COMMENTARY

INTELLIGENT TRANSPORTATION SYSTEMS
Research Products for Public Works Professionals

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Intelligent transportation systems (ITS) hold great promise for public works professionals seeking to optimize those public investment strategies that deal with traffic congestion and other growth pressures. Advanced traffic and fleet management systems as well as traveler information and vehicle-based systems can take advantage of information technology advances and private market products to substantially improve the productivity, connectivity, and safety of transportation. And as the new federal transportation act further spurs deployment of these systems, ITS research programs will continue to play a vital role in supporting such deployment and the overall evolution of ITS. Such research includes developing technology tools, providing testing and evaluation environments, and helping advance the state of the practice.

Continuing advances in information technology are creating unprecedented opportunities to improve the management and operation of our transportation systems. As discussed in John Collins and Norman Y. Mineta's Commentary in the April 2000 issue of *PWMP* (Collins & Mineta, 2000), the national and international emergence of intelligent transportation systems (ITS) presents a strategic opportunity for transportation professionals to improve vastly the productivity, connectivity, and safety of transportation. ITS is not simply new "gadgetry" that does what one is already doing. Rather, by exploiting the recently completed national system architecture (and the standards that emanate from it), ITS provides to public works planners for the first time a structured approach to transportation system management across jurisdictions, modes, and even the public and private sectors of the economy. This architecture describes the

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components of ITS, their individual functions, and how they can be connected, both physically and logically, to improve the overall transportation system.

ITS encompasses all elements of the transportation system—infrastructure, vehicles, and users. The technologies include (a) sensors to detect traffic conditions and vehicle motions, (b) wireless communications between roadside and vehicles and among different vehicles, (c) data processing and storage, (d) electromechanical actuators, and (e) software to implement and optimize the desired behaviors in these systems. Prototypes of all of these elements are being tested in laboratories and on test tracks, and some of them are already in public use in some locations. The power of ITS is attained by the intelligence embedded in software that links and controls these elements to create families of user services: (a) advanced traffic management, (b) traveler information, (c) transit and commercial vehicle fleet management, and (d) vehicle control and safety systems. And this power will be enhanced by interfaces that will make these systems "interoperable" (i.e., dissimilar systems can exchange and understand data).

Although there had been significant prior ITS activities in California and elsewhere, the exploration of ITS in the United States started in earnest with the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) (Saxton, 1993; Shladover, Bushey, & Parsons, 1993). ISTEA provided dedicated federal funding for ITS research, development, field testing, and evaluation; it also provided mandates for an automated highway demonstration and the development of a national ITS architecture. Under ISTEA, public agencies (in concert with academic and private industry partners) have pursued a number of ITS programs in both urban and rural areas—including focused field tests, broad multiapplication "showcases" and "model deployments," regional deployment plans, and the staging of the national automated highway demonstration in San Diego in 1997.

Now, under the new Transportation Equity Act for the 21st Century (TEA21), mainstream federal funds can be used for ITS deployments that are consistent with the national architecture. At the same time, private firms are pursuing ITS market opportunities, particularly in traveler information and vehicle-based safety systems. Generally, public and private sector investments are being made independently. However, the case of the California Alliance for Advanced Transportation Systems (the California chapter of ITS America) shows that a package of ITS deployment initiatives and investment strategies can be developed that addresses both governmental action and market opportunities.

Robust research programs—such as those at the federal level and in states like California, Texas, Minnesota, and Montana—are designed to support ITS deployment. Although many ITS products and services "have come out of the laboratories and off the shelves" (Collins & Mineta, 2000), the next several years will yield ever more capable and interoperable systems, and research, development, field-testing, evaluation, and refinement of such systems will continue. University-based programs such as California's Partners for Advanced Transit and Highways (PATH) are providing a range of expertise, functions, and facilities to address the variety of needs as technologies emerge from lab to field and applications evolve from simple to complex. In this environment, research priorities are set cooperatively among the ITS partners (see appendix).

ITS and the Public Works Challenge

With strong economic and population growth has also come a marked increase in congestion in many U.S. metropolitan areas in recent years. Los Angeles, Washington, D.C., Seattle, Atlanta, and Boston vie for the title of most congested area; each averages more than 65 hours of delay per year per driver (Texas Transportation Institute, 1999). According to the latest U.S. Census, population is expected to increase by 22% in the next 25 years (and by roughly a third in some of the largest states—California, Texas, and Florida), thus exacerbating the problem. The cost of expanding roadways in these congested areas has risen dramatically as increasingly dense development combines with fewer uncongested periods when road construction can be done. Consequently, transportation dollars now spent on expansion buy less new capacity than in the past.

In light of these facts, a central challenge for public works officials is to determine how to spend the limited funds available for transportation improvements. The simple answer, of course, is to use them in a way that maximizes the benefits. This suggests that the first priority should be to maintain the existing system—to protect the huge investment we have already made in it, particularly because deferred maintenance usually leads to higher costs in the long run. It also suggests that we should get the most out of the existing system by making improvements that make it more efficient or that help travelers use it in a more efficient manner. Finally, it suggests that system expansion (expanding or building new roads or initiating new transit services) should be done strategically. A good example of this would be opening up a small traffic bottleneck that is causing substantial upstream delay but whose opening would not cause substantial new downstream delay. However, determining which improvements will provide the greatest improvement per dollar expended requires better information about how the system is currently operating than is available in most areas today.

INTELLIGENCE IS NEEDED!

The first need is for intelligence about how the transportation system is currently operating and why. This need has been recognized for a long time, and traffic engineers have in the past made counts, recorded travel times, and measured traffic densities. But such measurements have been expensive and time-consuming, and therefore limited to only the most essential locations and situations. As a result, the models used to design and analyze the effects of improvements have been compromised by limited data. Even with up-to-date traffic surveillance systems, the kinds of data needed to support the most meaningful measures of system performance have been elusive at best.

Intelligence is also needed to manage the transportation system most effectively, to maximize its productivity and enhance modal connectivity. Accurate, current traffic information is needed to optimize the performance of signals and ramp meters and to promptly detect incidents and instantly inform travelers of them. Travelers also need reliable information about travel times to make the best choices of routes and modes. Finally, vehicle location and speed information is needed to manage fleets efficiently.

Research Products to Meet the Challenge

Federal and state research programs will be critical in meeting these needs. In California, PATH is currently developing products and capabilities in four areas that should be of direct interest and benefit to public works officials: (a) traffic monitoring technologies, (b) system performance measurement, (c) traveler information services, and (d) cooperative traffic management tools.

TRAFFIC MONITORING TECHNOLOGIES

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Researchers at UC-Berkeley and UC-Irvine have developed methods to use an old tool (inductive loop detectors) in new ways. One method identifies vehicles by their “magnetic signature” and matches observations between successive detector stations. The matches yield highly accurate real-time section travel time, speed, and density as well as vehicle classification and origin/destination information—from either double- or single-loop detector stations. One such system (used in the San Francisco Bay Area since October 1999) uses conventional double loops to identify vehicles and groups of vehicles based on their lengths, and then re-identifies them downstream (Coifman, 1999). Another system—still in development—uses newer but commercially available high-speed scanning cards to yield more accurate conventional travel time and density measurements, with average errors of only 2% to 3% (compared with errors measured up to 30% to 50% for the methods now commonly used). Equally important, this newer system can compensate for many detector failures by automatically adapting to the changes in loop inductance, thus overcoming most of the current reliability problems (Sun, 1999).

Prototype freeway and arterial field implementations of these newer methods are now under way in Southern California. One site of implementation is a major signalized intersection in Irvine, where these methods are being used at the City of Irvine Traffic Management Center to acquire data for real-time congestion monitoring, incident detection, and level of service measurement. Another site is Interstate 405 in Irvine, where these techniques will be used for real-time freeway operations. It should be operational by August 2000.

There are also a number of ongoing efforts to develop out-of-pavement detectors, which can be installed and maintained without disrupting traffic. Key among these are video image processing systems (VIPS), in which a computer is hooked up directly to a video camera to count, classify, and determine the speed of vehicles. Although commercial VIPS products have been on the market for many years, the price-performance curve has changed dramatically with recent developments in consumer computer video products. This allows the development of much more reliable and accurate VIPS detectors. For example, UC-Berkeley researchers are developing a “side-fire” system that can count and classify vehicles in congestion when vehicles in the near lanes partially block the view of the far lanes. Cal-Poly San Luis Obispo has operationally demonstrated a system that can re-identify vehicles from overhead cameras, which is computationally simpler but requires overhead placement. And researchers at UC-Davis have just developed a new type of out-of-pavement traffic detector based on lasers. Unlike existing commercial laser detectors, this system does not attempt to precisely time the speed of light (which is difficult and costly) but instead uses a much simpler and robust method of operation. The system works day and night independent of background illumination and provides very high-precision reliable information: it generates the top-down profile of each and every vehicle, allowing them to be re-identified downstream to generate continuous travel time and origin/destination information. The lasers are also extremely low powered, which allows the detector to be solar powered and therefore capable of being wirelessly deployed anywhere without the trenching and cabling that conventional installations require (Larson et al., 1998).

In cooperation with the cell phone industry, PATH is also investigating the quality and cost of travel time estimates that could be obtained from “vehicle probes” through the automatic location (now federally required) of cell phones that are placing 911 emergency calls. (This concept is also being tested in the Washington, D.C., area by the Maryland Department of Transportation and the University of Maryland.) Similar systems that track vehicles equipped with bridge or highway toll tags are already operational elsewhere in the United States, and with good results. With such systems, privacy protection must be and in fact has been designed into the process. Also, experience so far would indicate that the numerous customer services enabled by this approach would attract a critical mass of volunteers and subscribers to provide accurate roadway travel time information for both operating agencies and travelers. (For instance, the voluntary use of vehicle transponders by motorists in San Antonio provides the Transportation Management Center [TransGuide] there with highway link speeds that in turn provide the public with traffic information.) The vehicle probe approach seems to hold the best promise to provide travel time information throughout the roadway network—freeways, urban arterials, and rural roads.

SYSTEM PERFORMANCE MEASUREMENT

Imagine a company that produces a service for a large market but does not know how much it produces, what it costs, or how satisfied its customers are. The company would soon go out of business (unless it is a monopoly whose behavior did not repeatedly arouse the public's wrath). Unfortunately, the typical transportation agency is very much like this company: it cannot fully measure the quantity or quality of what it produces, or how much time and money it costs people to travel over its roadways or on its fleets. It responds when the public or political leaders are particularly agitated. But neither the public nor agency managers have the means to judge how well it performs.

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The Performance Measurement System (PeMS), developed at UC-Berkeley, is based on two commonsense beliefs: (a) you cannot manage a transportation system today if you don't know how it performed yesterday and (b) the best way to improve the system is to enable everyone to figure out easily how the system is performing every day (Skabardonis, 1999). A prototype of PeMS is operational in the State of California, Department of Transportation (Caltrans), Orange County district, with plans to extend coverage to all freeways in California in a year. Currently, PeMS receives loop detector data and uses a set of algorithms to compute several performance measures (e.g., vehicle miles or hours traveled, congestion delay) to determine the system performance. As improvements are made in traffic-monitoring technologies, PeMS will incorporate the enhanced and expanded data feeds.

Traffic engineers can use PeMS to analyze whether control equipment (such as ramp metering) is being used effectively and then to adjust those settings accordingly (see discussion below). They can track the most frequently congested freeway segments. They can determine the impact of lane closures.

Caltrans managers can use PeMS to obtain at the click of a mouse an objective, quantitative comparison of the daily performance of different parts of the freeway system. Poor performance can be diagnosed and corrected. Analyses can identify freeway bottlenecks so resources can be allocated to clear incidents quickly and to prevent congestion from choking those bottlenecks.

Transportation planners can use PeMS to discern traffic trends and to use comparative performance data to determine if transportation system performance can be improved by better operations or if new capacity has to be built.

Policy makers and the public can use PeMS to get a quantitative grip on the "transportation problem." They can see where congestion is frequent, how much it costs in terms of delay, whether traffic management strategies are effective, and where traffic growth is greatest. PeMS is designed to incorporate data from local streets and transit. As such data become available, PeMS would permit a gross objective appraisal of different transportation modes within a metropolitan area.

Finally, PeMS can serve as a key source of data for traveler information services.

In companion work at UC-Irvine, researchers have developed a "look ahead" process, aimed at providing a real-time assessment of the potential effectiveness of combined ITS strategies for responding to nonrecurrent degradations in traffic system performance. Using high-speed microscopic simulation and traffic control options, network performance can be evaluated and optimal strategies identified under different traffic conditions, including the occurrence of several types of incidents. The simulation can compare various networkwide performance measures (with and without the implementation of individual or concurrent control strategies), including

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- adaptive systemwide ramp metering,
- adaptive arterial traffic signal control, and
- traffic diversion based on driver response to message sign information.

The performance measures that can be considered include (a) overall network travel time reduction achieved by the implementation of those incident response plans suggested by optimal deployment of the three ITS response strategies; (b) the system's response time; and (c) the impact of the integration between the various control components (obtained by comparing the effect of fully integrated control plans, e.g., all three measures, to incomplete control plans). This methodology was recently used successfully to estimate benefit/cost ratios for a host of combined ITS projects under consideration in the Caltrans district in Orange County.

When deployed, the UC-Irvine real-time simulation system and PeMS will work in tandem—the former enabling transportation operators to find quickly the optimal solutions to traffic situations, and the latter providing feedback to the operators (and to the simulations) on how the system is actually performing and responding to control strategies.

TRAVELER INFORMATION SERVICES

Under ISTEA, a number of regional traveler information services were launched across the nation. Initially, many took the form of field operational tests and demonstration projects, but these are now transitioning into full deployment. Within California, examples of such efforts include TravelTip in Southern California, Yosemite Advanced Traveler Information in rural Central California, and TravInfo in Northern California. These regional initiatives attempt to go beyond simple broadcast traffic information (mostly about freeways) to include current and accurate condition information on the broad range of transportation systems and modes, including local arterial roads. Taking advantage of information technology advances, this information can be delivered to and personalized for the user through numerous media (including telephone, in-vehicle devices, and the Internet and other interactive platforms). Private industry is also expected to play a major role in information delivery and in packaging travel information with other "infotainment" services (as the Weather Channel is part of a cable TV multiple-channel package). The regional initiatives, therefore, involve private information service providers (beyond system managers and consultants) to differing degrees, and most involve multiagency partnerships.

PATH researchers served as evaluators on some of the California projects, and their evaluations indicate that both promise and challenges lie ahead. For instance, these initial efforts have firmly established a multimodal vision and personalized service approach to traveler information. However, partners need to have realistic expectations while working toward the common vision, projects should be phased as to technical and institutional complexity, and risk management strategies need to be developed. In addition, more effective business models need to evolve. One current, critical gap is the lack of accurate, real-time information on transportation system conditions. Data quality needs to be enhanced and scope expanded (off-freeway) if we are to realize the vision of dynamic information services that support "origin-to-destination connectivity" across modes and roads for the traveler.

Advances in traffic monitoring technology and performance measurements such as those described above will go far in plugging data gaps. And as we continue to evaluate and learn lessons from new ITS innovations, we should be able to overcome many of the other technical and institutional challenges, particularly as regional services mature and the national ITS architecture and standards take hold. The public works professional will play a key role in this process.

In research that should be of particular interest to traffic managers, UC-Irvine is developing a network evaluation framework under a series of driver route guidance options, including (a) user equilibrium route guidance, (b) system optimal route guidance, and (c) states in which the unguided traffic is assumed to be in user equilibrium. Compliance rates are assumed to be dependent on the reliability of the information. A framework was developed to model driver compliance behavior associated with information reliability involving three different types of information schemes: (a) optimized static route information, (b) instantaneous optimal route information, and (c) predictive optimal route information. These routing schemes were tested within the day-to-day compliance update framework, and the resulting long-term compliance rates and system performance were examined. Findings indicate that longer-term compliance is considerably different than initial compliance. Importantly, longer-term compliance is higher in the more advanced schemes (i.e., dynamic and predictive information) (Jayakrishnan, Tsai, Oh, & Adler, 1999).

COOPERATIVE, REAL-TIME TRAFFIC MANAGEMENT TOOLS

Typically, an individual traffic agency seeks to preserve its autonomy and to maintain control of the facilities under its jurisdiction while remaining cooperative with other agencies toward corridor or regional transportation goals. To this end, researchers at UC-Irvine have developed a distributed architecture for areawide incident response and traffic control management that unifies the problem-solving capabilities of multiple agencies toward a conflict-free, integrated response to traffic problems. This is accomplished through real-time, interacting decision-support systems that, although in separate locations, are able to perform cooperative reasoning and resolve conflicts to minimize overall delay in a corridor.

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This system will be deployed in a subarea of Irvine, which corresponds to a federally funded, field-operational test of centralized, adaptive freeway/arterial control strategies in a highly congested corridor. During the first stage of the deployment, advisory terminals are being placed in the City of Irvine and Caltrans District 12 Traffic Management Centers (TMC) to provide control recommendations for all components of the Irvine subarea—including ramp meters, traffic signals, message signs, and diversion plans. The second phase of the deployment will involve integration of the system into the traffic management systems of these two agencies.

Path to Deployment

The university-based research products detailed above have not been developed just to produce academic papers (although this is an important aspect in advancing and disseminating knowledge). Robust research programs in the United States incorporate a number of activities that directly support ITS deployment. In California, examples of these include ITS testing environments, professional capacity building, and transportation decision support.

REAL-WORLD TEST ENVIRONMENTS

The PATH Program, with the help of Caltrans and other public agencies, uses real-world testing environments for moving research products on toward deployment.

The Advanced Transportation Management Systems (ATMS) Testbed was initiated in early 1991 to provide an instrumented, multiagency transportation operations environment linked to university laboratories. It engages in field development, testing, and evaluation of near-term technologies and applications; it also serves as an ongoing testing ground for California and national ITS efforts. The ATMS Testbed is located in Orange County, California, and is under the direction of the UC-Irvine Institute of Transportation Studies.

The testbed is based on real-time, computer-assisted traffic management and communication. The transportation operations system that forms the backbone of the testbed is structured to provide intelligent computer-assisted decision support to traffic management personnel by integrating networkwide traffic information (both surface street and freeway) into a real-time operations and simulation environment. The testbed currently has direct links to three traffic operations centers (Caltrans District 12, City of Anaheim, and City of Irvine) that provide real-time data links from area freeways and major arterials directly to dedicated testbed research laboratories located at UC-Irvine. The testbed provides a cooperative environment that overcomes institutional, technical, and philosophical barriers to introducing innovative technologies and strategies into the management of complex transportation systems. It serves, therefore, as a "technology transfer" bridge between the research and deployment of ATMS technologies.

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Plans to incorporate an ITS Systems Testing Center into the testbed will enhance the facility's ability to accommodate the testing and evaluation of ATMS products and services developed by Caltrans and others (including private firms). Under this arrangement, both existing transportation management system software and proposed upgrades to that software can be tested and evaluated in a full ATMS setting. The evaluation uses not only the Testbed ATMS microscopic traffic simulator (Paramics) but also the testbed's access to both historical and real-time field data from the Caltrans District 12 system and the Cities of Anaheim and Irvine. Under the design scheme, the ITS Systems Testing Center will interact both with actual (real-time or "playback") field data and with specific operational scenarios developed from loop-simulated data generated by microscopic traffic models.

Similar PATH facilities and capabilities for field testing of both performance monitoring and vehicle-based safety and information technologies exist in Northern California (including at the Berkeley Highway Lab on Interstate 80 near Oakland and at PATH Headquarters in Richmond). All of these PATH facilities are networked to provide deployment support services across the range of ITS-advanced traffic and fleet management, traveler information, and vehicle control and safety systems.

PROFESSIONAL CAPACITY BUILDING

Based on the capabilities afforded by the testbed in Orange County, a partnership between UC-Irvine and Cal-Poly San Luis Obispo is designing an Integrated TMC Simulator. This simulator will train operators in the deployment and operation of ATMS technology as well as provide operator feedback in ATMS design. The TMC simulator will train TMC personnel in the use of transportation management system software while utilizing the full capability afforded by the Testbed ATMS microscopic traffic simulators and the testbed's access to field data from the Caltrans, Anaheim and Irvine systems. UC-Irvine will handle urban, regional, and local agency TMC simulation; microsimulation case studies; and TMC performance evaluation. Cal-Poly will handle overall training plan development, traffic fundamentals, satellite TMC operations, standardized emergency management, hazardous material awareness, and media relations.

Meanwhile, the University of California's Technology Transfer Program is developing workshops and courses for practitioners on a variety of topics related to PATH research. These include traffic and performance monitoring, ramp metering, dynamic messaging, and system engineering. These are in addition to the national ITS courses cited by Collins and Mineta (2000).

TRANSPORTATION DECISION SUPPORT

ITS improvements . . . are generally not what comes to mind when decision makers and the public are looking for transportation improvements. So transportation professionals must make the effort to bring appropriate ITS improvements to their attention.

ITS improvements differ from conventional transportation improvements in a number of ways, and thus raise new technical and institutional issues. On the positive side, they generally do not have negative environmental effects and may in fact reduce fuel consumption and emissions by making the existing system more efficient. Thus, their implementation may involve less conflict and may encounter less delay. However, the newer types are generally not what comes to mind when decision makers and the public are looking for transportation improvements. So transportation professionals must make the effort to bring appropriate ITS improvements to their attention. PATH's Web site on ITS implementation, ITS Decision (http://www.path.berkeley.edu/itsdecision), is one source that should be helpful to public works officials in learning about ITS opportunities and determining which would perform well in a particular situation.

Once a decision has been made regarding which ITS services to implement, many challenges remain. It is important to find firms or people who are experienced in implementing the particular ITS services, in systems engineering, in executing good contracts, and in providing for effective contract management. Another difficulty is that virtually all ITS services require maintenance people skilled in electronics and communications, and it is sometimes difficult to attract and retain such people. Finally, ITS improvements must generally compete with conventional improvements for funding, so ITS is likely to be implemented as part of conventional improvements. For example, a freeway widening may include inductive loops, closed-circuit TV, ramp meters, and changeable message signs. Although this approach is useful and necessary, it typically addresses neither more regional or systemwide opportunities for ITS deployment nor links to private sector services.

All of these indicate the continuing need to evaluate and document ITS deployment and to learn from the successful institutional innovations that are developed around the country (and indeed around the globe).

The Longer View

As technical and institutional barriers are overcome and ITS deployment matures, new mobility opportunities are likely to emerge. One scenario has a good portion of the population teleworking and telelearning as well as teleshopping (e-commerce). When one does have to travel, she or he might just have to push a button to find out when and how to travel most efficiently given available transportation system options (personal car, taxi, rideshare, carshare, transit, etc.) and actual conditions. Another button would execute the travel plan, alerting any transit or paratransit modes involved. Modal options would be expanded, with an array of customized and integrated mass transportation services that could potentially rival the personal automobile in convenience and connectivity. And an integrated system of transit fares and bridge/road tolls would mean a user has only one monthly bill to read and pay.

In a few more years, it should be possible for all individuals to be able to afford an "electronic chauffeur" to relieve the stress and tedium of highway driving. Imagine leaving work at the end of a long, hard day and only needing to drive as far as the nearest on-ramp to the local automated highway. Upon arriving at the on-ramp, you press a button to select the off-ramp closest to your home and then relax as the electronic systems on your car (in cooperation with roadside electronics and similar systems on other cars) guide your car smoothly, safely, and effortlessly toward your destination, saving you time by maintaining full speed even at rush-hour traffic volumes. At the end of the off-ramp, you resume normal control and drive the remaining distance to your home, better rested and less stressed than ever before. The same capability can also be used over longer distances, for family vacation trips that leave everybody—including the driver—relaxed and well rested even after a lengthy trip in adverse weather. These traveling scenarios are not the stuff of Buck Rogers or the Jetsons, but examples of how information technology and ITS user services can be packaged to improve transportation. Many of the individual elements are already being tested in the field.

Information technology has been used for many years to improve operating efficiency and safety in the air, rail, and marine transportation systems, and in facilitating "intermodality" between these systems. However, it has been curiously slow to make its impact in the far larger road transportation sector. Individual road vehicles (particularly buses and trucks, but also passenger cars to a lesser extent) have been enhanced by many electronic features within the past two decades. These features have improved their (a) energy efficiency and environmental impacts (electronic engine control), (b) driveability (electronic transmission, cruise control, suspension control), (c) safety (antilock brakes, passenger restraints), (d) entertainment (CD players), and (e) connectivity (wireless phones, traveler information services). However, the public roadway infrastructure has been slower to adopt information technologies that interact more effectively with vehicles and travelers. In part, this is because of the challenge associated with reconciling investment decisions made across jurisdictions. It is also difficult to make decisions that combine infrastructures with lifetimes of decades with vehicles that last for only years and information technologies that can become obsolete within months. However, this challenge can be overcome by carefully defining the interfaces between the roadway infrastructure and vehicles so individual components can be modified without affecting the entire system, in much the same way that individual components of a stereo system can be upgraded without requiring an entirely new system. Again, the national architecture and related ITS stan-

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dards should substantially help transportation professionals in meeting “packaging” and “interoperability” challenges.

Continuing Research Needs

Information technology is one of the most dynamic fields of human endeavor, subject to extremely rapid change. This means that neither developers nor users should remain static. Rather, they need to be active in keeping pace with continuing advances, fully exploiting them as opportunities to find ever better and more cost-effective solutions to transportation problems. This dynamic change also means that there is a continuing need for research to find the best new enabling technologies, to adapt them so that they provide the maximum transportation benefits, and to evaluate their real effectiveness in ameliorating transportation problems. Information technology can profoundly influence both the supply and demand “sides” of transportation’s economic paradigm, forcing reexamination of basic assumptions on both sides and also providing the tools to collect more and better data than have ever been available in the past. This research and the data it generates can, in turn, help improve understanding of the most fundamental nontechnological aspects of transportation (such as traveler decision making, driver behavior, and crash causality). It can also vastly improve the information base for transportation planning and open the door to new planning methods.

Appendix
The California PATH Program

The Partners for Advanced Transit and Highways (PATH) Program was established in 1986 jointly by the University of California (UC) and the California Department of Transportation (California DOT or Caltrans) as a comprehensive and cooperative ITS research and development effort. PATH is administered by the Institute of Transportation Studies at UC-Berkeley, but research is performed throughout the UC system as well as at other academic institutions in California.

References

Coifman, B. (1999). *Vehicle reidentification and travel measurement on congested freeways* (California PATH Working Paper UCB-ITS-PWP-99-18). Berkeley, CA: Author.

Collins, J., & Mineta, N. Y. (2000). Using technology in surface transportation to save lives, time, and money. *Public Works Management & Policy*, *4*, 267-273.

Jayakrishnan, R., Tsai, W. K., Oh, J.-S., & Adler, J. (1999). *Event-based ATIS: Practical implementation and evaluation of optimized strategies* (Part I) (UCB-ITS-PWP-99-7). Berkeley, CA: Author.

Larson, J. E., Van Katwyk, K., Liu, C., Cheng, H. H., Shaw, B., & Palen, J. (1998). *A real-time laser-based prototype detection system for measurement of delineations of moving vehicles* (California PATH Working Paper UCB-ITS-PWP-98-20). Berkeley, CA: Author.

Saxton, L. (1993, Spring). Mobility 2000 and the roots of IVHS. *IVHS Review*, pp. 11-26.

Shladover, S., Bushey, R., & Parsons, R. E. (1993, Spring). California and the roots of IVHS. *IVHS Review*, pp. 27-34.

Skabardonis, A. (1999). *Freeway performance measurement (PeMS) project*. Presentation at TRB freeway operations committee meeting, 78th TRB Annual Meeting, Washington, DC.

Sun, C. (1999). *Individual vehicle speed estimation using single loop inductive waveforms* (California PATH Working Paper UCB-ITS-PWP-99-14). Berkeley, CA: Author.

Texas Transportation Institute. (1999). *1999 Annual Mobility Report*. College Station: Texas Transportation Institute.