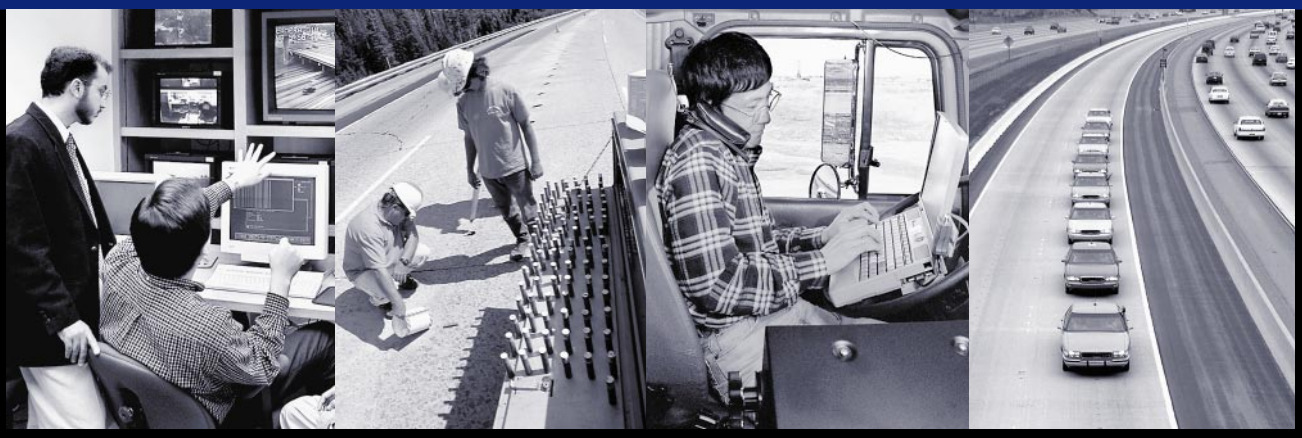


California PATH

Partners for Advanced Transit and Highways

Annual Report 1998

California PATH – Partners for Advanced Transit and Highways – is a collaboration between the California Department of Transportation (Caltrans), the University of California, other public and private academic institutions, and private industry. PATH's mission: applying advanced technology to increase highway capacity and safety, and to reduce traffic congestion, air pollution, and energy consumption.

California PATH

Partners for Advanced Transit and Highways

Annual Report 1998

Director's Introduction

The California PATH Program, a collaboration between Caltrans and the University of California, is a unique multidisciplinary research program that seeks advanced technological solutions to our worsening transportation problems. PATH's researchers and staff come from many countries and academic backgrounds and are spread across California's college campuses and into private industry. They are united by the goal of fulfilling the promise of ITS, Intelligent Transportation Systems, and finding solutions for today and tomorrow.

PATH brings together engineers and economists, geographers and urban planners, computer scientists and statisticians—among others. Its multidisciplinary atmosphere is responsible for shaping the "modern" transportation engineer, who is familiar not only with traditional disciplines but also with the emerging areas of sensors, communications, data structures, vehicle dynamics and control, and many other disciplines. We pride ourselves on the many students and post-docs who have "graduated" from PATH and gone on to influential positions at universities and in the public and private sectors, spreading the ITS vision.

Although we look back with regret at the demise of the National Automated Highway System Consortium (NAHSC), we take pride in having been a key part of its finest achievement, the most successful demonstration of vehicle automation technology ever held: Demo '97. PATH's demonstration of the platoon concept, with its eight-car fully automated platoon, as well as the joint Honda-PATH magnetic/computer-vision guided vehicles, were highlights of Demo '97. And even though the decision to disband the NAHSC will slow the development of any automated highway system, PATH and Caltrans will work together to fully realize AHS technology's potential to reduce the congestion that chokes our highways.

PATH's future looks bright as the need for intelligent transportation solutions becomes ever more clearly apparent. Bringing together the best minds in California to improve California's, the nation's and the world's transportation systems is PATH's goal!

Professor Karl Hedrick
Director

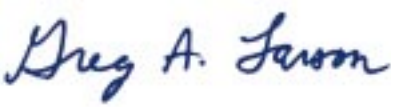
CALIFORNIA PATH

A Word from Caltrans

For the past thirteen years, California Partners for Advanced Transit and Highways (PATH) has earned national and international recognition for the quality and innovation of its research. Caltrans is proud of our role in helping to establish the PATH Program, and in the strong relationship we have developed with our colleagues at PATH.

A key element in PATH's success is its emphasis on research areas that offer potentially dramatic efficiency improvements in the operation of our transportation system. In California, rapid population growth and ever-increasing demand for travel threaten to choke the system and constrain the mobility of people and goods that is critical to sustain the vitality of our economy and our quality of life. PATH's research has improved the efficiency of our existing transportation system, and reduced the need to build expensive new facilities.

As Caltrans and its partners move closer to widespread deployment of Intelligent Transportation Systems, PATH continues to play a vital role in helping to find cost-effective solutions to mitigate congestion problems, enhance safety and efficiency, and improve the performance of California's transportation system. I am optimistic that together we will overcome many of these challenges, and excited by the opportunities that Caltrans and PATH will pursue as we enter the next century.



Greg Larson
Caltrans Management Liaison

Overview of California PATH

The California Partners for Advanced Transit and Highways Program (PATH) has been leading the way in ITS (Intelligent Transportation Systems) research since PATH's founding in 1986, before the term ITS or its predecessor IVHS (Intelligent Vehicle Highway Systems) had even been coined.

PATH's purpose is to develop foundations for the widespread adoption of advanced technologies to improve the operation of California's surface transportation systems. PATH'S specific goals are to increase highway capacity and safety, and to reduce traffic congestion, air pollution, and energy consumption.

Caltrans provides the seed funding for PATH's core research, based on its goal of promoting the development of new knowledge and new technology that can improve the productivity, safety, and environmental impacts of California's surface transportation systems.

PATH's charter includes the missions of conducting leading-edge research, evaluating operational tests, developing public/private/academic partnerships, and educating students as well as practitioners about ITS. It does not include the deployment or operation of systems, which remain the responsibilities of the Caltrans district offices and relevant local agencies.

PATH focuses on research with the potential for dramatic improvements in the operations of California's transportation system, rather than diffusing its efforts in areas where only incremental improvements are possible. California's population and its transportation demands are growing so rapidly that the effects of incremental solutions would likely be absorbed by the time they could be implemented. Hence, PATH emphasizes relatively long-term, high-impact solutions. But PATH also addresses the progressive steps needed to achieve those long-term solutions. PATH research also attempts to identify impediments to progress, both technical and institutional, and to devise strategies for overcoming those impediments.

Research and development done under PATH auspices includes:

- identification of problems and needs
- basic research on enabling technologies
- applied technology R & D
- system-level design and evaluation
- experimental verification of design predictions
- evaluations of existing technologies or equipment
- evaluations of costs and benefits
- technology assessments
- predictions of users' behavioral responses
- predictions of the impacts of technologies' use
- evaluations of legal and institutional issues.

PATH is managed by the Institute of Transportation Studies of the University of California at Berkeley, which established the PATH Program Headquarters Office at the University's Richmond Field Station in 1986. Policy issues are addressed by ITS's PATH Executive Committee, and by the Caltrans-PATH Joint Management Team, composed of program managers from both Caltrans and the University. PATH's day-to-day operations are managed by the headquarters staff.

PATH headquarters has about 35 full-time staff members, including a core group of research staff members, plus program managers and administrators. A substantial body of research is done by the full-time research staff at PATH headquarters, but most PATH research work is done by faculty members employing graduate students on the campuses of the twelve universities that form the PATH partnership. This work is supplemented by subcontracts to private companies as needed, and by cooperative research agreements with a variety of organizations, including private companies as well as public institutions, both domestic and international. The product-development-oriented work of private companies complements the basic work of the academic researchers, so that each group can concentrate on what suits it best. Publication of PATH research work is coordinated at PATH headquarters.

PATH Activities in National and International ITS Programs

PATH has received substantial funding from the Federal Department of Transportation (DOT), including support from the Federal Highway Administration (FHWA),

Federal Transit Administration (FTA), and National Highway Traffic Safety Administration (NHTSA) on a variety of projects that predated current Federal ITS programs. PATH participation in DOT ITS programs during the past year include the National Automated Highway System Consortium and evaluations of California ITS operational tests.

National Automated Highway System Consortium

PATH was one of the ten core participants in the NAHSC, which began the System Definition Phase of the AHS program in October 1994. PATH researchers were active in most of the tasks of the NAHSC work plan, and had the lead responsibility for developing AHS modeling and analysis tools. They also worked heavily on development and evaluation of enabling technologies for AHS, development of the August 1997 AHS technical feasibility demonstration (Demo '97), and evaluation and selection of AHS operating concepts. NAHSC activities were concluded during 1998, after withdrawal of support from USDOT.

PATH demonstrations of automated vehicles got enormous, favorable, national and international exposure in 1997 and 1998, first at the NAHSC's Demo '97 in San Diego (August 1997), then at the Dutch Ministry of Transport and Water Management's Demo '98 in Rijnwoude, the Netherlands (June 1998). Leading transportation professionals, politicians, and journalists from print and electronic media were impressed after riding in the PATH vehicles. Media coverage was uniformly very favorable, increasing the level of public interest in the opportunities offered by vehicle automation, and in PATH research.

Evaluations of California ITS Operational Tests

PATH currently serves as evaluator for the following Field Operational Tests:

- TravInfo (Bay Area)
- Smart Call Box (San Diego)
- Adaptive Traffic Control (Anaheim)
- Integrated Ramp/Signal Control (Irvine)
- Mobile Surveillance (Orange County)
- Wireless Spread Spectrum Communication (Los Angeles);
- TransCal (Bay Area to Reno)

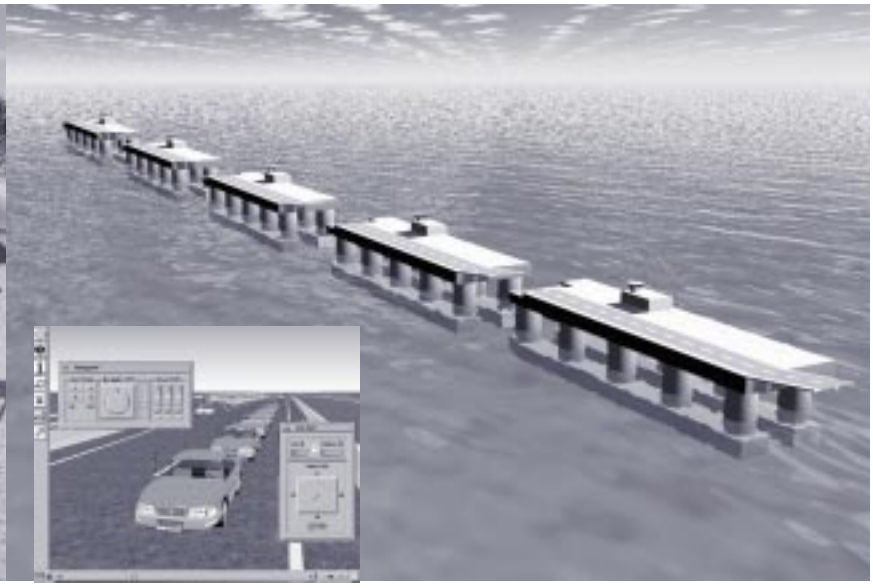
State-Funded Core Program of ITS Research

The core of the PATH program is its collection of research projects funded by Caltrans' New Technology and Research Program. Currently, there are about 95 such projects, selected on the basis of an annual Request for Proposals (RFP) and proposals submitted from throughout California. These involve the work of about 45 professors, representing 15 academic departments on 12 different university campuses, supervising the research of more than 100 graduate students and post-doctoral researchers. Projects are currently being conducted at: UC Berkeley, UC Davis, UC Irvine, UC Los Angeles, UC Riverside, UC Santa Barbara, California Polytechnic State University at San Luis Obispo, the Claremont Graduate School, San Diego State University, the University of Southern California, MIT, and Texas A&M.

New projects

PATH attracted research support from a variety of new sources during the past year, based in large part on the favorable reactions to Demo '97. Some of the new projects:

- Development of enhanced adaptive cruise control, permitting smooth operations at low speeds and in stop-and-go traffic, for BMW
- Implementation of a three-vehicle platoon demonstration and a single-vehicle low-speed "mini demo" for the Rijkswaterstaat (Dutch Ministry of Transport, Public Works, and Water Management) at Demo '98
- Implementation of PATH's magnetic guidance system for the Dutch Combi-Road consortium's automated truck in Ridderkerk, the Netherlands, under contract to TNO/TPD (also at Demo '98)
- Literature review and assessment of AHS modeling tools and evaluations, for Japan's Advanced Cruise-Assist Highway System Research Association (AHSRA), under subcontract from SRI International
- Development of a control system for the Office of Naval Research's Mobile Offshore Base, which will link huge semi-submersible self-propelled barges together on the open sea to form a runway for large aircraft
- Implementation of PATH's magnetic guidance system on a four-mile stretch of Interstate 80 over Donner Summit, in collaboration with the Advanced Highway Manitenace and Construction Technology Center (AHMCT) at UC Davis, for phase one of the Advanced Snowplow Program partnership between California, Arizona, and Montana.

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PATH research is subdivided into three broad categories:

- A**TMIS -** Advanced Transportation Management Information Systems (which includes the more traditional categories of ATMS, ATIS and APTS);
- **AVCSS -** Advanced Vehicle Control and Safety Systems (which includes Automated Highway Systems - AHS);
- **Systems** - the cross-cutting and institutional issues that apply to both ATMIS and AVCSS, as well as communications and system architecture.

A summary of current PATH projects by category follows and a list of current PATH research reports, working papers, and technical notes can be found on on pages 25-33.

Advanced Transportation Management Information Systems

ATMIS Research

1.1 ATMS (Advanced Transportation Management Systems)

Adaptive Dynamic Macroscopic Freeway Traffic Flow Prediction Model Using Genetically Optimized Time-Delay-Based Neural Networks

Baher Abdulhai, PATH

An attempt to fill the need for better traffic flow forecasting models, using the unprecedented real-time traffic data availability at the Advanced Traffic Management Testbed at the Institute of Transportation Studies (ITS), University of California, Irvine (UCI).

Assessment of the Effectiveness of ATMIS Strategies

Alexander Skabardonis, UCB

We will apply the INTEGRATION and CORSIM(WATSim) simulation models on the Santa Monica Freeway Corridor (the Smart Corridor). Concepts to be assessed include ramp metering, signal timing optimization,and incident management systems. The aim is to determine which model can best simulate existing traffic conditions and model ATMIS strategies.

Implementation of Advanced Techniques for Automated Freeway Incident Detection

Baher Abdulhai, PATH

In stage one we integrate existing algorithms into the ATMS Testbed labs at UCI and rigorously test and modify them in a simulated on-line environment. Stage two capitalizes on the on-line connection of the UCI ATMS Labs with the Caltrans District 12 TMC and will test and modify the algorithms as they communicate in real-time with the TMC. Stage three is implementation, testing and evaluation of selected algorithms in the TMC environment.

Incident Management: Process Analysis and Improvement

Randolph Hall, USC

The objective of this project is to examine the incident management process as a whole, and to assess potential process improvements, including potential for new technologies. These improvements may occur within transportation management centers or in the field. The project will collect detailed data on actual incidents, to document incident management processes from start to finish, and to document the effects of incident management on highway performance (principally delay).

PATH Center for ATMIS Research at UC Irvine

Will Recker, UCI

The purpose of this project is to manage the UC Irvine ATMS laboratory. PATH researchers and the Testbed management team will generally be responsible for software enhancements to the laboratory "bench top" system for modeling and evaluating ATMS.

Real-Time Algorithms for Travel Time, Origin-Destination Estimates, and Incident Detection

Pravin Varaiya, Alexander Skabardonis, UCB

Algorithms to estimate travel time using loop data or video data have been developed over the past several years. In this project, these algorithms will be further developed and implemented in a real-world environment. After the travel time estimates have been proven to be satisfactory, other algorithms, including incident detection, incident verification, and origin/destination estimation will be developed and demonstrated.

TRICEPS: An ATMIS Field Implementation

Michael G. McNally, UCI

TRICEPS (Testbed Real-time Integrated Control and Evaluation Prototype System) is a software platform that facilitates the testing and evaluation of a wide range of algorithms for adaptive traffic control, ATMIS, and ATIS. TRICEPS provides researchers with a distributed computing platform that allows them to implement and evaluate the effectiveness of integrated traffic management and control schemes which employ multiple interdependent ITS applications. This project centers on the adaptation of TRICEPS for use with real-world data from real-time connections with transportation facilities in the Irvine Freeway and Arterial Adaptive Control Field Operational Test (Irvine FOT).

1.2 Traffic Surveillance

Automated Travel Time Measurement Using Vehicle Lengths From Loop Detector Speed Traps

Mike Cassidy, UCB

Our goal is to produce an inexpensive, automated process for vehicle reidentification and travel time measurement using existing paired loop detector speed traps.

The project will also develop incident detection strategies based on the travel time data, and investigate the usefulness of supplying measured travel time information to drivers for ATIS applications.

Caltrans District 10 Fog Monitoring System

Art MacCarley, Cal Poly San Luis Obispo

This project involves two tests. The first is a field test of a fog detector system for Caltrans District 10 in Stockton. The second component is a feasibility study of a video based surveillance system.

Developing and Using Surveillance Data for Research

Joy W. Dahlgren, PATH

This project has three components. First, to develop surveillance capability on Interstate 80 in Emeryville to serve as a mini-laboratory for observing traffic behavior and for testing concepts, algorithms, and theories developed in earlier PATH research. Second, to document the process of developing that surveillance capability, from the loop detectors and video cameras to the uses of surveillance data. The third component, putting the data to use, is the final test of the surveillance system — is the data usable? The data will be used to study travel volume patterns before and after improvements that affect capacity in the observed section of I-80.

Development of Real-Time Laser-Based Non-Intrusive Detection System for Measurement of True Travel Time on the Highway

Harry Cheng, UCD

Phase Two of the development of a laser-based vehicle identification system. A PC-based field testing system for detection of site-independent delineations of vehicles for true travel time measurement will be developed and field tested.

Section-Related Measures of Traffic System Performance: Field Prototype Implementation

Stephen Ritchie, UCI

Demonstrates and evaluates new methods for obtaining true "section-related" performance measures, initially for freeways, based on pattern recognition technology and use of either existing loop detectors or overhead mounted infrared sensors. Results will help determine the potential benefits of applying these techniques to congestion monitoring, incident detection, traveler information, and system performance measures.

Use of Los Angeles Freeway Service Patrol Vehicles as Probes

James E. Moore II, USC

Focuses on the feasibility of using existing telemetry and Mobile Data Terminals (MDT) installed on Los Angeles Freeway Service Patrol vehicles to enable FSP tow trucks to be used as probe vehicles when cruising. Caltrans District 7's loop detectors are single-trap mechanisms that produce accurate volume counts but inferior estimates of speed. Combining single-trap loop detector counts with probe vehicle data would improve speed estimates considerably.

Video-Based Vehicle Signature Analysis and Tracking System, Phase 2B: System Deployment and Operational Test

Art MacCarley, Cal Poly San Luis Obispo

Phase One of this project involved preliminary work to test the accuracy, reliability and robustness of the detection system. Phase Two will involve the development of experimental hardware and software for automated vehicle detection.

1.3 ATIS (Advanced Traveler Information Systems)

Experiment in Privatizing the Operations of Regional Transportation Information/Management Centers: How Well is it Working?

Mark Miller, PATH

How can a private, for-profit company operate a transportation information and management center (in this case, a Traveler Information Center) that would normally and customarily be operated by a public sector organization, such as a state or local department of transportation, or a regional transportation authority or commission? This unique study examines the TravInfo Field Operational Test, where a private sector organization is operating TravInfo's TIC and PATH is currently executing an independent evaluation of the TIC's effectiveness.

Consumer Research on ATIS Technologies: Surveys of ATIS Users

YoungBin Yim, PATH

Objectives are to understand the user and supplier issues of the telephone-based ATIS, to identify demographic and trip behavioral characteristics of internet users, and to assess market demand for in-vehicle and hand-held ATIS devices through a public-private partnership. A series of consumer surveys will be conducted in conjunction with the private sector.

Daily Activity and Multimodal Travel Planner

Ryuichi Kitamura, UCD, Kyoto University

This project will provide ATIS in the state of California with the capability to search a database and generate an itinerary for a day's travel. A Travel Itinerary Planner will generate a day's itinerary based on input such as desired destinations and arrival times. Heuristic algorithms will be developed and existing databases effectively used to produce Planner prototypes. The Travel Itinerary Planner will aid in promoting public transit and ridesharing for non-commute trips.

Event-Based ATIS: Practical Implementation and Evaluation of Optimized Strategies

R. Jayakrishnan, UCI

This project will further adapt and enhance previous research of relevance to event-based Advanced Traveler Information Systems (ATIS) and implement algorithms for traffic management in Anaheim. It will generate traffic rerouting plans for changeable message signs and Highway Advisory Radio.

Financing Plan for Public Supported ATIS

YoungBin Yim, PATH

Investigates public-private partnership models currently available for ATIS deployment in the US and other countries from the Transportation Information Center (TIC) operator perspective. Objectives are to understand the market structure of ATIS and to identify revenue models for TIC operation.

Provision of Traffic Information–A Study of Supply and Market Structure

Adib Kanafani, UCB

Investigates the structure of the market for traffic information. In particular, this project is concerned with the supply of information by private and public providers. It will develop a comprehensive model of how private and public information is provided, and of the organization of the market in which information is acquired and disseminated to end users or value added resellers.

1.4 APTS (Advanced Public Transportation Systems)

Design, Implementation, and Evaluation of an APTS; Intermodal Field Test of Car Sharing: A Case Study of the BART Station Car Program

Daniel Sperling, UCD

A market and institutional analyses of smart station car rental at BART stations. Findings will be generalized to broader applications of intelligent communications and reservation systems to intermodal and paratransit systems and car-sharing organizations. The overall goal is to examine economic and institutional barriers and opportunities to IC/R systems, analyze potential demand for these technologies and systems, and to explore the role of public/private partnerships in creating these new systems.

Assistive Devices and Services for the Disabled

Reginald G. Golledge, UCSB

Examines how auditory information (e.g., Remote Infrared Signage System, or Talking Signs®) and auditory travel guides (e.g. Personal Guidance System) can assist blind and vision-impaired travelers to use public transit. In a pilot study, we first experimented with sign location (in terminals, on buses, on streets) and message content (natural vs. technical language).

Efficient Transit Service Through the Application of ITS

Randolph Hall, USC

Tracking and other ITS technologies have the potential to improve the productivity of transit systems in many ways, including better schedule control, driver feedback, and improved data for route planning. This project investigates the potential benefits and uses of ITS from the standpoint of efficiency.

AVCSS/AHS Research

2.1 Concept Definition

Evaluation and Analysis of Automated Highway System Concepts and Architectures

Petros Ioannou, USC

Conclusion of an ongoing project to develop predictions of the spacings that can be used between automated vehicles to improve both throughput and the safety of highway traveling. Issues such as lane-changing maneuvers, roadside traffic flow control, and synchronization of maneuvers by different vehicles are considered here, so that differences among different approaches to vehicle automation can be better understood. This will contribute to the selection of the most viable approaches for automated vehicle operations.

Mixed Automatic and Manual Traffic

Petros Ioannou, USC

Proposes and evaluates an AHS design in which it is possible to mix automated and manual traffic under some conditions. This study also considers vehicle address control, communication and sensor requirements, roadway restrictions, roadway control, and possible benefits and drawbacks of the AHS designs involved. The contribution of the research is to provide answers to the above issues supported by analysis and simulations.

2.2 Vehicle Dynamics and Control

Brake System Modeling and Control, and Integrated Brake/Throttle Switching

Karl Hedrick, UCB

A continuing investigation of the automatic control of vehicle braking, which is essential to safety and performance of automated vehicles. Work includes accurate measurement of the level of braking force (or torque) and use of that information to provide accurate control of braking. The techniques and hardware used here are ahead of the state of the art in the automotive industry, which was not able to provide components or systems to meet the performance specifications for this research. Results will contribute to the definition of system performance limits for automated vehicle operations. *http://vehicle.me.berkeley.edu/~khedrick/*

Control of Heterogeneous Platoons

Benson Tongue, UCB

We seek to produce a control design methodology that allows the production of platoon controllers having a marked insensitivity to variations in system parameters and/or environmental variations. We shall utilize the mu control approach as the backbone of this effort and will produce a clearly documented design paradigm that allows the control designer to specify what particular elements the controller should be most able to withstand variations from.

Optimized Vehicle Control/Communication Interaction in an Automated Highway Systems

Karl Hedrick, UCB

Our goal is to define and optimize the interaction between the communication system and the vehicle control system, from both a hardware and software standpoint. We are using vehicle control algorithms developed by PATH researchers at UC Berkeley and off-the-shelf communication technology to design a coordination protocol by which the control and communication systems can effect the various maneuvers required by an automated highway system. *http://vehicle.me.berkeley.edu/~khedrick/*

2.3 Fault Detection and Malfunction Management

Design of Fault Tolerant Control Systems for AHS: Fault Detection, Fault Handling and Verification

Shankar Sastry, Roberto Horowitz, Karl Hedrick, UCB

This project expands on earlier research to define a unified framework for a fault-tolerant automated vehicle control system. Prior work has shown how vehicle control systems can be designed to work extremely well under normal conditions. The important remaining challenges are to ensure that they also work well enough when failures occur that the vehicle users can be assured of safety. This project aims at detecting failures and then proving that safety can be maintained even in the presence of failures.

Emergency Operation of Platoons: Collisions, Emergency Deceleration, and Platoon Lane Change

Shankar Sastry, Nancy Ann Lynch, D. Swaroop, UCB, MIT, Texas A&M

Design and analysis of regulation and low-level coordination controllers for emergency platoon operation. The central theme is the issue of collisions within a platoon: we incorporate collision modeling into our system description, determine the effect of collisions on the system performance (lateral deviation, passenger injury, vehicle damage) and attempt to optimize the system performance with respect to these considerations.

Emergency Vehicle Maneuvers and Control Laws (EVMCL) for Automated Highway System (AHS)

Roberto Horowitz, Shankar Sastry, UCB

Explores how an AHS can be designed to most effectively accommodate the operation of emergency vehicles when they are needed to recover from an incident. This is important in order to minimize emergency response times so that injured people can receive medical attention and full operation of the system can be restored as quickly as possible, facilitating better traffic flow.

Failure Diagnosis and Monitoring Design for Intra-Platoon Communication Systems

Raja Sengupta, PATH

Our objective is to design a fault diagnosis and monitoring system for intra-platoon communication systems. The intra-platoon follower control relies on a time-drive communication system to supply front and lead vehicle information at regular intervals. This information is used for real-time longitudinal control. The reliable operation of this communication system is important for safe and comfortable longitudinal control. We will develop general diagnostic and monitoring designs that minimize the set of assumptions used in diagnostic design, and base our designs on common properties of the systems.

Integration of Fault Detection and Identification into a Fault Tolerant Automated Highway System

Jason L. Speyer, UCLA

In this project, the fault detection and identification methods developed earlier will be extended and combined with the results of work by other researchers to lead to the development of a comprehensive fault tolerant control system that can be verified in subsequent work. This is needed in order to ensure that vehicle automation systems can be developed with viable combinations of safety, performance and cost.

http://talus.seas.ucla.edu/path

System Fault Detection in Human-Augmented Automated Driving

Theodore Cohn, Masayoshi Tomizuka, UCB

First in a series of studies to explore human augmentation of AHS system components. Concentrates on the issue of fault detection in a lateral control task. Similar work will be necessary in longitudinal control, in lane changing, and in other maneuvers projected for implementation in AHS. The human operator is expected to be able to bring a unique perspective to the problem of lateral control due to detailed human knowledge of the driving environment, to a robust sensory capability, and to high-level reasoning capabilities.

2.4 System Safety

Design of Safe Switched and Feedback Based Maneuvers for Vehicle Control Systems

Roberto Horowitz, Shankar Sastry, UCB

This project continues research on the design of safe switched and feedback based maneuvers for vehicle control systems: specifically, research on developing systematic and practical methodologies for evaluating hierarchical control architectures for ensuring safe system operation even after failures have occurred.

Evaluation of Work Crew and Highway Hazard Conspicuity

Jim Misener, PATH

Builds on previous work with a model of human vision for target acquisition, to extend it to application for crash warning and avoidance situations. This is expected to be useful for establishing a base case (unaided driver performance) for safety comparisons with collision warning and avoidance systems.

Models of Vehicular Collision: Development and Simulation with Emphasis on Safety

Oliver M. O'Reilly, Panos Papadopoulos, UCB

Continues an ongoing effort to develop refined predictions of the effects of vehicle crashes using a mathematical modeling approach that combines relatively high fidelity and computational efficiency. It will produce predictions of the degree of damage to vehicles and (indirectly) injury to passengers involved in crashes. This contributes to a better understanding of the safety implications of automated vehicle operations at different spacings.

Safety Analysis of Concept Systems for Guidance and Control of Transit Buses

James Bret Michael, PATH

This project continues the study of the safety of one of the most promising early-stage AVCS systems, which would provide guidance and possibly control to transit buses for precision docking at high-level platforms to permit easy access by elderly and handicapped riders. The next step will consist of two tasks: structuring the bus guidance and control safety issues, and characterization of the safety of operation of conventional buses. Completion of this step will

result in a preliminary safety case for bus guidance and control systems.

Safety Evaluation of Vehicle Following Operations by Fault Tree and Sensitivity

Ching-Yao Chan, Andrew Segal, James Bret Michael, PATH

Overall reliability of an AHS was assessed using Fault Tree Analysis (FTA) in our earlier research. The next step is to perform a detailed parametric analysis of one or more of the system functions, with a particular emphasis on the sensor systems, using cut sets and other techniques. This is important to develop an understanding of how demanding the system and component performance specifications need to be in order to have a sufficiently safe AHS.

Studies of Collisions in Vehicle Following Operations by Two-Dimensional Impact Simulation

Ching-Yao Chan, PATH

Focuses on the effects of operating conditions on vehicle damage and post-impact vehicle motions. Extends the current evaluation of operational parameters influencing the severity of vehicle-following collisions. Simulation codes obtained from NHTSA and UMTRI are being modified for our vehicle control research purposes. Closed loop control laws will be incorporated into the simulations of vehicle-vehicle collisions and the post-impact response, to determine how effectively the effects of the collisions can be mitigated by high performance vehicle control.

Testing, Verifying, and Validating Critical Real-Time Vehicle Control Software

Andrew Segal, James Bret Michael, PATH

Focuses on software embedded in PATH's experimental system for lateral control of a vehicle. One major area is the extreme difficulty of proving the safety of software-intensive systems (such as vehicle control systems). Uses the Pisces software tools to test the PATH real-time vehicle control code, including a "software harness" to test the lateral and longitudinal controllers together. It should contribute to our knowledge of the usefulness of systematic testing to identify software problems as part of the verification and validation process.

2.5 Design, Modeling and Simulation Tools

General Framework for Verification, Simulation, and Implementation of Real-Time Control Algorithms

Farokh Eskafi, PATH

We are investigating and implementing a general framework for the simulation, verification, and prototyping of control algorithms for intelligent vehicles and highways. The proposed framework uses a coherent set of tools that model the system at hand; it takes a control design and verifies and simulates it, and generates codes that can be executed on a target real-time software platform in the physical system.

Regulation Layer Software Integration

Akash Deshpande, PATH

The vehicle lateral and longitudinal control algorithms developed at PATH enable fully automated multi-car platoon operation with close spacing, computer-controlled throttle, brake and steering. While this development is successful, significant demands are being placed on regulation layer functionality. The regulation layer software integration work under this proposal is a natural extension of the existing work at PATH. It can be viewed as a process of maturing the vehicle control technology developed at PATH into the second generation by refining and restructuring it to meet the future demands on regulation layer functionality.

2.6 Enabling Technologies

Address Resolution, Configuration Management, and Routing in Wireless Communication for AVCS

Pravin Varaiya, UCB

A difficult task in the design of vehicle-vehicle and vehicle-roadway data communication systems for the regulation and coordination layers is the design of protocols (or distributed algorithms) for vehicle address resolution, configuration management, and routing. We propose to solve these three problems by inventing protocols for each problem. The protocols will be formally specified, verified for correctness, and analyzed for performance. We will also examine how these protocols can be implemented in the wireless systems currently used or under development at PATH.

Aggregation of Direct and Indirect Positioning Sensor for Vehicle Guidance

Alice Agogino, Randy Galijan, UCB, Stanford Research Institute

This comprehensive aggregation scheme would integrate information from all vehicle positioning sensors, consider safety relevant sensors, and take into account the possibility of sensor failure and how that failure may affect vehicle control. In addition, recommendations for sensor development will be issued for input of sensor information from several sensors in a variety of situations that cannot be covered by one sensor alone.

http://best.ME.Berkeley.EDU/~goebel/path.dir/path.html

Designating a Framework for Vehicle-to-Vehicle and Vehicle-to-Roadside Communication

Farokh Eskafi, PATH

We are designing a suitable hierarchical communication structure that can support a mobile environ-

ment with the distinct characteristic that the topology of the communication network changes and has to be adapted as the mobiles (vehicles and platoons) move. We will populate the structure with channel assignment protocols and fault handling algorithms as pertains to the communication systems.

Development of Binocular Stereopis for Vehicle Lateral Control and Obstacle Detection

Jitendra Malik, UCB

Applies computer vision techniques to the problems of vehicle control on highways. We have developed a stereo algorithm that uses the output from a pair of video cameras to detect and localize obstacles on the roadway; also a lane tracking system that determines the position and orientation of the car with respect to the lane markers on the road surface. We now focus on understanding how these systems can be used as part of an integrated vehicle control system.

PATH Laboratory

Jay Kniffen, PATH

PATH Lab research work falls into three major categories: wireless communications, inertial navigation, and real-time software. Specific areas of research to be addressed are: intervehicle control communications, data fusion, vehicle-to-roadway communications, inertial navigation, and GPS. Work is underway to develop and test vehicle-to-vehicle communications systems, and methods for integrating carrier-phase DGPS with inertial measurements to obtain precise vehicle positioning information.

2.7 System Operations (network, link, coordination layers)

Performance of Hybrid (Automated/Nonautomated) Freeways

Carlos Daganzo, Mike Cassidy, Wei-Hua Lin, UCB

Continues basic research on the interaction of traffic flows between automated and non-automated parts of a freeway, so that the effects of transient disruptions to traffic flow can be better understood. These results are expected to be applicable to other hybrid freeway operations, such as separate HOV lanes, as well as to automated systems.

2.8 Aerodynamics

Transient Aerodynamic Vehicle Interactions

Ömer Savas, UCB

Continues experimental evaluation of transient aerodynamic effects on automated vehicles, using scale model vehicles in a wind tunnel. The effects of transient vehicle movements, such as lane changes, are tested to insure that we understand the effects that aerodynamics will have on the performance of vehicles. The results will provide essential input to control system designers so that they can ensure that the vehicle control systems will be able to maintain effective and safe performance at all times, including when the traffic stream includes a mixture of diverse vehicles.
http://www.me.berkeley.edu/fml/abstracts/chena970.html

Transient Aerodynamics in the Intervehicle Flowfield

Fred Browand, Bogdan Marcu, USC

Investigates flow mechanisms for intervehicle flowfields when vehicles are operated in close proximity (e.g. in a platoon formation). Field tests suggest the existence and importance of large-scale turbulent vortex structure within the flowfield. This behavior can be better understood by obtaining the velocity vector field information. The objectives provide answers to two concerns of interest: how large-scale unsteady flow motions produce fluctuating aerodynamic force, and how they provide for ventilation in-to and out-of the intervehicle flowfield.

2.9 Heavy Vehicles

Lateral Control of Heavy Duty Vehicles for Automated Highway System

Masayoshi Tomizuka, UCB

Extends an earlier project on lateral control of heavy vehicles, from analysis and design to experimental verification. It involves implementing control laws on heavy vehicles (single or multiple unit trucks and/or buses) and then testing them.

Longitudinal Control of Heavy Duty Vehicles: Experimental Evaluation

Ioannis Kanellakopoulos, UCLA

Involves implementing control laws on heavy vehicles (single or multiple unit trucks and/or buses) and then testing them to ensure that the vehicles perform as intended. This is important because of the economic potential for heavy vehicles to be early users of vehicle automation technology.
http://ansl.ee.ucla.edu/ahv

SYSTEMS Research

3.1 Architecture

California Systems Architecture Study-Part III

Tom Horan, Randolph Hall, Claremont Graduate School, USC

Examines the relationship between the emerging national ITS systems architecture and architecture developments occurring in the State of California. The primary objective of the project will be to ensure that system operators and implementers in California can provide input into implementation strategies for ensuring efficient deployment of the national architecture within the state.

3.2 Policy and Planning

HOT Lanes and Demand for Travel Time Savings

Joy W. Dahlgren, PATH

The High Occupancy Toll (HOT) lanes on ten miles of State Route 91 in Orange County offer a rare opportunity to study elasticity of demand for freeway time savings, and the time savings elasticity of carpool formation. Policy questions addressed are: What are the relative benefits of added HOT or other lanes, in terms of person-delay and emissions? What do those benefits suggest about possible revenue from tolls, or about opportunities for constructing cost-effective, financially and politically feasible HOT or toll lanes in California?

3.3 Benefits and Impacts Assessments

Ventura/Lompoc Smart Card Demonstration Evaluation

Genevieve Giuliano, Ted Chira-Chavala, James E. Moore, II; USC, UCB

This project is evaluating the Ventura/Lompoc Smart Card Demonstration. It will integrate a Passenger Transaction Unit and a Vehicle Monitoring system.

Cost-Benefit Analysis for ITS Management Decisions

David Gillen, Jianling Li, UCB

Major goals of this continuing project are to support Caltrans (and other public agencies in California) in making a variety of transportation management decisions, ranging from planning through investment to operation, and in developing information appropriate to supporting these various decisions. Since one purpose of providing this information is to help build a broad consensus, we will also consider the communication needs of a secondary audience of public officials, the public themselves, and various stakeholder groups, including the private sector.

Evaluation of Orange County Transit & Traffic Management Integration and Traveler Information

Randolph Hall, USC

An evaluation of the cooperative agreement established between Caltrans and the Orange County Transportation Authority (OCTA) to develop an integrated information system for transit/traffic management and traveler information. The project is intended to improve the cooperative management of the transportation system and also allow travelers to get real-time information on both transit and traffic conditions in Orange County.

Evaluation of the Advanced Traffic Control System Field Operational Test

C. Arthur (Art) MacCarley, James E. Moore II, R. Jayakrishnan, Michael G. McNally; Cal Poly, USC, UCI

The project will evaluate an advanced traffic control system (SCOOT) in the City of Anaheim as part of the FHWA Field Operational Test Program. It will also evaluate a video traffic detection system.

ATMIS Field Operational Tests Oversight

Robert Tam, PATH

This project will oversee three field operational test evaluations: TransCal, Lompoc Smart Card, Orange County Transit & Traffic Management Integration.

Independent Evaluation of City of Irvine Advanced Traffic Control System Field Operational Test

C. Arthur (Art) MacCarley, R. Jayakrishnan, Michael G. McNally, James E. Moore II; Cal Poly San Luis Obispo, USC, UCI

An evaluation of the advanced traffic control system in the City of Irvine. It will evaluate the effectiveness of an integrated freeway and arterial control system for the FHWA Field Operational Test Program.

ITS Evaluation Website

Joy W. Dahlgren, PATH

Our highest priority task is adding evaluatory information to the LEAP website (http://www.path.ber-

keley.edu/~leap/) regarding ITS services and technologies. Concurrently, there will be improvements to website presentation, plus additional publicity and the addition of information regarding systems architecture and analytical tools to assist potential implementers. Once all of the published evaluatory information has been added to the website, attention will be directed toward seeking out evaluatory information from unpublished sources.

Phase Two Evaluation of the Los Angeles Spread Spectrum Radio FOT

Victor Li, USC

This project is to conduct a Phase Two evaluation of the City of Los Angeles Spread Spectrum Radio Field Operational Test. The performance of this technology will be evaluated at 87 signalized intersections in the Mar Vista area of Los Angeles. The evaluation will assess the ability of the technology to economically and reliably interconnect project signals.

San Gabriel Valley Smart Shuttle Technology Field Operational Test Evaluation

Genevieve Giuliano, James E. Moore, II, USC

This project's original objective was to evaluate the Athena project, investigating the potential for real-time ride matching and personalized public transportation services. However, the field operational test has been canceled, and the funds will be used to evaluate the Smart Shuttle technology Field Operational Test Project in the San Gabriel Valley. The Smart Shuttle will act as a responsive transit feeder to a fixed route bus service.

TransCal Field Operational Test Independent Evaluation

Aram Stein, UCD

The evaluation will assess field operational test systems and their components for reliability, maintainability, and usability. User acceptance of various technologies that will be used to disseminate information will also be studied, as will the overall effect of the test on altering travel patterns, reducing fuel consumption, and improving traffic flow and air quality. A cost-benefit analysis will identify the costs to public and private entities, and determine whether the benefits offset the costs, and whether the systems being tested can move into the implementation mode.

TravInfo Evaluation–Target, Network Performance, and VAR Customer Studies

Youngbin Yim, Robert Tam, PATH

The target survey covers a selected corridor to assess the benefits of TravInfo in the event of major incidents. The network performance evaluation focuses on analyzing major incidents, in a congested location, where travel alternatives exist. Detailed case studies will compare incidents before TravInfo to incidents after, using a simulation model. The Value-Added

Reseller customer survey will provide information on consumers who actually purchase and use ATIS devices and subscribe to TravInfo services.

3.4 Transportation Modeling

Identification and Prioritization of Environmentally Beneficial Intelligent Transportation Technologies: Year Two

Daniel Sperling, UCD

Analyzes the emissions and energy impacts associated with the deployment of a range of intelligent technologies and systems. Results can be used to formulate strategies and designs to fast-track those technologies that have positive impacts, and to enhance the environmental attractiveness of those that yield little or no environmental benefits. The research approach involves policy and regulatory analysis, market research, and emissions and demand modeling.

Simulation of ITS on the Irvine FOT Area Using The PARAMICS Scalable Microscopic Traffic Simulator

Baher Abdulhai, PATH

This research utilizes the previously unavailable capabilities of the UC Irvine labs and the ATMIS Testbed. These are: the fairly young, well instrumented and manageable Irvine network: the variety of ITS modeling components of the Testbed and its on-line real-time data acquisition capabilities; and the capabilities of PARAMICS, a newly acquired traffic simulation and visualization tool.

Information and Media

PATH researchers share the results of their work in a variety of media: demonstrations, presentations, research reports, via PATH's newsletter *Intellimotion*, on the Web, on PATH's own videos, and by cooperating with the many interested news organizations who come to PATH to do interviews and shoot video and photographs.

Video and Photo

The past year saw video and radio production crews from Britain, Sweden, Japan, Hong Kong, and the US at the Richmond headquarters. PATH's Publications group supports news organizations with our own stock photographs and video footage, as well as producing video and still images for PATH's own use.

Reports and Presentations

PATH produced almost a hundred research reports, working papers, technical notes, and specialty brochures, plus an annual report and well over a thousand pieces of material for presentations, trade show exhibits, and informational booths. (PATH researchers presented at over 60 conferences, workshops, and seminars last year.)

PATH Web Site

Much of this work, along with a What's New page, an index to PATH research projects and researchers, a media info page, and links to other ITS sites, is available on the Web at http://www.path.berkeley.edu/

Intellimotion

PATH's world-class newsletter serves to explain PATH research to people who have a professional interest in intelligent transportation systems but are not necessarily specialists in the field being discussed. *Intellimotion* mainly covers advances in PATH's own research, occasionally reaching farther afield, as far as Europe or Asia, to explore new work of particular interest to PATH partners. *Intellimotion* appears four times a year. Recent issues have looked at recent advances in vehicle control, PATH projects in progress, transit research, traffic management, a special issue on Demo '97, and a two-issue examination of developments in traffic surveillance. For a free subscription to *Intellimotion*, contact Bill Stone, Publications Manager–by phone at (510) 231-5601 or by email at bstone@uclink.berkeley.edu.

Intellimotion is available on the Web at: www.path.berkeley.edu/PATH/Intellimotion


CARPOOL
LANE
AHEAD
FASTRAK
LANE
AHEAD

Recent PATH Publications

Research Reports, Working Papers, and Technical Notes from July 1997–July 1998 are listed below. Those marked with an asterisk (and still more recent publications) can be found on the World Wide Web at: http://www.path.berkeley.edu/PATH/Publications

ATMIS

(Advanced Transportation Management Information Systems)

1.1 ATMS (Advanced Transportion Management Systems)

Alternative Traffic Signal Illumination

Theodore E. Cohn, Daniel Greenhouse, Richard Knowles

New technologies have made it possible to produce traffic signals with significant advantages over standard incandescent signals, including greater energy efficiency and lower maintenance costs. We have developed a quality index we term the usability factor (UF) that can be used to evaluate the visibility of a new device relative to that of a standard reference lamp, and have measured UFs of a variety of new types of lamps.

UCB-ITS-PRR-98-19*

April 1998, 15 pp, $5.00

Design of a Machine Vision-Based, Vehicle Actuated Traffic Signal Controller

Michael Cassidy, Benjamin Coifman

Presents a signal controller algorithm to capitalize on the extended information provided by wide-area detection at isolated intersections. Using computer simulation, different control strategies are evaluated and the performance of the proposed wide-area detection system with conventional signal controllers is compared. Results indicate that wide-area vehicle actuated (VA) control can yield significant improvements over conventional VA control strategies.

UCB-ITS-PRR-98-7

February 1998, 28 pp, $10.00

Effects of Data Inaccuracy on the Performance of Traffic Signal Timing Plans

Wei-Hua Lin, Lawrence C. Liao

Studies signal timing plans calibrated with perfect or imperfect information. The information considered includes arrival rates and arrival distributions. The study is conducted for different levels of arrival rates and different forms of arrival distributions under a wide range of arrival information inaccuracy and traffic intensity, and for intersections with balanced and unbalanced flows.

UCB-ITS-PWP-98-6

February 1998, 20 pp, $5.00

Interstate-880 Field Experiment: Effectiveness of Incident Detection Using Cellular Phones

Alexander Skabardonis, Ted Chira-Chavala, Daniel Rydzewski

Cellular phones have the highest detection rate among the detection sources examined. They detect 38 percent of freeway incidents (accidents and lane-blocking disablements). The combination of cellular phones, freeway service patrol (FSP), and the California Highway Patrol detect 75 percent of all the incidents.

UCB-ITS-PRR-98-1*

January 1998, 61 pp, $15.00

Los Angeles Freeway Service Patrol (FSP) Evaluation: Study Methodology and Preliminary Findings

Karl Petty, Robert L. Bertini, Alexander Skabardonis, Pravin Varaiya

A methodology for evaluating the effectiveness, in terms of benefit-to-cost ratio, of the Freeway Service Patrol (FSP) in a Los Angeles freeway section. The methodology addresses the process of estimating incident delay using probe vehicles, and the lack of "before" field data. We discuss the difficulties that these problems present. We also report some preliminary findings.

UCB-ITS-PWP-97-17*

May 1997, 27 pp, $10.00

Review of the Optimized Policies for Adaptive Control Strategy (OPAC)

Lawrence C. Liao

OPAC is a real-time demand-responsive traffic signal timing optimization algorithm for individual intersections that can serve as a building block for demand-responsive decentralized control in a network. This paper describes its development history, implementation, and performance.

UCB-ITS-PWP-98-9

April 1998, 9 pp, $5.00

1.2 Traffic Surveillance

Development Testing and Evaluation of Advanced Techniques for Freeway Incident Detection

Stephen G. Ritchie, Baher Abdulhai

We present a definition of the attributes and capabilities that a potentially universal freeway incident detection framework should possess, discuss the training and testing of a probabilistic neural network (PNN) to fulfill the defined universality requirements, and evaluate the PNN relative to the proposed universality template.

UCB-ITS-PWP-97-22*

July 1997, 33 pp, $10.00

Los Angeles Freeway Service Patrol (FSP) Evaluation: Site Selection and Database Development

Robert Bertini, Karl Petty, Alexander Skabardonis, Pravin Varaiya

From an initial list of ten possible sites, detailed analysis was performed in order to rank the sites according to specific parameters developed by the study team. Site selection was based on congestion levels, average travel speeds, shoulder width, number of in-lane FSP assists, average daily traffic, directionality, and the density of functional loop detectors. Once the site was selected, a detailed, comprehensive, computerized database was developed that completely describes traffic conditions six hours each day for thirty-two weekdays.

UCB-ITS-PWP-97-16

May 1997, 60 pp, $15.00

Videobased Vehicle Signature Analysis and Tracking Phase 1: Verification of Concept and Preliminary Testing

Art MacCarley

Phase One of this four-phase study involves field data collection and laboratory data reduction to validate the operational concept of using computer-vision methods to make simple measurements of external dimensions, points of optical demarcation, and predominant colors of each vehicle. We conclude that the method is valid for the tracking of individual vehicles through freeway traffic, but only with adequate ambient lighting, or with either supplemental illumination or the use of improved dynamic range video cameras.

UCB-ITS-PWP-98-10*

May 1998, 39 pp, $10.00

1.3 ATIS (Advanced Traveler Information Systems)

Consumer Research on Advanced Traveler Information Systems: TravInfo Field Operational Test

Youngbin Yim

The purpose of the evaluation study is to measure changes in individual travel patterns that result from the TravInfo advanced traveler information system (ATIS) project and to assess traveler acceptance of and preference for ATIS technology. Consumer choice concepts were investigated to better understand the impact of ATIS on travel choices with real-time traveler information and to establish a conceptual framework in which the TravInfo evaluation study could be conducted.

UCB-ITS-PWP-97-18

July 1997, 23 pp, $5.00

Exploration of the Market for Traffic Information

Shirley Chan, Matthew Malchow, Adib Kanafani

Since traffic information is indirectly priced and experiences significant economies-of-scale, it can not be described by the classic demand model normally used to explain most goods. Therefore, this report focuses on the derivation of a demand model that describes the supply and cost mechanisms influencing the market for traffic information. Several suggestions for both the commercial broadcast stations and the public agencies that aim to maximize the total benefits of traffic information are presented.

UCB-ITS-PRR-97-35*

October 1997, 46 pp, $10.00

Smart Call Box Field Operational Test Evaluation: Subtest Reports

James H. Banks, Patrick A. Powell

Smart call boxes are an enhanced version of devices used as emergency call boxes in California. The Smart Call Box FOT evaluated the feasibility and cost-effectiveness of using them for five data processing and transmission tasks: traffic census, incident detection, hazardous weather reporting, changeable message sign (CMS) control, and video surveillance. This report presents detailed evaluation results for the individual subtests.

UCB-ITS-PRR-97-32

July 1997, 202 pp, $30.00

Supply-Side Evaluation of Radio Traffic Information

Youngbin Yim, Brian Pfeifle, Paul Hellman

This study investigated the data collection and dissemination processes of radio traffic information in the San Francisco Bay Area. The program directors from thirty-two radio stations were interviewed to understand the processes, and radio traffic reports were analyzed to evaluate the contents. Radio information is limited to traffic flow, incident conditions, and transit schedule. Travel time delays or lane blockage durations were not included in typical radio reports.

UCB-ITS-PWP-97-20

July 1997, 14 pp, $5.00

Survey of Value Added Resellers: Private Sector Views on Advanced Traveler Information Markets

Jean-Luc Ygnace, Youngbin Yim, Stein Weissenberger

Analysis of interviews conducted among private sector firms participating in the federal Field Operational Test of TravInfo, ranging from product manufacturers to service providers, including traffic information reporting firms, geographic data collection and dissemination firms, and ATIS device distributors. The consensus is that cooperation between the private and public sectors is most important for ATIS implementation, but that there is a lack of established public policy direction regarding long-term goals and near-term implementation strategies.

UCB-ITS-PWP-97-19

July 1997, 15 pp, $5.00

TravInfo Evaluation (Technology Element) Traveler Information Center (TIC) Study (September 1996 - June 1997)

Mark A. Miller, Dimitri Loukakos

TravInfo is part of the Federal Highway Administration (FHWA) Field Operational Test (FOT) program. The project's objective is to develop a multi-modal, public/private traveler information system for the San Francisco Bay Area. This report documents the evaluation of TravInfo's main public-sector component, a Traveler Information Center (TIC) that collects and integrates both static and dynamic traveler informationwith respect to system reliability, communications interface, and operator interface elements.

UCB-ITS-PWP-98-7*

March 1998, 93 pp, $20.00

TravInfo Evaluation: Traveler Response Element Broad Area Study

Youngbin Yim, Randolph Hall, Stein Weissenberger

The purpose of this survey was to define baseline attitudes, opinions and travel behavior of Bay Area travelers for the assessment of TravInfo's general impact. Questions were directed to the trip characteristics, the acquisition patterns of pre-trip and en route traffic information, the effects of traffic information on travel behavior and the demographic profiles of Bay Area travelers.

UCB-ITS-PWP-97-9*

March 1997, 27 pp, $10.00

TravInfo Field Operational Test: Work Plan for the Target, Network, and Value Added Reseller (VAR) Customer Studies

Youngbin Yim, Randolph Hall, Alex Skabardonis, Robert Tam, Stein Weissenberger

The target study focuses on a high impact Bay Area corridor to evaluate TravInfo impacts or benefits to Bay Area travelers. The network performance evaluation simulates road conditions in that corridor to estimate TravInfo impacts at the aggregate level. The VAR customer study provides information on consumers who use Advanced Traveler Information Systems.

UCB-ITS-PWP-97-14*

April 1997, 40 pp, $10.00

1.4 APTS (Advanced Public Transportation Systems)

Advanced Public Transportation Systems: A Taxonomy, Commercial Availability and Deployment Phase II

Asad Khattak, Mark Hickman, Pierce Gould, Thananjeyan Paramsothy

This study refines a taxonomy of transit technologies developed during Phase I of the study and uses it to explore the availability of new technologies and their impacts in transit agencies. Three surveys were conducted and their results are reported. To explore the availability of APTS technologies, technology suppliers and transit operators were surveyed.

UCB-ITS-PRR-97-16

April 1997, 82 pp, $25.00

Evaluation of ITS Technology for Bus Timed Transfers

Randolph Hall, Maged Dessouky, Ali Nowroozi, Ali Singh

This paper evaluates dispatching rules at timed transfer transit terminals with respect to total passenger delay and to the number of passengers missing their connections. Empirical data collected by the Los Angeles County Metropolitan Transit Agency on bus stop arrival times are used. We conclude that ITS provides modest benefits in terms of reduction in passenger delay.

UCB-ITS-PRR-97-37*

October 1997, 75 pp, $5.00

Control Strategies for Transit Priority

Alexander Skabardonis

Traffic control methods to give priority to transit vehicles could improve transit operations, reduce operating costs, and increase transit ridership. This report critically reviews existing control strategies implemented in signal controlled networks and proposes control strategies to improve transit performance, along with an analysis technique to evaluate their effectiveness.

UCB-ITS-PRR-98-2

January 1998, 30 pp, $10.00

Impact of Intelligent Transportation Systems on Bus Driver Effectiveness

Diane E. Bailey, Randolph Hall

Analysis of data gathered from observations at nearly 300 bus stops indicates that while ITS may potentially improve driver effectiveness, current practices among drivers and passengers are likely to limit actual gains. The clearest benefits of ITS come in the automatic processing of information related to transferring passengers, and in the increased speed with which emergency and maintenance calls can be handled.

UCB-ITS-PWP-97-25

October 1997, 36 pp, $10.00

ITS Information and Services to Enhance the Mobility of Disabled Travelers

Wan-Hui Chen, Rochelle Uwaine, Kelley Klaver, Ken Kurani, Paul P. Jovanis

A stated preference survey inquired as to whether subjects would make more trips by transit, paratransit, or real-time paratransit if kiosk, onboard, in-home, and/or personal information systems were available. Results show that these systems allow for more trip flexibility than what is now available.

UCB-ITS-PRR-98-20*

May 1998, 18 pp, $5.00

Light Rail System Safety Improvements Using ITS Technologies

Ted Chira-Chavala, Ben Coifman, Dan Empey, Mark Hansen, Ed Lechner, Chris Porter

Describes research to identify and analyze the effectiveness of countermeasures designed to reduce light rail crashes. Focus is on collisions with road vehicles at intersections. The light rail system for the Santa Clara County Transportation Agency in California served as the focus of the study.

UCB-ITS-PRR-97-39

November 1997, 192 pp, $25.00

Median Light Rail Crossings: Accident Causation and Countermeasures

Benjamin Coifman, Robert L. Bertini

Light rail systems often incorporate a grade crossing into an intersection environment. These complex intersections can be confusing to drivers. It can be a matter of centimeters from the left turn lane to the right-of-way on the median trackage. We synthesize accident causation literature from many fields as related to median crossings.

UCB-ITS-PWP-97-13*

April 1997, 30 pp, $10.00

Orange County Transit Probe Evaluation: Phase I Institutional Findings

Randolph W. Hall

First report of a multi-phased evaluation of this multi-agency project, intended to equip a fleet of buses with GPS (global positioning system) based tracking equipment, and to use tracking data for: bus schedule adherence and fleet management, collection of information on roadway traffic congestion, and dissemination of transit data to patrons.

UCB-ITS-PWP-97-12*

March 1997, 17 pp, $5.00

Advanced Information Techniques and Paratransit Services to Enhance Mobility of Elderly and Disabled Travelers

Wan-Hui Chen, Kelley Klaver, Rochelle Uwaine, Paul P. Jovanis

Follow-up study to a previous study. Computer Assisted Telephone Interviews (CATI) as well as mail-out-and-call-in surveys were administered, and system attribute and stated preference questions were employed. Results show that it is possible to increase the mobility of elderly and disabled travelers with the provision of important public transit information.

UCB-ITS-PRR-98-21

May 1998, 153 pp, $15.00

Transit ITS Simulator (TRANSITS): Design Document

Maged Dessouky, Ajay Singh, Randolph Hall

Describes a model developed to simulate different kinds of transit networks with varying numbers of bus lines and different travel patterns. An actual system can be simulated. A set of experiments is being developed to analyze the effect of using ITS on several performance metrics, including average bus arrival and departure lateness, average passenger trip time, and average total passenger waiting time.

UCB-ITS-PWP-97-26

October 1997, 36 pp, $10.00

AVCSS/AHS

(Advanced Vehicle Control and Safety Systems and Automated Highway Systems)

2.1 Concept Definition

Evaluation and Analysis of Automated Highway System Concepts and Architectures

Petros Ioannou

The purpose of this project was to select, evaluate and analyze a number of promising Automated Highway System (AHS) operational concepts based on previous work. The evaluation and analysis includes headway distributions for vehicle following and lane changing, capacity calculations, and the modeling, analysis and control of the resulting traffic flow. Floppy disks containing the "Inter-Vehicle Spacing Software Tool" are included.

UCB-ITS-PRR-98-12*

March 1998, 225 pp, $25.00

Evaluation of Mixed Automated/Manual Traffic

Petros Ioannou

Analyzes the requirements, issues and effects on safety and efficiency that will result from allowing semi-automated and fully-automated vehicles to operate on the existing highway system together with manually driven vehicles. Simulations reveal that significant improvement in the traffic flow can be achieved with a high degree of penetration of fully-automated vehicles in mixed traffic. One of the significant findings is that a single semi-automated/fully-automated vehicle may attenuate large disturbances caused by rapid accelerations/decelerations and prevent the slinky effect from propagating.

UCB-ITS-PRR-98-13*

March 1998, 112 pp, $20.00

Focus Group Study of Automated Highway Systems and Related Technologies

Youngbin Yim

Findings focus on attitudes to adaptive cruise control and collision avoidance systems in the San Francisco Bay Area. A majority of the participants had a favorable reaction to AHS despite the fact that almost all were concerned about its safety and funding capability. Responses to adaptive cruise control were generally positive. Participants recognized the safety benefits, convenience, and especially the stress reduction of using an automated highway system, when comparing it to the collision avoidance system.

UCB-ITS-PWP-97-23

July 1997, 31 pp, $10.00

National Automated Highway System Consortium: Modeling Stakeholder Preferences Project

John Lathrop

Describes results of the project's primary tasks: 1) A social decision-analytic framework for evaluating AHS options. 2) Results of two stakeholder focus group meetings, used to elicit concerns, anticipated benefits and impacts (including spin-offs and deployability/transition concerns), and performance/impact measures (PIMs) that represent those concerns/benefits/impacts. 3) Interpretation of the results of the focus group meetings in the form of useful guidance for AHS option development.

UCB-ITS-PRR-97-26*

June 1997, 93 pp, $20.00

2.2 Vehicle Dynamics and Control

Approximate Method to Determine the Worst Case Performance of a Nonlinear Dynamical System

Benson H. Tongue, Andrew Packard

A method through which a user can evaluate differing platoon control strategies and determine each strategy's worst case behavior under bounded parametric variations. The usefulness of the approach is that a platoon designer can determine how robust her design strategy is in the face of system uncertainties. The method allows for an arbitrary number of uncertain parameters, unmodeled system components, and system inputs.

UCB-ITS-PRR-98-3*

January 1998, 31 pp, $10.00

Brake System Analysis, Reliability Testing and Control Using Bench Experiments

Z. Xu, B. Yang

Investigation of the dynamics and reliability of a brake control system using a Lincoln Town Car brake system. Two models are obtained, based on experimental results: one for the whole brake-actuator system, the other for the hydraulic actuator.

UCB-ITS-PRR-97-10

February 1997, $10.00

Brake System Modeling, Control and Integrated Brake/Throttle Switching: Phase I

J.K. Hedrick, J.C. Gerdes, D.B. Maciuca, D. Swaroop

Presents findings obtained during the first year of a three-year project on modeling and control issues regarding braking in an Intelligent Vehicles and Highway Systems (IVHS) environment. Specifically, the report addresses the issue of vehicle control in an automated highway system, brake actuation, and coordinated brake and throttle switching.

UCB-ITS-PRR-97-21

May 1997, 90 pp, $15.00

Development and Experimental Evaluation of Autonomous Vehicles for Roadway/Vehicle Cooperative Driving

Petros Ioannou

Describes the design and testing of a vehicle control system to achieve full vehicle automation in the longitudinal direction. The system consists of a supervisory controller that processes inputs from the driver, the infrastructure, other vehicles, and on-board sensors, and sends appropriate commands to the brake and throttle controllers. Experiments on I-15 demonstrate the performance of the throttle controller.

UCB-ITS-PRR-98-9*

February 1998, 144 pp, $25.00

Fundamental Issues of Vehicle Steering Control for Highway Automation

Jürgen Guldner, Han-Shue Tan, Satyajit Patwardhan

Implementation of 'look-down' reference systems for detecting lateral vehicle displacement from the lane center has encountered practical constraints and limitations, expecially for highway-speed driving. By analyzing lateral vehicle dynamics in the light of these contraints, we establish a general framework for automatic steering control in an AHS environment and contrast various directions for control design.

UCB-ITS-PWP-97-11*

March 1997, 36 pp, $10.00

Integrated Maneuvering Control Design and Experiments: Report for Phase III

J.K. Hedrick, T. Yoshioka, Y.H. Chen, T. Connolly, L.R. Shen

Presents a control system called CICC for vehicle-following and collision-avoidance. CICC contains several sub-systems, such as cruise control and distancing control. While each sub-system is designed to maintain system stability, CICC achieves good comfort as well as sufficient capacity for avoiding collisions. Performance of a CICC has been evaluated through simulations with a vehicle model containing several non-linearities to emulate real vehicle responses.

UCB-ITS-PRR-97-30

July 1997, 58 pp, $15.00

Integrated Maneuvering Control for Automated Highway Systems Based on a Magnetic Reference/Sensing System

Hung Pham, Masayoshi Tomizuka, J.K. Hedrick

A 26-state simulation model is proposed that offers the necessary level of fidelity for the study of combined vehicle maneuvers in typical freeway operations, while minimizing the level of complexity. To facilitate coupled control design for multiple input, multiple output (MIMO) systems with unseparable input nonlinearities, sufficient conditions are presented for the existence of an approximate (numerically obtained) control that guarantees bounded tracking.

UCB-ITS-PRR-97-28

July 1997, 101 pp, $20.00

Longitudinal Control Development for IVHS Fully Automated and Semi-Automated System Phase III

J.K. Hedrick, V. Garg, J.C. Gerdes, D.B Maciuca, D. Swaroop

The concluding findings of a three-year project concerned specifically with vehicle control in an automated highway system, brake actuation, and brake control. Automated vehicle platooning on isolated lanes of an automated highway are included. Performance specifications, control system architecture, vehicle control algorithms, actuator and sensor specifications, and communication requirements are also addressed. The issue of switching from throttle to brake actuation is addressed in detail.

UCB-ITS-PRR-97-20

May 1997, 58 pp, $15.00

Robust Automatic Steering Control for Look-Down Reference Systems with Front and Rear Sensors

Jürgen Guldner, Wolfgang Sienel, Han-Shue Tan, Jürgen Ackermann, Satyajit Patwardhan, Tilman Bünte

Previous studies showed that reliable automatic driving at highway speed may not be achieved under practical conditions with look-down reference systems that have only one sensor at the front bumper. An additional lateral displacement sensor is added here at the tail bumper to solve the automatic steering control problem. Performance and robustness of the final controller was verified experimentally at PATH.

UCB-ITS-PWP-97-24

September 1997, 17 pp, $5.00

String Stablility of Interconnected Systems: An Application to Platooning in Automated Highway Systems

D.V.A.H.G. Swaroop

From an application point of view, this study proposes practical platooning strategies. From a theoretical point of view, it extends the concepts of stability to a countably infinite interconnection of general nonlinear dynamical systems and introduces techniques for analysis and design of decentralized control laws for them.

UCB-ITS-PRR-97-14

April 1997, 115 pp, $20.00

Trajectory Design and Implementation of Longitudinal Maneuvers on AHS Automated and Transition Lanes

Pin-Yen Chen, Luis Alvarez, Roberto Horowitz

This new design is a modification of the safe trajectory proposed earlier for the regulation layer maneuvers in the PATH AHS hierarchical architecture.

UCB-ITS-PRR-97-49*

November 1997, 40 pp, $10.00

Unified Lateral Motion Control of Vehicles for Lane Change Maneuvers in Automated Highway Systems

Wonshik Chee, Masayoshi Tomizuka

The unified lateral guidance algorithm proposed consists of a desired yaw rate generator and a yaw rate tracking controller. The desired yaw rate for lane following maneuvers is obtained by analyzing the kinematics of the lateral position measurement from the magnetic road reference system. The desired yaw rate for lane change maneuvers is obtained from the virtual desired trajectory. A mode switching algorithm for smooth transitions from the lane change to lane following is proposed.

UCB-ITS-PRR-97-29

July 1997, 72 pp, $15.00

2.3 Fault Detection and Malfunction Management

Design of Fault Tolerant Control Systems for AHS

S. Sastry, R. Horowitz, J.K. Hedrick

Describes fault detection and handling designs used in the longitudinal control system of platooned automated vehicles, with results from experimental testing of the designs. We have extended past work on fault handling to deal with several special fault classes, and have also designed a consistent interface between the fault detection and handling modules and implemented it in the SHIFT programming language for the specification of hybrid systems.

UCB-ITS-PRR-98-16*

April 1998, 65 pp, $15.00

Fault Detection and Identification with Application to Advanced Vehicle Control Systems

Randal K. Douglas, Walter H. Chung, Durga P. Malladi, Robert H. Chen, Jason L. Speyer and D. Lewis Mingori

A continuation of earlier work, in which a preliminary design of a health monitoring system for automated vehicles was described. Refinements to the residual generation scheme are described that bring our systems in closer alignment with the needs of the UC Berkeley group.

UCB-ITS-PRR-97-51*

December 1997, 45 pp, $15.00

Integration of Fault Detection and Identification into a Fault Tolerant Automated Highway System

Randal K. Douglas, Walter H. Chung, Durga P. Malladi, Robert H. Chen, Jason L. Speyer and D. Lewis Mingori

A continuation of earlier work on vehicle fault detection and identification, which describes a vehicle health management approach based on analytic redundancy. This system combines dynamic state information already generated by the existing filter designs with intervehicle analytic redundancy.

UCB-ITS-PRR-97-52*

December 1997, 275 pp, $35.00

2.4 System Safety

Intelligent Diagnosis Based on Validated and Fused Data for Reliability and Safety Enhancement of Automated Vehicles in an IVHS

Alice Agogino, Susan Chao, Kai Goebel, Satnam Alag, Bradly Cammon, Jiangxin Wang

This report is mainly concerned with the control system modules that take validated and fused sensor data as input and give probablilities of hazards as output. These modules are: Fault Detection, Hazard Analysis, and Safety Decision Maker. We carried out detailed failure mode effect analysis for the longitudinal sensors to systematically capture the effects and reasons for failures.

UCB-ITS-PRR-98-17

April 1998, 135 pp, $20.00

Intelligent Sensor Validation and Fusion for Vehicle Guidance Using Probabilistic and Fuzzy Methods

Alice Agogino, Kai Goebel, Satnam Alag

Sensor information is always corrupted to some degree by noise; moreover, sensors can fail. Sensor validation is needed to assess and adjust the integrity of the sensor information. In the presence of redundant information, sensor data must be fused. In this report, several methods to accomplish the validation and fusion are developed. Probabilistic techniques perform better in the presence of Gaussian noise alone, while the fuzzy approach behaves better in the presence of some non-Gaussian noise.

UCB-ITS-PRR-97-31

July 1997, 113 pp, $30.00

Models of Vehicular Collision: Development and Simulation with Emphasis on Safety I: Development of a Model for a Single Vehicle

Oliver M. O'Reilly, Panayiotis Papadopoulos, Gwo-Jeng Lo, Peter C. Varadi

The development of a novel model for a single vehicle is outlined, using the theory of a Cosserat point to account for the deformable nature of the vehicle. The complete set of ordinary differential equations governing the vehicle's motion are presented and numerical simulations of the model under various operating conditions are discussed.

UCB-ITS-PRR-97-15*

April 1997, 34 pp, $10.00

Models of Vehicular Collision: Development and Simulation with Emphasis on Safety II: On the Modeling of Collision between Vehicles in a Platoon System

Oliver M. O'Reilly, Panayiotis Papadopoulos, Gwo-Jeng Lo, Peter C. Varadi

Presents an algorithm for the detection of collision between two vehicles. Includes four examples of vehicular impact scenarios in order to illustrate the applicability of the proposed algorithm.

UCB-ITS-PRR-97-34*

August 1997, 29 pp, $10.00

Models of Vehicular Collision: Development and Simulation with Emphasis on Safety III: Computer Code, Programmer's Guide and User Manual for MEDUSA

Oliver M. O'Reilly, Panayiotis Papadopoulos, Gwo-Jeng Lo, Peter C. Varadi

The program MEDUSA, which is capable of simulating the impacts of several vehicles,assumes that the collisions are elastic, and is consequently applicable for low relative velocity impacts.

UCB-ITS-PRR-98-10*

February 1998, 93 pp, $20.00

Safety Analysis of Automated Highway Systems

Nancy G. Leveson

Focuses on safety analysis techniques and tools as applied to Automated Highway Systems (AHS). Discusses the basic features of Requirements State Machine Language (RSML) relevant to the model. Concludes with a description of safety analysis techniques, including forward and backward simulation, generation of fault trees, and consistency and completeness analysis.

UCB-ITS-PRR-97-36

October 1997, 164 pp, $25.00

Studies of Collisions in Vehicle Following Operations by Two-dimensional Simulation

Ching-Yao Chan

With vehicles moving closely together in platoons, the hazards of "chain-reaction" collisions become a concern. In this study, collision analysis is conducted with a two-dimensional simulation program by which the translational and rotational movements of vehicles can be fully represented. This should provide insights for the evaluation of the safety hazards and control strategies in AHS. Also presented are simulation scenarios where control actions are taken in post-impact conditions.

UCB-ITS-PRR-98-11*

March 1998, 16 pp, $5.00

Vehicle Collision Model for Platoon Controller Development

Benson H. Tongue, Andrew Packard, Douglas Harriman

Description of a simple dynamical model that can be used for determining the physical interaction of vehicles in a collision scenario. A source of real world collision data is identified, and a procedure for determining model parameters to match the data is given. Model implementation issues are discussed and the results of the completed model are presented.

UCB-ITS-PRR-97-22

May 1997, 41 pp, $10.00

2.5 Modeling and Simulation

Design Framework for Hierarchical, Hybrid Control

John Lygeros, Datta N. Godbole, Shankar Sastry

We approach the problem of large-scale systems from a hierarchical, hybrid control viewpoint and apply it to the automated vehicle following problem. Our analysis is based on a new hybrid dynamical system formulation that allows us to model large scale systems in a modular fashion. A design procedure is proposed that naturally leads to hierarchical, hybrid control schemes, with continuous controllers trying to optimize each agent's resource utilization at a lower level and discrete controllers resolving inter-agent conflicts at a higher level.

UCB-ITS-PRR-97-24*

May 1997, 40 pp, $10.00

Development of Vehicle Simulation Capability

James W. Stoner, Douglas F. Evans, Daniel McGehee

Summarizes work performed at the University of Iowa to develop simulation databasing tools and procedures to support driving human factors experiments. A complete description of the Iowa Driving Simulation facility is provided. The specification and description of the visual features of the ORCHIDS database illustrate the capabilities generated. Experimental design procedures are outlined from initial experiment descriptions and simulation release specification, through database flythroughs and pilot testing.

UCB-ITS-PRR-97-25*

June 1997, 25 pp, $20.00

Intervehicle Spacing: User's Manual

Petros Ioannou, Alexander Kanaris, Alex Grammagnat

Software and documentation that enable a user to perform the following tasks regarding vehicle spacing: calculate the minimum initial spacing between two vehicles, calculate the possibility and severity of collision between two vehicles, visualize the motion of the two vehicles in the longitudinal direction during braking maneuvers, and calculate highway capacity given factors for velocity, spacing, and size of vehicles and platoons.

UCB-ITS-PWP-97-10*

March 1997, 22 pp, $5.00

Object-Oriented Database for IVHS

Pravin Varaiya

Work done under this project resulted in the system called SmartDB, implemented on top of the commercial object-oriented database management system Versant. SmartDB is documented in the PhD thesis included as Appendix, and in several papers. Testing with SmartDB revealed major limitations in Versant, which the manufacturer was unable to overcome. Further development of

SmartDB was stopped. Instead, the experience gained with SmartDB was used in the design of the highly successful simulation language SHIFT.
UCB-ITS-PWP-98-2
January 1998, 42 pp, $10.00

SmartPath Regulation Layer Implementation: A User's Guide

Jason Carbaugh, Luis Alvarez, Pin-Yen Chen, Roberto Horowitz
Describes implementation of regulation layer maneuvers for hierarchical architecture on SmartPath, plus modifications or additions to existing maneuvers. Includes sample code for the join maneuver and some programming tools.
UCB-ITS-PRR-97-48*
November 1997, 74 pp, $15.00

2.6 System Operations (Network, Link, Coordination Layers)

Design and Evaluation of an Automated Highway System with Optimized Lane Assignment

Randolph W. Hall, Cenk Caliskan
Extends earlier research on optimal lane assignment on an automated highway to dynamic networks. A path-based linear program is formulated and solved through a 20 column generation method. The algorithm has been applied to networks with as many as 20 on and off ramps, 80 segments, 4 lanes and 12 time periods.
UCB-ITS-PRR-97-44*
November 1997, 29 pp, $10.00

Safe Platooning in Automated Highway Systems

Luis Alvarez, Roberto Horowitz
Addresses the problem of designing safe controllers for the hybrid system comprising the interaction of the regulation and coordination layers in the hierarchical PATH AHS architecture. Results obtained allow one to decouple the design and verification of the regulation and coordination layers, greatly reducing the overall complexity of the design and verification of the AHS as a hybrid system.
UCB-ITS-PRR-97-46*
November 1997, 92 pp, $15.00

Traffic Flow Control in Automated Highway Systems

Luis Alvarez, Roberto Horowitz
The control laws proposed in this report stabilize vehicular density and flow around predetermined profiles. The link layer controller exhibits important properties for implementation: it is distributed, in the sense that only local information is used, and it avoids highway dynamics inversion. The link layer control schemes were implemented and tested using SmartPath-3 AHS simulation software. Simulation results were in complete agreement with theoretical predictions.
UCB-ITS-PRR-97-47*
November 1997, 42 pp, $10.00

2.7 Vehicle Aerodynamics

Aerodynamic Forces on Misaligned Platoons

Bogdan Marcu, Fred Browand
Summarizes wind tunnel experimental measurements on the aerodynamic interaction between members of misaligned platoons, made using 1/8 scale models of a Chevrolet Lumina minivan. Automatization of the testing procedures allow measurements of drag, side force and yawing moment with extremely fine position resolution. Results are presented in the form of color maps of the drag, side force, and yawing moment coefficient ratios for each individual vehicle in the platoon.
UCB-ITS-PRR-98-4*
February 1998, 53 pp, $15.00

Drag Forces Experienced by Two Full-Scale Vehicles at Close Spacing

Patrick Hong, Bogdan Marcu, Fred Browand, Aaron Tucker
Documents drag reduction for a two-vehicle platoon of full-scale Ford Windstar vans in tandem on a desert lakebed. Drag forces are measured with the aid of a towbar force measuring system designed and manufactured at USC. Results show that drag behaviors for the vans agree with earlier conclusions drawn from wind tunnel tests: both vans experience substantial drag savings at spacings of a fraction of a car length.
UCB-ITS-PRR-98-5*
February 1998, 21 pp, $5.00

Influence of Close-Following Upon Cooling Module Air Flow

Fred Browand, Bogdan Marcu, Christian Sharpe
The purpose of this report is to experimentally determine the air flow through the cooling module (air-conditioning condenser plus engine radiator) of a Ford Windstar minivan when the van is operated at a fraction of a vehicle length behind a lead van. Substantial decreases in air flow will result in a diminished operating envelope for the vehicle in close-following.
UCB-ITS-PRR-98-6*
February 1998, 23 pp, $10.00

Transient Aerodynamics in Vehicle Interactions: Data Base Summary

A.L. Chen, K. Hedrick, O. Savas
Investigates transient aerodynamic forces on automotive vehicles traveling in close proximity to each other in a wind tunnel. Scale vehicle models are longitudinally aligned in a platoon configuration with various separation distances between the models. The drag force, side force, and yawing moment are measured to quantify the transient interactions of the vehicle flow fields.
UCB-ITS-PWP-98-3
February 1998, 146 pp, $10.00

Transient Vehicle Aerodynamics in Four-Car Platoons

A.L. Chen, Omer Savas, Karl Hedrick
Wind tunnel measurements were made of a 4-car platoon of scale vehicle models performing lane change maneuvers. The drag force, side force, and yawing moment on each of the 4 vehicles was measured for various configurations of the platoon.
UCB-ITS-PRR-97-50*
December 1997, 122 pp, $20.00

2.8 Enabling Technologies

Combined Approach to Stereopsis and Lane-Finding

Jitendra Malik, Camillo J. Taylor, Joseph Weber, Dieter Koller, Quang-Tuan Luong
Proposes a new approach for vision-based longitudinal and lateral vehicle control. The novel feature is the use of binocular vision. We integrate two modules consisting of a new, domain-specific, efficient binocular stereo algorithm, and a lane marker detection algorithm, and show that the integration results in improved performance for each of the modules.
UCB-ITS-PRR-97-27
July 1997, 40 pp, $20.00

Development of Binocular Stereopsis for Vehicle Lateral Control, Longitudinal Control, and Obstacle Detection

Jitendra Malik, Camillo J. Taylor, Philip McLauchlan, Jana Kosecka
Describes the progress we have made in applying computer vision techniques to the lateral and longitudinal control of an autonomous highway vehicle. We report the results from the experimental demonstration of the system as part of the National Automated Highway Systems Consortium (NAHSC) Demonstration in August 1997 in San Diego.
UCB-ITS-PRR-97-41*
November 1997, 26 pp, $10.00

Feasibility Study of Fully Automated Vehicles Using Decision-Theoretic Control

Jeffrey Forbes, Nikunj Oza, Ronald Parr, Stuart Russell
This project investigated the feasibility of constructing an autonomous vehicle controller based on probabilistic inference and utility maximization. We have been successful in identifying the major technical issues to be resolved, and we believe that the "high level" driving problem can be handled satisfactorily, although much remains to be done in terms of real-time operation.
UCB-ITS-PRR-97-18
April 1997, 45 pp, $10.00

Field Test of Vehicle-Mounted, Forward Looking Range Sensor in Closed-Loop AVCS

Alex Kanaris, Petros Ioannou

Presents the results of the testing on PATH vehicles and the evaluation of a low-cost, short-range radar sensor developed by the Amerigon corporation. The radar is designed to be used as a ranging sensor for automatic vehicle following applications, mounted in the front of a vehicle to provide measurements of the distance between the front of the vehicle and the rear of any vehicle or object ahead within a maximum distance of 17 feet.

UCB-ITS-PRR-98-14*

March 1998, 85 pp, $20.00

FMCW MMW Radar for Automotive Longitudinal Control

William David

Addresses the fundamental capabilities and limitations of millimeter wave (MMW) radar for ranging and contrasts its operation with that of conventional microwave radar. The report can serve as a primer or tutorial for researchers who are working in the field of automotive control, and who may apply radar for headway and lane control studies during platooning operations.

UCB-ITS-PRR-97-19*

May 1997, 25 pp, $10.00

2.9 Heavy Vehicles

Analysis, Design, and Evaluation of AVCS for Heavy-Duty Vehicles with Actuator Delays: Final Report for MOU 240

Diana Yanakiev, Jennifer Eyre, Ioannis Kanellakopoulos

Describes a new generation of longitudinal controllers for commercial heavy vehicles with and without intervehicle communication. These algorithms use nonlinear spacing policies, backstepping control design, and aggressive prediction schemes to deal with the presence of significant delays and saturations in the fuel and brake actuators. Their superior performance removes several major obstacles to the implementation of many different ITS scenarios to commercial heavy vehicles (CHVs), ranging from adaptive cruise control to fully automated operation.

UCB-ITS-PRR-98-18*

April 1998, 93 pp, $20.00

Lateral Control of Heavy Duty Vehicles for Automated Highway Systems

Meihua Tai, Jeng-Yu Wang, Pushkar Hingwe, Chieh Chen, Masayoshi Tomizuka

Linear analysis of a tractor semitrailer model, followed by the design of a simple linear controller for lane following. Off-tracking analysis is presented for a single unit vehicle and tractor semitrailer. This analysis is independent of the control design. Modeling of multi-unit articulated vehicles is also presented. Both a complex simulation model and a simplified control design model are derived for a general road train.

UCB-ITS-PRR-98-8

February 1998, 93 pp, $15.00

Lateral Control of Single Unit Heavy Vehicles

Pushkar Hingwe, Masayoshi Tomizuka

Presents two H-infinity control-theory based lateral controllers. The control designs are a natural combination of input-output linearization technique and the H-infinity control design techniques.

UCB-ITS-PRR-97-43

November 1997, 34 pp, $10.00

Longitudinal Control of Heavy Duty Vehicles: Experimental Evaluation

Diana Yanakiev, Jennifer Eyre, Ioannis Kanellakopoulos

Describes the results of the first phase of this project, consisting of 1) improved modeling of air brakes for heavy trucks and buses, which accounts explicitly for both nonlinearities and delays, and 2) novel nonlinear algorithms for longitudinal control of commercial heavy vehicles without intervehicle communication. The significance is that now we have removed one of the major obstacles to autonomous vehicle following for commercial heavy vehicles (CHVs).

UCB-ITS-PRR-98-15*

March 1998, 58 pp, $10.00

Modeling and Control of Articulated Vehicles

Chieh Chen, Masayoshi Tomizuka

A generalized coordinate system is introduced to describe the kinematics of a tractor-semitrailer vehicle, and equations of motion are derived. Experimental studies conducted to validate the effectiveness of this modeling approach and two nonlinear lateral control algorithms are described.

UCB-ITS-PRR-97-42

November 1997, 59 pp, $15.00

2.10 Deployment Studies

Automated Highway System Field Operational Tests for the State of California: Potential Sites, Configurations and Characteristics

Randolph W. Hall, Viral Thakker, Thomas A. Horan, Jesse Glazer, Chris Hoene

Describes possible objectives for a test of automated vehicles on a real roadway, identifies potential test sites in California, and evaluates the merits of these sites for conducting different types of tests. We conclude that there are many potential sites, the best in suburban locations where either an existing roadway has substantial surplus capacity, or where there is already a desire to construct high occupancy specialized facilities focused on transit or trucking.

UCB-ITS-PRR-97-45*

November 1997, 147 pp, $20.00

SYSTEMS

3.1 Policy and Planning

Case Study: Road Pricing in Practice

David Levinson

The history of turnpikes, from their first deployment in the 17th century through their decline in the 19th century and some restoration in the 20th century, is analyzed with a view to understanding the systematic causes of these changes. Key factors include length of trips, size of governing jurisdiction, and the transactions costs of collection. Discusses what would be required for turnpikes to become the preferred financing mechanism for highways.

UCB-ITS-PRR-97-38*

November 1997, 32 pp, $10.00

Comparative Systems-Level Analysis: Automated Freeways, HOV Lanes, Transit, Land Use Intensification, and Pricing Policies

Robert A. Johnston, Caroline J. Rodier

Travel and emissions effects of freeway automation and travel demand management measures were simulated with a regional travel demand model (SACMET 95) for a twenty-year time horizon in the Sacramento region. Pricing policies reduced travel delay and emissions; freeway automation reduced travel delay but increased emissions.

UCB-ITS-PRR-97-17

April 1997, 115 pp, $25.00

Economic Analysis of Network Deployment and Application to Road Pricing

David M. Levinson

Develops an economic framework for developing strategies necessary to deploy networks, and applies the framework to the deployment of road pricing. The deployment of three main elements relating to road pricing are discussed: use of electronic toll collection on existing toll roads, construction of new toll roads, and conversion of existing untolled roads to toll roads.

UCB-ITS-PWP-98-1*

January 1998, 46 pp, $15.00

Evaluation Framework for Commercial Vehicle Responses to Congestion Pricing

Martin Wachs, Kazuya Kawamura

This model can be used to assess the short-run impacts of congestion pricing, as well as other forms of toll roads, on the welfare of commercial vehicle operators. The essential information required are the roadway and vehicle operating characteristics, toll schedule, and the cumulative distribution for the value of time. The marginal social cost function with respect to traffic volume must be known to analyze the overall impact on society.

UCB-ITS-PWP-97-27*

November 1997, 18 pp, $5.00

ISTEA/ITS Connection in California: State of the Relationship and Opportunities for Productive and Beneficial Linkages

Mark A. Miller, Wenyu Jia

Our objective is to (1) investigate the current state of California's implementation of ISTEA with respect to ITS, (2) assess the extent to which ITS has been integrated within the State's transportation planning process, and (3) recommend opportunities for linkages between ISTEA and ITS that have not yet been recognized. This report contains results of a literature review of the ISTEA legislation and how it has been implemented in California, a survey of transportation professionals, and survey analysis findings .

UCB-ITS-PRR-98-22*

May 1998, 103 pp, $20.00

ITS Standards: A System Management Perspective

Chris Intihar, Randolph Hall

Focuses on the role of standardization in managing and controlling the transportation system. Reviews activities and processes used by standards-setting organizations in transportation. As standards evolve, transportation agencies will attain greater flexibility in installing systems and sharing information with each other. However, standardization has not addressed the need to develop protocols and procedures for standardization likely to address this need.

UCB-ITS-PWP-97-29*

December 1997, 30 pp, $10.00

Why ITS Projects Should be Small, Local, and Private

Stein Weissenberger

Implementing Intelligent Transportation Systems (ITS) requires acquiring new technical knowledge and developing new supporting institutions. Studies of technology development show that such knowledge and institutions can only be achieved through intimate and idiosyncratic processes of learning by doing and using. To produce and capture useful knowledge, early ITS projects should be local, small, and focused on realistic goals. Private industry should be used wherever possible, especially to perform tasks for which it is best qualified; it should be looked upon as a source of skills rather than as a source of funding.

UCB-ITS-PRR-98-23*

June 1998, 60 pp, $15.00

3.2 Benefits and Impacts Assessments

Costs and Benefits of Telecommuting: An Evaluation of Macro-Scale Literature

Kevan R. Shafizadeh, Debbie A. Niemeier, Patricia L. Mokhtarian, Ilan Salomon

A conceptual framework is proposed to organize the inputs and outputs of a macro-scale telecommuting benefit-cost analysis. Four federal and regional reports are then examined in terms of methodology, assumptions, economic approach, and major findings. Common inputs are identified, and the critical assumptions that routinely affect results are discussed. Finally, the economic approaches and major findings are presented and compared.

UCB-ITS-PWP-98-5*

February 1998, 52 pp, $15.00

Definition and Measurement of Transportation System Performance

Joy Dahlgren

Discusses the benefits and costs of transportation and recommends specific measures to use as indicators of the benefits and costs, as well as data sources and methods of measurement. Considers the role of intelligent transportation systems as both an object of measurement and a means of measurement

UCB-ITS-PRR-98-24*

June 1998, 60 pp, $15.00

Evaluating System ATMIS Technologies via Rapid Estimation of Network Flows: Final Report

James E. Moore II, Geunyoung Kim, Seongdil Cho, Hsi-Hwa Hu, and Rong Xu

Incorporates efficient transportation modeling technology in seismic risk analysis procedures, for the purpose of evaluating transportation network links, e. g. bridges, in terms of the system cost of failure. Objectives are: to develop an efficient transportation network analysis (TNA) procedure for many different traffic flow analyses under numerous earthquake scenarios, and to evaluate the applicability of the procedure to a large-scale transportation network.

UCB-ITS-PRR-97-54*

December 1997, 497 pp, $50.00

Identification and Prioritization of Environmentally Beneficial Intelligent Transportation Technologies: Year Two Final Report

Susan Shaheen, Troy Young, Daniel Sperling

Documents a project being conducted by the Institute of Transportation Studies at Davis and the Claremont Graduate School. Provides an extensive review of the literature on the energy and environmental impacts of Intelligent Transportation System technologies, a presentation of the development of deployment/modeling scenarios, and a description of the modeling effort.

UCB-ITS-PWP-98-8*

March 1998, 295 pp, $35.00

Traffic Management Systems Performance Measurement: Final Report

James H. Banks, Gregory Kelly

Possible actions that could be taken to improve performance measurement include research to compare loop-detector-based travel time estimates with measured travel times, development of a quality control system for traffic information, development of a traffic system performance monitoring system plan, research concerning the feasibility of relating incident and accident data, further research on non-loop-based travel time measures, extension of loop detector coverage, and development of data reduction and display software for performance monitoring.

UCB-ITS-PRR-97-53

December 1997, 38 pp, $15.00

Traffic Management Systems Performance Measurement: Study Directions and Scope, Proposed Measures of Effectiveness, and Proposed Action Priorities

James H. Banks, Gregory Kelly

Documents research to analyze performance measurement requirements for Caltrans Transportation Management Centers (TMCs), to identify and assess the feasibility of data collection and management activities required to support TMC performance measurement, and to recommend specific actions by Caltrans and PATH that will facilitate performance measurement.

UCB-ITS-PRR-97-13*

March 1997, 38 pp, $10.00

Traffic Management Systems Performance Measurement: Working Paper #2

James H. Banks, Gregory Kelly

Traffic Data System Improvement Plans were prepared for Caltrans Districts 11 (San Diego) and 12 (Orange County). The plans evaluate existing systems, identify possible improvements and resource requirements, and document the districts' priorities for action. Although committed to providing sophisticated traffic data collection and data management systems, the districts do not necessarily have a clear vision of how to use the data to monitor performance, and lack the organizational structure and staffing to carry out evaluation studies, performance monitoring, and data quality control.

UCB-ITS-PWP-97-28

November 1997, 37 pp, $10.00

3.3 Communications

Conceptual Simulation Framework for Mobile Radio Communications: A Flexilevel Approach

John A. Silvester

Presents a modeling/simulation framework for radio communications networks in Advanced Traffic Management and Information Systems (ATMIS). Component models are introduced and their interfaces are discussed. A baseline model that is used to study the effect of channel models on system and user performance is also introduced. Simulation results are reported.

UCB-ITS-PRR-97-40

November 1997, 28 pp, $10.00

Impacts of Computer-Mediated Communication on Travel and Communication Patterns: The Davis Community Network Study

Prashant Narayan Balepur

It has been hypothesized that electonic forms of communication may replace some travel. However, the results of this study of a Computer-Mediated Communication Network, which provided electronic mail and Internet access capabilities to its users, show that this is not the dominant effect.
UCB-ITS-PWP-98-11*
May 1998, 110 pp, $20.00,

Integrated Traffic and Communications Modeling Environment for ATMIS

P. Varaiya, J. Walrand, F.F. Wu, A. Polydoros, J. Sylvester
Section 1 presents a framework for estimating vehicle-roadside communications requirements, taking the San Francisco East Bay region as a case study, and determining whether existing wide-area wireless technologies can be used to support those requirements. Section 2 describes enhancements made to the NetPlan planning tool for designing wireline communication networks. It has models of LANs (eg., Ethernet) and WANs; standard communication protocols (eg., CSMA/CD, TCP/IP); and various simulation and network optimization tools.
UCB-ITS-PWP-97-21
July 1997, 26 pp, $10.00

3.4 Commercial Vehicle Operations

Commercial Vehicle Operations in Intermodal Transportation Management Centers

Randolph W. Hall, Chris Intihar
Motor carriers are not opposed to Intelligent Transportation Systems (ITS), certainly not opposed to moving toward a paperless system. They are willing and perhaps eager to invest and participate in projects that possess four basic characteristics:
- Modest investment
- No new taxes or user fees
- Promote operating efficiency, customer service, or safety
- Voluntary.

The industry is much more inclined to favor CHP-led efforts over those initiated by Caltrans, the DMV, or other state agenicies.
UCB-ITS-PRR-97-11
March 1997, 35 pp, $10.00

Commercial Vehicle Operations: Government Interfaces and Intelligent Transportation Systems

Randolph W. Hall, Chris Intihar
This study concludes that at present, there exists no strong market push to better integrate motor carrier operations with governmental agencies in California. As companies adopt ITS technologies for vehicle tracking and wireless communication, they are clearly not pushing for electronic transfer of information to and from governmental agencies. Likewise, none of the companies in the vehicle tracking industry has given priority to improving governmental interfaces.
UCB-ITS-PRR-97-12*
March 1997, 36 pp, $10.00

3.5 Transportation Modeling

Comparison of Traffic Models: Part II Results

Hong K. Lo, Wei-Hua Lin, Lawrence C. Liao, Elbert Chang, Jacob Tsao
Second part of a series comparing dynamic traffic flow models. Documents the results of comparison based on the framework defined in Part 1. The traffic models selected for comparison are DINOSAUR, DYNASMART, INTEGRATION, and METS. The areas of comparison comprise four categories: functionality, traffic dynamics, route choice mechanism, and network performance.
UCB-ITS-PWP-97-15
May 1997, 84 pp, $15.00

Data for Transportation Modeling in the Santa Monica Corridor

Joy Dahlgren
An assessment of the data available for a simulation testbed for testing alternate traffic management strategies in the Los Angeles Santa Monica Freeway Corridor (the Smart Corridor). Describes data needs, potential sources, and data preparation required; presents a work plan and resource requirements for acquiring the necessary data. Appendix analyzes conditions under which a simulation testbed is worthwhile.
UCB-ITS-PWP-98-4*
February 1998, 17 pp, $5.00

Improved Modeling Environment for ATMIS

Alexander Skabardonis, Edward Lieberman, Paul Menaker
Describes enhancements to the WATSim model (an extension of the widely used TRAF-NETSIM microscopic simulator) to simulate vehicles with route guidance/information systems, and interface with dynamic traffic assignment algorithms. The extended model can generate origin-destination and path matrices from observed turning movement counts, and provides comprehensive statistical, graphical and animation outputs of the vehicle movements. When applied to the San Francisco Embarcadero network, results demonstrated that it can be used to evaluate the effectiveness of ATMIS strategies.
UCB-ITS-PRR-97-33
August 1997, 99 pp, $20.00

NETCELL Simulation Package: Technical Description

Randall Cayford, Wei-Hua Lin, Carlos F. Daganzo
NETCELL is a freeway network simulation program that captures the dynamic evolution of multicommodity traffic over a freeway network in a way that is consistent with the hydrodynamic theory of highway traffic. This version incorporates some enhancements to the model and memory handling improvements to allow NETCELL to model very large networks.
UCB-ITS-PRR-97-23*
May 1997, 44 pp, $15.00

Queue Spillovers in Transportation Networks with a Route Choice

Carlos F. Daganzo
Explores traffic phenomena occurring when vehicle queues back up past intersections that provide two alternative routes to the same destination. Findings suggest that the time-dependent traffic assignment problem with physical queues is chaotic in nature and that (as in weather forecasting) it may be impossible to obtain input data which is accurate enough to make reliable predictions of cumulative output flows on severely congested networks.
Tech Note 97-1*
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Seyem Petrites, PATH Database Manager at:
spetrite@library.berkeley.edu
Michael Kleiber, PATH Database Librarian at:
mkleiber@library.berkeley.edu

Captions and Credits

Full-page photos:

p 2—An eight-car platoon of PATH-automated Buick LeSabres on the express lanes of Interstate 15 in San Diego, California, during the NAHSC Technical Feasibility Demonstration (Demo '97).
Photo: Bill Stone, PATH

p 4—Interstate 5 just south of Balboa Park in San Diego. Astronomical cost of building new freeway lanes is major impetus for PATH research efforts.
Photo: Gerald Stone, PATH

p 6—Congestion on Interstate 80 along San Francisco Bay at University Avenue, Berkeley, California. PATH research aims at making more efficient use of existing highways.
Photo: Gerald Stone, PATH

p 11—Double-trap inductive loop detectors on Interstate 580 just south of PATH headquarters. PATH researchers are using loop detectors to measure vehicle travel time.
Photo: Bill Stone, PATH

p 12—The El Toro Y, junction of Interstate 5 and Interstate 405, part of the PATH Advanced Transportation Management Information Systems (ATMIS) Testbed at UC Irvine.
Photo: Gerald Stone, PATH

p 22—Video, radio, and print media interview PATH researchers Han-Shue Tan and Bénédicte Bougler at Demo '98 in Rijnwoude, the Netherlands.
Photo: Jay Sullivan, PATH

p 24—FasTrak Electronic Toll Collection lane on Carquiñez bridge over Sacramento River on Interstate 80. PATH has done benefit-cost analysis of FasTrak for Caltrans.
Photo: Gerald Stone, PATH

p 34—Caltrans work crew installing magnetic markers in Interstate 80 over Donner Summit, for Advanced Snowplow Program.
Photo: Gerald Stone, PATH

p 36—Surveillance trailer on Interstate 5 in Anaheim, California, part of PATH-evaluated Orange County Mobile Surveillance Field Operational Test.
Photo: Lawrence Emerson, Caltrans

p 38—Advanced Snowplow guided by PATH magnetic guidance system leads conventional snowplow in clearing Interstate 80 over Donner Pass, which in most winters gets more snowfall than any other road in the Lower 48 states.
Photo: Aaron Steinfeld, PATH

p 40—PATH engineers Han-Shue Tan and Bénédicte Bougler test-drive Advanced Snowplow. Magnetic guidance screen in left center shows operator plow's position relative to path of magnetic markers embedded in roadway.
Photo: Gerald Stone, PATH

Other photographs by Gerald Stone and by:

Don Tateishi, Caltrans (p 7–Sen. Barbara Boxer and James van Loben Sels at Demo '97)
Jay Sullivan, PATH (pp 8-9–Demo '98; p 10–Mobile Offshore Base graphic; p 16–bird's-eye view of Buick test car simulating automated bus docking–photo and graphic)
Delnaz Khorramabadi, PATH (p 10–SmartPATH graphic)
Carlos Sun, PATH (p 14–ground-truthing video)
Bret Michael, Naval Postgraduate School (p 17–bus at shelter)

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