PATH Project Milestone:

4-Car Platoon Demos a Significant Step for IVHS

PATH’s multiple vehicle-following project has been busy showing California just what it’s made of. After successfully demonstrating the capabilities of a two-car platoon system last January, development of the four-car system culminated in recent performance tests on the I-15 HOV lanes north of San Diego, CA. Demonstration rides in the four-vehicle platoon were given to 15 visitors from the Federal Highway Administration (FHWA) on May 16 and to FHWA Administrator Dr. Thomas D. Larson and FHWA Region IX Administrator Ed Wood on July 9.

Testing Procedure
The experiments put together by PATH researcher Dr. Kwang Soo Chang and others included two different tests: one in which the lead vehicle traveled at a constant speed of approximately 55 mph; and another, the “acceleration/deceleration” test, in which the platoon speed was varied between 55 and 75 mph. In both experiments, the lead vehicle performed under manual control, while the three following cars operated under automatic longitudinal control. In both cases, the spacings between consecutive vehicles were maintained within about 1 meter of the required 9 meter spacing, with good ride quality.

Components of a Four-Vehicle Platoon System
Each of the four platoon vehicles provided by the Ford Motor Co. is equipped with an IPCS (Integrated Platoon Control System) unit. The IPCS is made up of a computer (IBM PC compatible, 386 model); a communication system; a radar system; sensors measuring and monitoring speed, acceleration, throttle angle, brake pressure, engine speed, intake manifold pressure, and intake manifold temperature; and actuators (throttle and brake). The interface to sensors and actuators is provided by the data acquisition board. The sampling of each channel is performed at a rate of 20 Hz, with the control loop also running at the same rate.

The radar system (provided by VORAD Safety Systems, Inc.) consists of a radar antenna and signal processing unit which measures the distance

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Rethinking California’s Transportation Plan

-A Word from Director Donald E. OUne

When PATH was first set up, many researchers believed that high-speed, close-headway platooning and advanced electric propulsion offered the greatest potential for alleviating traffic problems. Today, the picture has been clarified. These technologies remain long-term goals, increasing recognition is given to the importance of intermediate products such as collision warning avoidance devices and advanced travel information systems.

These intermediate products are necessary to sustain public support for continuing research and development. And while they do not improve traffic flow to the same dramatic extent as fully automated systems, they do increase driver safety, comfort, and convenience. Moreover, the data gathered from the development and implementation of these technologies will help to push us towards the longer-term goals.

All of this adds up to the need for an evolution in the perception of PATH’s role in the increasingly complex field of IVHS research. The dilemma is that PATH’s wishes to diversify without becoming unfocused and dilute.

Part of the answer lies in developing a strategic plan for improving California’s transportation system (similar to that developed by IVHS America). Tactical planning to secure the overall strategic goals is also essential. Strategic planning for California should be led by Caltrans, and should encompass all of their advanced technology programs (e.g., high-speed rail, tiltrotor aircraft). The IVHS segment of this overall plan will then become a key document in guiding the PATH program. In this way, both the sponsor (Caltrans) and the contractor (PATH) will have input into the “game plan” for California’s transportation future.

The strategic planning process is in fact underway. Recently, I facilitated two Caltrans-sponsored workshops to help outline an “action plan” that includes overall strategy as well as such tactical elements as budgeting and scheduling. Participants in these workshops included Caltrans program managers, transportation research directors from four California universities, PATH management, a national laboratory’s IVHS director, and three major defense/aerospace contractors. All participants worked together enthusiastically to produce a strong outline for a statewide program.

The final “action plan” document has been drafted and will soon be discussed with top management in Caltrans. Follow-through will include periodic plan upgrades and regular progress monitoring.

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Project Leader Dr. Kwang Soo Chang illustrates major components of a platoon vehicle as Dr. Steven Shladover, Dr. Thomas Larson, and Ed Wood look on.

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Project Milestone:

Multiple Vehicle-Following Demos

- A Word from Director Donald E. Oune

between two vehicles as well as the closing rate using the Doppler effect.

VORAD also designed throttle and brake actuators for the automatic vehicle control. To actuate the throttle, a stepper motor was installed with a connection to the throttle valve. The brake actuator is presently in development. Until now, all experiments were performed using the throttle actuator without brake actuation.

The control algorithm requires data to be transmitted from one vehicle to another. To accomplish this, a communication link between the two vehicles was designed using the off-the-shelf components. This approach includes a radio antenna mounted on the roof of each vehicle, a PROXIM digital transceiver, and a Metacom communication interface board. Communication is half-duplex, which means that transmitted data is not echoed back for error comparison purposes. Using a radio link through spread-spectrum digital radio transceivers, the speed and acceleration measurements of the lead vehicle are transmitted to the following vehicle. The controller in the following vehicle uses these measurements to calculate the proper actuation commands to the throttle or brake depending on the lead vehicle’s position, velocity and acceleration. Each vehicle in a multi-vehicle platoon transmits its own information in sequence, so that they do not interfere with each other.

Communication and Control

VORAD’s work on longitudinal control has emphasized the concept of vehicle-following control over that of point-following control. Using inter-vehicle communication links as well as direct measurements, a platoon of closely spaced vehicles can be precisely controlled to provide the desired spacing. The measurements transmitted from the lead vehicle are used to cancel the accumulated effects of time delays and lags on the inter-vehicle spacing control.

The Next Phase

Although these recent four-car platoon tests proved successful in many ways, Chang and fellow researchers are once again behind the wheel of the project, preparing for the next phase, where they plan to work on a variety of elements including: brake actuator implementation; “pseudo-pulse” radar sensor enhancements; more accurate speed sensor implementation; torque converter modeling; tire slip modeling; intelligent cruise control design; alternative sensor evaluations (e.g., ultrasonic, lidar, etc.) and more.

Acknowledgments

This PATH project was made possible by financial support from Caltrans, RWA, and the National Highway Traffic Safety Administration, and by the participation of staff from U.C. Berkeley, VORAD Safety Systems, Ford Motor Company and the Automobile Club of Southern California.

The efforts of Dr. Kwang Soo Chang were joined by PATH research scientist Devlin, Professors Karl Hedrick and Pravin Varaiya, and their U.C. Berkeley graduate students. In addition, members of staff from Caltrans and VORAD Safety Systems contributed to the success of this demonstration phase.
Ranging Sensor Technology Continues to Make Headway

Some of the hard work done on vehicle-following components is paying off. This July marks the on-schedule completion of the first phase of the research and development of one of the distance sensors for PATH's longitudinal vehicle control projects. U.C. Berkeley Professor Jean Walrand heads the research team working in conjunction with Qualimatrix, a local designer and manufacturer of optoelectronic measurement systems chosen to develop and test different sensor models.

State Professor Walrand, "In the past, sensor performance proved to be the area of weakness in vehicle-following tests. Yet a reliable, inexpensive, accurate, and fast distance sensor is a crucial component for platooning." Since currently available sensors did not seem to fulfill the necessary requirements, Qualimatrix began work on two promising designs.

The DSPT (Distance Sensor with Passive Target) was developed based on an existing Optocilor® design (i.e., an opto-electronic, non-contact measuring device). This model incorporates a laser diode which emits an infrared beam modulated at a selected frequency (e.g., 10,000 Hz), and uses laser beam triangulation to measure distance. The system consists of a pulse-modulated laser source, a receiver consisting of a focusing lens and a one-dimensional, high-resolution, position-sensitive detector (PSD).

An alternative design is the DSAT (Distance Sensor with Active Target). This device incorporates an infrared LED or Laser Diode source mounted on the target and an optical receiver mounted on a fixed or reference platform. The receiver consists of two optical subsystems separated by a baseline distance. One optical subsystem has a focusing lens and a PSD (position sensitive detector). Light from the active target is imaged on each PSD and a distance is calculated from the known, constant values in the geometry. The DSAT is comprised of one active target and two lenses. Although both sensors provide benefits, developers favor the DSAT model. "The biggest advantage of this design is the increased signal-to-noise ratio provided by the active target," says Walrand. "The main limitation of the DSPT sensor is its dependence on optically reflective surfaces to produce reliable, repeatable range data. The DSAT will have the ability to operate over greater distances than the DSPT sensor with less uncertainty, and will also be less affected by adverse environmental conditions."

Laboratory tests to date show that the DSAT will be capable of determining distances in the range of 2-20 meters. Qualimatrix proposes to modify the sensor so that it will be accurate over longer distances (20-200 feet). Furthermore, by evaluating various commercially available parts, designers hope to keep packaging and use costs down.

The next step proposed in sensor development includes testing within an on-site environmental simulation chamber. In addition, the system would be packaged for use on actual test vehicles.

Although the ultimate applicability of these sensors requires additional testing, groups like Qualimatrix are working alongside PATH's research team to advance the state of vehicle-following projects.

The information for this article was derived from a proposal entitled "PATH Optical Ranging System Development" by Qualimatrix and Dr. Joan Walrand of U.C. Berkeley.

New Project Proposal

Over the last several months, a group of PATH researchers has been working with Caltrans, the Metropolitan Transportation Commission and the private sector to develop a plan for a Bay Area ATS testbed.

Created as a partnership between the public and private sectors, this project is aimed at enabling widespread dissemination of real-time information about travel conditions and options. The fundamental premise of the testbed is that a traffic surveillance and public database system designed to open-architecture standards will be the most effective stimulus for private sector innovations in technology development and, ultimately, in their deployment.

When complete, the testbed infrastructure will include state-of-the-art surveillance systems including probe vehicles, loop detectors and video-imaging processing; public databases designed to open-architecture standards enabling third-party delivery of traveler information; models for real-time prediction of future travel conditions; and systems for communicating to travelers during pre-trip and en route.

The system's public database will contain up-to-the-minute information on all available travel options, including automobile, bus and rail. Eventually, it will also contain specialized information for commercial vehicles, such as waiting times at toll plazas.

The ATIS testbed is designed to take full advantage of both private and public sector partnerships, with the State of California chiefly responsible for the development and operation of the databases and surveillance systems. The private business sector will have major responsibility for the development and deployment of technologies for information delivery.

As part of this effort, U.C. Berkeley PATH researchers and Byrant Yim and Randy Hall have submitted a comprehensive research plan to Caltrans. Elements of this plan include annual surveys of a panel of travelers, system modeling of traffic networks and field operational testing of new technologies.

The university-based PATH program will be responsible for research, testing and evaluation of information technologies. By establishing this public-private partnership, the testbed is expected to catalyze the growth of an ATIS industry, and to overcome the institutional barriers that have slowed the diffusion of ATIS technologies. In addition, this project will allow for the development and testing of ATIS standards, which can eventually be used by developers throughout the country.

For information on this project, please contact Randy Hall at 510/238-9495.
Much Adieu...
P A T H Publications regretfully bids farewell to Anna Marie Bozzi, who has accepted a position as Associate Marketing Communications Manager at Applied Biosystems, Inc. in Foster City, CA. In the nearly 3 years Ms. Bozzi worked with PATH, she developed a solid marketing communications program, producing a series of useful tools including this newsletter. Her efforts helped to promote national and international awareness of this organization, benefiting PATH partners worldwide. Ms. Bozzi was also responsible for planning and coordinating the successful PATH/Caltex exhibits at the recent IVHS America meeting in Newport Beach, CA. PATH is deeply grateful for her valuable management and teaching skills. Her leadership, dedication and expertise will be sorely missed. We wish Anna all the well-deserved success in her new position.

Cal's ITS Extension Offers New Course in ATMS/AVCS

Cal's Institute of Transportation Studies Extension Programs is offering a course entitled "IVHS Applications of Advanced Traffic Management and Advanced Vehicle Control Systems" in the fall of 1992. The course will take place first on October 23-25 at the Radisson Plaza Hotel in Irvine, CA, and again on October 26-28 at the U.C. Museum at Blackhawk in Danville, CA. This U.C. Extension offering is designed for personnel with backgrounds in transportation, planning, automotive or electronic engineering, or related disciplines who are employed by private firms or public sector agencies.

Karl Hedrick, Professor of Mechanical Engineering at U.C. Berkeley; Michael Van Aerde, Professor of Civil Engineering at Queen's University in Kingston, Ontario; and Pravin Varaiya, Professor of Electrical Engineering & Computer Science at U.C. Berkeley are teaching the course, which is divided into two parts. The first focuses on ATMS and includes an overview of potential ATMS strategies for urban traffic flow, in congested signalized networks and freeway corridors, as well as in-depth examinations of how to develop these strategies and evaluate their cost-effectiveness. The course emphasizes strategies for real-world dynamic networks in which a mixture of both real-time and fixed-time controls are deployed. Sample strategies are demonstrated and evaluated using the INTEGRATION simulation model as part of the case studies. ATMS topics and analytical techniques include:
- Fixed-time vs. SCOOT-like signal control
- Isolated vs. coordinated ramp metering
- Incident detection and response
- Dynamic traffic diversion and assignment
- Generation of synthetic origin-destination data
- FHWA and bus priorities
- System vs. user oriented optimization
- Integrated control and IVHS

The second part of this course aims to familiarize participants with the systems concept and with developments in and potential applications of AVCS. Topics include:
- IVHS system architecture
- Communication technology
- Sensors
- Longitudinal control
- Lateral control
- Vehicle maneuvers
- Automated highway simulation
- Platoon concept
- Systems integration

For more information, please contact ITS Extension at 510/231-6990.

PATH Researcher To Bring French Expertise Home to California

Dr. Youngbin Yin, a research stationed at PATH's Richmond facility, is soon to embark on a six-month sabbatical in Lyon, France to complete work on an ATIS demonstration project for the city and suburbs of Paris. The purpose of the visit is to participate in a joint effort between U.S. and French researchers in a study of Advanced Traffic Management and Traveler Information Systems (ATIS/TVIS). The project itself is an experimental study of in-vehicle communication systems. The objective of this study is to test the performance levels of different types of communication devices for the control and management of traffic conditions in and around the Paris area. These models include a voice synthesis module with alphanumeric display for providing real-time information about traffic conditions and parking availability; a voice synthesizer and monitor with a graphic display of traffic and parking information overlaid onto an area map; a color monitor and voice module (sans map) that only provides traffic and parking information, but displays the position of the car in relation to this information; and finally, a versatile navigation and route guidance system which provides traffic, parking, and route guidance information.

With an invitation from leading research organization INRETS, Dr. Yin will work closely with Dr. Jean-Luc Ygnace in their office in Lyon. Over the past three years, INRETS and PATH have established a scholar- exchange program between Europe and the U.S. for research and development in IVHS. Two INRETS scholars, Ygnace and Monique Vernet, previously worked at PATH's Richmond office in joint ATIS and AVCS project efforts. Dr. Yin's visit marks the first opportunity for a PATH researcher to work in the INRETS environment.

Dr. Yin's research abroad has three interrelated objectives: to gain knowledge of the current IVHS technology in the European communities; to contribute to the research programs currently underway in France; and to exchange research ideas with INRETS in the area of ATIS.

States Dr. Yin, "In many ways, the French system is an excellent model for U.S. transportation planners because its infrastructure is more advanced." In downtown Paris, 400 of the 1000 intersections are signalized and linked to the centralized urban traffic management system. The Parisian beltway, the "Boulevard Peripherique," is already capable of collecting data about traffic flow, road occupancy, and vehicle speed. In addition, variable message signs are stationed at every exit ramp and access point. Highways just outside the city are equipped with 400 magnetic loops, 260 video units, and variable message signs. Installation of additional variable message signs is scheduled for completion by the end of 1994.

Since most freeways surrounding Paris are already equipped with loop detectors and video cameras, researchers are now concerned with finding the most cost-effective means of disseminating real-time traffic information to motorists.

Dr. Yin believes the technology transfer between the two countries will strongly benefit transportation efforts in the U.S. In addition, he research will assess the effectiveness of "low-cost" and "high-cost" in-vehicle communication devices for traffic control and management. The expertise gained from the French experiment is expected to substantially benefit the forthcoming ATIS tested projects in California (see article on page 4).

Strengthening the research collaboration between the U.S. and Europe is sure to promote the exchange of knowledge and experience, thereby ensuring PATH's place alongside others at the forefront of international IVHS research.

"Oh, the places we go..."
Visiting PostDoc Researcher Huei Peng is working at PATH on automatic vehicle lateral guidance with the PATH research staff. Dr. Peng has been with PATH as a graduate research assistant while working on his Ph.D. in Mechanical Engineering, which he received from U.C. Berkeley in May, 1992.

PATH welcomes Programmer/Analyst Bruce Hongola, who will be investigating traffic flow, safety, and capacity issues for AVCS system studies. Previously, Mr. Hongola was a Systems Engineer for GE Aerospace. Bruce holds an M.S. in Operations Research from U.C. Berkeley, and an M.S. in Mathematics from CSU Sacramento.

Malou Babilonia Pollard has accepted a permanent position as Assistant Editor in PATH’s Publications office. Previously she worked in Marketing Communications for a real-time software company, Wind River Systems. Ms. Pollard also produces video news segments for a local Filipino television channel. Her education includes a B.A. in both Film and English Literature from U.C. Berkeley.