demonstration projects that have toured or are touring the nation and are related to each other. Discussion of the other four follows.

Other Related Demonstration Projects

- *Traffic-Control Equipment and Software (DP 93)*. This was a two- to two-and-one-half day workshop on and hands-on demonstration of recently developed electronic traffic control equipment and software used at intersections. The project includes controller detectors, communications, preemption, test equipment, conflict monitors, closed-loop/distributed systems, centralized control systems, hybrid control systems, and other peripherals found in National Electrical Manufacturer's Association (NEMA) and Type 170 cabinets. Twenty-five manufacturers and vendors provided technology to be displayed in a 48-foot tractor/semitrailer. The presentations emphasized the benefits of adopting and implementing more reliable and powerful traffic-control systems to reduce urban congestion.

The project began a nationwide tour in January 1993 and concluded in July 1996. It has been presented to managers, traffic engineers, and traffic-signal technicians from city, county, and State transportation agencies from 49 States, Puerto Rico, and the District of Columbia. These jurisdictions control the majority of the nation's signalized intersections, many of which are expected to be improved because of the information presented in this demonstration project. The presentation was given to representatives from equipment manufacturers that supply about 85 percent of the traffic-control technology in the United States. Initial response from participants has been overwhelmingly positive.

- *Incident-management Workshop (DP 86)*. This is a two-day workshop that demonstrates the concepts of incident management. It reaches people from many different disciplines and agencies, such as police, fire, State and local highway, towing, and media, who respond to incidents on freeways and surface streets. DP 114 will not deal with any of these components of incident management.
- *Advanced Motor Carrier Operations Technologies (DP 111)*. The goal of DP 111 is to demonstrate new technologies and programs that enhance motor carrier safety and productivity. The project will focus on three themes: administrative technology applications, in-vehicle technology applications, and roadside technology applications. The mechanism for this demonstration will be a mobile exhibit housed in an expandable trailer. Equipment obtained on loan from vendors will be displayed in a hands-on format and kiosks containing product, service, and program information will be provided in the trailer. Short presentations and workshops will be presented to address the technological and institutional barriers that hinder the implementation and use of new technologies. The primary target audiences of DP 111 are the enforcement community, the trucking industry, and truck drivers. The demonstration will be taken to truck shows, national and regional conferences and symposiums, and to sites in States across the country where safety and weight enforcement agency personnel can be reached.
- *Integrated Information Transportation system (ITIS) (DP 113)*. ITIS is a demonstration project designed to showcase the benefits of combining highway, transit, and intermodal-related information systems into a single information system architecture. This is a two- to three-day workshop and hands-on demonstration of the various methods and technologies that an agency can utilize in building an ITIS. The process implies at least three kinds of integration; institutional, process or information flow, and technological. It will assist management in determining at what point they

are in the integration process and what needs to be further accomplished. The methods will include business process reengineering, total quality management, and adoption of standards. The tools and technologies to be discussed/demonstrated include data warehousing, client/server architecture, and Intranet. This represents a management vision of a new framework for doing business.

1.2 BACKGROUND

Congestion on the Nation's urban freeways and arterials has significantly worsened during the past few years. Delay due to traffic congestion is projected to increase fivefold from 1984 to 2005. As congestion on urban freeways and arterials is increased, an increase in accident potential, undesired long delays, adverse pollutants, increased operating costs, and adverse sociological effects results.

Numerous transportation-management systems have been developed and implemented in lieu of significant new roadway construction. These systems are used as remedial measures for freeway and arterial congestion and improving traffic operations in corridors. A "corridor," as used in this context, comprises, in addition to the freeway and its ramps, freeway frontage roads, arterial streets, and cross streets that are links between the freeway ramps and the arterials. Freeway corridors comprise the key components of an overall regional multimodal transportation system. Corridor traffic management consists of monitoring and controlling the actual conditions on the corridor system in a manner that will maximize the use of the existing roadway system. Strategies used to manage corridors include ramp metering and control, freeway-to-freeway metering and control, priority control, incident management, freeway surveillance, driver information, electronic toll collection, and work zone traffic management.

Since 1990, there has been a strong emphasis on the development of enhanced and advanced technologies to bring greater efficiency to our transportation systems. This is part of the initiative for Intelligent Transportation Systems (ITS) mandated by Congress as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The goal is to create efficiencies within the transportation infrastructure that will mitigate congestion and improve safety and, at the same time, reduce the need to build more lanes of highway. ITS has been developed and advanced traffic management and control efforts will continue to escalate so as to provide remedial measures for traffic congestion and options for improving traffic operations. ITS includes a wide variety of current and evolving technologies that, when effectively integrated and deployed, offer a number of benefits including more efficient use of energy resources and significant improvement in safety, mobility, accessibility, and productivity.

In the past, ITS technologies were represented and structured around a set of user services. There were 29 user services, listed below, defined for the ITS program. The purpose of defining user services was to relate ITS strategies and technologies to specific user needs. User services represented a customer orientation rather than a facility or technology orientation. These user services follow:

Travel and Transportation Management

- En-route driver information
- Travel services information
- Traffic control
- Route guidance
- Incident management
- Emissions testing and mitigation

Travel Demand Management

- Pretrip travel information
- Ride matching and reservation
- Demand management and operations

Public Transportation Management

- En-route transit information
- Public transportation management
- Personalized public transportation
- Public travel security

Emergency Management

- Emergency notification and personal security
- Emergency vehicle management

Advanced Vehicle Control and Safety Systems

- Longitudinal collision avoidance
- Lateral collision avoidance
- Intersection collision avoidance
- Vision enhancement for crash avoidance
- Safety readiness
- Precrash restraint deployment

- Automated highway systems

Electronic Payment Services

Commercial Vehicle Operations

- Commercial vehicle electronic clearance
- Automated roadside safety inspection
- Commercial vehicle administrative processes
- On-board safety monitoring
- Freight mobility
- Hazardous material incident response

A wide variety of ITS technologies has been developed and tested. Most have exhibited the potential for significant benefits, yet few have been deployed extensively to date. The desire to accelerate deployment of these technologies prompted the U.S. Department of Transportation (USDOT) to establish, on January 10, 1996, a national goal: "To build an intelligent transportation infrastructure across the United States within a decade, to save time and lives and improve the quality of life for Americans."

The intelligent transportation infrastructure can pertain to the following components:

- Metropolitan Areas (Operation Timesaver Focus)
- Commercial Vehicle Operations
- Rural Areas

Infrastructure components are essential to each area and by nature, infrastructure underpins all areas. However, the rest of this document concentrates on the metropolitan component of the infrastructure. It is in these metropolitan applications that the elements of the intelligent transportation infrastructure, as defined below, will be referenced.

The creation of the national intelligent transportation infrastructure has reclassified the ITS technologies into elements that are both stand-alone and components of a larger ITS platform. Each element of the infrastructure can be deployed on its own merits. If deployed as an integrated system, however, the performance of these technologies would be enhanced. A freeway-management center would be able to talk to and share information with a traffic-control center. This information would help that center manage its system better without necessarily giving up authority and control. Up-to-date (real-time) information passed on to transit systems, multiple management and control centers, emergency vehicles, etc., will enhance operations of those recipients.

Through the intelligent transportation infrastructure and vision of the USDOT, successful traffic- and transportation-management programs will be deployed throughout the country. Such efforts will

create the platform needed for these intelligent transportation technologies to effectively monitor, manage, control, and operate traffic on the Nation's freeways and surface streets. As this platform is being implemented across the nation, there will be an increasing need to fully understand, evaluate, and optimize traffic flow patterns and to maximize the roadway throughput. There will be an enormous need for dynamically modifying signal timing and patterns in response to changing traffic demands and real-time traffic data. Equally important will be the need for integrated freeway-surface street systems with various control and management strategies.

1.2.1 METROPOLITAN INTELLIGENT TRANSPORTATION INFRASTRUCTURE

The nine elements that make up the metropolitan intelligent transportation infrastructure follow:

Freeway-Management Systems

Real-time information about traffic flow and roadway conditions is key to managing the roadway network in a proactive manner. Methods for monitoring freeway conditions include inductive-loop detectors, video cameras (with and without signal processing capability), and microwave radar and ultrasonic monitors. These sensors provide occupancy, presence, count, and in some cases, speed and queue length data. Other sources of information on the freeway include the traditional inputs from police and maintenance personnel as well as increasing numbers of cellular phone reports from drivers. Information collected by the freeway-management systems can also be used by the other intelligent transportation infrastructure elements. Relevant information can be made available to support incident management and congestion mitigation activities on the freeway and to allow coordination of these actions with adjacent traffic-signal control systems. With video coverage of incidents on the freeway, the incident-management team can determine the severity and type of incidents that have occurred and can direct the appropriate resources to the scene. This permits both faster response and better utilization of the incident/emergency response resources, through a tailored response.

The freeway-management system(s) include(s) a Freeway Management Center (or multiple centers when responsibility for the freeway system is shared by more than one jurisdiction) and information links to the Regional Multimodal Traveler Information Center and other transportation-management and control systems in the metropolitan area. These capabilities can provide, or be enhanced to provide, for the coordination of emergency response and incident management, and to support the management of special-event situations. Examples of integrated/cooperative management include regular analysis and updating of control and incident response strategies and coordination with other local traffic-management systems in the area for handling special events.

Deployment objectives:

- Provide critical information to travelers through infrastructure-based dissemination methods, such as variable message signs and highway advisory radio.
- Monitor traffic and other environmental conditions on the freeway system.

- Identify recurring and nonrecurring flow impediments so that short-term and long-term actions can be taken to alleviate congestion.
- Implement various control and management strategies (such as ramp metering and/or lane control, traffic diversion).
- Use probe vehicles as an additional sensor for collecting real-time traffic information.

Traffic-Signal Control Systems

Signaling systems that react to changing traffic conditions are an important element in improving transportation system efficiency. To be effective, advanced signal-control systems require an accurate current picture of the traffic flow and status on the roadway network. This information consists of real-time inputs from traffic sensors (inductive loops, video cameras, etc.), status and incident reports from police and cellular call-ins, etc. Historical demand information, such as time-of-day specific data would, at a minimum, permit the establishment of separate time-of-day signal-control strategies. Advanced signal systems automate the use of real-time traffic flow information to change the signal timing to efficiently accommodate traffic demands on all streets.

State-of-the-art traffic signal-control systems are capable of dynamically modifying signal timings in response to changing traffic demand. They coordinate operation between adjacent signals to maximize the roadway (network) throughput. Coordination of adjacent signals allows the traffic manager to establish timing that moves vehicles through selected portions of the traffic network with less delay. At a minimum, these coordinated signal-control systems can provide for the selection of several time-of-day or special signal-timing patterns that can optimize operations along major arterial routes and over traffic networks. When part of an integrated intelligent transportation infrastructure, traffic-signal control can give priority to transit or emergency vehicles. These “open-architecture” hardware/software systems are designed to be upgraded in capability, enabling relatively inexpensive installation of improved products. This open-architecture approach also supports the potential extension and integration of capabilities, such as coordinated operation with adjacent freeway and arterial systems. The National Transportation Communications for ITS Protocol (NTCIP) is being developed to support interoperability and interconnectivity of traffic control and ITS devices and support capabilities such as variable message sign control, camera control, vehicle classification, and general purpose data collection and device control.

The various signal systems in a region should be capable of electronically sharing traffic flow information with the signal systems of adjoining jurisdictions in order to provide metropolitan-wide signal coordination. This information sharing supports coordination of traffic-signal systems along major corridors, and results in smooth traffic flows across jurisdictional boundaries.

Deployment objectives:

- Deploy signaling systems that react quickly to changing traffic conditions.
- Collect and process real-time traffic information to provide up-to-date status of the transportation system.

- Install automated tools that take all traffic data into account and provide the traffic manager with a clearer picture of the status of the transportation system.
- Deploy modular systems that facilitate future upgrades and allow addition of new capabilities as they become available.

Transit-Management Systems

On-time performance is a critical factor in the public's decision to choose transit as a mode of travel. Transit fleet management includes hardware/software components on buses and in dispatching centers, radio communications systems, and operations and maintenance facilities and personnel. Depending upon the specific needs of the jurisdiction's fleet-management system, additional capabilities could be considered such as automatic vehicle location, advanced voice and data communications, automatic passenger counting, driver information (voice and visual), vehicle diagnostics, geographic information system databases for schedule management and emergency response, as well as computer-aided dispatching. These systems reduce cost by improving efficiency, while also providing better information to travelers.

Advanced fleet-management systems, which include Automated Vehicle Location Systems, provide reliable bus position information to the dispatcher. With computer assistance, the dispatcher can compare the vehicle's actual location with schedule information to track schedule adherence and, when necessary, take corrective actions to either get the vehicle back on schedule or to dispatch additional resources to cover the route. This function could be performed manually by the dispatcher or automatically, depending upon the level of automation. In addition, any pertinent schedule information would be disseminated in near-real-time to the traveler, either via kiosks or at home or the office. This information can be used by travelers in conjunction with information from other sources, and allows trip planning to include mode selection. The system can be enhanced to provide a display of information on routes and schedules for transit passengers on the vehicle. Other enhancements include in-vehicle sensors to monitor information such as passenger loading, fare collection, vehicle diagnostics, etc., to support efficient management of the transit system. In the event of an emergency, the dispatcher can notify the police or other support services of the situation and direct the responding authorities to the exact location of the incident. Information links from transit management to and from freeway- and signal-control functions can be valuable, as when a transit vehicle may require priority at signalized intersections to better meet route schedules.

Deployment objectives:

- Provide real-time, accurate transit information to travelers.
- Monitor the locations of transit equipment so as to provide more timely information on arrival times.
- Optimize travel times for transit vehicles.
- Support flexible routing of transit vehicles.
- Support automated maintenance monitoring of transit vehicles.

Incident-Management Programs

Rapid and effective response to incidents is a key factor in saving lives and reducing travel delay. Many metropolitan areas have programs for quickly identifying and responding to incidents that occur on freeways and major arterials. The objectives are to rapidly respond to incidents with the proper personnel and equipment, to aid crash victims, and to facilitate the rapid clearance of the incident from the roadway. Timely execution of these activities saves lives while minimizing the buildup of queues and reducing the delays and frustrations of the traveling public. In this manner, the involved public agencies and individuals can satisfactorily meet their requirements and responsibilities. To accomplish incident management, real-time input from the freeway and arterial surveillance systems and the agencies responsible for managing them is critical.

The various jurisdictions and agencies responsible for operations and enforcement in the metropolitan area work together to develop policies and operating agreements that define specific responsibilities for all aspects of incident management, including detection, verification, response, clearance, scene management, traffic control, and information dissemination. These multi-jurisdictional operating agreements ensure routine cooperation, coordination, and communications among all agencies, including law enforcement, fire, ambulance, highway traffic control and maintenance, environmental (as well as HAZMAT response teams) and other public agencies, as well as private towing services. Improved surveillance, augmented by rapid and accurate reporting of incidents, allows the rapid dispatch of appropriate equipment and personnel to the incident scene. Availability of accurate and timely incident information to the traveling public will further help reduce delays for drivers and transit riders. Use of a common regional digital map system by the various traffic and incident-management organizations will allow the incident-management team to better locate the reported incident, and will facilitate coordination among the several agencies involved in the incident response.

Deployment objectives:

- Coordinate incident management across regional boundaries to ensure efficient and sufficient response.
- Use traffic-management capabilities to improve response times.
- Use on-board moving map route guidance equipment to assist incident response vehicles (e.g., ambulances and tow trucks).
- Reduce traveler delays due to incidents.

Electronic Toll-Collection Systems

Electronic toll collection reduces delays at toll plazas and operating costs of toll agencies. Electronic toll-collection systems are in operation within or around a number of metropolitan areas (and on segments of rural interstate systems) for automated toll collections. The systems include hardware and software for roadside and in-vehicle use, including payment cards or tags, and a communications system between the vehicle and the roadside. Toll payment is processed as the vehicle passes the toll station at a safety speed, thereby decreasing delays and improving system productivity.

The system may include any combination of debit, credit, or stored value toll tag capability. Electronic toll-collection systems can be installed in various configurations, including mainline barrier plazas and systems where tolls are based on entry and exit points. Specific functional components of the system will include automatic vehicle identification, automatic determination of toll amount for differing classes of vehicles, automated enforcement of toll violations, and flexibility in financial arrangements (e.g., prepaid debit tag, payment cards).

Deployment objectives:

- Reduce delays at toll-collection plazas.
- Reduce costs incurred by toll operating agency.
- Use common toll readers and tags to promote interoperability and reduce cost to the traveling public.
- Reduce handling and processing of money.

Electronic Fare Payment Systems

Electronic fare payment is both convenient for the traveler, who no longer has to fumble for exact change, and a cost savings for public agencies as they reduce manual handling and processing of money. Electronic fare payment systems will be in operations for collection of transit fares, parking lot fees, etc. The systems will include hardware and software for roadside, in-vehicle, and in-station use, and passenger/driver payment cards, which might include financial and card accounting systems. Electronic fare collection eliminates the need for travelers to carry exact fare (change) amounts and facilitates the subsequent implementation of a single fare payment medium for all public transportation services.

These systems can include debit, credit, and/or stored value cards. Manual cash payment will continue to be supported. Eventually, travelers will be able to use standard financial institution credit cards to pay fares, much as they use a credit card at the gas pump today. Where appropriate, the system would facilitate private-company participation in programs where the employer subsidizes employee work-related travel on the transit system by directly depositing funds in employees' transit accounts.

Deployment objectives:

- Provide a single medium for paying travel-related fares and parking fees.
- Reduce the necessity for travelers and public agencies to handle money.

Regional Multimodal Traveler Information Centers

Providing timely travel information enables the public to make informed transportation choices. Metropolitan areas generally consist of multiple local jurisdictions and State level organizations, each responsible for providing some level of traffic surveillance, management, and control within their own jurisdictions. There is a need for an integrated source of roadway and transit information to provide

a comprehensive and integrated view of the roadway and transit conditions throughout the metropolitan area or region. Some users such as travelers, traffic managers and transit operators, and private-sector transportation-intensive businesses may use this information directly. Additionally, the private sector may elect to repackage this data and provide it as part of a marketable value-added service.

The information repositories may be either centralized (i.e., housed and managed in one facility) or distributed (i.e., housed and managed in separate facilities) systems that directly receive roadway and transit information from the various roadway-surveillance systems and other information sources, either public or private. The intelligent transportation infrastructure will be capable of combining the data from the various sources; this allows packaging of the data in a variety of formats and providing the information to the users through different distribution channels, such as telephone voice and data services, radio and TV broadcasts, kiosks, computer-based (e.g., Internet) services, etc. Various options exist for either public or private-sector distribution of transportation information.

Traveler information may be provided both directly to the public and to public or private-sector Information Service Providers (ISPs) that will supplement it with additional information, features, and services, and market the enhanced service products. Traveler information will be pulled from the various intelligent transportation infrastructure elements into a comprehensive regional information system, thereby facilitating the timely distribution of critical travel-related information to the traveler and transportation-related commercial users.

Deployment objectives:

- Promote regional coordination in collecting, processing, and presenting traveler information.
- Collect and maintain comprehensive transportation data.
- Format/package this data in such a way that it will be meaningful to the traveler.
- Provide travel information to the public via a range of communication devices (broadcast radio, cellular telephone, the Internet, cable TV) for presentation on a range of devices (home/office computers, television, kiosks, radio).

Emergency Response Systems

Efficient management and use of emergency equipment is an important contributor to a safe transportation system. By equipping emergency response vehicles with automated vehicle location capabilities, these vehicles allowing dispatchers to know the locations of various pieces of equipment. Also, this location information can be used to get emergency vehicles to their destinations more quickly. Assignments of response vehicles to cover reported incidents can be based on vehicle location when, for instance, they are not at their station and the routing of these vehicles to the incident scene can be accomplished more effectively based upon accurate knowledge of current vehicle location and traffic condition. Use of a common regional digital map system by emergency services personnel will facilitate the coordination among the several agencies involved in the incident response and will improve their ability to respond to an incident. Emergency management services will also support automated MAYDAY capabilities, a concern in rural areas where accidents may be undiscovered for lengthy periods of time.

Deployment objectives:

- Use traffic-management capabilities to improve response times.
- Use on-board moving map route guidance equipment to assist emergency vehicle operators.
- Improve response to HAZMAT incidents by providing emergency personnel with timely, accurate information.

Rail-Highway Grade Crossing Systems

Railroad Grade Crossings are a special form of roadway intersection. The fact that one of the roads is a railroad with trains that travel at high speeds and can take up to a mile or more to stop poses special challenges. As a result, automated systems that allow the deployment of safety systems to adequately warn drivers of crossing hazards are now becoming available. The railroad grade crossing component eventually may support real-time information on train position and estimated time of arrival at Highway-Rail Intersections (HRI), real-time roadway traffic conditions at HRIs, proactive train control by train control centers, and interactive coordination between roadway Traffic Management Centers (TMCs) and train control centers. The railroad grade crossing component is expected to interface with planned and existing rail automation and safety systems including:

- Advanced Train Control System (ATCS), which interacts with the Central Dispatch System; the On-Board Locomotive System; the On-Board Work Vehicle System; and the Field System. These subsystems are interconnected by a Data Communications System.
- Vehicle Proximity Alerting System (VPAS), being tested as a potential communication system between trains and special classes of vehicles (e.g., school buses, large trucks, hazardous materials haulers, and emergency vehicles).
- Remote monitoring systems that will warn local rail dispatchers and/or TMCs of equipment failures at HRIs.

Deployment objectives:

- Improve and automate warnings at highway rail crossings.
- Provide travelers with advanced warning of crossing closures.
- Coordinate rail movements with the traffic-signal control system.

These systems identify recurring and nonrecurring congestion by collecting and monitoring real-time traffic information at a transportation management center. When appropriate, the TMC implements appropriate control and management strategies such as ramp metering, lane control, and priority-access control. The TMC provides critical traffic information to travelers via dynamic message signs, in-vehicle systems, highway advisory radio, or area-wide traffic information broadcasts. (The benefits of these systems can be found in Appendix A).

1.3 METROPOLITAN AREA INTELLIGENT TRANSPORTATION INFRASTRUCTURE MODEL DEPLOYMENT INITIATIVE

The objective of the Model Deployment Initiative (MDI) is to demonstrate four metropolitan area deployments of intelligent transportation system infrastructure that feature integrated, regional, multimodal, inter-jurisdictional transportation-management systems and traveler information services. The model deployment sites will also provide a setting for conducting rigorous evaluation of an integrated, metropolitan area ITS deployment. In addition to introducing the public to the benefits of ITS products and services, these four sites will serve as “showcases” for local decision makers across the United States and will support tours and seminars on the benefits of ITS infrastructure investments by both the public and private sectors. A more detailed description of each site’s model deployment project follows.

New York, New Jersey, Connecticut

The **New York, New Jersey, Connecticut** region’s model deployment initiative will showcase the intelligent transportation infrastructure to millions of commuters and travelers. No other region in the Nation can compare with the transportation volumes, modes, and complexities of this region. The implementation of the model deployment in the region will create a seamless, intermodal, multimodal, inter-jurisdictional intelligent transportation system that will dramatically raise the level of multimodalism in the region’s travel and greatly increase travelers’ access to real-time transportation information. SmartRoutes Systems will manage the traveler information component of the region’s model deployment, and will develop fee-paying clients for customized traveler information services. TRANSCOM, a coalition of 14 transportation and public safety agencies New York-New Jersey-Connecticut metropolitan area, will be the lead organization. TRANSCOM was created in 1986 to provide a cooperative coordinated approach to regional transportation management. Other partners in the Model Deployment project include Lockheed Martin Federal Systems; PB Farradyne; JHK & Associates; Walcoff & Associates; Sam Schwartz Company; SmartRoute Systems; Navigation Technologies; MetroCommute Options Group; Metro Vision of North America; Shadow Broadcasting Services; CALSPAN.

Phoenix, Arizona

The **Phoenix, AZ**, AZTech Model Deployment features an integrated transportation-management system that coordinates the freeway and traffic-signal systems across jurisdictional boundaries. Etak and Metro Networks will manage the traveler information component of AZTech, and will promote business development of fee-paying clients. The Phoenix AZTech Model Deployment will integrate the Trailmaster Freeway-Management System, seven local area city Traffic-Signal Operations Centers along identified priority (SMART) corridors, city of Phoenix Public Transit Department management and dispatching system, Maricopa County Emergency Management System, Sky Harbor International Airport management/information system, and electronic fare systems associated with the Phoenix Public Transit Department and Sky Harbor International Airport for a truly regional, multimodal transportation-management system.

The partners include the Arizona Department of Transportation; Maricopa County; Pima County; the cities of Phoenix, Tucson, Chandler, Glendale, Mesa, Scottsdale, and Tempe; Regional Public Transit

Authority; Phoenix Transit Department; Maricopa Association of Governments; Pima Association of Governments; Arizona State University, Sky Harbor International Airport; TRW Transportation Systems; Scientific Atlanta, Inc.; and the Etak Team (Metro Networks, CUE Paging Corp., Differential Corrections Inc., SEIKO Communications Inc., SkyTel, Hewlett Packard, Fastline, Clarion, Delco Electronics, Volvo, IT Network, Delco Electronics, and AT&T).

San Antonio, Texas

The objective of **San Antonio's** model deployment initiative is to provide and integrate additional technologies into the existing TransGuide infrastructure. Intelligent transit management and emergency management systems will be integrated with TransGuide's advanced traffic-management system. Intelligent transportation infrastructure components such as coordinated traffic-signal control, highway-rail intersection monitoring, and multimodal traveler information will also be incorporated. From the moment a visitor arrives in San Antonio, every possible activity will demonstrate the importance of ITS. For example, the airport baggage pickup will have information kiosks; taxi cabs and rental cars will be equipped with in-vehicle route guidance; bus stops next to major hotels will provide real-time information to riders; real-time traffic information will be available through the Internet and via UHF channel 54. The model deployment will expand the existing advanced traffic management system by developing and deploying 300,000 intelligent vehicle registration tags with embedded transponders and 83 Automatic Vehicle Identification (AVI) readers so that these vehicles may be used as traffic probes. The readers will provide accurate real-time travel speeds on freeway and major arterials throughout the metropolitan area. To protect individual privacy, the transponders will not be connected to the vehicle identification numbers or the drivers of vehicles. The partners in the project include the Texas Department of Transportation, VIA Metropolitan Transit Authority, city of San Antonio Department of Public Works, city of San Antonio Police Department, City of San Antonio Fire Department, Brooke Army Medical Center, Alpine Electronics Research of America, Zexel USA, Scientific-Atlanta, Amtech Systems Corporation, and Southwest Research Institute.

Seattle TimeSaver

The **Seattle TimeSaver** Model Deployment will provide intermodal transportation management and integrated, real-time highway and transit information services for the entire Seattle metropolitan area. The Seattle TimeSaver Model Deployment project will implement and integrate seven features of the intelligent transportation infrastructure, including traveler information, transit management, electronic payment, traffic management and signal control, freeway management, and incident management. Multimodal congestion and transit information will be gathered and disseminated to all jurisdictions. Agencies will be able to independently control their respective systems, but will now have system-wide information available for their transportation-management decision making. The project will add real-time transit arrival information at Metro Transit stations, incorporate traveler information into Washington Information Network kiosks, a cable TV channel, and real-time traffic and transit information and video for TV-quality, Internet based traveler information for the public and for output to Information service providers using personal digital assistants, two-way pagers, in-vehicle navigation devices, and interactive TV. Etak and Metro Networks will manage the traveler information component of the Seattle model deployment, and will promote business development of fee-paying clients.

The partners in the project include the Washington State Department of Transportation; Amerigon, Inc.; Arel International, Inc.; Battelle Pacific Northwest Laboratories; Boeing Company; city of Bellevue Transportation Department; David Evans and Associates, Inc.; Etak Inc.; Fastline; IBI Group; Infrastructure Consulting Corporation; King County Department of Transportation; Metro Traffic Control, Inc.; Microsoft, Inc.; Overlake Transportation Management Association; Pacific Rim Resources, Inc., PB/Farradyne Inc., Rockwell International Corporation, Seiko Communications Systems, Inc.; TCI Telephony Services, Inc.; Puget Sound Regional Council; TRAC-UW; Transportation Division Seattle Engineering Department; US WEST Communications; University of Washington; Washington State Department of Information Services; Washington State Department of Transportation; Willows Corridor Transportation Partnership; and XYPOINT Corporation. (Case Studies of ITS deployments in major metropolitan U.S. areas can be found in Appendix B).

1.4 OBJECTIVES OF WORKSHOP

The objectives of this workshop are:

- To provide technology transfer on state-of-the-practice transportation-management techniques/technologies to improve mobility and safety;
- To make top management, administrators, and planning policy-makers aware of the significant role of these transportation-management systems in improving mobility and safety; and
- To provide hands-on training on the state-of-the-practice hardware and software in transportation-management systems.

1.5 PURPOSE OF THE REFERENCE MATERIAL

The purpose of the Participant Reference Material is to provide a comprehensive document for participants to be used as a reference in meeting the objectives of the workshop. It contains descriptions of the intelligent transportation infrastructure elements as well as the techniques/strategies and technologies of each component. It also includes the various emerging technologies.

1.6 ORGANIZATION OF THE REFERENCE MATERIAL

This reference material is generally organized around the intelligent transportation infrastructure elements. Each chapter is designed to reflect an element, addressing the various control and management components that make up the element. Each element component is further broken down into techniques/strategies and technologies that make up the component. For each component and/or element, sources and Internet Web page addresses are provided for further discussion on the topic.

Chapter 2 provides a complete description of the Freeway Management Systems element.

Control components, including ramp control (e.g., ramp metering, ramp closure), mainline control (e.g., mainline metering, freeway-to-freeway metering), dynamic roadway control (e.g., lane control, dynamic speed control), and priority control (e.g., priority access control, HOV facilities) are discussed. Components on traffic management and vehicle monitoring and detection, including transportation management during reconstruction, surveillance, and detection, dynamic message signs and traveler information systems, vehicle user devices, and communications, are discussed.

Chapter 3 provides a complete description of the Traffic-Signal Control Systems element.

Components on traffic-signal control (e.g., isolated intersections, interconnected signals, central control, special control) and integrated freeway-surface street signal control (e.g., corridor control, areawide integrated strategy, diversion strategy) are discussed. In addition, the various technologies and systems used for signal control (e.g., closed-loop systems, real-time traffic adaptive signal control, SCOOT, traffic controllers) are presented.

Chapter 4 provides a complete description of the Incident-Management Programs element.

Components and techniques/strategies on management of incidents (e.g., detection, verification, response and clearance, driver information) are discussed. In addition, the various technologies (e.g., media, patrol, courtesy vehicles, aerial surveillance, CCTV, electronic sensors, DMS, HAR, commercial radio) used for the detection and verification of incidents are presented.

Chapter 5 provides a complete description of the Electronic Toll-Collection Systems element.

Components and technologies on electronic toll collection (e.g., optical/infrared, inductive loop, radio frequency, surface acoustical wave) are presented and discussed.

Chapter 6 provides a complete description of the Transit-Management Systems element.

Components and techniques/strategies on management of transit systems (e.g., automatic vehicle location, global positioning systems, on-board displays) are discussed. In addition, the various technologies (e.g., GPS satellite, differential GPS, dead reckoning) used for locating and tracking transit vehicles are presented.

Chapter 7 provides a complete description of the Regional Multimodal Traveler Information Center element.

Components and techniques/strategies for regional multimodal traveler information centers (e.g., single control center, multiple integrated control centers) are discussed. In addition, the various technologies (e.g., support systems, data management, dissemination of traveler information) are presented.

Chapter 8 describes integration of systems, including the integration of the elements of the metropolitan intelligent transportation infrastructure.

Chapter 9 describes funding resources including ISTEA, NEXTEA, and innovative financing strategies.

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