PATH Project Update: Wind Tunnel Tests Explore Automation Advantages

PATH researchers at the University of Southern California (USC) are currently working to determine the effect of inter-vehicle spacing on the drag of each vehicle in 2, 3 and 4-car automated platoons. This study, entitled *Aerodynamic Testing of a Platoon of Vehicles*, will help determine the optimum inter-vehicle spacing within a platoon. In addition, it is significant for transportation system planners because of its ability to determine the effects of automated platooning and inter-vehicle spacing on fuel economy and automobile emissions.

For automatic control system designers, the research will also provide information about the forces experienced by cars in a platoon under a variety of inter-vehicle spacings, misalignments, and crosswinds. Understanding this information is essential for the proper design of a vehicle control system since driving conditions may be considerably different for a car in a platoon compared to one that is not.

This study will also examine the effects of platoon misalignments, crosswinds and varying vehicle shapes on drag, side forces and yaw moments experienced by vehicles. Results will be extendable to platoons of any size, and to actual road and car situations.

*continued on page 2*
USC Researchers Follow the Wind to Study Aerodynamic Effects on Vehicles

Project researchers at USC use the Dryden Wind Tunnel to simulate various atmospheric driving conditions. This historic facility, donated by the National Bureau of Standards, is one of the first and best low-turbulence wind tunnels in the country. Two to four vehicle models, each about 2 ft. long, are placed on a "road" section 19 ft. in length, within an octagonal tunnel cross-section 54 inches wide.

"Aerodynamic drag is responsible for up to 90 percent of the total resistance encountered by cars at high speeds," said Professor Fred Broduand, project director at USC. "Race car drivers and bicyclists are well aware of the benefits of traveling in tandem, or drafting, to reduce aerodynamic drag, but the information available to us is largely anecdotal. What we're trying to do is quantify these benefits with the aid of more than two vehicles in tandem." Experimental Set-up

The experimental set-up has three main components: the ground plane, which simulates the road surface; the vehicle models; and the force sensors, which are used to measure the forces on the models.

The Ground Plane

The vehicle models in the wind tunnel sit stationary on a ground plane which simulates the road surface. A complex box-like structure with a porous upper surface, the ground plane mechanism houses pressure measuring devices, electrical connections for the force sensors, and a rail system on which the vehicles are mounted. The plane is also designed to rotate 10 degrees to simulate crosswinds. In addition, the mounting system allows the vehicle models to be positioned off the centerline so that the effects of misalignments can be studied.

During actual testing, however, researchers encounter a region of slow moving air, or boundary layer, which develops on the ground plane surface when wind blows past the car models. Since this layer is not present on an actual road, researchers are eliminating it from the simulation model as well. This is being accomplished through a suction system to the rear of the ground plane box which removes the fluid (air) build-up along the plane surface and returns it downstream of the test section.

Lateral Control System Tests Right On Track

"Automated lateral control of vehicles is one significant piece of a whole plan of action for the increased safety and productivity of the highway transportation system," states Zhang. He continues, "A lateral control system that allows vehicles to tightly follow a predetermined reference system means highway lanes could be narrower than today's standard 3.6 meter width, enabling more lanes to be placed on a freeway without major changes to the infrastructure. In addition, built-in safety mechanisms will reduce or even eliminate human errors shown to be the leading cause of accidents." PATH's approach differs from many current world-wide research efforts on autonomous vehicle control systems in that it focuses on using both roadway and on-vehicle elements to perform anticipatory steering control. In the system demonstrated, a series of magnetic markers is mounted in the roadway to define the center of a traffic lane. By alternating polarities of these magnets, upcoming road curvature information can also be previewed. Sensors in the vehicles acquire both lateral displacement and encoded road geometry information. A "preview controller" provides the steering actuator with the commanded steering angle based on current vehicle deviation and the steering angle necessary for negotiating the curve. This system relies only on existing technologies, therefore, allowing both vehicle and roadway components to be made using low cost devices.

Earlier experimentation on PATH's lateral control system began in 1980 with a scaled test vehicle configured to pull a line of six car models along a straight line in an S-shaped pattern.
The Year in Review: PATH in '92

The California PATH program — experienced a pivotal year in 1992 — a year in which more than a dozen research projects coalesced in successful demonstrations of systems to automatically control steering, speed, and spacing of vehicles. The notable progress toward an automated highway system attracted national and international interest, including visits from Congreessman Norman Mineta (D-San Jose), incoming Chair of the House Public Works and Transporation Committee), Caltrans Director James van Loben Sels and Federal Highway Administrator Thomas D. Larson.

PATH researchers demonstrated their achievements for VIPs during several visits over the spring and summer. PATH Director Donald E. Orme and Deputy Director Steven Shladover outlined their future plans, indicating the kind of support researchers will need to reach their goals. They noted that achievement of PATH's goals will help the U.S. reach one of Congress's stated goals: development of a prototype automated highway system by 1997.

Perhaps the major milestones reached in 1992 were successful tests showing the capabilities of both longitudinal and lateral controls that have been developed in California over the past four years.

Tests of the longitudinal control system were conducted using a four-car platoon of the High Occupancy Vehicle (HOV) lane in the median strip of Interstate 15 just north of San Diego. Three Lincoln Continentals were laboring mightily to invent the in-carscent lamp other non-visionary incenists must have been laboring mightily, too, to improve the candle. It is unfortunate that some make this into a pejorative dichotomy of dreaming versus problem solving. Nothing is going to change the norm of incrementalism in the vast transportation research industry nor should that norm be changed. What ought to be changed is awareness that imagination is in short supply and that it is something that should be cultivated. The exact best means of cultivation is unknown but that should not stop one from trying.

I have a continuing interest in the subjects of innovation, imagination, vision, and creativity, and often wonder if their elements can be isolated and taught. Casual observation indicates that these are relatively rare natural talents even among gifted researchers.

One arena of continuing discussion is the apparent practice of extrapolating from the known world, the literature, and not consciously looking for the conceptual leap to a higher plateau of understanding. A sobering perspective is that incremental steps, tiny as they may be, have higher probabilities of successful additions to knowledge than high stakes gambles on major new insights. As most research is sponsored and has required deliverables, there is supportable skepticism that any requirement to "invent a new concept by 4:30," as it were, is totally unrealistic. Too, none of the really worthwhile research starts with a blank sheet of paper but instead builds from what is already known.

The counter argument is that certainly one must start with a base of experience and learning and must also perform work in manageable pieces so that objectives are met during the period of performance. But, more is possible. No, more is demanded if dramatic new break-throughs are to occur. The often cited example is that while Edison was laboring mightily to invent the incandescent lamp other non-visual inventors must have been laboring mightily, too, to improve the candle. It is unfortunate that some make this into a pejorative dichotomy of dreaming versus problem solving. Nothing is going to change the norm of incrementalism in the vast transportation research industry nor should that norm be changed. What ought to be changed is awareness that imagination is in short supply and that it is something that should be cultivated. The exact best means of cultivation is unknown but that should not stop one from trying.

---

The Little Boy by Helen E. Bailey

Once a little boy went to school
He was quite a big boy,
And it was quite a big school.
But when the little boy
Found that he could go to his room
By walking right in from the door outside,
He was happy,
And the school did not seem
Quite so big any more.

One morning
When the little boy had been in school awhile,
The teacher said,
"Today we are going to make a picture.
"Good!" thought the little boy.
He liked to make pictures.
"But the teacher said,
"What is it not time to begin?"
And she wanted until everyone looked ready.

"No," said the teacher,
"No we are going to make a dish.
"Good!" thought the little boy.
He liked to make dishes.
And he began to make some
That were all shapes and sizes.

The teacher said,
"Wait!
And I will show you how.
And she showed everyone how to make one deep dish.
"There," said the teacher.
"Now you may begin.

The little boy looked at the teacher's dish,
And he began to make his own.
When he had made the dish,
He thought it was delicious.
But the teacher said,
"Wait! And I will show you how.
And it was red, with green stem.

"There," said the teacher.
"Now you may begin.

The little boy looked at the teacher's flower.
Then he looked at his own flower.
He liked his flower better than the teacher's.
But the teacher said,
"I didn't say this.
He just turned his paper over.
And made a flower like the teacher's.
It was red, with a green stem.
On another day,
When the little boy had opened
The door from the outside all by himself,
The teacher said,
"Today we are going to make something with clay.
"Good!" thought the little boy.
He liked clay.
He could make all kinds of things with clay.
Sticks and stones,
Kittens and mice,
Cats and trucks.
And he began to pull and pinch.
No hall of clay.
But the teacher said,
"Wait! It is not time to begin!
And she waited until everyone looked ready.

"No," said the teacher,
"We are going to make a dish.
"Good!" thought the little boy.
He liked to make dishes.
And he began to make some
That were all shapes and sizes.

The teacher said,
"Wait!
And I will show you how.
And she showed everyone how to make one deep dish.
"There," said the teacher.
"Now you may begin.

The little boy looked at the teacher's dish,
And he began to make his own.
When he had made the dish,
He thought it was delicious.
But the teacher said,
"I didn't say this.
He just turned his paper over.
And made a flower like the teacher's.
It was red, with a green stem.

And make a dish like the teacher's.
It was a deep dish.
And pretty soon
The little boy learned to wait.
And to listen.
And to make things just like the teacher.
And pretty soon
He didn't make things of his own anymore.
Then it happened
That the little boy and his family
Moved to another house,
In another city.
And the little boy
Had to go to another school.
This school was even bigger
Than the other one,
And then was no door from the outside
Into his room.
He had to go up some big steps,
And walk down a long hall
To get into class.
And the very first day
He was there.
The teacher said,
"Today we are going to make a picture.
"Good!" thought the little boy.
And he waited for the teacher
To tell him what to do.
But the teacher didn't say anything.
She just walked around the room.
When she came to the little boy
She said,
"Don't you want to make a picture?"

"Yes," said the little boy.
"What are we going to make?"
"I don't know until you make it," said the teacher.
"You will tell me to make it!" said the little boy.
"Why, anybody can see," said the teacher.
"And one color!" said the little boy.
"Any color!" said the teacher.
"If everyone made the same picture,
And said the same colors,
How would I know who made what?
And which was what?
"I don't know," said the little boy.
"And he began to make a red flower
With a green stem."
CLEAN AIR, SAVE TIME: Recent Advanced Transportation Study Shows How

PATH Explores Regional Impacts of Large-Scale Roadway Electrification & Automation in Southern California

The project, headed by PATH Transportation Engineer Mark Miller, addressed the problems of freeway congestion, air pollution, and dependence on fossil fuels. Roadway electrification and high-way automation were investigated to determine to what extent these advanced technologies could alleviate the problems. In addition to these objectives, attention was given to utility, environmental, and economic impacts of the roadway electrification applications. Furthermore, the feasibility of future demonstrations of these advanced technologies in the SCAG region was discussed and analyzed. The completion of this project is significant because it provides further documentation of the possible impacts of two particular advanced technologies with potential for widespread roadway applications,” said Mark Miller, “Urban traffic congestion and air pollution are crucial issues in the world, especially in metropolitan areas, but are more acute in Southern California than in most other regions. So it was natural to perform the analysis for this region.”

Roadway Electrification

In this study, the representation of roadway electrification involved electric vehicles (RPEVs) that derive power from electrical cables buried beneath the roadway surface. An inductive coupling system that transfers electric power from the road to the vehicle recharges the RPEV’s battery and powers its traction motor.

Highway Automation

Full-scale highway automation as modeled for the study included longitudinal and lateral vehicle control, as well as overall highway and vehicle system management features.

Scenario Development

This PATH study compared both the electrification and automation scenarios with a baseline scenario, which SCAG developed specifically for this project. This scenario consists of forecasts of transportation, socioeconomic, environmental, utility and institutional data for the year 2025. In developing both advanced technology scenarios, network configuration, technology concerns, and the demand for services were addressed. For example, the key consideration for the roadway electrification scenario was the effect of battery limitations on vehicle range. Issues such as hourly lane capacity improvements, special access and egress facilities, and separation of automated and non-automated vehicles were among the most important factors considered in the highway automation scenario.

The roadway electrification scenario was of relatively modest size, 1,035 freeway lane miles (9.6 percent of the total in the region) and 3.3 percent of AM-peak trips taken by electrified vehicles. The automation scenario was more ambitious, taking advantage of the technology's expected highway capacity improvements (6,000 vehicles per lane, per hour): 2,165 lane miles and 19.3 percent of AM-peak trips taken by automated vehicles.

General Results:

Roadway Electrification Scenario

In comparing the roadway electrification with the baseline scenario, results indicated a daily reduction of more than 2 million gallons of gasoline consumed. A 60 percent increase in natural gas use for transportation purposes was also shown, though plentiful supply is forecast. It is important to recognize that this sizable percentage increase is based on a very small baseline value (natural gas as an intermediate factor in the production of gasoline). In addition, a 1 percent increase in electricity generating capacity for the region's utilities is required. The emission reductions range was 7-15 percent for all examined pollutants (hydrocarbons, carbon monoxide, nitrogen oxides, sulfur oxides and particulate matter). RPEV technology appears to have similar life-cycle costs (per vehicle mile) to the internal combustion engine vehicle, even when ignoring economic benefits of air quality improvement, and with no subsidy of the infrastructure cost.

Highway Automation Scenario

When comparing the highway automation with the baseline scenario, results for the AM-peak period showed significant reductions in travel delay time and associated

Figure 1: Average speed effects of freeway automation

Figure 2: Net percent reduction in delays from freeway automation relative to baseline
PATH Activities In Retrospect

"We hope that the milestones we have achieved in 1992 in ATMIS and AVCS continue to build a solid foundation for the future development of intelligent transportation systems."

— Steven Shladover PATH Deputy Director

Town Cars under automatic control were able to maintain precise spacing while following one another and a manually driven lead car at speeds of 55-75 m.p.h.

Tests of the lateral control system were conducted on the PATH test track at UC Berkeley's Richmond Field Station. Under normal conditions, the test car was able to negotiate the sharpest curve on the test track at a steady lateral acceleration of 0.27g (slightly more aggressive than is typical of most drivers) while keeping the car within 10 centimeters (about 4 inches) of the lane's center. The accuracy was maintained within 15 centimeters even when various abnormal conditions were introduced.

The next leap for PATH researchers in the area of automated highway technologies will be combining the longitudinal and lateral control systems. PATH will need more test vehicles and facilities to accomplish that, Shladover told visiting national and state policy makers. Currently, PATH has only four test vehicles used at San Diego and one used at the Richmond test track.

Meanwhile, of course, Advanced Vehicle Control Systems research is continuing, with 23 of the 52 currently active PATH projects directly or indirectly classified as AVCS. Another 72 proposals were submitted for funding through PATH in the new academic year. Of these, 25 involved AVCS.

PATH's timeline calls for AVCS systems that will be deployable in 10-20 years. The 'intelligence' that makes the systems work will most likely be split between the vehicle and the highway lanes where they will operate. Some lanes that are now used for regular vehicles could be converted for automated vehicle use and separated from other lanes on the freeway. "We're not talking about additional right of way," Shladover said. "We're talking about converting lanes."

To be sure, the California PATH program is much more than an Advanced Vehicle Control Systems (AVCS) program. Progress has occurred on many fronts in Advanced Transportation Management and Information Systems (ATMIS). At USC, computer models have been developed to assist in the design of roadside-vehicle communication systems. At UC Irvine, new algorithms, based on Artificial Intelligence techniques, have been developed to interpret inductive loop data and detect freeway incidents. About one of four PATH progress has continued on the development of "Dynamat," a micro-processor based traffic simulation model. A recent new development is the "DynaTrack" software tool designed to determine the safety and effectiveness of traveler information systems. The software is designed for testing the Hughes driving simulator, as well as in their own ITS laboratory. At UC Berkeley, the "Intelligent" simulation model is being used to study the benefits of IHS on real traffic networks. Other work has included development of adaptive signal control algorithms, and development of a traffic modeling package to predict the long-term effects of traffic incidents.

In the coming year, PATH will place increased emphasis on field tests of new technologies. Toward this end, PATH researchers are working on a major evaluation of a..."
CLEAN AIR, SAVE TIME: Regional Impacts Study Shows How

Acknowledgments
This project involved several organizations with management coordination at PATH under the supervision of Transportation Engineer Mark Miller. Primary technical research and analysis was provided by both PATH and the Southern California Association of Governments (SCAG), with additional technical support furnished by Systems Control Technology, Inc., University of California at Davis, Cambridge Systematics, Inc., and JHKS and Associates. Funding for the project was provided by the Federal Highway Administration, Caltrans, and SCAG.

This information article is based on a paper written by Mark Miller. If you would like more information on this study, please contact him at 510-231-9465.

increases in speeds, with automated vehicles traveling at 55 m.p.h. on enhanced capacity freeway lanes. The mobility improvements occurred not only on the automated facility, but on conventional mixed flow (non-automated) freeway lanes and arterials. (See figures 1 and 2 for more information.)

Details of these results can be found in Mark Miller's TRB papers: "Roadway Electrification: Regional Impacts Assessment" and "Highway Automation: Regional Mobility Impacts Assessment."

Conclusion
Research results show the potential benefits for both advanced technologies. Documenting their operational benefits is significant, particularly for highway automation because it is at an earlier state of research and development than roadway electrification. This marks the first time a comprehensive examination has been made of the impacts of both advanced technologies. Valuable lessons were learned in adapting current urban transportation models to accurately represent these technologies on the transportation network. An important area for future research is developing modeling tools that can more readily be used to study these as well as other advanced transportation technologies. The benefits reported for both advanced technologies will provide an important foundation for future research.

Lateral Control Tests Right on Track

PATH researchers including Deputy Director Steven Shladover concur with Congresswoman Matsui and guests during the lateral control demonstration at the Richmond Field Station Test Site.

continued from page 3

provided by Nippondenso. In 1991, PATH conducted a large scale experiment in conjunction with IMRA America, Inc., who provided a full-size test vehicle with a hydraulic steering actuator. Inexpensive ceramic magnets (10 cm, long, 2.5 cm in diameter) were installed about one meter apart in a 500-meter long test track. Four magnetic sensors were mounted under the front bumper of the vehicle. A control computer was used to process signals, execute the preview control algorithm and issue steering commands. Experiments were performed under normal, abnormal and adverse physical and environmental conditions, and repeated a few hundred times at different vehicle speeds. Tests run under abnormal conditions included the variation of vehicle speeds (acceleration and deceleration), increase of vehicle load and reduction of tire pressure. Experiments with imperfect roadway reference systems (i.e., misaligned or missing roadway markers) were also conducted. To test performance on a slippery road surface, some 2000 kg of chopped ice was packed on a 25-meter section of curved roadway. Results of such rigorous experimentation showed that the test vehicle could track its reference to within 10 centimeters under normal conditions, and 15 centimeters under adverse conditions.

Although it is unrealistic to expect implementation of a fully automated lateral control system within the next few years, PATH researchers envision possible smaller scale near-term applications (e.g., guidance of snow plows, factory robots, etc.). However, the hard work continues. In the next two years, PATH's lateral control research group plans to perform a series of new and more difficult tests in categories such as high-speed vehicle operation, lane changing, merging, and diverging, and overtaking of other vehicles. Soon we will see the merging of lateral and longitudinal control research efforts as PATH heads towards the eventual completion of a fully integrated vehicle control system for safer, more efficient highway transportation.

Acknowledgments
This portion of PATH research was made possible by financial support from Caltrans, and by participation of UC Berkeley and Caltrans staff. IMRA America, Inc., provided the experimental vehicle for the full scale project. Participants include PATH researchers Wei-Bin Zhang, Hsiu Peng, Peter Devlin and Steven E. Shladover, Professor Masayoshi Tomizuka of the UC Berkeley Mechanical Engineering department and his students Thomas Hesseburg, and Fatih Chanat Sahayji, IMRA researcher Alan Arai, and Caltrans researchers named Benour, David Aschakian, Mimi Hsieh, Charles Price and Somphol Chaturapipak; and others who have dedicated time and work to this project. A steering committee including Roy Bushey of Caltrans' Steven Shladover of PATH; Michael Dearing, and later Takashi Otomo of IMRA America; and Robert Parsons of Parsons Transportation Associates provided valuable guidance throughout the project.

The information for this article was provided by Wei-Bin Zhang. For more information, contact Wei-Bin Zhang at 510-231-9585, or via e-mail: wzhang@garnet.berkeley.edu.
Takeshi Sukekane (AKA "Tak") has accepted the position of Manager of the Publications office. He previously worked as the public affairs officer, Monterey Institute of International Studies; senior academic editor, California State University, Fresno; publications editor, UC Santa Barbara; and as a journalist for the San Francisco bureau of United Press International.

Yesterday, while commuting to work in his car, listening to the radio's depressing traffic news, and surrounded by cars lined up bumper to bumper, all parked on the freeway with their engines idling, he dejectedly thought, "Why doesn't someone do something about this mess?" Suddenly, aha! the new PATH employee with egg-on-his-face realized that's what We — the people of PATH — are now doing and planning for in the future. Tak says he hopes to direct PATH's publications and public relations efforts to promote and share valuable information about the many important and exciting research projects being conducted within the California PATH program. In a support role, he says he is looking forward to working closely with researchers, administrators, and staff from all PATH partnership campuses and Caltrans to get the word out about PATH's work on dealing with "that mess."

ISSN-1061-4311

PATH Publications
University of California, Berkeley
Institute of Transportation Studies-PATH
Bldg. 452 Richmond Field Station
1301 South 46th Street
Richmond, CA 94804

TV35
California PATH at the 72nd Annual TRB Meeting
Washington, D.C.
January 1993

Special INTELLIMOTION Insert, Winter 1993
## Presentations of California PATH Research Results at TRB 1993

<table>
<thead>
<tr>
<th>AUTHORS</th>
<th>TITLES</th>
<th>TRB PAPER #</th>
<th>DATE</th>
<th>TIME</th>
<th>SESSION #</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robert Parsons, Parsons Transportation Associates</td>
<td>Status of Developing an IVHS System Architecture</td>
<td>N/A</td>
<td>Monday 1/11/93</td>
<td>8:30 a.m.</td>
<td>12</td>
<td>Sheraton</td>
</tr>
<tr>
<td>Mark A. Miller, California PATH; Anne Bresnack, Cal-Poly University, Pomona; Edward H. Lechner, Systems Control Technology, Inc.; Steven E. Shladover, California PATH</td>
<td>Highway Automation: Regional Mobility Impacts Assessment</td>
<td>930522</td>
<td>Tuesday 1/12/93</td>
<td>8:30 a.m.</td>
<td>94 A</td>
<td>Hilton (Jefferson East)</td>
</tr>
<tr>
<td>Anthony Hitchcock, California PATH</td>
<td>Intelligent Vehicle/Highway System Safety: Specification and Hazard Analysis of a System with Vehicle-Borne Intelligence</td>
<td>930435</td>
<td>Tuesday 1/12/93</td>
<td>10:30 a.m.</td>
<td>94 B</td>
<td>Hilton (Jefferson East)</td>
</tr>
<tr>
<td>Bobby S.Y. Rao, California PATH; P. Varanay and F. Estakhri, University of California, Berkeley</td>
<td>Investigations into Achievable Capacities and Stream Stability with Coordinated Intelligent Vehicles</td>
<td>930803</td>
<td>Tuesday 1/12/93</td>
<td>10:30 a.m.</td>
<td>94 B</td>
<td>Hilton (Jefferson East)</td>
</tr>
<tr>
<td>Bobby S.Y. Rao, California PATH; P. Varanay, University of California, Berkeley</td>
<td>Flow Benefits of Autonomous Intelligent Cruise Control in Manual and Automated Traffic</td>
<td>930616</td>
<td>Tuesday 1/12/93</td>
<td>10:30 a.m.</td>
<td>94 B</td>
<td>Hilton (Jefferson East)</td>
</tr>
<tr>
<td>Paul P. Jovanis and Ryuichi Kitamura, University of California, Davis; Cheryl Hein, Hughes Aircraft Company</td>
<td>Effects of In-Vehicle Route Guidance Information on Driving Performance</td>
<td>930920</td>
<td>Tuesday 1/12/93</td>
<td>2:00 p.m.</td>
<td>114</td>
<td>Sheraton</td>
</tr>
<tr>
<td>Hongjun Zhang, Stephen G. Ritchie, and Zhen-Ping Lo, University of California, Irvine</td>
<td>Macropscopic Modeling of Freeway Traffic Using an Artificial Neural Network</td>
<td>930493</td>
<td>Tuesday 1/12/93</td>
<td>2:00 p.m.</td>
<td>123</td>
<td>Shoreham</td>
</tr>
<tr>
<td>Rocky L. Chen, Wilfred W. Recker, and Stephen O. Ritchie, University of California, Irvine</td>
<td>Calibration of NTRAS for Simulation of 30-Second Loop Detector Output</td>
<td>930592</td>
<td>Tuesday 1/12/93</td>
<td>7:30 p.m.</td>
<td>138</td>
<td>Sheraton</td>
</tr>
<tr>
<td>Jeffrey L. Adler, Wilfred W. Recker, and Michael G. McNally, University of California, Irvine</td>
<td>In-Laboratory Experiments To Analyze Arcroute Driver Behavior Under ATIS</td>
<td>931067</td>
<td>Wednesday 1/13/93</td>
<td>8:30 a.m.</td>
<td>174</td>
<td>Hilton</td>
</tr>
<tr>
<td>Yonnel Gardes, University of California, Berkeley; Mark Lumwood, KPMB/Peat Marwick; Adolf D. May, University of California, Berkeley; Michel van Aarle, Queen's University, Kingston, Ontario, Canada</td>
<td>Application of the Integration Model to Demonstrate the Simulation of Advanced Traveler Information Systems</td>
<td>930474</td>
<td>Wednesday 1/13/93</td>
<td>8:30 a.m.</td>
<td>152</td>
<td>Sheraton (Ampacois)</td>
</tr>
<tr>
<td>Stephen G. Ritchie, University of California, Irvine</td>
<td>Real-Time Expert Systems in the California ATMIS Textbook [Presentation]</td>
<td>—</td>
<td>Wednesday 1/13/93</td>
<td>8:30 a.m.</td>
<td>115</td>
<td>Sheraton</td>
</tr>
<tr>
<td>Steven E. Shladover, California PATH</td>
<td>AVCS Perspective [Presentation]</td>
<td>—</td>
<td>Wednesday 1/13/93</td>
<td>8:30 a.m.</td>
<td>151</td>
<td>Sheraton (Baltimore)</td>
</tr>
<tr>
<td>Kenneth M. Vaughan, Mohamed A. Ahrabi, Ayat, Ryuichi Kitamura, and Paul P. Jovanis, University of California, Davis</td>
<td>Experimental Analysis and Modeling of Sequential Route Choice Behavior Under ATIS in a Simplicistic Traffic Network</td>
<td>930962</td>
<td>Wednesday 1/13/93</td>
<td>8:30 a.m.</td>
<td>174</td>
<td>Hilton</td>
</tr>
<tr>
<td>Haitham Al-Ibeid and Abd Al-Kanafani, University of California, Berkeley</td>
<td>Recent Findings on the Benefits of Route Guidance</td>
<td>930667</td>
<td>Wednesday 1/13/93</td>
<td>7:30 p.m.</td>
<td>219</td>
<td>Hilton</td>
</tr>
<tr>
<td>Anne Bresnack, Cal-Poly University, Pomona; Mark A. Miller, University of California, Berkeley; Edward H. Lechner, Systems Control Technology, Inc.; Steven E. Shladover, California PATH</td>
<td>Roadway Electrification: Regional Impacts Assessment</td>
<td>930528</td>
<td>Thursday 1/14/93</td>
<td>8:30 a.m.</td>
<td>241</td>
<td>Hilton (Lincoln West)</td>
</tr>
</tbody>
</table>
Sessions Chaired by California PATH People

<table>
<thead>
<tr>
<th>CHAIR</th>
<th>SESSION TITLE</th>
<th>DATE</th>
<th>TIME</th>
<th>#</th>
<th>LOC.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paul P. Jovanis, University of California, Davis</td>
<td><em>Heavy Truck Safety</em></td>
<td>Monday 1/11/93</td>
<td>8:30–10:15 a.m.</td>
<td>13A</td>
<td>Sheraton</td>
</tr>
<tr>
<td>Ryuichi Kitamura, University of California, Davis</td>
<td><em>Emerging Approaches in Travel Behavior Modeling</em></td>
<td>Monday 1/11/93</td>
<td>8:30–10:15 a.m.</td>
<td>20A</td>
<td>Hilton</td>
</tr>
<tr>
<td>Ryuichi Kitamura, University of California, Davis</td>
<td><em>Advances in Activity-Based Travel Analysis</em></td>
<td>Monday 1/11/93</td>
<td>10:30 a.m.</td>
<td>20B</td>
<td>Hilton</td>
</tr>
<tr>
<td>Steven E. Shladover, California PATH</td>
<td><em>Advancement Toward Automated Highways</em></td>
<td>Tuesday 1/12/93</td>
<td>10:30 a.m.</td>
<td>94 B</td>
<td>Hilton</td>
</tr>
<tr>
<td>John West, California Department of Transportation</td>
<td><em>New Technology Influences on Aircraft and Airport Development</em></td>
<td>Thursday 1/14/93</td>
<td>8:30 a.m.</td>
<td>236</td>
<td>Shoreham</td>
</tr>
</tbody>
</table>

Committees Chaired by California PATH People

<table>
<thead>
<tr>
<th>CHAIR</th>
<th>COMMITTEE</th>
<th>DATE</th>
<th>TIME</th>
<th>#</th>
<th>LOC.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adolf D. May, Jr., University of California, Berkeley</td>
<td>Committee on Highway Capacity and Quality of Service</td>
<td>Sunday 1/10/93</td>
<td>7:00 p.m.</td>
<td>A3A10</td>
<td>Sheraton</td>
</tr>
<tr>
<td>Adolf D. May, Jr., University of California, Berkeley</td>
<td>Committee on Highway Capacity and Quality of Service</td>
<td>Monday 1/11/93</td>
<td>9:00 a.m.</td>
<td>A3A10</td>
<td>Sheraton</td>
</tr>
<tr>
<td>Daniel Sperling, University of California, Davis</td>
<td>Committee on Alternative Transportation Fuels</td>
<td>Wednesday 1/13/93</td>
<td>7:30 a.m.</td>
<td>A1F06</td>
<td>Hilton</td>
</tr>
<tr>
<td>Ryuichi Kitamura, University of California, Davis</td>
<td>Committee on Traveler Behavior and Values</td>
<td>Wednesday 1/13/93</td>
<td>9:00 a.m.</td>
<td>A1C04</td>
<td>Hilton</td>
</tr>
</tbody>
</table>

For further information, contact:

California PATH
Administrative Headquarters
University of California
Institute of Transportation Studies
Building 452, Richmond Field Station
1301 S. 46th Street
Richmond, CA 94804

tel. 510/231-9495
fax 510/231-9565