The Parsons Traffic and Transit Laboratory (Parsons T² Lab) was created by the California PATH program under an agreement with the University of California and the California Department of Transportation (Caltrans). The motivation for the lab is to serve diversified research project needs. The Parsons T² Lab is designed to support in-depth understanding of traffic and transit operations and behaviors along arterial corridors, to facilitate the development of advanced solutions in a lab environment, to conduct scientific evaluation of Intelligent Transportation Systems (ITS) systems and elements, and to build up testing corridors for the implementations of new methodologies and technologies. In order to serve this wide range, fine resolution and high quality traffic data from corridors and intersections with different characteristics, high resolution vehicle probe data in sync with traffic and signal status data, and vehicle movement data near and within intersections are collected and archived.

The Parsons T² Lab is a unique transportation laboratory which features: (1) high quality traffic and transit data from arterials and corridors, (2) a growing number of data management and analysis tools, and (3) a full range of experimental environments. All of the three features and their specific applications will be elaborated in the following pages.

The Parsons T² Lab is now a critical tool for existing research projects in traffic, transit and safety areas. Examples of the projects include “Development of Performance Measures for Arterial Highways (APeMs)”, “Field Operational Tests of Adaptive Transit Signal Priority (ATSP)”, “Investigation of red light running avoidance and Cooperative Intersection Collision Avoidance (CICAS) Systems”, “Development of Hardware-in-the-Loop (HiL) Simulation and Paramics/VS-PLUS Integration”, “Sensor fusion methodologies for Vehicle Infrastructure Integration (VII)” and “Integrated Corridor Management (ICM) Initiative”. continued on page 2
The Parsons T^2 Lab is a dedication to Robert E. Parsons who devoted his career to innovative transportation systems in the United States. Mr. Parsons was the founding director of California PATH Program and established a solid foundation for PATH’s success. (See Intellimotion 11.4, 2005).

**High Quality Data**

The Parsons T^2 Lab is collecting detailed, high resolution, real-time traffic and transit data from a number of arterials, urban areas and transit systems. Currently, we have five data collection sites which cover both northern and southern California as shown in Figure 1. In the northern California, data from two segments of El Camino Real corridor including 39 intersections at San Mateo County and Santa Clara county, CA and 9 intersections along the San Pablo Avenue Corridor at Alameda County, CA are continuously being transmitted to the lab. In the Southern California, the Parsons T^2 Lab is collecting data from the downtown San Diego area and Pacific Coast Highway in the Los Angeles area.

The incoming high quality field data fall into two categories: traffic and transit. For the traffic related data, the Parsons T^2 Lab collaborated with Caltrans engineers in the development of the interface software with 170/2070 traffic signal controllers. Such development facilitates second by second traffic signal status and control status data, loop detector count and occupancy data to the Parsons T^2 Lab. Such detailed traffic data collection is unique in the United States. Some other traffic data collection means are listed in Figure 2, including the traditional pneumatic road tubes and counters to collect traffic volume and vehicle speed data and Doppler radar to collect continuous vehicle speed data. Currently, we are also testing some cutting edge data collection means for traffic data collection. For example, the super tiny Smart Dust sensor applying micro-electro-mechanical systems (MEMS) and wireless communication technologies makes traffic volume and speed data collection more readily and accurate. Moreover, several Autoscope video cameras have been placed at some testing intersections along El Camino Real Corridor, and traffic surveillance data and traffic volume and speed data processed from images are continuously coming into Parsons T^2 Lab.

The other category of the collected field data is transit related data from transit vehicles. The Parsons T^2 Lab developed an innovative cell-phone based automatic vehicle location (AVL) system. Such systems by applying Global Positioning System (GPS) and General Packet Radio Service (GPRS) technologies, are more cost-effective compared with most available radio based commercial AVL systems and works quite reliably. More than forty such devices have been installed on Alameda-Contra Costa (AC) transit buses, San Mateo County transit district (SamTrans) buses, Santa Clara Valley Transportation Authority (VTA) buses, and San Diego trolleys. The Parsons T^2 Lab also developed a PC104 based AVL system. Along with GPS location data, the system is capable of collecting door open/close status, continued on page 4.
Fuel Cell Vehicle Drive Clinic Launches in Sacramento

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California PATH

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On August 8, 2007, researchers from California PATH and the Institute of Transportation Studies launched a fuel cell vehicle and infrastructure study at the California Fuel Cell Partnership in West Sacramento. This fuel cell vehicle “user perception” study is being conducted in conjunction with the California Department of Transportation (Caltrans) and DaimlerChrysler.

The study provides an opportunity for up to 200 employees of Caltrans, the California Air Resources Board (CARB), the California Energy Commission (CEC), and the University of California (UC), Berkeley to test drive a hydrogen fuel cell vehicle on public roads, under real-world driving conditions (called a “drive clinic”), and view a hydrogen fueling event. The research effort also includes four focus groups for more in-depth analysis of user response to fuel cell vehicles and infrastructure.

Caltrans is supporting this research with a $75,000 grant and DaimlerChrysler is providing the vehicles that Caltrans and PATH employees have been driving in a fleet setting since late-2005. The project takes advantage of three recent placements of hydrogen-powered “F-Cell” vehicles by DaimlerChrysler with Caltrans and UC Berkeley. The project is being led by California PATH and the Transportation Sustainability Research Center (TSRC), with project partners Caltrans, DaimlerChrysler, the California Fuel Cell Partnership, and AC Transit.

Television, radio, and newsprint media representatives attended the kick-off event. The keynote speaker was Randell “Randy” Iwasaki, Chief Deputy Director at Caltrans. Additional speakers were Susan Shaheen of PATH; TSRC Director and Energy and Resources Group Associate Professor Alex Farrell; Tim Lipman of TSRC; and Peter Friebe, General Manager for Fuel Cell Operations of DaimlerChrysler.

The drive clinic is being conducted as part of a California PATH research study: “Exploratory Test of Early Fleet Niches for Hydrogen Fuel Cell Vehicles and Fueling Infrastructure.” Researchers designed this study to gain a stronger understanding of opinions and perceptions of the general public regarding fuel cell vehicles and hydrogen fueling. The study includes a number of elements designed to elicit the opinions of persons who have an opportunity to drive hydrogen vehicles or become educated about them. The key research elements include:

- The “Ride-n-Drive” clinic in West Sacramento (held at the California Fuel Cell Partnership in August) and Richmond, California (held at PATH and AC Transit in September) to provide an opportunity for up to 200 people to drive a DaimlerChrysler fuel cell vehicle and view the cars being fueled.
- Focus groups with Caltrans and PATH staff who were trained to drive and fuel the hydrogen-powered vehicles and who have driven the cars regularly in a shared-fleet setting.
- Focus groups with members of a carsharing organization (i.e., short-term vehicle access) that have been provided a brief tutorial about hydrogen and hydrogen fuel cell vehicles. Members of carsharing organizations are familiar with the concept of reserving a specific vehicle type to meet their trip needs, making them potentially interesting early users of hydrogen-powered vehicles.

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wheelchair lifting status, and vehicle wheel speed through digital inputs, the data is transmitted back to the lab periodically through wireless communication. Two San Diego trolleys have been instrumented with these advanced data acquisition systems and are transmitting data back to the Parsons T² Lab.

Data Management and Analysis Tools

In addition to the detailed data, the data management and analysis tools have been or are being developed to provide easy access to the data, data preprocessing and analysis. As shown in Figure 3, field data continuously streams to the lab server through different communication means and protocols and is then managed and stored in a MySQL-based traffic and transit system database. Around the central database, the data pre-processing tools, data mining tools, administration tools, and simulation interface tools are being developed. An online monitoring tool has been developed using a Google Map application programming interface (API). With the interactive interface (figure 4), users can pick any date and any number of transit vehicles to visually trace their locations on the top of the Google Map.

Around the traffic and transit system database, data mining and analysis tools are being developed for each specific research project. For example in the project "Relieve congestions at the light rail and highway grade crossings in San Diego", we developed trajectory analysis tools in order to obtain an in-depth understanding of the existing passive trolley signal priority system. Figure 5 is a 3-D plot which shows a typical northbound San Diego trolley trajectory starting from the Imperial station at the southeast corner toward the America Plaza station at the northwest corner. For this trip, the trolley makes six stops at the circle areas which are trolley stations and the other five stops at the non-circle areas which are signalized intersections. The total stop time (marked by diamonds) at the signalized intersection is 78 seconds. Based on the thorough analysis over hundreds of trips, we understand that the passive priority is not enough to help trolleys through all signalized intersections. However, for the more common scenario when trolleys are not present, normal traffic wastes time at intersections waiting for "nothing" on the trolley direction. In order to address such "pains", an active trolley signal priority system based on real-time trolley locations has been proposed and verified via microscopic traffic simulation tool. A small-scale field operational test (FOT) will follow to further examine and demonstrate its effectiveness.

Another application is for the project "Investigation of red light running avoidance and Cooperative Intersection Collision Avoidance (CICAS) Systems". Red light running (RLR) problem is recognized as a significant safety problem. In 2001, there were almost 218,000 RLR crashes, which result in as many as 181,000 injuries and 880 fatalities. The annual economic loss is estimated to be $14 billion. The phenomenon of RLR is influenced by a variety of factors. Some of them are behavioral factors, which represent the characteristics and choices made by individual drivers; some are technical factors like vehicle characteristics and some are traffic operations factors, like traffic flow and signal timings, which contribute to the exposure to RLR. Many studies have estimated the impact of traffic operations parameters (i.e., speed, traffic flow and signal timing) on RLR. However, those studies are based on aggregated data, such as average daily traffic (ADT), and some form of detailed RLR-related data has been rolled up. In the Parsons T² Lab, synchronized second-by-second loop detector data and signal status data (phase and interval) are being col-
lected from dozens of intersections along El Camino Real. These detailed data make it possible to capture the relevant factors in the smallest relevant time-frame, i.e., utilizing cycle-based data analysis. The traffic count measurement at the advance loops, which are normally 56 meters (184 feet) upstream from the stop-bar, are used to present the arrival flow, and the count measurement at the stop-bar loop are used to capture the RLR occurrence. Data processing and analyzing tools are developed at the Parsons T² Lab to find a RLR related factor that is 1) statistically significant, 2) imposing a substantial impact on RLR, and 3) is controllable. Based on a discrete choice model analysis, it is found that the arrival flow during the yellow signal (yellow arrival) satisfied the three aforementioned conditions. The impact of yellow arrival on RLR probability was found to be in the order of 12%-32%, as shown graphically in Figure 6.

This finding motivated the development of an offset optimization algorithm which takes yellow arrival into consideration. Utilizing the facilities at the Parsons T² Lab, an iterative process was developed to fine-tune the offset. Simulation evaluation based on TRANSYT-7F for a corridor with 6 intersections has demonstrated the performance of the developed algorithm: the yellow arrival on the corridor is reduced significantly (46.7% reduction) and the impact on traffic is minor compared with the existing field scenario.

**Experimental Environments**

Not only can the Parsons T² Lab contribute at the research stage by providing valuable field data and the data analysis tools, but also at the stage of pushing academic research towards field deployment, the Parsons T² Lab is playing an important role and has developed a three-step strategy towards FOTs. The first step after the development of control algorithms and methodologies is to conduct hardware-in-the-loop (HiL) simulation. In the HiL simulation, as shown in Figure 7, traffic vehicles will be generated by a microscopic traffic simulation tool, e.g. PARAMICS or VISSIM. The other hand, the signalized intersections are controlled by real traffic controllers through the controller interface devices (CID). By using HiL, we can easily debug the developed methodologies, verify the applicability, and evaluate the impacts. After HiL simulation tests, the second step is to conduct laboratory testing. At this step, the testing intersection at Richmond Field Station of University of California, Berkeley and the testing vehicles will facilitate the pseudo field testing. Except for the flowing traffic, all of the communication and control hardware and software, roadside and on-vehicle detection sensors, and the movement of testing vehicles are consistent with the field situation.

In the Parsons T² Lab, monitoring programs, database tools and data analysis software have been developed to help researchers and engineers tune the proposed system. Finally, the third step is a FOT. The Parsons T² Lab is able to support a FOT in monitoring the testing progress, storing and organizing testing data, and provide online data analysis.

**Future Work**

The researchers and engineers at PATH are devoting significant efforts to enrich data collection sources and data qualities, improving data management, data analysis, and lab testing capabilities. We are also seeking collaboration worldwide with researchers and stakeholders to conduct research to better understand traffic behaviors and the development of effective traffic control approaches utilizing this unique traffic and transit laboratory.

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**References**

On July 12, 2007, eight delegates (named below) from the Netherlands traveled both to the Richmond Field Station and Palo Alto for demonstrations.

Mr Bert Keijts, Director General Rijkswaterstaat  
Mr Luc Kohsiek, Deputy Director-General Rijkswaterstaat  
Mr Joris Al, Managing Director Transport and Navigation Department  
Mr Luitzen Bijlsma, Managing Director Water Management Department  
Dr Mrs Jean-Marie Stam, Coordinator International Affairs  
Mrs Annelie Kohl, Sr. Expert International Affairs  
Mr Hans de Jongm Counselor for Transportation, Royal Netherlands Embassy  
Mr Marc Mellen, Netherlands Office of Science and Technology, San Mateo

At the Richmond Field Station (RFS) they were introduced to PATH, Caltrans and ITS. After the introduction they received a Metropolitan Transportation Commission (MTC) presentation on Integrated Corridor Management. Following the presentation the visitors were lead on a tour and demonstration of some of PATH’s projects including Precision Docking, Onboard Truck Monitoring, and the Traffic and Transit Laboratory. Following the tour at the RFS the delegates headed to Palo Alto for presentations on Vehicle Infrastructure Integration from VII California. There they received demos from both Toyota and BMW. By the end of the day the Dutch visitors were quite animated and excited about the work being done at both sites.
TRB Committee


The Transportation Research Board Joint Summer Meeting brought the government, industry and academic leaders of VII and CICAS programs together, and PATH researchers and staff once again shined. This gathering provided participants with the current status (including a roadmap to deployment), potential issues with the proposed deployment, and an update on research activities. The workshop also identified the future research topics and data needs of VII/CICAS.

The workshop was highlighted by demonstrations performed by VII California partners and in particular, PATH, with the assistance of the San Mateo County Transit District (SamTrans). The demonstrations included:

**Traveler Information** - With a network of Dedicated Short Range Communication (DSRC) roadside units, traveler information systems provide information that may be relevant to the safety of a traveler’s trip, including travel times, incident alerts, road closures, school and work zones, and weather conditions.

**Intersection Safety** - The application of low latency, high availability, and safety critical messaging between Roadside Equipment (RSE) and Onboard Equipment (OBE) for cooperative intersection safety, with a focus on signal violation and dilemma zone warning (which addresses the onset of a yellow signal phase, thus reducing left-turn crashes). This family of applications may require high data rates, as wireless map updates may constitute a significant component of the message.

**Signal Phase and Timing** - CICAS-V and PATH-developed cooperative signal violation information was experimented with at two intersections, the second of which transmitted to an in-service SamTrans bus. One directly connected to the 2070 controllers and the other “sniffed” on the 170 legacy controller. This demo provided a snapshot of what is happening in VII California, underscoring the real world accomplishments of a dynamic, creative team.

**Advanced Transit Signal Priority** - This new development uses the advantage of cell phone technology to communicate with RSEs and give signal priorities to public transit vehicles. This application increases the accuracy and reliability of on-time arrival and enhances the efficiency of public transit busing.

**Transit Safety** - Extensive research has been carried out to promote improvements and feasibility in transit safety. With the latest, cutting edge technology including radar detection, sensors, and advanced collision warning systems, improvements in transit safety have been made.
California PATH on Paper
An Updated List of PATH Research Publications

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Commercial Vehicle Parking In California: Exploratory Evaluation of the Problem and Possible Technology-Based Solutions, Caroline J. Rodler, Susan A. Shaheen, 18 pp.
UCB-ITS-PRR-2007-11

Reservation, Scheduling, and Navigation System for a Checkpoint DRT Service, Yuwei Li, Nicole Folella, Ken Elkabany, Fan Yang, Anthony Wee, Michael Cassidy, 49 pp.
UCB-ITS-PRR-2007-12

UCB-ITS-PRR-2007-13


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Drive Clinic

The purpose of the drive clinic is to gain feedback from individuals with a wide variety of backgrounds that are provided with an opportunity to drive the F-Cell vehicles and view a fueling demonstration. After completing a brief “before” survey, participants drove the vehicle in groups of two on a three-mile route in West Sacramento or Richmond, with a researcher observing and answering questions from the back seat. The maximum speed along the routes was 45 to 50 miles per hour.

Participants had the opportunity to drive the vehicle and to ride as a passenger to maximize their exposure to the experience. After driving, the participants viewed a fueling demonstration and completed an “after” questionnaire. Conducting surveys “before” and “after” exposure to the vehicles and the refueling event allowed researchers to gauge the impact of driving, fueling, and learning about the vehicle and fueling, as well as to capture opinions and perceptions regarding hydrogen as a fuel, fuel cells as a transportation technology, and considerations such as vehicle range, limited fueling infrastructure, and environmental impact. Employees from Caltrans, CARB, and CEC attended the drive clinic at the California Fuel Cell Partnership from August 8 to 17, 2007. UC Berkeley employees attended the drive clinic at the Richmond Field Station from September 15 to 27, 2007.

Focus Groups

The purpose of the focus groups is to capture the participants’ opinions and perceptions in a smaller, interactive setting. The focus groups with Caltrans and PATH staff—who have driven the fuel cell vehicles for the past year (after a brief training)—provided a setting for the drivers to talk about what they liked and disliked about the vehicles, how the approximate 100-mile range affected their choice of when to use the vehicle, and with what aspects of the fueling process they were more and less comfortable. PATH drivers were trained to refuel the car at the AC Transit bus maintenance facility in Richmond and after training could fuel without supervision. Caltrans drivers do not refuel the vehicle themselves, but rather bring the car to the California Fuel Cell Partnership where a trained technician performs the refueling.

The focus groups with members of a carsharing organization will be conducted in San Francisco and Berkeley this fall. Members of carsharing organizations are able to reserve vehicles for short time periods. They often have a choice of a variety of vehicles. For example, a drive to the grocery store might be best conducted in a small car that is easy to park, while the task of moving furniture might require a pick-up truck. For members of carsharing organizations, the fuel is paid for as part of their usage fee, so they do not pay to refuel the vehicles with gasoline. However, they are required to fuel the car (with a carsharing fueling card), if the gas gauge hits a certain level.

For the hydrogen-powered vehicle research, this population is interesting from a number of perspectives. First, early applications for hydrogen fuel cell vehicles could be fleets, where fueling can be managed from a central location. Second, members of carsharing organizations are more familiar with the idea of matching vehicle characteristics with trip needs. They also may be more likely to understand how to manage a shorter-range vehicle, knowing when it is best to use a fuel cell vehicle for trip making. Third, individuals driving a limited range fuel cell car may

continued on next page
require access to a longer-range vehicle with wider fueling options. Carsharing fleets typically provide members with a range of vehicle choice to meet their needs, which could complement a limited-range car. Fourth, many members of carsharing organizations have joined to reduce their environmental impacts, so hydrogen cars might have appeal to this population. Finally, carsharing organizations could provide a few fueling options: training members that want access to the vehicle or having a staff member on hand to fuel the vehicles when necessary.

Conclusion

At the conclusion of the drive clinic and the focus groups, researchers will have gained feedback from: 1) participants who have driven a hydrogen fuel cell car for the first time, 2) those that have driven the F-Cell for up to a year, and 3) those that may represent an attractive niche application for early placement of hydrogen fuel cell vehicles. Researchers expect to provide Caltrans with a deeper understanding of how hydrogen fuel cell vehicles will fit into the overall California fleet and how Caltrans can prepare for and assist with these developments.

Technical Aspects of the F-Cell

- Power system: 72 kW (97 horsepower) proton exchange membrane fuel cell system with a 20 kW/1.4 kWh nickel-metal hydride battery
- Propulsion system: 65 kW (87 hp) electric motor
- Hydrogen storage: 2 kg of hydrogen stored as compressed gas at 5,000 psi (350 bar)
- Driving range: Approximately 100 miles
- Other features: regenerative braking (braking energy turned into electricity and stored in battery), hydrogen leak sensors, and emergency hydrogen pressure release valve on roof of car.

Technical Aspects of Refueling

- Fuel: purified hydrogen in gaseous form at 5,000 psi (350 bar)
- Refueling time: varies with level in tank and level of sophistication of station, typically 5-10 minutes
- Precautions: no electrical devices within 20 feet during refueling; mobile phone turned off or left in car during refueling; and redundant ground cable connected to vehicle.

Finally, this research effort supports Assembly Bill (AB) 32–California’s Global Warming Solutions Act—and AB 1493—the Pavley Law, which seek to limit greenhouse gas (GHG) emissions from transportation sources and other industrial and commercial activities. With a successful commercial introduction, hydrogen powered vehicles can play a key role in reducing GHG emissions in the State. AB 32 requires that California’s GHG emissions be reduced to 1990 levels by 2020 through an enforceable statewide cap and in a manner that is phased in starting in 2012.

The results of the research will be available in early 2008 and will include recommendations for further studies that will assist Caltrans in understanding how hydrogen fuel cell vehicles may fit into the overall fleet of vehicles driving on California highways. ©
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Daimler-Chrysler
California Fuel Cell Partnership
AC Transit

For more information on fuel cell vehicles and hydrogen see:


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