TRAVEL DEMAND MANAGEMENT AND INTELLIGENT VEHICLE-HIGHWAY SYSTEMS

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INTRODUCTION

Many metropolitan areas throughout the United States are facing serious problems related to increasing levels of traffic congestion, declining mobility, and air quality and environmental concerns. In response to these growing issues, numerous areas are focusing on better management of the overall transportation system, rather than the construction of new facilities. Travel demand management (TDM) is a pertinent technique being actively pursued in many parts of the country. Travel demand management covers a variety of actions that better manage the demand on transportation facilities by acting to shift more commuters into transit and multi-occupant vehicles and into less congested travel periods. TDM strategies focus on providing inducements to ridesharing, transit use, and peak-period travel spreading, combined with deterrents to driving alone.

Another approach being actively pursued in numerous areas is the use of a wide range of advanced technologies to better manage all aspects of the transportation system. Commonly referred to as intelligent-vehicle highway systems (IVHS), a variety of advanced technologies are being developed, tested, implemented, and operated with the common goal of improving the efficiency of the overall transportation system. More specifically, IVHS technologies are directed at improving mobility and transportation productivity, enhancing safety, maximizing current transportation facilities, and enhancing the environment.

Although approaching current transportation issues from different perspectives, the use of both TDM strategies and IVHS technologies focus on improving the efficiency of the existing transportation system through better management, rather than building new capacity. Further, the use of IVHS and other advanced technologies appears to hold promise for enhancing the successful implementation of TDM strategies. Many potential applications of IVHS technologies with TDM actions are just beginning to be explored and implemented by public and private sector groups. This resource paper is intended to help foster, enhance, and expand this discussion, and to assist in bringing together the different groups involved in both IVHS and TDM. In addition, the paper generates further ideas and suggestions for operational tests, demonstration projects, and research studies to advance the integration of IVHS with TDM strategies.

To accomplish this the paper is divided into three sections following this introduction. The next section provides a brief overview of TDM strategies and IVHS technologies. The major elements of both are summarized to provide a common understanding of the depth and breath of the two approaches. This section also summarizes the different groups involved in funding, research and development, implementation, and evaluation of IVHS technologies and projects. This is followed by a discussion of techniques to utilize IVHS technologies to enhance the use of TDM actions. This section includes a review of examples of current state-of-the-art projects and discusses other potential applications. It also summarizes some of the major issues associated with the possible development of IVHS/TDM projects and approaches for addressing these concerns. The paper concludes with a summary of the major topics covered and the identification of areas where further research is needed.

OVERVIEW OF TDM AND IVHS

What Is TDM?

Travel demand management (TDM) includes a wide variety of techniques and actions aimed at managing the demand on transportation facilities by encouraging commuters to change from driving alone to using a high-occupancy vehicle or shifting into less congested travel periods. Thus, TDM actions focus on a variety of approaches to encourage ridesharing, transit use, alternative work schedules, parking management and parking pricing, and other techniques.

Although many of these approaches are not new, increasing levels of traffic congestion and related air quality and energy concerns have resulted in major emphasis being placed on the use of TDM strategies in many urban areas. This is especially true in locations classified as air quality non-attainment areas under the 1990 Clear Air Act Amendments. These areas must meet specific requirements by established deadlines or face possible sanctions. Further, many states and cities have implemented additional regulations to increase vehicle occupancy levels and reduce single occupant vehicle use. TDM programs have become integral elements in the approaches being taken in many areas to meet these requirements.

As discussed more extensively in other resource papers, TDM strategies include a wide range of actions focusing on the use of both incentives and disincentives. TDM strategies may include expanded or new transit services, ridesharing programs, parking policies and parking pricing, flexible work hours, telecommuting, walking, bicycling, and other techniques. Incentives—such as employer paid bus passes or employee benefits for using HOVs—and disincentives—such as increasing parking rates or penalizing individuals who drive alone—may be used. Recent TDM programs are also characterized by increased private sector involvement. This may occur through the formation of Transportation Management Associations or Organizations (TMAs/TMOs), employee TDM coordinators, and joint efforts between public agencies and private businesses.

As noted in other resource papers, the experience with different TDM actions appears to be mixed. Further, the experience with many techniques is still evolving. As discussed in this paper, the use of IVHS technologies with TDM strategies appears to hold promise for making the use of high-occupancy commute modes more convenient and enhancing other TDM actions. Thus, combining the two—IVHS and TDM—may help meet the goal of improving the overall efficiency of the transportation system and may assist in meeting other environmental and societal goals.

What is IVHS?

A major focus of recent transportation research and development activities has been on a variety of technologies being examined under the general heading of intelligent vehicle-highway systems (IVHS). Intelligent vehicle-highway systems include the application of a wide range of advanced technologies that share the common goal of improving the efficiency of the overall transportation system. More specifically, IVHS technologies are directed at improving mobility and transportation productivity, enhancing safety, maximizing current transportation facilities, and enhancing the environment. These efforts are being supported by federal and state policy directives, private industry groups, university research institutions, and others.

Before discussing the wide range of technologies and potential applications of IVHS, it is first important to have an understanding of the different groups involved in funding, research and development, implementation, operation, and evaluation of IVHS. The interest in IVHS and the development of projects and operational tests has accelerated rapidly over the past few years. Numerous federal, state, and local agencies, private consultants, private industries and vendors, defense industries, university research institutes, and other groups are all actively involved. Further, the development of many IVHS technologies, products, and tests are being jointly funded and conducted by consortiums involving both public and private sector groups. In addition, numerous IVHS projects and research activities are being conducted in European countries and Japan. The major roles and activities of these different groups are briefly summarized next to help individuals involved in TDM better understand the functions of each.

U.S. Department of Transportation

The U.S. Department of Transportation (DOT) and the modal administrations—the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), and the National Highway Traffic Safety Administration (NHTSA)—are responsible for the federal IVHS program. The Intermodal Surface Transportation Efficiency Act (ISTEA) established an IVHS Program and authorized $600 million in funding for the 6-year period (1). The Congressional appropriations have maintained a high level of funding for IVHS and the FY 94 appropriation is anticipated to be approximately $200 million. In addition, part of the focus of the $70 million Rebuild America Program proposed by Congress for FY 94 focuses on the conversion of defense industry technologies to transportation and other domestic applications.

The ISTEA required that the U.S. Department of Transportation submit to Congress a strategic plan for the federal IVHS program within one year of passage of the Act. The Department's *IVHS Strategic Plan: Report to Congress* (2) contains the mission statement, goals and objectives, program organization, and program milestones for the federal IVHS program. Overall leadership and coordination for the Department's IVHS program is through the DOT IVHS Coordinating Group and the DOT IVHS Working Group. The DOT IVHS Coordinating Group is comprised of top-level representatives from the modal agencies and other federal departments. The DOT IVHS Working Group is comprised of senior-level agency staff and is responsible for coordinating programs, funding, planning, and implementation across the Department.

The FHWA has been designated the lead agency for coordinating the Department's IVHS program. In addition, FHWA is responsible for various elements of the overall program. The IVHS program within FHWA is administered through the Office of Traffic Management and IVHS. Within the FTA, IVHS-related activities are focused in the Advanced Public Transportation Systems (APTS) program in the Office of Technical Assistance and Safety. Both agencies are moving forward with funding a variety of research and development activities, early deployment planning, operational tests, and other projects. Many of these activities have been funded in response to requests for proposals issued by the different agencies. In addition, Congress has earmarked funding for specific projects through the appropriations process.

IVHS America

IVHS America is a non-profit educational and scientific association formed to plan, promote, and coordinate the development and deployment of IVHS in the United States. *IVHS America* resulted from the work of Mobility 2000, an informal assembly of interested individuals in the public and private sectors who met periodically between 1989 and 1990 to help advance IVHS. *IVHS America* is designed as a utilized Federal Advisory Committee to the U.S. Department of Transportation.

Membership in *IVHS America* is open to public and private sector groups interested in all aspects of IVHS. The structure of *IVHS America* is focused on a series of technical committees and task forces composed of voluntary members. The work of the technical committees is organized through the Coordinating Council, which in turn reports to the Board of Directors. *IVHS America* completed a *Strategic Plan for IVHS in the United States* (3) and a *Federal IVHS Program Recommendations for Fiscal Years 1994 and 1995* (4) in 1992. Both of these documents were forwarded to the U.S. Department of Transportation. Although many of the *IVHS America* committees may address TDM-related activities, the three that are most focused on TDM are the TDM Task Force, the APTS Committee, and the Advanced Traveller Information Systems (APTS) Committee.

Private Sector Groups

A wide variety of private sector groups have been and will continue to be involved in IVHS activities. These include transportation consulting firms, automobile manufacturers, electronic companies, communication-related business, other technology firms and vendors, and defense industries. Recent interest at the federal level, as evident in the Rebuild America Program, has focused on the potential conversion of defense industry products to transportation and other domestic uses.

State and Local Governments and Agencies

Many State departments of transportation (DOTs) have become actively involved in IVHS activities and projects. For example, state DOTs in California, Texas, Minnesota, Colorado, Washington, Florida, and Virginia are developing, implementing, operating, and evaluating different IVHS technologies and projects. Local governments and agencies are also involved in IVHS activities in many areas. These include transit agencies—such as those in Houston, Ann Arbor, Minneapolis-St. Paul, and the San Francisco area—and local units of government.

Universities and University Research Institutes

A number of universities and university-based research institutes have been actively involved in a wide range of IVHS activities. Universities are currently playing important roles in many of the IVHS operational tests, demonstration projects, and research and development activists. The FHWA recently selected three schools—Texas A&M University, the University of Michigan, and Virginia Polytechnic Institute and State University—through a competitive process as IVHS Centers of Excellence. In addition, a number of universities in California, the University of Minnesota—which was given funding for IVHS through ISTEA—and other schools will continue to be actively involved in many IVHS projects.

IVHS Technology Classifications

Two different classification schemes are being used to describe IVHS technologies. The first divides IVHS into six broad categories focusing on general applications. The second focuses on IVHS technologies from a user perspective. Both approaches are briefly summarized next.

The six general categories used to describe IVHS technologies are advanced traffic management systems (ATMS), advanced traveler information systems (ATIS), advanced public transportation systems (APTS), advanced vehicle control systems (AVCS), commercial vehicle operations (CVO), and advanced rural transportation services (ARTS). There is overlap among the categories and many technologies within each are in the research and development stage. A brief description of each of the six categories is provided below.

- Advanced Traffic Management Systems (ATMS) - development and operation of advanced transportation surveillance and monitoring systems to provide detection, communications, and control functions in major travel corridors.

- Advanced Traveler Information Systems (ATIS) - provision of pre-trip and in-vehicle information to motorists on current traffic and other conditions and real-time guidance on route information.

- Advanced Public Transportation Systems (APTS) - use of advanced technology to improve the delivery of transit services and enhance the cost-effective and efficient provision of these services.

- Advanced Vehicle Control Systems (AVCS) - use of advanced technologies to enhance vehicle control and operation, thus providing a "Smart Vehicle."

- Commercial Vehicle Operations (CVO) - utilization of IVHS technologies to improve the efficiencies and effectiveness of commercial vehicles.

- Advanced Rural Transportation Services (ARTS) - improve the safety and efficiency of the rural transportation system through the use of advanced technologies.

The second approach to defining IVHS technologies focuses on describing the different services from a users perspective. This approach is being used in the development of the *National IVHS Program Plan*. This plan, which is being developed by the United States Department of Transportation and *IVHS America*, will identify the near-term program for IVHS development and deployment. The 27 user services highlighted in this plan are summarized next.

- Pre-trip travel information
- Enroute driver information
- Enroute transit information
- Traveler services information

- Route guidance
- Ride matching and reservations
- Incident management
- Travel demand management
- Traffic control
- Electronic payment services
- Commercial vehicle preclearance
- Automated roadside safety inspections
- Commercial vehicle administrative processes
- Onboard safety monitoring
- Commercial fleet management
- Public transportation management
- Personalized public transit
- Emergency notification and personal security
- Public travel security
- Emergency vehicle management
- Longitudinal collision avoidance
- Lateral collision avoidance
- Intersection crash warning and control
- Vision enhancement for crash avoidance
- Impairment alert
- Pre-crash restraint deployment
- Fully automated vehicle operation

Detailed user service plans are being developed for each of these areas. These plans include a description of the operational concepts, possible technologies, potential costs and benefits, the roles of different groups, milestones and activities, and related projects. The user service plans will form a major focus for directing and coordinating the development of IVHS projects and activities. A number of these user services focus specifically on features that are directly related to or are supportive of TDM actions. First, travel demand management is one of the user services. This user service focuses on the application of a wide range of technologies to enhance TDM actions, including mode change support services, HOV facility management and control, parking management and control, congestion pricing, and air pollution and emission detection (5). Further, other user services, such as those oriented toward pre-trip travel information, enroute driver and transit information, ride matching and reservations, electronic payment services, personalized public transit, and public travel security, all support TDM strategies. Thus, as discussed more extensively in the next section, there appears to be numerous opportunities to utilize advanced technologies to enhance TDM actions.

COMBINING IVHS AND TDM

This section discusses the potential of combining IVHS technologies and TDM strategies to better manage commute travel in congested areas. The use of IVHS and other advanced technologies appears to offer numerous opportunities to enhance the successful implementation of TDM actions. This section reviews the general concept of combining IVHS and TDM, examines current and planned projects, and identifies other potential applications.

The Concept of Combining IVHS and TDM

Advanced technologies can be used in numerous ways to enhance the implementation, operation, management, and evaluation of TDM actions. First, IVHS technologies can be used to provide pre-trip and enroute real-time information to commuters on traffic conditions, transit alternatives, weather, and other elements to help individuals select the most appropriate travel mode and to encourage greater utilization of high-occupancy vehicles. Second, the application of advanced technologies can enhance the convenience and ease of use for all types of HOVs. Third, IVHS technologies can be used to help manage and enforce TDM strategies related to HOV use, parking, and congestion pricing. Finally, a wide range of advanced technologies is enhancing the potential for telecommuting.

The provision of real-time information on traffic conditions and transit alternatives to individuals in their home and work place represents an important step in making commuters more aware of both current conditions and the options available to them. In order to influence commuters to change from driving alone to using some form of high-occupancy vehicles, this information needs to be provided in advance of the first mode selection. Thus, as discussed under the examples of current projects, some operational tests are focusing on the provision of real-time traffic and transit information to individuals in their home and work place to allow commuters to make more informed decisions regarding their travel and mode choices. The real-time traffic and transit information may be obtained and coordinated through the use of advanced traffic management systems (ATMS), automatic vehicle identification (AVI), automatic vehicle location (AVL), and other advanced technologies. The information could be provided to individuals through the use of touch-tone telephones, cellular or pocket telephones, television, microcomputers, and videotex terminals. Ensuring that the information provided is accurate and timely appears to be critical to continued use by individuals (6).

The application of IVHS technologies can also make using all HOV modes more convenient and attractive to commuters. For example, fare payment methods can be simplified and made more convenient through the use of *Smart Cards* and other automatic fare payment methods. These techniques focus on the use of pre-paid fare media ranging from a relatively simple pass to a more advanced programmable memory chip card. Further, *Smart Cards* could be used to provide integrated fare payment among different transit modes in an area. In addition, *Smart Cards* could be expanded into multi-purpose cards linking transit, parking facilities—including the ability to charge lower rates for carpools and vanpools—and other services such as banking and credit card purchases. *Smart Cards* could also be used by businesses to help track the use of HOVs by employees as part of incentive programs or to charge more for the use of parking for drive alone commuters. Other IVHS technologies could be used to provide real-time carpool matching capabilities, enhanced guaranteed ride home programs, and other techniques to make the use of all high-occupancy vehicles more convenient.

IVHS technologies may also be appropriate to assist with the management, operation, and enforcement TDM actions related to HOV facilities, parking management, and congestion pricing. A wide range of advanced technologies, including AVI tags, *Smart Cards*, remote sensing, and other devices may be used to help operate and enforce various TDM strategies. For example, AVI tags are currently in use on a number of toll facilities throughout the country to provide electronic toll collection. Individuals purchase AVI tags which are encoded with a prepaid toll value. The AVI tags, which are usually located on the front windshield, are read by receivers at special toll plazas, allowing vehicles to pass through the plaza without stopping. This approach is currently being used with buses equipped with electronic tags on the Route 495 HOV lane on the approach to the Lincoln Tunnel in New York City. The potential for other applications using IVHS technologies to better manage and enforce TDM actions are discussed more extensively later in this paper.

Finally, advanced technologies are being used to enhance the use of telecommuting. Advances in telephone, fax, video conferencing, and other technologies are allowing increasing numbers of workers to spend one or more days a week working at home or at a remote job site. Although the exact number of telecommuters is not known, it appears that the use of telecommuting is increasing. In addition to the TDM benefits of removing trips from the roadway system, telecommuting offers businesses the potential to realize savings in real estate costs. For example, AT&T estimates that it has saved approximately $24 million in real estate costs through telecommuting programs since 1992 (7).

Current and Planned Examples

There are a number of projects throughout the country in different phases of planning and implementation that focus on the use of IVHS and other advanced technologies to enhance TDM actions. Examples of a few projects currently moving forward throughout the country that combine different aspects of IVHS and TDM are briefly summarized in this section. The projects described are intended to provide an indication of the variety of applications currently being considered. Projects in Houston, the Bellevue-Seattle area, the San Francisco-Bay area and other parts of California, the Minneapolis-St. Paul area, and Dallas are briefly highlighted next.

Houston Smart Commuter IVHS Operational Test

The Houston *Smart Commuter* IVHS Operational Test is examining the potential for gaining more efficient use of major travel corridors through greater utilization of high-occupancy commute modes, shifts in travel routes, and changes in travel time through the application of innovative approaches using advanced technologies. The operational test is based on the hypothesis that commuters who have quick and easy access to relevant, accurate, and up-to-date information on existing traffic conditions, bus routes, bus schedules, how to use the bus, and instant ridematching services in their home and work place will be more likely to use public transportation and other high-occupancy commute modes. The travel time savings and travel time reliability offered by the Houston HOV lanes provide further incentives for changing travel modes. In addition, individuals may alter their travel time or route based on this information.

The Houston *Smart Commuter* IVHS Operational test has been developed and is being implemented through the joint efforts of the Texas Department of Transportation (TxDOT), the Metropolitan Transit Authority of Harris County (Houston METRO), the Federal Transit Administration (FTA), the Federal Highway Administration (FHWA), and the Texas Transportation Institute (TTI), a part of The Texas A&M University System. The first phase of the operational test is currently moving forward.

The *Smart Commuter* IVHS Operational Test includes two different, but compatible, components. Both components are intended to make better use of the Houston HOV facilities, which have been developed and funded as multi-agency projects. The bus component focuses on the traditional suburban-to-downtown travel market in the I-45 North corridor. This element focuses on encouraging a mode shift from driving alone to using the bus, changing travel times, and shifting travel routes. These changes in travel decisions will result from the provision of current traffic and transit information to individuals in their home and work place through state-of-the-art videotex and telephone technologies.

The second component focuses on the suburban-to-suburban travel market in the I-10 West corridor to the Post Oak/Galleria area. This corridor, which is more difficult to serve with traditional regular-route bus service, provides the opportunity to test the use of a comprehensive employer-based carpool matching service. This system will include the ability to provide real-time carpool matches and is structured to encourage a mode shift from driving alone to carpooling and also to encourage an increase from 2 to 3 person carpools.

The two components of the *Smart Commuter* IVHS Operational Test, the advanced traffic and transit information system in the I-45 North corridor and the comprehensive employer based instant rideshare matching service in the I-10 West corridor, are being implemented and evaluated over a five-year period. The *Smart Commuter* Operational Test represents the first major demonstration of the use of IVHS technologies to encourage an increase in average vehicle occupancy. It provides an opportunity to test the ability to collect, process, and transmit current traffic and transit information and instant rideshare matching services to individuals in their home and work place through a variety of advanced technologies. The *Smart Commuter* Operational Test also provides an opportunity for highway and transit interests to work together to better manage the overall transportation system through the innovative application of IVHS technologies, enhanced information, and improved services (8).

Bellevue *Smart Traveler*

This project is testing the use of cellular telephones and voice mail to help facilitate the formation of carpools in the Bellevue, Washington area. An operational test is planned to demonstrate the use of dynamic ride matching through the use of mobile communications. The first phase of the project developed a set of information-based services for ridematching. The second phase is focusing on testing a prototype computer-based interactive commuter information center in a downtown Bellevue office building. It is anticipated that individuals—both those who currently carpool and those who currently drive alone—will register to participate in the project. Both groups will be provided with cellular telephones and access to electronic voice mail (9, 10).

Minneapolis - St. Paul *TravLink*

The *TravLink* project represents one element of the larger *Minnesota Guidestar* program, which is a multifaceted IVHS program in Minnesota. The *TravLink* program is being developed and implemented through the joint efforts of the Minnesota Department of Transportation (MnDOT), the University of Minnesota (U of M), the Regional Transit Board (RTB), the Metropolitan Transit Commission (MTC), and the Federal Highway Administration (FHWA).

A major component of the *TravLink* project focuses on the provision of transit and traffic information to transit users and carpoolers in the I-394 corridor. This is a radial route corridor linking the western suburbs to downtown Minneapolis. The corridor contains a freeway HOV lane, park-and-ride lots, and transit stations. The HOV lanes, which include segments of both concurrent flow and reversible, barrier separated lanes, are connected to three major parking garages on the edge of downtown Minneapolis. The parking garages contain bus waiting and transfer areas and provide reduced parking rates for carpoolers and vanpoolers using the I-394 HOV lanes.

The *TravLink* project will attempt to increase the use of high-occupancy commute modes in the corridor through the provision of transit and traffic information to individuals at home, at work, and at major transit terminals. In addition, transit users at transit stations along the corridor and at the transit terminals in the parking garages will be provided with real-time information on bus arrival and departure times (11).

San Francisco Bay Area

A number of projects are moving forward in the San Francisco Bay area focusing on improving access to transit information and integrating fare payment among multiple transit providers. One project is examining the potential to coordinate the provision of transit information among all providers in the region. Currently, different services have their own information numbers. This may require a potential transit user to call multiple providers in order to obtain the desired information. A study was conducted to examine different approaches to providing one common information number. The results of this study are being examined and it is anticipated that a decision will be made to select and implement one approach (13).

Transit systems in the San Francisco area are also considering coordinating fare collection through the use of a common fare prepayment method. The *Translink* project currently involves the Metropolitan Transit Commission (MTC), Central Contra Costa County Transit (CCCT), and Bay Area Rapid Transit (BART). The use of a stored value fare card, which could be upgraded at a later point to a *Smart Card* is anticipated. Additional providers are also expected to be added in the future (14).

California *Smart Traveler*

The California *Smart Traveler* contains numerous advanced public transportation system (APTS) elements as part of the California Department of Transportation's (Caltrans) overall IVHS program. The California *Smart Traveler* project focuses on the design, testing, and evaluation of a variety of IVHS technologies to transit, paratransit, and ridesharing. The first phase of the project included the evaluation of potential test sites and technologies. Five sites have been identified for the actual implementation and evaluation of operational tests. It is anticipated that these will involve a partnership between public and private sector groups (9, 10).

Dallas HOV Monitoring and Enforcement

A research study is being conducted in Dallas examining the potential use of IVHS technologies to enhance the monitoring and enforcement of the vehicle occupancy requirements on the East R. L. Thorton Freeway HOV lane. The project is being conducted jointly by the Texas Transportation Institute, Dallas Area Rapid Transit (DART), FHWA, and DTA. The intent of the study is to assess the applicability of various automated enforcement technologies and to test the use of the most promising alternative on the East R. L. Thorton HOV lane. It is hoped that the use of advanced technologies can reduce enforcement costs and police exposure to traffic and weather. Technologies currently being examined for possible use include AVI tags, imaging systems, and infrared applications (12).

Other Potential Applications

The projects described previously provide an indication of a few applications of IVHS technologies focusing on TDM related actions. In addition to these projects, other activities are being conducted around the country which focus on related types of applications and other approaches combining IVHS and TDM. Further, there appears to be a great deal of potential for other applications of IVHS technologies to enhance TDM actions. A few suggestions for additional research, operational tests, and demonstration projects are provided in this section.

- Real-Time Transit and Traffic Information. Although there are a few projects focusing on the provision of real-time traffic and transit information to individuals in their home and work place, additional projects testing other technologies appear appropriate. Combining real-time transit information on the status of buses, obtained through AVL systems, with real-time traffic data from ATMS and providing both to individuals in different locations through numerous technologies could be considered.

- TDM Multi-Purpose *Smart Cards*. A series of operational tests could be conducted focusing on the use of multi-purpose *Smart Cards* for TDM programs. These operational tests would develop, implement, and evaluate the use of *Smart Cards* for transit use, HOV and SOV parking, and other commute modes. The cards could be used to both pay for and access the different modes and for organizations to track use of these modes by employees. Multiple tests using different approaches, different sizes and types of businesses, and alternatives combinations of incentives and disincentives could be explored.

- HOV Toll Pricing. Currently preferential pricing for HOVs is provided at some toll facilities in the United States. The use of AVI tags provides the opportunity to greatly enhance and expand the use of HOV discounts and HOV preferential treatment at toll plazas. Operational tests could be conducted to test and evaluate the use of HOV pricing strategies and preferential treatments with toll roads, bridges, and tunnels in this country.

- Enhanced Ridesharing. Rideshare matching software has improved significantly over the last 5 years. The potential exists to combine this software with GIS and other technologies to greatly enhance response time for ridematching services and provide real-time matches. A few operational tests are currently focusing on this area, but more projects appear appropriate.

- HOV Facility Monitoring and Enforcement. The results of the Dallas project described previously should provide a good deal of information on possible IVHS technologies to enhance the monitoring and enforcement of HOV facilities. Additional operational tests and projects could be developed in this area.

- Telecommuting. Rapid advances in communications technology are making telecommuting more easy and more wide spread. Additional projects testing different approaches to telecommuting, as well as monitoring and evaluating existing programs, appears appropriate.

- Air Pollution and Emission Detection. IVHS technologies could be used to identify air quality hot spots and air pollution violations on a real-time basis. Projects could be developed to first identify actions to be taken in response to these situations and then to implement the recommend projects when air quality incidents occur.

Potential Issues Associated with Integrating IVHS and TDM

A number of issues may emerge as projects and operational tests combining IVHS and TDM are planned, implemented, operated, and evaluated. Although technology problems may emerge—especially those relating to testing new products and approaches—it appears that most of the concerns will focus on institutional and organizational issues.

Individually, both TDM and IVHS projects usually involve a diverse group of individuals and organizations from the public and private sectors. Projects which combine the two will require that even more diverse groups work together. Further, to date, individuals in the TDM and IVHS areas have not worked together on many projects, and thus may not be aware of the other area. Thus, building a strong working relationship between the different groups, which includes an understanding of the roles, responsibilities, strengths, and weakness of each group, will be critical to advance projects integrating IVHS and TDM.

CONCLUSION

This paper has presented a discussion of the potential for greater integration of IVHS technologies with TDM actions to better manage the demand on transportation facilities in congested areas. It has presented a brief overview of TDM strategies and IVHS technologies, identified the different groups involved in IVHS, discussed the concept of integrating IVHS and TDM, and illustrated a few examples of current projects. Further, suggestions for additional demonstrations and projects were identified.

The current projects and possible applications outlined in this paper provide a strong indication of the potential benefits the use of a wide range of IVHS technologies may have on the successful implementation of TDM actions. As noted in this paper, additional research projects, operational tests, and full deployment are needed to help advance the state-of-the-art in integrating IVHS and TDM. This paper has helped foster, expand, and enhance the discussion of greater integration of IVHS and TDM and has assisted in furthering activities focused on this area.

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