California PATH

Partners for Advanced Transit and Highways

Annual Report 1999

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

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Annual Report 1999

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.

Caltrans and PATH share a vision of congestion relief through highway automation. PATH's demonstration of an eight-car fully automated platoon, as well as the Honda/PATH magnetic/computer-vision guided vehicles, were highlights of the most successful demonstration of vehicle automation technology ever held: Demo '97. PATH has since participated in follow-up automation technology demonstrations, including Demo '98 in the Netherlands and Demo '99 in Ohio. Caltrans and PATH are currently planning for a major demonstration in 2002 that will showcase automation technology for heavy trucks and buses.

PATH's research activities in the area of Advanced Traffic Management and Information Systems (ATMIS) have greatly expanded in the last few years. An exciting new Center for Commercialization of ITS Technologies (CCIT) will open in August 2000 near the Berkeley campus. CATIS will team up University faculty and graduate students, private sector companies, and government transportation agencies in a new facility with the mission of facilitating the commercial deployment of advanced traffic information system technologies.

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.

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

Intelligent Transportation Systems are developing at a phenomenal rate on a global basis. Here in California, Caltrans and PATH are committed to employing all possible developments to improve the safety and efficiency of our surface transportation system. We have taken the national lead in performing research to discover methods for improving traveler safety, reducing traffic congestion, enhancing the mobility of people and goods, and promoting the transportation system's economic productivity. Our goal for the immediate future is to emphasize real-world implementations, a natural progression as we advance beyond the stage of theoretical studies and design towards deployment.

We are very happy this year to begin a collaborate research initiative with Caltrans Traffic Operations. The mission: optimizing freeway operations, measuring the benefits, and transfering results to the implementers. We have established two testbeds, one in Orange County and the other in the San Francisco Bay Area, that will enable us to do practical research in a real-world environment. We are also opening a center at Berkeley for joint academic and private-sector research on information technology in the transportation field. This Center for Commercialization of ITS Technologies (CCIT) will provide the facilities necessary to further the development and commercialization of transportation products.

Caltrans and PATH look forward to demonstrating fully automated heavy vehicles on I-15 in Southern California in the fall of 2002. Strategic planning for this demonstration is now underway, including tactical elements such as budgeting and scheduling. The heavy-vehicle demo will be a giant step forward in our goal to move closer to widespread deployment of Automated Highway Systems that support all vehicle types.

Caltrans and the California PATH Program will address each new challenge of the coming year with enthusiasm, strength, and determination. We will continue to work together to create a transportation system that is both safe and efficient.

Greg A. Larson

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.

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 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.

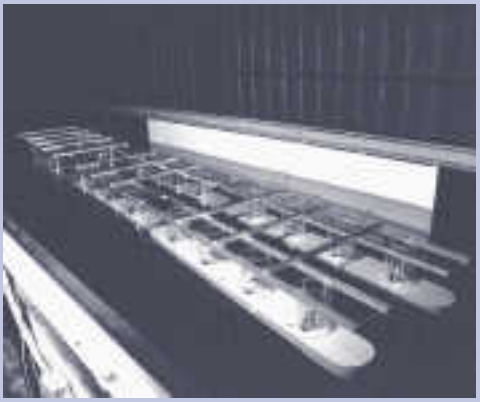
PATH Activities in National and International ITS Programs

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 includes several projects within the Intelligent Vehicle Initiative (IVI) program and evaluations of California ITS operational tests.

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 14 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, the University of Southern California, Stanford, Rowan University, Ohio State University, MIT, and Texas A&M.

New projects

PATH attracted research support from a variety of sources during the past year. Some of the new projects include:

- Development of enhanced adaptive cruise control, permitting smooth operations at low speeds and in stop-and-go traffic, for BMW
- 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 Maintenance and Construction Technology Center (AHMCT) at UC Davis, for the initial phases of the Advanced Snowplow Program partnership among California, Arizona, and Montana.
- Evaluation of the effectiveness of an innovative rear-collision warning system, for a major motor vehicle manufacturer.
- Development and assessment of technologies for "Sensor-Friendly Vehicle and Roadway Systems", in collaboration with Bechtel and Carnegie-Mellon University, for the USDOT Intelligent Vehicle Initiative (IVI) program.

Other notable developments during the past year included:

- Completion of a nationwide search for a permanent program manager for the ATMIS Program, leading to the hiring of Pat Conroy from Caltrans, effective July 1, 1999.
- Extension of the PATH research staff capabilities to include expertise in human factors, an important discipline in which we had previously been deficient.
- Participation with Caltrans in the development of The Phoenix Project to revive international interest in highway automation, following the demise of the National Automated Highway System Consortium in 1998. These efforts culminated in an international workshop in Los Angeles on May 12-14, 1999.

THE PHOENIX PROJECT

Automated Highway Systems

PATH research is subdivided into two broad categories:

- **ATMIS** - 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);

A summary of 1999 PATH projects by category follows and a list of current PATH research reports, working papers, and technical notes can be found on on pages 23-28.

ATMIS Research

ATMS (Advanced Transportation Management Systems)

Surveillance Technologies

In the past year, surveillance technologies developed in university laboratories made their way onto real-world streets and freeways for field testing.

- Research done at UC Irvine using inductive loop signatures for reidentification was implemented on a local street at two loop stations, providing the researchers with a 70% match of all vehicles passing through the loops. This system is currently being implemented at an intersection, to measure the turning movements of all the vehicles.
- The Video-Based Vehicle Signature Analysis and Tracking System (V2SAT) developed by Cal Poly San Luis Obispo was deployed and tested at two overcrossings on US 101, and demonstrated that it could measure travel times very reliably.
- Finally, the UC Davis-developed Laser Based detection system was deployed on a Sacramento freeway. Researchers demonstrated that reproducible vehicle lengths can be obtained from the laser system for reidentification purposes. These technologies will continue to be tested in the field this year, along with a field test of probe vehicles using GPS (global positioning system) and cellular technologies.

Section-Related Measures of Traffic System Performance: Field Prototype Implementation, MOU 336; Stephen Ritchie, UC Irvine.

Use of Los Angeles Freeway Service Patrol Vehicles as Probe Vehicles, MOU 347; James E. Moore II, University of Southern California.

Video-Based Vehicle Signature Analysis and Tracking System, Phase 2B: System Deployment and Operational Test, MOU 350; C. Arthur (Art) MacCarley, California Polytechnic University, San Luis Obispo.

Development of Real-Time Laser-Based Non-Intrusive Detection System for Measurement of True Travel Time on the Highway, MOU 351; Harry Cheng, UC Davis.

Investigation of Vehicles as Probes Using Cellular Phones and the Global Positioning System, MOU 378; Youngbin Yim, California PATH.

Development of a Cost-Effective Surveillance System in Caltrans District 4, MOU 382; Joy Dahlgren, California PATH.

Development and Testing of Field-Deployable Real-Time Laser-Based Non-Intrusive Detection System for Measurement of True Travel Time on the Highway, MOU 3005; Harry Cheng, UC Davis.

GPS/GIS Technologies for Traffic Surveillance and Management: A Testbed Implementation Study, MOU 3006; Michael G. McNally, UC Irvine.

Field Investigation of Advanced Vehicle Reidentification Techniques and Detector Technologies, MOU 3008; Stephen Ritchie; UC Irvine.

Field Operational Test of GPS and Cellular Technologies for Vehicle Probes, MOU 3015; Youngbin Yim, California PATH.

Traffic Estimation

Data from various surveillance technologies being developed at PATH will lead to better information both for travelers and transportation managers.

- A Berkeley Highway Lab established by PATH on I-80 includes nine loop detector stations; in the near future it will be equipped with video cameras. A inductive loop based algorithm has been field tested in the Berkeley Highway Lab that will provide real-time speed or travel time on the web.
- A UC Berkeley team is also developing a vision-based measurement of travel time that will have an incident detection algorithm that can be integrated with the loop-based algorithm.
- Algorithms for vehicle classification and traffic flow prediction have been developed by a research team at UC Irvine.
- Another UC Berkeley project is working on sensor fusion: combining data from several surveillance technologies and algorithms to provide more accurate and robust measurements of traffic conditions. The aim is to field test these research products in a real world environment like the Berkeley Highway Lab or the ATMIS Testbed in Irvine.

Automated Travel Time Measurement Using Vehicle Lengths From Loop Detector Speed Traps, MOU 352; Mike Cassidy, UC Berkeley.

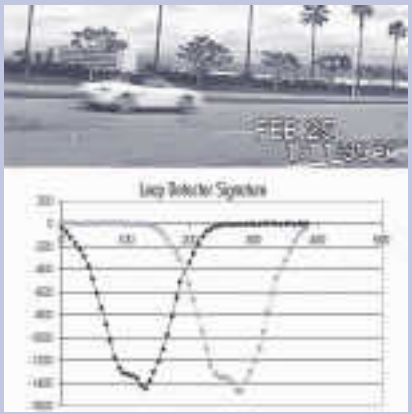
Real-Time Algorithms for Travel Time and Origin-Destination Estimates, Incident and Verification, MOU 353; Pravin Varaiya, Alexander Skabardonis, UC Berkeley.

Developing and Using Surveillance Data for Research, MOU 356; Joy Dahlgren, California PATH.

Adaptive Dynamic Macroscopic Freeway Traffic Flow Prediction Model Using Genetically Optimized Time-Delay-Based Neural Networks, MOU 360; Baher Abdulhai, University of Toronto.

An Investigation in the Use of Inductive Loop Signatures for Vehicle Classification, MOU 376; Carlos Sun, California PATH/Rowan University.

Dynamic Origin/Destination Estimation Using True Section Densities, MOU 377; Carlos Sun, California PATH/Rowan University.



Traffic Data Measurement and Validation, MOU 3000; Ben Coifman, Ohio State University.

Development of Tools to Assess the Effects on Traffic Safety of Changes in Traffic Flow Conditions under ATMS Operations, MOU 3007; Tom Golob, UC Irvine.

Improving Operations, Driver Information and Safety Using Advanced Surveillance Metrics, Wireless Communication and Existing Traffic Detectors/Controllers, MOU 3010; Pravin Varaiya, UC Berkeley, Ben Coifman, Ohio State University.

Multi-Sensor Traffic Data Fusion, MOU 3021; Jitendra Malik, UC Berkeley.

Traffic Control and Management Strategies

PATH research confirms that there are benefits to be reaped from better traffic control and management strategies.

- Real-time signal control at intersections in Los Angeles can reduce delays for drivers and increase capacity on the roads.
- A full analysis of the incident management process in Los Angeles showed there are areas of improvement, especially in the area of dispatching emergency or maintenance vehicles. More research is needed in the area of corridor management, both technically and institutionally.
- This coming year research will focus on the benefits of ramp metering and how to increase capacity at bottlenecks and weaving sections. A TMC (Transportation Management Center) Simulator will be constructed at the ATMIS Testbed at UC Irvine to test and train operators on new management and control strategies.

TRICEPS: An ATMIS Field Implementation, MOU 346; Michael McNally, UC Irvine.

Incident Management: Process Analysis and Improvement, MOU 354; Randolph Hall, University of Southern California.

Implementation of Advanced Techniques for Automated Freeway Incident Detection, MOU 358; Baher Abdulhai, University of Toronto.

HOT Lanes and Demand for Travel Time Savings, MOU 361; Joy Dahlgren, California PATH.

Benefits of Real-Time Signal Control, MOU 379; Robert Tam, California PATH, Alexander Skabardonis, UC Berkeley.

Access Control Strategies to Manage Traffic Backups and Increase System Capacity, MOU 3004; Carlos Daganzo, UC Berkeley.

Examining How ATMIS Can Increase Freeway Bottleneck Capacity, MOU 3011; Mike Cassidy, UC Berkeley.

Development and Evaluation of Adaptive Ramp Metering, MOU 3013; Michael Zhang, UC Davis.

Development of an ITS Systems Testing Center, MOU 3017; Will Recker, UC Irvine.

Simulation and Modeling

PATH has investigated and examined many traffic models and simulations for ATMIS applications and found that all have their shortcomings. The most promising is the Paramics model, which has a very attractive visual output and is scalable to handle a large network. Also, it provides hooks so other modelers can attach new modules to enhance the fidelity of the model.

- UC Irvine is heading the effort to calibrate and validate the Paramics model in Orange County. The first applications of the Paramics model will be a ramp meter study by UC Davis and an emission modeling project by UC Riverside.
- In the coming year PATH will develop a Paramics modeling capability in the San Francisco Bay Area with a ramp metering study as the first application.

PATH Center for ATMIS Research at UC Irvine, MOU 341; Will Recker, UC Irvine.

Simulation of ITS on the Irvine FOT Area Using The Paramics Scalable Microscopic Traffic Simulator, MOU 359; Baher Abdulhai, University of Toronto.

Assessment of the Effectiveness of ATMIS Strategies, MOU 362; Alexander Skabardonis, UC Berkeley.

Integrating a Comprehensive Modal Emission Model into ATMIS Transportation Modeling Frameworks MOU 381; Matthew J. Barth, UC Riverside.

Development of a Simulation Capability to Support ATMIS Studies, MOU 399; Bruce Hongola, California PATH.

Fabrication of Integrated TMC Simulator Facility, MOU 3014; Will Recker, UC Irvine.

ATIS (Advanced Traveler Information Systems)

The TravInfo Field Operational Test evaluation performed by PATH in the San Francisco Bay Area revealed that ATIS does affect travelers choices of departure time and route. Travelers value the information and are pleased with the TravInfo telephone system and various traffic web pages that use TravInfo data.

- Devices like the multimodal travel planner prototype developed at UC Davis, which have access to a rich dataset of transportation information, can be used to discover the fastest or cheapest way to travel.
- A field test around the Anaheim baseball stadium deployed changeable message signs directing the drivers to the stadium. Measurable delay savings occurred when the traffic flows were balanced and distributed around the special event.

Daily Activity and Multimodal Travel Planner, MOU 339; Ryuichi Kitamura, UC Davis.

Caltrans D10 Fog Monitoring System, MOU 342; 350; C. Arthur (Art) MacCarley, California Polytechnic University, San Luis Obispo.

The Provision of Traffic Information—A Study of Supply and Market Structure, MOU 344; Adib Kanafani, UC Berkeley.

Event-Based ATIS: Practical Implementation and Evaluation of Optimized Strategies, MOU 348; R. Jayakrishnan, UC Irvine.

Consumer Research on ATIS Technologies: Surveys of ATIS Users, MOU 363; Youngbin Yim, California PATH.

Financing Plan for Public Supported ATIS, MOU 364; Youngbin Yim, California PATH.

An Experiment in Privatizing the Operations of Regional Transportation Information/Management Centers: How well is it Working? MOU 365; Mark Miller, California PATH.

ATIS for Ground-to-Air Connectivity, MOU 3003; Randolph Hall, University of Southern California.

APTS (Advanced Public Transportation Systems)

A new paradigm for public transportation must be developed in order for it to be a viable option for many travelers. The system must be flexible and reliable. PATH has started an aggressive research agenda to develop new systems to meet the needs of the traveler for door to door service.

- CarLink is a smart carsharing system tested in conjunction with the San Francisco Bay Area Rapid Transit (BART) system. BART riders can reserve cars that will be waiting for them at their destination to drive from the station to work. While they are at work, the car can be used by other people for errands or other activities.
- A research project at UC Santa Barbara tested a "talking sign" device that allows visually impaired transit users to find their way around the bus terminal and board the correct bus. Similar research is needed to develop ways to make it easier and more attractive to use public transit.

San Gabriel Valley Smart Shuttle Technology Field Operational Test Evaluation, MOU 340; Genevieve Giuliano, James E. Moore II, University of Southern California.

Assistive Devices and Services for the Disabled, MOU 343; Reginald G. Golledge, UC Santa Barbara.

Efficient Transit Service Through the Application of ITS, MOU 345; Randolph Hall, University of Southern California.

Design, Implementation, and Evaluation of an APTS, Intermodal Field Test of Car Sharing: A Case Study of the Bart Station Car Program, MOU 349; Daniel Sperling, UC Davis.

Assessing Opportunities for Intelligent Transportation Systems in California's Passenger Intermodal Operations and Services, MOU 375; Mark Miller, California PATH.

User, Economic, and Institutional Evaluation of "Smart" Car Sharing, MOU 380; Daniel Sperling, UC Davis.

Consumer Research on Personalized Demand-Responsive Transit Service, MOU 398; Youngbin Yim, California PATH.

Evaluating the Impact of ITS on Personalized Public Transit, MOU 3002; Maged Dessouky, University of Southern California.

Expanded, Year-Two CarLink Demonstration: A User, Economic, and Institutional Evaluation of "Smart" Carsharing, MOU 3009; Daniel Sperling, UC Davis.

Decision Support and Benefit/Cost Analysis

Decisions on transportation improvements are sometimes made without hard facts or weighing all the options. PATH has embarked on a quest to collect the needed information to make an intelligent decision for transportation planners and managers.

- PATH's LEAP website (now ITS Decision) has a huge body of literature from field test evaluation or studies on Intelligent Transportation Systems. This website allows a person to check other people's experience with a particular technology or system before implementation.
- A Freeway Performance Measurement System (PeMS) has been developed and implemented in Caltrans District 12. This system allows the user to see if the transportation system is performing better or normal with easy to understand real-time measurements.
- A rigorous cost/benefit analysis framework has been developed at UC Berkeley to be used by planners to estimate the value of different ITS strategies. Researchers have investigated Electronic Toll Collection, Ramp Metering, and Advanced Traveler Information Systems, and are currently looking at ITS in public transit and the Freeway Service Patrol service.

Identification and Prioritization of Environmentally Beneficial Intelligent Transportation Technologies: Year Two, MOU 337; Daniel Sperling, UC Davis.

California Systems Architecture Study-Part III, MOU 338; Tom Horan, Claremont Graduate School, Randolph Hall, University of Southern California.

ITS Evaluation Website, MOU 355; Joy Dahlgren, California PATH.

Cost-Benefit Analysis for ITS Management Decisions, MOU 357; David Gillen, UC Berkeley.

Evaluation Methods for Measuring the Value of ITS Services and Benefits from Implementation, MOU 3001; David Gillen, UC Berkeley.

Freeway Performance Measurement System, Phase II, MOU 3012; Pravin Varaiya, UC Berkeley.

Technology Transfer and the PATH project, MOU 3016; Linda Howe, UC Berkeley.

Institutional Initiatives: Interdisciplinary Investigation In Support of an ITS-based Traveler Information System, MOU 3019; J. Karl Hedrick, UC Berkeley, Thomas Horan, Claremont Graduate University.

ITS Decision

Analysis of Implementation of Intelligent Transportation Systems

www.path.berkeley.edu/itsdecision

Advanced Vehicle Control and Safety Systems

AVCSS Research

Control of Heavy-Duty Vehicles

In the past year, a Class 8 tractor-trailer combination was instrumented for the experimental demonstration of lateral and longitudinal controls of heavy-duty vehicles. Both open-loop and closed-loop lateral control experiments were conducted.

- A gain-scheduled H-infinity optimal controller with look-ahead lateral error as the control feedback and a loop-shaping controller for steering actuators was designed and tested in closed-loop for speeds up to 45 mph. These controllers will continue to be fine-tuned. For longitudinal control, a series of open-loop experiments on throttle and brake response were conducted to determine the gains, time constants and delays present in the throttle and brake dynamics. Closed-loop experiments were also conducted by adding brake actuators and implementing control schemes with smaller intervehicle spacings.
- A framework has been developed for integrating and coordinating advanced compression braking methods with conventional braking systems for longitudinal control of heavy duty vehicles. It was concluded that the compression braking is a good vehicle retarder because it combines high braking capability with fuel economy benefits and emission reduction.
- A generic power-train simulation model for longitudinal control of a Class 8 truck has been developed to accurately represent the transient and nonlinear behavior of the engine and the vehicle during the transition from maximum combustion power to maximum engine brake power. In the next phase, the engine braking model and the vehicle dynamics will be integrated. Controllers for coordinating conventional brakes with compression brakes will then be designed.
- Two new projects that started in 1999 deal with robust longitudinal control of trucks and the performance of trucks with vehicle control systems in safety-critical conditions.

Lateral Control of Heavy-Duty Vehicles for AHS, MOU 313; Masayoshi Tomizuka, UC Berkeley.

Longitudinal Control of Heavy-Duty Vehicles: Experimental Evaluation, MOU 314; Ioannis Kanellakopoulos, UCLA.

Advanced Braking Methods for Longitudinal Control of Commercial Heavy Vehicles; MOU 372, Anna Stefanopoulou, UC Santa Barbara.

Robust Lateral Control of Heavy Duty Vehicles, MOU 385; Masayoshi Tomizuka, UC Berkeley.

Safety Performance and Robustness of Heavy Duty Vehicles, MOU 390; Christian Gerdes, Stanford University.

Integrated Longitudinal Control for Safe Automation of Commercial Heavy Vehicles, MOU 393; Christian Gerdes, Stanford University, Ioannis Kanellakopoulos, UCLA, Anna Stefanopoulou, UC Santa Barbara.

Vehicle Control Experiments and Field Tests

A significant portion of the AVCSS work at PATH requires experimental vehicles to support the research, development, testing and validation of the control systems. In the past year, PATH has supported hardware and software development for demonstrating low-speed precision docking, testing vehicle controls for heavy-duty vehicles, preparing communication systems on the vehicles, and supporting the research on DGPS/INS system for vehicle location. The PATH experimental group will continue to provide support for the projects on heavy-duty vehicles, longitudinal control code revision, failure diagnosis and mitigation, evaluation of longitudinal range and range rate sensors, communication systems, and vehicle location.

Vehicle Control Experimental Research and Support, MOU 331; Dan Empey, PATH.

Vehicle Control Under Abnormal Conditions

The performance and robustness of the PATH magnetometer-based lateral control system when either the front or rear set of magnetometers fails has been evaluated both analytically and experimentally. It has been shown that magnetometer fault tolerance can be achieved at low speeds by modifying existing control schemes. In the next phase the autonomous lateral control system, based on the IRIS technology developed to measure the lateral error and yaw error relative to the vehicle in front, will be studied and combined with the magnetometer-based lateral control system to enhance safety and reliability performance.

- A model for emergency platoon deceleration has been developed for SmartAHS. The model calculates the lateral, longitudinal, and yaw velocities of two vehicles after impact. In a parallel develop-

ment, emergency platoon deceleration maneuvers for a multiple-vehicle platoon were modeled using the hybrid input-output automata modeling language. A probabilistic estimate of collision severity was made based on a probability distribution on the deceleration capability of the vehicles.

Emergency Operation of Platoons: Collisions, Emergency Deceleration and Platoon Lane Change, MOU 319; Hariharan Krishnan, PATH, Darbha Swaroop, Texas A&M University.

Vehicle Lateral Control Under Fault in Front and/or Rear Sensors, MOU 384; Masayoshi Tomizuka, UC Berkeley.

Fault Diagnosis and Management

Efforts have been devoted to developing and enhancing components of the fault diagnostic system for lateral control and the detection and processing of multiple faults in the longitudinal control system. A hierarchical structure for fault detection and identification in the lateral control system has been constructed. This structure uses health signals in various sensors and actuators as local fault detectors.

- The specific problem of detection and reconfiguration of the system when the front or rear magnetometer information is lost has also been analyzed. A significant development is the idea of a fault-tolerant controller. This controller simultaneously stabilizes both the nominal and faulty plant. The identification of faults via residual processing has been investigated for the longitudinal control system. An extended residual processor, which uses additional residuals and fuzzy logic to perform a deeper diagnosis, has been developed to correctly identify both single and double faults in the longitudinal control system.
- A fault diagnostic system that resides in the application layer of a layered communication architecture was designed for detecting intraplatoon communication faults. The diagnosers, plant and communication channel were formally described by the SHIFT programming language for hybrid automata; specifically the Petri net approach for modeling fault diagnosis in distributed systems. The logical correctness of the design is verified by KRONOS, a timed automata verification tool.

Design of Fault Tolerant Control Systems for AHS: Fault Detection, Fault Handling and Verification, MOU 312; Roberto Horowitz, UC Berkeley, Karl Hedrick, UC Berkeley.

Integration of Fault Detection and Identification into a Fault Tolerant AHS, MOU 315; Jason Speyer, UCLA.

System Fault Detection in Human-Augmented Automated Driving, MOU 323; Theodore Cohn, UC Berkeley.

Failure Diagnosis and Monitoring Design for Intra-Platoon Communication Systems, MOU 332; Raja Sengupta, PATH.

Development and Implementation of a Vehicle-Centered Fault Diagnostic and Management System for the Extended PATH-AHS Architecture, MOU 373; Masayoshi Tomizuka, Roberto Horowitz, Karl Hedrick, UC Berkeley

Vehicle Braking Control

PATH has developed a torque-based brake controller to improve brake controller performance in cases when brake pressure feedback is not sufficient. The controller was experimentally tested and the result showed that there was a sudden drop in brake torque as a function of pressure gain during a skid. A differential braking control algorithm, based on an extension of the Adaptive Feedforward cancellation technique, has been developed to adaptively cancel brake rotor warp-induced vibrations. The algorithm has been tested in simulation, and it will be experimentally tested in the next phase.

Brake System Modeling, Control and Integrated Brake/Throttle Switching, MOU 308; Karl Hedrick, UC Berkeley.

AHS Safety Analysis and Simulation

Two projects studying the severity of vehicle-following collisions have been completed In the past year. A single vehicle model was developed to model the deformation of a vehicle body in one of the projects. Using this model, a collision-detection algorithm was developed to detect possible collisions between vehicles. The algorithm performs a series of local minimizations of a distance function between two ellipsoids representing two vehicles.

- In another project, the effects of collisions in vehicle-following operations and the dynamics of post-impact vehicle motions were studied using a simulation package. Several crash scenarios were simulated to reflect the most critical failure conditions that might occur. Those failures include: a miscommunication from the leading vehicle to the following vehicle, a failure in the range sensor on the following vehicle, or a failure in the brake actuator on the following vehicle. Several parameters, such as initial spacing between the two vehicles as well as vehicle speed were varied in the simulated scenarios. Revisions to the source codes were also made to implement a closed-loop control model with the crash and dynamic models.
- Vehicle control algorithms can now be tested in crash scenarios to examine the feasibility and effectiveness of controlling vehicle motions during or after a collision. The vehicle maneuvers include steering and braking inputs to perform lane following or lane changing.
- Safety analysis and evaluation of advanced vehicle control and

safety systems such as vehicle longitudinal and lateral control systems has also been performed, so that errors in the process of specification, design, development, and integration can be revealed prior to the implementation of the new technologies, and hazardous consequences can be prevented. This effort will continue.

Models of Vehicular Collision: Development and Simulation with Emphasis on Safety , MOU 309; Oliver O'Reilly and Panayiotis Papadopoulos, UC Berkeley.

Studies of Collision in Vehicle Following Operations by Two-Dimensional Impact Simulation, MOU 324; Ching-Yao Chan, PATH.

Safety Evaluation of Vehicle Following Operations by Fault Tree and Sensitivity Analysis, MOU 325; Ching-Yao Chan, UC Berkeley, J. Bret Michael, Naval Postgraduate School.

Development of Integrated Meso/Microscale Traffic Simulation Software for Testing Fault Detection and Handling in AHS, MOU 383; Roberto Horowitz, UC Berkeley.

Safety Assessment of Advanced Vehicle Control and Safety Systems (AVCSS): A Case Study, MOU 395; Wei-Bin Zhang, Ching-Yao Chan, PATH.

Communication Systems

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 for vehicle address resolution, configuration management, and routing. An address resolution protocol (ARP), a distributed algorithm that defines the binding and maps the logical identifier of a user to its physical location, was designed for an AHS with only one lane. The configuration management problem is a dynamic address resolution problem, since the updating process of an ARP provides a means to figure out how the composition of a subnet of radios that communicate with each other changes. Configuration management is a prerequisite to routing. In this past year, a configuration protocol and a routing protocol were also designed and verified.

- A hierarchical communication structure has been designed that can support a mobile environment with the distinct characteristic that the communication network's topology changes and has to be adapted as the mobiles (vehicles and platoons) move. This structure has also been simulated using SHIFT and SmartAHS. The communication architecture developed has five layers: physical layer, data link layer, network layer, transport layer, and application layer. The communication network was designed to provide a quality of service (QOS) interface that meets the needs of the control applications. Examples of QOS parameters are delay, jitter, loss probability, average bit rate, and burst size. Development of QOS specifications are being continued.
- A new project that started in 1999 is devoted to designing robust communication link and data access protocols by considering the problem that the overall communication architecture for an AHS is complicated by the propagation environment of the signals, the existence of multiple interference signals, and the mobility and dynamic character of platoons.

Address Resolution, Configuration Management, and Routing in Wireless Communication for AVCSS, MOU 318; Pravin Varaiya, UC Berkeley

PATH Laboratory, MOU 329; Raja Sengupta and Chin-Woo Tan, PATH

Designing a Framework for Vehicle-to-Vehicle and Vehicle-to-Roadside Communication, MOU 334; Raja Sengupta, PATH

A Robust Communication Link and Architecture Design for AHS, MOU 389; Andrea Goldsmith, Stanford University

Advanced Vehicle Location Systems

In the past year a carrier-phase differential GPS-aided inertial navigation system (INS) was integrated into current vehicle control systems at PATH. Information available from the GPS-aided INS was analyzed to improve accuracy and evaluate different mechanisms for using the information for vehicle control. Existing vehicle control software was modified so that GPS-aided INS data can be used. The interface between the GPS-aided INS software and the vehicle control software was implemented. The software developed was tested and evaluated on a PATH vehicle, so that the GPS/INS combination can be compared to magnetometer information. The robustness of the integrated magnetometer and GPS/INS system was evaluated to achieve the performance and reliability necessary for automated vehicle control. A demonstration of closed-loop vehicle control based on data from the integrated system will be performed on a PATH vehicle.

- An inertial navigation system consisting of a distributed array of accelerometers was developed under another project to estimate the position of a moving rigid body. More precise position estimates are obtained with a combination of INS measurements and GPS reference data source. However, since both the INS measurements and GPS codes have unpredictable embedded error sources, algorithms were developed to filter out the errors in the data provided by the INS and GPS receivers.
- Error-correction algorithms have been developed to correct or estimate error sources that include: bias and scale (nonlinearity) errors of accelerometers, temperature-dependent drift errors, location and orientation errors of accelerometers, cross-axis sensitivity error between a pair of accelerometers, random noise of sensors and supporting electronics,

attitude (reference frame) errors, and numerical (integration) errors. These algorithms will continue to be simulated and experimentally tested.

Aggregation of Direct and Indirect Positioning Sensors for Vehicle Guidance, MOU 322; Alice Agogino, UC Berkeley.

GPS-Based Error Correction of Gyro-Free Inertial Navigation System, MOU 371; Chin-Woo Tan, PATH.

Integration of GPS-aided INS into AVCSS, MOU 374; Jay Farrell, Matthew Barth, UC Riverside.

Integration of GPS/INS and Magnetic Markers for Advanced Vehicle Control, MOU 391; Jay Farrell, UC Riverside.

Aerodynamics

Experimental evaluation of transient aerodynamic effects on automated vehicles was continued, using scale mode vehicles in a wind tunnel. Experiments were conducted to measure and characterize the transient aerodynamic forces on vehicles traveling in close proximity to each other and their impacts on vehicle controllability. The effects of transient vehicle movements, such as lane changes, were tested to understand the changes of aerodynamics on the performance of vehicles. The changes of drag forces and the impact on fuel economy, and the effects of the side force and yaw moment on vehicle stability and controllability, were also studied.

- Vehicles that operate in close proximity interact aerodynamically. These interactions define the aerodynamic forces upon each vehicle and the flowfield in the immediate vicinity of the vehicles. A series of field tests were completed to measure the drag forces of both members of a two-car platoon at close spacing. These field tests were conducted to provide an independent verification of the wind tunnel predictions. The results show substantial correspondence between full-scale and wind tunnel measurements. Quantitative flowfield measurements were performed using the Digital Particle Image Velocimetry (DPIV) technique. The field tests were carried out at the El Mirage dry lake where the image of flowfield structure was made visible by the dust swept up from the floor of the lake. The results have demonstrated the existence and importance of a large-scale turbulent vortex structure within the intervehicle flowfield. This structure produces fluctuating forces that must be anticipated and overcome by the control algorithms.
- A new project was started in 1999 to carry out wind tunnel measurements of drag and potential fuel savings for two scale model tractor-trailers in tandem at short headway. Measurements will also be made to derive sufficient vehicle roll stability margin for safe handling of Class 8 trucks at high speeds and under strong cross-wind conditions.

Transient Aerodynamic Vehicle Interactions, MOU 307; Omer Savas, UC Berkeley

Transient Aerodynamics in the Intervehicle Flowfield; MOU 321, Frederick Browand, USC

The Aerodynamics of Heavy Trucks, MOU 387; Frederick Browand, USC

AVCSS Concepts

In the past year, predictions of spacings that could be used between automated vehicles in order to improve both highway throughput and safety were developed. An algorithm that calculates the minimum longitudinal spacing that the vehicles should initially have was developed to determine if a particular lane changing or merging maneuver would be free of collisions. The traffic flow of a highway system in which manual and semiautomated (ACC) vehicles are mixed under some conditions was also evaluated.

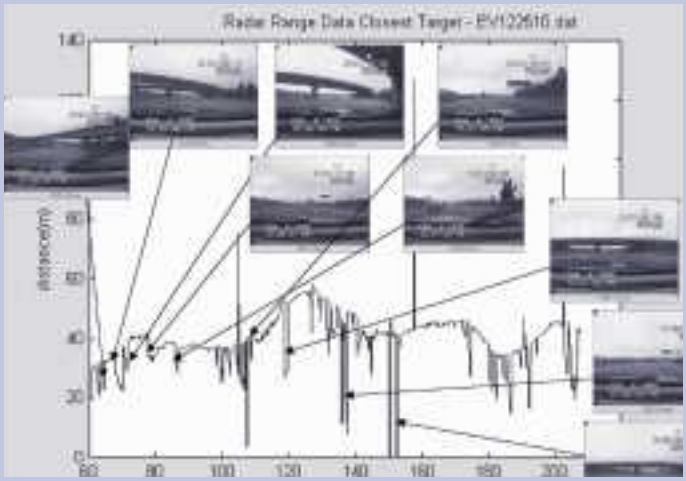
- Microscopic analysis of the effect of ACC vehicles on the transient behavior of traffic flow was conducted. It was shown that when a manual vehicle in front performs smooth acceleration maneuvers, an ACC vehicle behind is free of slinky effect and can accurately track the position and velocity of the front vehicle. When the lead vehicle accelerates rapidly, the ACC vehicle filters out such response and maintains a smooth traffic flow. This is done, however, at the expense of larger position, velocity, and acceleration errors, and sometimes at the expense of falling behind the vehicle ahead.
- By using simulations it was demonstrated that the fuel consumption and pollution levels present in manual traffic modeled by the Pipes linear car following model can be reduced during rapid acceleration transients by 7.3% and 15%-20% respectively due to the presence of 10% ACC vehicles. A new project started in 1999 will carry out actual vehicle following experiments to validate the analytical and simulation results, and quantify the benefits of ACC vehicles in mixed traffic.
- Another new project will determine how the interface between the AHS and the arterial street network could be designed to accommodate the high volume of AHS traffic, and evaluate ways to maximize the benefits that accrue from added capacity. The focus is on how to accommodate concentrations of capacity within narrow corridors or a limited number of interchanges, and its implications on the surrounding street system.

Evaluation and Analysis of AHS Concepts and Architectures, MOU 304; Petros Ioannou, USC

Mixed Automatic and Manual Traffic, MOU 317; Petros Ioannou, USC

Sensor-Friendly Highways: Investigation of Progressive Roadway Changes to Facilitate Deployment of AHS, MOU 368; James Misener, PATH

The AHS/Street Interface Effects of Capacity Concentrations on System Performance; MOU 386; Randolph Hall, USC



Evaluation of the Effects of ICC Vehicles in Mixed Traffic; MOU 392, Petros Ioannou, USC.

Bus Rapid Transit

The safety of systems that provide guidance and possibly control to buses for precision docking at high-level platforms to permit easy access by elderly and handicapped riders was studied. Two types of automated docking systems have been developed to show that buses can be made to dock consistently at precisely the desired distance to the curb, thus eliminating the gap between bus and docking platform. The first type, a docking assistance system, tells the driver where the bus is with respect to the dock. The second type provides full or partial-authority automatic control of the bus during docking: the driver lets the automated system drive or steer the bus.

- For a docking system to be operational, its safety issues must be evaluated in the environment of the intended use. Different ways to collect, manage, and present safety information about automated docking systems to regulatory, certification, and other decision-making committees have been studied. An initial set of safety considerations for building safety cases for automated bus docking systems was developed. They are based on field observations of manual bus docking in downtown San Francisco, which has a high volume of transit bus and other traffic such as pedestrians and bicyclists.
- PATH has developed a precision docking system for automobiles and demonstrated robust performance for docking with an accuracy of 1.5 cm distance from the curb. This precision docking system will be implemented on a bus to demonstrate that the precision docking system can provide superior docking accuracy and reduce the stress of the bus operator. The design and development of an actuator system, the installation of magnetometers, computer and data acquisition system, and the development of data processing and control software will be continued.
- A new project was started in 1999 to identify and investigate the institutional aspects of Bus Rapid Transit (BRT) in California, and recommend strategies for the resolution of the institutional issues. The investigation will include an appreciation of what issues there are, their relative level of importance, and their likelihood of occurring. Promising sites that will facilitate the operation of an efficient BRT will be identified.

Safety Analysis of Concept Systems for Guidance and Control of Transit Buses, MOU 327; Bret Michael, Naval Postgraduate School.

Institutional Aspects of Automated Bus Rapid Transit Operation, MOU 394; Mark Miller, PATH.

Develop Precision Docking Function for Bus Operation; MOU 397, Han-Shue Tan, PATH.

PATH, AHMCT Win Award for Caltrans

PATH's automated vehicle demonstration at the 1999 California Alliance for Advanced Transportation Systems Annual Meeting, held 13-15 September in Sacramento, formed an integral part of a Caltrans exhibit that brought home one of the meeting's Awards of Excellence. Speeding forward and in reverse through cones on a half-mile track with very tight (39m radius) turns, a fully automated PATH Buick LeSabre demonstrated precision lateral control as well as precision automated docking. Passengers were impressed as the vehicle took the tightest turn at 0.5 g, no-hands, no-feet. "Fascinating," said Bernie Orozco, principal consultant to California Senate Majority Leader Richard Palanco, at the end of his ride.

Also on display at the Caltrans exhibit were automated highway maintenance vehicles from the Advanced Highway Maintenance and Construction Technology Center at UC Davis (AHMCT). Featured were the Advanced Snowplow, which uses the PATH Magnetic Guidance System, and a front loader, cone truck, and herbicide-spray vehicle.

From left to right: Caltrans staffers Jan Hoggatt, Pete Hansra, PATH liaison Greg Larson, Larry Baumeister, Hassan Aboukhadijeh, Bill Okwu, and Asfand Siddiqui with the award, inscribed:

1999 Award of Excellence
CAATS Civic Entrepreneur
presented to the Caltrans Office of
Advanced Highway Systems.

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. The past year saw video and radio production crews from Australia, Britain, Japan, and the US at the Richmond headquarters.

Video and Photo

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. 1999 saw PATH research featured on local, state, national and international, news and documentary programs, and at least one network's wrap-up of the millennium included a fleeting glimpse of PATH automated cars hurtling into the future.

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 car sharing, paratransit, high occupancy vehicle/toll lanes, collision avoidance, intelligent traffic surveillance, advanced traffic control and PATH projects in progress. For a free subscription to *Intellimotion*, contact Bill Stone, Publications Manager–by phone at (510) 231-5601 or by email at bstone@uclink4.berkeley.edu.

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

Recent PATH Publications

Research Reports, Working Papers, and Technical Notes from January 1 - December 31, 1999 are listed below. Those marked with an asterisk (older and more recent publications also) can be found on the World Wide Web at:
http://www.path.berkeley.edu/PATH/Publications

ATMIS

(Advanced Transportation Management / Information Systems)

ATMS (Advanced Transportation Management Systems)

Advanced Image Sensing Methods for Traffic Surveillance and Detection
Art MacCarley
The goal is improved visibility under conditions of fog or dust using wavelengths longer than that of the visible spectral band. Technologies considered included ten types of infrared video cameras and one millimeter-wave still-frame imaging system. Evaluation criteria were structured to reflect the surveillance needs of traffic management center personnel and information needs of computer vision systems.
UCB-ITS-PRR-99-1*
March 1999, 125 pages, $20

Individual Vehicle Speed Estimation Using Single Loop Inductive Waveforms
Carlos Sun, Stephen G. Ritchie
Previously, speeds were mainly acquired from double inductive loops configured as speed traps, since single-loop speed estimates based on assumptions of a constant vehicle length were inaccurate. More accurate measurements can now be accomplished with single loops by utilizing inductive waveforms of vehicles output from newer detector cards. Using the extensive single loop surveillance infrastructure is a cost-effective way of obtaining more accurate network-wide travel time information.
UCB-ITS-PWP-99-14*
October 1999, 31 pages, $10

Empirical Comparison of Travel Time Estimation Methods
Xiaoyan Zhang, John Rice, Peter Bicke
The methods concerned are a regression method based on an intuitive model, and the conventional method of using an identity relating speed, flow, and occupancy with the assumption of a common vehicle length.
UCB-ITS-PRR-99-43*
December 1999, 46 pages, $10

Short Term Freeway Traffic Flow Prediction Using Genetically-Optimized Time-Delay-Based Neural Networks
Baher Abdulhai, Himanshu Porwal, Will Recker
Presents a new short term traffic flow prediction system based on an advanced Time Delay Neural Network model, the structure of which is optimized using a Genetic Algorithm. The model predicts flow and occupancy values at a given freeway site based on contributions from their recent temporal profile as well the spatial contribution from neighboring sites.
UCB-ITS-PWP-99-1*
January 1999, 42 pages, $10

Identifying the Onset of Congestion Rapidly with Existing Traffic Detectors
Benjamin Coifman
Presents a new approach for traffic surveillance using existing dual loop speed detectors. Instead of reporting local conditions at detectors, this new strategy identifies when the link between two detector stations becomes congested. The proposed strategy is shown to be compatible with the existing detector infrastructure. It is intended to augment local measurements made by conventional surveillance strategies.
UCB-ITS-PWP-99-17*
November 1999, 23 pages, $5

Mobile Surveillance and Wireless Communication Systems Field Operational Test. Final Report: Volume 1: Executive Summary
Lawrence A. Klein
This project comprised two evaluation tests, the Anaheim Special Event Test, which assessed the ability of surveillance trailers to transmit video imagery to a traffic management center in support of arterial traffic signal control, and the Interstate-5 Test, which evaluated the ability of the mobile surveillance and ramp meter trailers to transmit video imagery and data in support of freeway ramp metering. This volume describes project objectives, results, conclusions, and recommendations.
UCB-ITS-PRR-99-6
March 1999, 45 pages, $10

Mobile Surveillance and Wireless Communication Systems Field Operational Test. Final Report: Volume 2: FOT Objectives, Organization, System Design, Results, Conclusions, and Recommendations
Lawrence A. Klein
Discusses overall goals and objectives of the FOT and the design of the mobile surveillance and wireless communication system. Specific objectives of the Anaheim Special Event and the I-5 Tests, lessons learned, test results, and recommendations are expanded on. Photographs and drawings are used liberally to illustrate the types of equipment and test configurations that were tested.
UCB-ITS-PRR-99-7
March 1999, 164 pages, $25

Mobile Surveillance and Wireless Communication Systems Field Operational Test. Final Report: Volume 3: Appendices A-J Containing Evaluation Data Gathered During the Anaheim Special Event and I-5 Tests
Lawrence A. Klein
Consists of ten appendices that contain data and other information gathered during the tests.
UCB-ITS-PRR-99-8
March 1999, 471 pages, $50

Vehicle Reidentification and Travel Measurement on Congested Freeways
Benjamin Coifman
Presents a vehicle reidentification algorithm for consecutive detector stations on a freeway. Using this algorithm, a vehicle measurement made at a downstream detector station is matched with a corresponding measurement at an upstream station. Measured vehicle lengths from paired loop detector speed traps are used to illustrate this method. The algorithm rules out unlikely matches, and also eliminates unlikely sequences.
UCB-ITS-PWP-99-18*
November 1999, 23 pages, $5

Visualizing Loop Detector Data
Xiaoyan Zhang, John Rice
The information in large loop detector datasets accumulated over the years by transportation management centers often lies dormant, partly because of the lack of effective means to display the data. We present a simple visualization technique using color-encoded images to visualize loop detector measurements as a function of space and time.
UCB-ITS-PWP-99-21*
December 1999, 11 pages, $5

Evaluation of the Anaheim Advanced Traffic Control System Field Operational Test: Introduction and Task A: Evaluation of SCOOT Performance
James E. Moore, II, M. G. McNally, C. Arthur MacCarley, R. Jayakrishnan
Overview of the federally-sponsored FOT, and of the technical issues associated with the evaluation of SCOOT performance during this test. Summarizes an introduction to the project, the evaluation objectives for Tasks A and B, and Task C of the three part evaluation project. Separate reports summarize Tasks B and C, assessment of institutional issues and the advanced Video Detection Systems, respectively.
UCB-ITS-PRR-99-26
July 1999, 134 pages, $20

Evaluation of the Anaheim Advanced Traffic Control System Field Operational Test: Executive Summary
M.G. McNally, James E. Moore, II, C. Arthur MacCarley, R. Jayakrishnan

The primary FOT objective was the implementation and performance evaluation of adaptive traffic signal control technologies including an existing second generation approach (SCOOT), and a 1.5 generation control (1.5GC) approach under development. Also selected for implementation was a video traffic detection system (VTDS). Both SCOOT and the VTDS were implemented with some degree of success, with technical and institutional issues limiting expected performance.
UCB-ITS-PRR-99-18
July 1999, 15 pages, $5

Predictability of Time-Dependent Traffic Backups and Other Reproducible Traits in Experimental Highway Data

Karen R. Smilowitz, Carlos F. Daganzo
Traffic data from a 4-mile long congested rural road in Orinda, California, are used to show that traffic delays and vehicle accumulations between any two generic observers located inside a road section can be predicted from the traffic counts measured at the extremes of the section. The traffic model does not require "recalibration" on the day of the experiment, and works well despite what appears to be location-specific driver behavior.
UCB-ITS-PWP-99-5*
March 1999, 35 pages, $10

The Access Control Problem on Capacitated FIFO Networks with Unique O-D Paths is Hard

Alan L. Erera, Carlos F. Daganzo, David J. Lovell
This paper is concerned with the performance of multi-commodity capacitated networks with continuous flows in a deterministic but time-dependent environment. It is shown that even if all input functions are smooth, there are instances of the problem with a finite but possibly very large number of solutions.
UCB-ITS-PRR-99-35
November 1999, 5 pages, $5

Advanced Coordinated Traffic Responsive Ramp Metering Strategies

Klaus Bogenberger, Adolf D. May
Introduces different ramp control algorithms, implemented or not implemented, but based on promising new mathematical techniques. 17 different approaches are described.
UCB-ITS-PWP-99-19*
November 1999, 54 pages, $15

Implementation of Advanced Techniques for Automated Freeway Incident Detection

Baher Abdulhai, Stephen G. Ritchie, Mahadevan Iyer
This project extended existing freeway incident detection research conducted by both PATH and under the UC Irvine ATMS Testbed Research Program. A probabilistic neural network was integrated into the Testbed for on-line operation on the testbed network in Southern California. The PNN was then started on-line on a five-mile section of Interstate 405 for monitoring and testing.
UCB-ITS-PRR-99-42*
December 1999, 50 pages, $10

High Occupancy Vehicle/Toll Lanes: How Do They Operate and Where Do They Make Sense?

Joy Dahlgren
Examines the circumstances in which HOT lanes could provide a more desirable alternative to HOV lanes. In most cases modeled, a HOT lane results in substantially less delay than an HOV lane. It also performs better or almost as well as a mixed flow lane. In locations where tolling would be feasible and where HOV lane utilization is low, HOTs might be a preferable alternative to the HOV lane.
UCB-ITS-PWP-99-8*
June 1999, 31 pages, $10

Simulation of ITS on the Irvine FOT Area Using Paramics 1.5 Scalable Microscopic Traffic Simulator: Phase I: Model Calibration and Validation

Baher Abdulhai, Jiuh-Biing Sheu, Will Recker
Presents an attempt towards the calibration, validation, and evaluation of Paramics 1.5, a microscopic traffic simulator designed for modeling Intelligent Transportation Systems (ITS) in Southern California. The study also attempts to compile a list of attributes that a successful traffic simulator should posses in order to model ITS.
UCB-ITS-PRR-99-12*
April 1999, 64 pages, $15

ATIS (Advanced Traveler Information Systems)

Evaluation of the OCTA Transit Probe System

Randolph W. Hall, Nilesh Vyas, Chintan Shyani, Vikas Sabnani, Simit Khetani
The Orange County Transit Authority (OCTA) Transit Probe Project is a field operational test of an automatic vehicle location system. This report provides a detailed description of the system and the motivation for its design, analyses of data reliability and accuracy, and analysis of the usefulness of transit probe data for predicting automobile travel times.
UCB-ITS-PRR-99-39
November 1999, 119 pages, $20

Ventura/Lompoc Smart Card Demonstration Evaluation: Final Report: Volume 1–Technical Performance, User Response, and Institutional Analysis

Genevieve Giuliano, James E. Moore II, Jacqueline Golob
Presents evaluation results of the Smart Card Phase III Field Demonstration, the purpose of which was to demonstrate the feasibility of using Smart Cards and other technology to provide an integrated fare medium across several transit operators. Despite deployment problems, participating agencies were generally enthusiastic about the technology, and ultimately it became a permanent part of transit operations in the county.
UCB-ITS-PRR-99-30
August 1999, 267 pages, $35

Event-Based ATIS: Practical Implementation and Evaluation of Optimized Strategies (Part I)

R. Jayakrishnan, Wei K. Tsai, Jun-Seok Oh, Jeffrey Adler
This research focuses on finding an optimal routing scheme, using algorithms which focus on changeable message sign (CMS) routing. Static network optimization and dynamic stimulation approaches are used to find the optimal routing scheme. A framework is created that is designed for use in event-based congestion management.
UCB-ITS-PWP-99-7
June 1999, 61 pages, $15

Daily Activity and Multimodal Travel Planner: Phase II Final Report

Ryuichi Kitamura, Cynthia Chen, Jiayu Chen
The goal is to develop an "Itinerary Planner" that attempts to identify the most desirable itinerary, desirability being a weighted sum of seven criteria (i.e., total travel time and monetary cost). It is demonstrated that the Planner is capable of effectively generating alternative itineraries for a tour that involves multiple trips and multiple modes, with complex constraints, and that the Planner prototype serves as a practical tool for travelers in itinerary planning.
UCB-ITS-PRR-99-1*
January 1999, 87 pages, $15

Evaluation of Caltrans District 10 Automated Warning System (CAWS): Year Two Progress Report

Art MacCarley
District 10 encompasses an area of seasonal fog and dust-related visibility problems that have caused many fatal collisions. CAWS, which includes remote meteorological stations and changeable message signs, is currently being evaluated by PATH. This report summarizes the technological and operational evaluations.
UCB-ITS-PRR-99-28*
August 1999, 79 pages, $15

Market for Traffic Information - A Study of Industry Structure and Prospects

Shirley Chan, Matthew Malchow, Adib Kanafani
Examines the structure and operation of the traffic information industry and the behavior of the industry's participants. Gives an overview of the commercial traffic information services in the US, followed by an analysis of the nature of the traffic information industry. Investigates what kinds of enterprise activities and arrangements would best meet traveler needs, including the role of public agencies that are concerned with system management.
UCB-ITS-PRR-99-17
June 1999, 29 pages, $10

Some Aspects of the Market for Broadcast Traffic Information

Matthew Malchow, Adib Kanafani
Examines the market for broadcast

traffic information in the US. Focuses on supply and demand curves representing the behavior of information providers and broadcast stations in determining the level of output to be consumed. Potential roles for public involvement are investigated based on different scenarios and situations.
UCB-ITS-PWP-99-9
June 1999, 18 pages, $5

APTS (Advanced Public Transportation Systems)

Spatial and Temporal Factors in Estimating the Potential of Ride-Sharing for Demand Reduction

H.-S. Jacob Tsao, Da-Jie Lin
Can current population density, origin-destination distribution, pick-up and drop-off delays, departure time distribution, and deviation from preferred departure time support a sizable carpooling population that can reduce traffic demand? Under the assumptions made in the paper, carpooling among unrelated partners (i. e. interhousehold carpooling) has little potential for demand reduction.
UCB-ITS-PRR-99-2*
January 1999, 62 pages, $15

Bus Operations in Santa Clara County, Potential Uses of AVL, and Framework for Evaluating Control Strategies

T. Chira-Chavala, David Gillen, Lee Klieman, Amy Marshall
The Santa Clara (California) Valley Transportation Authority (VTA), is currently installing automatic vehicle location (AVL) equipment on its bus fleet. This report presents the results of Phase 1 research, which examines the various performance and operational characteristics of the fixed-route bus system with an eye to identifying performance characteristics that could be improved utilizing AVL, (and without using it), transit, bus, schedule adherence, transfer coordination, control strategy, passenger waiting time, passenger information, transit information, transit performance, automatic vehicle location, AVL.
UCB-ITS-PRR-99-25*
July 1999, 126 pages, $20

Towards an Accessible City: Removing Functional Barriers to Independent Travel for Blind and Vision Impaired Residents and Visitors

Reginald G. Golledge, James R. Marston
Describes a study that examined the impact of Remote Infrared Signage Systems on the performance of blind or vision-impaired people in using buses. Auditory messages were transmitted by the Remote Infrared Signage Systems. The value of the systems were seen in reduced anxiety and increased confidence levels for performing different spatial tasks.
UCB-ITS-PRR-99-33*
September 1999, 34 pages, $10

Evaluation of ITS Technology for Bus Transit Systems

Randolph Hall, Maged Dessouky, Lei Zhang, Ajay Singh, Vishal Patel
Transit service providers have recently begun to adopt ITS technologies such as global positioning systems (GPS) and mobile data terminals. We evaluate bus control strategies using ITS against those without ITS. Results of a simulation analysis show that ITS-based strategies have the potential to improve connectivity between origins and destinations while reducing passenger waiting times.
UCB-ITS-PRR-99-38
November 1999, 119 pages, $20

User's Manual for Transit ITS Simulator (TRAN-ITS)

Maged Dessouky, Lei Zhang, Ajay Singh, Randolph Hall
Describes a simulation model that was used to evaluate the impact of Intelligent Transportation Systems (ITS), such as Global Positioning System (GPS), on bus tracking and bus control in wide-area transit networks. Bus control strategies using ITS were evaluated against those without ITS.
UCB-ITS-PWP-99-13
September 1999, 34 pages, $10

Dynamics in Behavioral Adaptation to a Transportation Innovation: A Case Study of CarLink–A Smart Carsharing System

Susan A. Shaheen
Uses new survey research methods to determine how the use of information and communication technologies can enhance flexibility and mobility, and what value travelers will place on new transportation methods. Integrates social marketing and learning theories with human activity analysis approaches to explain these processes.
UCB-ITS-PRR-99-41*
December 1999, 469 pages, $50

Assessing Opportunities for Intelligent Transportation Systems in California's Intermodal Operations and Services – Review of Literature

Mark Miller, Camille Tsao
This literature review was performed to help develop a baseline knowledge of California's current passenger intermodal services and operations, to find methods for evaluating intermodal performance, and to assess how intelligent transportation systems have already been applied to intermodal systems in both the United States as well as internationally.
Tech Note 99-1*
August 1999, 17 pages, $10

Decision Support and Benefit/Cost Analysis

Evaluation of the Anaheim Advanced Traffic Control System Field Operational Test: Final Report Task B; Assessment of Institutional Issues

M. G. McNally, James E. Moore, II, C. Arthur MacCarley, R. Jayakrishnan
Summarizes Task B of the three part evaluation project. Institutional factors included inconsistent project management due to staff changes and delays due to contractual issues. Both SCOOT and a modified version of the VTDS are in current use in selected areas, with plans for system expansion.
UCB-ITS-PRR-99-27
July 1999, 114 pages, $20

Southern California Intelligent Transportation System Priority Corridor Action Summary

Thomas Horan
Describes short-term actions which are necessary for achieving the recommendations set forth in the previously issued Strategic Guide. The actions focus on: 1) emphasizing short-term deployment of ITS transportation services; 2) standards needed for enhancing corridor transportation services; and, 3) emphasizing the institutional arrangements needed to facilitate Corridor Network ITS deployment
UCB-ITS-PWP-99-12
September 1999, 28 pages, $10

PATH ATMIS State of the Research Annual Report Fiscal Year 1998-1999

Robert Tam
Brief project descriptions state the objectives of the project and outline its status and some of its principal results. Taken together, the collection should give a reader an overview of the entire program. In general we have described only projects which are completed or have produced specific results and reports.
UCB-ITS-PWP-99-15,
October 1999, 36 pages, $10

Evaluation Methodologies for ITS Applications

David Gillen, Jianling Li
Presents a framework for conducting benefit-cost analyses of Intelligent Transportation Systems (ITS) projects. For each benefit-cost analysis, impact analysis, and cost effectiveness analysis, the authors discuss the orientation, scope, strength and weakness, decision criteria, and basis of evaluation. The quantity of benefits and how they can be measured, calculated, or forecast are then described.
UCB-ITS-PWP-99-2
February 1999, 145 pages, $25

Decision-Oriented Framework for Evaluating Deployment Strategies for Intelligent Transportation Systems

H.-S. Jacob Tsao
Deployment issues may limit design options for ITS concepts and technologies and, hence, can be viewed as constraints on ITS research and development. This paper develops a framework to help recognize and organize such issues. The findings can be used in developing deployable ITS concepts and technologies, and in deploying ITS technologies already developed.
UCB-ITS-PRR-99-4*
February 1999, 41 pages, $10

Identification and Prioritization of Environmentally Beneficial Intelligent Transportation Technologies: Modeling Effort

Troy Young, Daniel Sperling, Susan Shaheen

Objectives were to review previous environmental assessments of ITS, review regulatory and policy contexts encompassing ITS, develop a modeling framework suitable for assessing short-term impacts of ITS, identify ITS technologies with positive environmental effects, and ranked those technologies according to their energy and emission benefits.

UCB-ITS-PWP-99-20*

December 1999, 26 pages, $10

California System Architecture Study: Architecture for Action: A Strategy for Facilitating Near-Term Deployment

Thomas A. Horan, Lawrence Jesse Glazer, Christopher Hoene, Randolph Hall, Christopher Intihar, Ronald Ice

Identifies challenges to ITS deployment in California and offers recommendations for overcoming them. Analysis is based upon an extensive literature review, interviews, and focus groups conducted with over seventy-five transportation professionals from around the State. We recommend a decentralized, evolutionary strategy we call "Architecture for Action" – decentralized through an emphasis on increased regional and local authority, evolutionary in its focus on developing the architecture around near-term deployment.

UCB-ITS-PRR-99-3*

February 1999, 173 pages, $25

Assessing the Benefits and Costs of Intelligent Transportation Systems: Ramp Meters

Seungmin Kang, David Gillen

The impact of ramp metering on traffic behavior is simulated based on a cell transmission model and an assumed travel demand on the freeway as well as the ramp. Temporal travel demand change is determined based on the average travel pattern obtained from the I-880 freeway database. We identify and quantify the benefits and costs based on established assumptions, and analyze the economic value of ramp metering.

UCB-ITS-PRR-99-19*

July 1999, 51 pages, $15

Assessing the Benefits and Costs of Intelligent Transportation Systems: The Value of Advanced Traveler Information Systems

David Levinson, David Gillen, Elva Chang

ITS technology such as in-vehicle navigation systems can reduce travel time and vehicle operating costs, but at a social cost, e. g., increased demand for travel. After reviewing the literature on information and travel behavior and on the value of time, this paper explores the effects of systems from a theoretical economic perspective and then simulates stylized cases

UCB-ITS-PRR-99-20*

July 1999, 67 pages, $15

Assessing the Benefits and Costs of ITS Projects: Volume 1–Methodology

David Gillen, Jianling Li, Joy Dahlgren, Elva Chang

A framework for evaluating ITS projects is developed. We reach two fundamental conclusions: first, agencies need to put in place an information system that is oriented to the collection of more business and economic data to establish a database for evaluating future ITS projects. Second, there would be great value in estimating some well constructed demand models associated with ITS transportation projects.

UCB-ITS-PRR-99-9*

March 1999, 30 pages, $10

Assessing the Benefits and Costs of ITS Projects: Volume 2–Application to Electronic Toll Collection

David Gillen, Jianling Li, Joy Dahlgren, Elva Chang

Cost estimation is relatively easy, but benefit estimations require sophisticated assumptions and modeling techniques, since different assumptions and modeling techniques will result in different inputs for calculation of benefits. ITS project evaluators should be fully aware of these limitations There is an urgent need to collect data from ITS deployments and developing models that can be used to accurately predict demands and benefits of ITS applications.

UCB-ITS-PRR-99-10*

March 1999, 97 pages, $15

AVCSS/AHS

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

Vehicle Control Experiments and Field Tests

Design of a Controller for a Following Vehicle in an Emergency Lane Change Maneuver

D. Swaroop, Seok Min Yoon

A lane change maneuver is one of the many appropriate responses to an emergency situation. This paper considers the design of an integrated lateral and longitudinal controller that enables a following vehicle to track the lead vehicle's trajectory, while maintaining a desired following distance. A sliding mode controller is developed for this purpose and its performance is demonstrated in simulations.

UCB-ITS-PWP-99-3*

February 1999, 16 pages, $5

Intelligent Cruise Control System Design Based on a Traffic Flow Specification

D. Swaroop, R. Huandra

An Intelligent Cruise Control (ICC) algorithm, if implemented by every vehicle in the traffic, must guarantee that density disturbances attenuate as they propagate upstream. Such a property is dependent on the spacing policy employed by automated vehicles. Part I investigates the design of a spacing policy: Part II is concerned with synthesizing an ICC algorithm for automated vehicles.

UCB-ITS-PRR-99-5*

February 1999, 25 pages, $5

Fault Diagnosis and Management

Diagnosis and Communication in Distributed Systems

Raja Sengupta

Examines diagnosis and communication problems in distributed systems within the context of a language-theoretic discrete event formalism. Distributed systems are examined and plant properties as they relate to diagnosis are derived. Findings from this study can be applied to the diagnosis of failures in a wireless local area network (LAN) that is used to support the real-time operation of automated vehicles.

UCB-ITS-PRR-99-16

May 1999, 18 pages, $5

Fault Diagnosis for Intra-Platoon Communications

Hidayet Tunc Simsek, Raja Sengupta, Sergio Yovine, Farokh Eskafi

Presents the design and logical verification of a fault diagnosis and monitoring system for intra-platoon communication systems. The second part presents a general framework for the simulation, verification, and implementation of real time control algorithms for intelligent vehicles and highways.

UCB-ITS-PRR-99-24*

July 1999, 49 pages, $10

AHS Safety Analysis and Simulation

Models of Vehicular Collision: Development and Simulation with Emphasis on Safety V: MEDUSA: Theory, Examples, User's Manual, Programmer's Guide and Code

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

MEDUSA can simulate both the normative driving dynamics and collision dynamics of an arbitrary number of vehicles. This report presents the vehicle and road models, including tire, collision, suspension, and sprung mass models. Also contains the simulation results of several representative vehicular collision scenarios.

UCB-ITS-PRR-99-32*

August 1999, 124 pages, $20

Simulation and Animation Tools for Analysis of Vehicle Collision: SMAC (Simulation Model of Automobile Collisions) and Carmma (Simulation Animations)

Bruce Hongola, Ching-Yao Chan

Describes the functional capabilities of computer programs. SMAC has been used extensively in recent work at PATH to investigate the consequences of vehicle collisions

and the effects of vehicle-following parameters on collisions. Carmma can animate simulations. This document constitutes a simple yet thorough manual for the research tools developed for the subject matter.
UCB-ITS-PWP-99-10*
July 1999, 9 pages,$5

Studies of Vehicle Collisions - A Documentation of the Simulation Codes: SMAC (Simulation Model of Automobile Collisions) Update 1

Ching-Yao Chan
Focuses on vehicle collisions in vehicle-following operations. Contains documentation for the computer program (SMAC), the core element of simulation tools for vehicle collision dynamics. The structure of the program is outlined with descriptions of the major subroutines. Added options for implementing user-specified steering inputs and feedback controllers are explained.
UCB-ITS-PWP-99-4*
March 1999, 10 pages, $5

Safety and Capacity Analysis of Automated and Manual Highway Systems

Jason Carbaugh, Datta N. Godbole, Raja Sengupta
Compares safety of automated and manual systems with respect to resulting rear-end collision frequency and severity. Results show that automated driving is safer than the most alert manual drivers, at similar speeds and capacities.
UCB-ITS-PRR-99-36*
November 1999, 33 pages, $10

Communication Systems

Address Resolution in One Lane Automated Highway Systems

Soheila V. Bana and Pravin Varaiya
Address Resolution Protocols (ARP) are used in Automated Highway System inter-vehicle communication to determine the network address of neighboring vehicles. We are proposing an innovative solution that takes advantage of the automated road infrastructure for providing addresses initially and then uses the communication network itself for updating the network communication addresses in a one lane automated highway system.
UCB-ITS-PRR-99-22*
July 1999, 35 pages, $10

Position Location in AHS by Magnetic Pseudo-Noise Signals

Soheila V. Bana and Pravin Varaiya
This research proposes a novel method for position location by automated vehicles, similar to GPS in the sense of using pseudo-noise codes for range measurement. The phase of a pseudo-noise signal can be mapped to the receiver's range from a reference point where the signal correlation properties insure accurate phase estimation. The magnetic markers that are installed on the road for vehicles' lateral control are proposed as the medium to carry the signal.
UCB-ITS-PRR-99-21*
July 1999, 21 pages,$5

Simple Results on Communication With Neighbors

Anuj Puri and Pravin Varaiya
In this research we consider the question of whether it is possible to build an address finding protocol that uses only such information as intervehicle distances. We prove that no such protocol can exist. A proposed protocol that uses the absolute location of vehicles may be considered to be information-wise optimal.
UCB-ITS-PRR-99-23*
July 1999, 6 pages, $5

Network Layer for Intelligent Vehicle Highway Systems

Farokh Eskafi, Marco Zandonadi
In this research we describe the network layer of a communication stack to be used in Automated Highway Systems (AHS). The communication model we propose allows cars to form private subnets. Each car can be part of multiple subnets and can send broadcast, multicast and point-to-point messages to other vehicles. Each subnet is managed by a server: a car that is in charge of accepting/rejecting join requests and of keeping a consistent state within the subnet.
UCB-ITS-PWP-99-11*
July 1999, 10 pages, $5

Aerodynamics

Transient Aerodynamic Effects on a Four-Car Platoon During Passing Maneuvers: Data Summary

L. Tsuei, J. K. Hedrick, Ö. Savas
We examined transient aerodynamic effects experienced by a platoon when a single car passes by. Wind tunnel experiments were conducted. Four factors were investigated: mobile model's direction; relative velocities between the mobile model and the platoon; lateral spacings between the mobile model and the platoon; and, the shapes of the mobile model.
UCB-ITS-PRR-99-29
August 1999, 118 pages, $20

Collision Avoidance Analysis for Lane Changing and Merging

Hossein Jula, Elias B. Kosmatopoulos, Petros A. Ioannou
We calculate the minimum longitudinal spacing that vehicles performing a particular lane change/merge scenario should initially have so that no collision takes place during the maneuver. Simulations of a number of examples of lane changing maneuvers are used in order to demonstrate the results. Sensors and equipment on board vehicles could use our results to assess the safety of lane changing maneuvers and warn drivers of imminent collisions, or take evasive actions.
UCB-ITS-PRR-99-13*
May 1999, 45 pages, $10

AVCSS Concepts

Analysis of Traffic Flow with Mixed Manual and Semi-automated Vehicles

Arnab Bose, Petros Ioannou
Analyzes the effects on traffic flow characteristics and environment when semi-automated vehicles with automatic vehicle following capability operate in the same lane with manually driven vehicles. Demonstrates the beneficial effect of semi-automated vehicles in mixed traffic in improving air quality and fuel consumption. Due to the randomness and uncertainties of human driving, the numbers obtained are valid qualitatively.
UCB-ITS-PRR-99-14*
May 1999, 46 pages, $10

Other pre 1999 projects

Validation of the Incremental Transfer Model

Tim Lawson, Wei-Hua Lin, Michael Cassidy
The authors validate an Incremental Transfer (IT) model, a macroscopic traffic flow model that is capable of handling freeway systems with special lanes and priority vehicles. The model predicts separate versus coalesced queues that result from capacity reduction on the exit ramp. The focus of the validation is to examine the extent to which the queuing pattern observed in the field is captured by the model.
UCB-ITS-PWP-99-16
October 1999, 72 pages, $10

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

Jitendra Malik, Jana Kosecka, Camillo J. Taylor, Philip McLauchlan
Describes the application of computer vision techniques to the control of an autonomous highway vehicle. Focuses on various feedback strategies where measurements obtained from vision at some look-ahead distance are used directly for control. Also presents initial results comparing the quality of vision range measurements with a scanning laser radar sensor system.
UCB-ITS-PRR-99-37*
November 1999, 33 pages, $10

Parametric Study of Platoon Dynamics and Robust H∞ Controller Design

Pahngroc Oh, Andy Packard, Benson H. Tongue
A comprehensive simulation capability is presented for the analysis of platoons. A separate collision module is integrated within the platoon simulation package to allow the recognition and dynamic simulation of intra-platoon collisions. An alternative control strategy, one based on H∞ optimization, is described.
UCB-ITS-PRR-99-40
November 1999, 54 pages, $15

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

Farokh H. Eskafi

Presents a framework for the modeling, design, simulation, verification, and prototyping of large scale systems. The framework uses a set of tools that model the system, analyze, verify, and simulate a control design, and generate a code that can be run in a target real-time software platform. The QNX real-time operating system, which is currently in use in the California PATH program in automated vehicles, is used as the target platform for the generated code.

UCB-ITS-PRR-99-15*

May 1999, 19 pages, $5

Regulation Layer Software Integration

Akash R. Deshpande

This research develops PATH vehicle control technology into a second generation by refining and restructuring it to meet the future demand on regulation layer functionality. This development combines experience with formal methods-based approaches for the design and implementation of real-time control systems. Our work introduces benefits such as tighter system integration, event-oriented system behavior, and fault management capabilities.

UCB-ITS-PRR-99-34

November 1999, 95 pages, $20

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The California PATH Database provides access to the largest and most comprehensive collection of bibliographic information on Intelligent Transportation Systems (ITS). The Database is now accessible on the Internet through a partnership between the California PATH Program and the Transportation Research Board.

The Database, created in 1989, is sponsored by Caltrans and the Federal Highway Administration. It is maintained by the Harmer E. Davis Transportation Library (HEDTL) at the Institute of Transportation Studies, University of California at Berkeley. The web site is administered by the Transportation Research Board and is updated monthly.

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The Database contains references to all aspects of Intelligent Transportation Systems, ranging from historical materials dating back to the 1940s to topics of current and international research and applications. It reflects a wide coverage of information on ITS, including monographs, journal articles, conference papers, technical reports, theses, web sites, and selected media coverage. Currently, there are nearly 20,000 records with abstracts contained in the Database. Full bibliographic information is provided, and URLs are included for documents that are available in electronic format. The majority of the indexed items are held at the Harmer E. Davis Library.

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For information regarding the availability of documents held at other University of California at Berkeley libraries, go to:
http://www.lib.berkeley.edu/ILS/nonuc.html

Loans and photocopies of materials are available to persons affiliated with the University of California and California PATH sponsors. For others, information on interlibrary loans or photocopies may be obtained at the HEDTL web site. Questions regarding the Database may be directed to:
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