Virtual Weigh Station: A Systems Evaluation of the Problems and Solutions

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PATH on Paper

In just the last five years, commercial vehicle travel in California has increased by more than 50 percent, and by 2020 freight volume is expected to grow by almost 80 percent. Not surprisingly, expansion of traditional Commercial Vehicle Enforcement Facilities, which are very expensive to build and operate, has and is not expected to keep pace with truck traffic growth. And yet, the consequences of inadequate enforcement are numerous and costly.

If the number of trucks requiring inspection exceeds station capacity, then queues form, which waste drivers’ time and fuel, worsen air pollution, and create roadway safety hazards. As a result, inspection station operators routinely allow trucks to bypass overcrowded stations and non-compliant vehicles escape inspection. Compounding this problem are scofflaw commercial vehicle drivers who strategically choose routes to avoid inspection stations. Overweight trucks cause millions of dollars of damage each year to California’s highway infrastructure. Many crashes involving trucks result from regulatory non-compliance and are often catastrophic.

While electronic pre-clearance programs, such as PrePass® in California, have streamlined inspection processes by using communication and transponder technology to keep the safest and most compliant carriers out of weigh and inspection stations. These programs are voluntary and tend to be used most frequently by larger trucking firms that practice qualifying fleet maintenance and safety procedures. Small independent truckers typically do not join these programs because participation costs are perceived too high. A large number of trucks must still pass through facilities to be weighed and visually screened by law enforcement personnel, and scofflaws routinely circumvent these stations.

In response to these problems, the California Department of Transportation (Caltrans) is investigating the potential application of detection and communication technology to virtual weigh stations to cost-effectively improve enforcement with commercial vehicle regulations. California PATH is assisting Caltrans in this effort in a research project, titled “Virtual Weigh Stations: A Systems Evaluation of the Problem and Solutions,” which launched on January 13, 2006. This unique project brings together researchers from both the University of California at Berkeley and the University of Southern California with expertise in pavement and structural performance (Dr. Samer Madanat), safety technology (James Misner), and policy analysis (Drs. Genevieve Giuliano, Susan Shaheen, Caroline Rodier, and Mark Miller).
This two-year multi-phased research effort seeks an in-depth understanding of commercial vehicle enforcement problems in California, possible technology-based solutions, and their cost effectiveness. The key outcomes from this research, based on extensive data analysis, literature reviews, as well as expert and stakeholder interviews, include:

- An inventory of baseline statistics on the current commercial vehicle compliance and enforcement processes in California;
- Estimates of future demand placed on compliance processes and likely resources to meet this demand;
- Identification of significant commercial vehicle compliance and enforcement-related problems and locations in California (e.g., pavement and structural damage, crashes, air pollution, and security); and
- Assessment of current and emerging technologies and applications including performance, costs, and institutional barriers.

Based on these findings, researchers will recommend alternatives with the greatest likely return on investment.

At present, the virtual weigh station concept is most fully deployed outside of North America. For example, in New South Wales, Australia, one hundred cameras located on freight routes, weigh stations, and mobile inspection units record speed, fatigue, and weight inspection offences as part of the TruckScan program. Weigh-in-motion detectors are installed at weigh inspection locations on the mainline. If an offence is detected, then a citation is issued to the driver or operator, and the offence is recorded on the driver’s license and the vehicle’s registration. If four offences are issued within a three-year period, then the driver’s license can be suspended.

More recently, North American programs in Kentucky, Indiana, Florida, Minnesota (U.S.) and Saskatchewan (Canada) have begun research and development of virtual weigh station applications. These programs differ with respect to levels of deployment and enforcement automation, but all use image capturing and sensing technologies to increase enforcement.

Caltrans is providing approximately $750,000 in funding for the current research effort and has provided instrumental guidance in the early phases of the project. The current project builds on preliminary Caltrans-supported research activities including a stakeholder workshop hosted by METRANS at Long Beach State on in February 2005; an initial investigation of the magnitude of the pavement damage problem (UCB-ITS-PWP-2005-5); a general review of legal and institutional barriers (UCB-ITS-PRR-2005-33); and testing of camera technology to capture truck images and license plate numbers at the Cordelia Weigh Station in Northern California.


We would like to acknowledge the Division of Research and Innovation at Caltrans for their support of the project.
On December 20th, 2005, representatives of DaimlerChrysler Corporation delivered a Mercedes-Benz “F-Cell” hydrogen fuel cell vehicle to researchers at the University of California (UC) – Berkeley’s Institute of Transportation Studies and California Partners for Advanced Transit and Highways (PATH). UC Berkeley researchers have reached an agreement with DaimlerChrysler to test and conduct research on the F-Cell vehicle for a period of two years. The UC Berkeley program involves placing the vehicle in a motor pool-type setting at the PATH Headquarters facility at the Richmond Field Station in Richmond, California.

This arrangement is part of an agreement between the U.S. Department of Energy (DOE), DaimlerChrysler, BP, and other partners to test hydrogen-powered vehicles over the next four years. DaimlerChrysler, BP, and UC Berkeley are partners on one of five U.S. DOE awards under the “Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Program” program. Ford Motor Company, General Motors Corporation, Texaco Energy Systems LLC, and Air Products and Chemicals Inc are leading the other four teams.

UC Berkeley to Test and Conduct Travel Behavior Research with DaimlerChrysler “F-Cell” Hydrogen Fuel Cell Vehicle

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The F-Cell vehicle employs a 72-kilowatt proton-exchange membrane fuel cell system, manufactured by Ballard Power Systems, and a 15-kilowatt battery to power the vehicle’s electric motor. The vehicle achieves an approximate 100-mile driving range on about 2 kilograms of hydrogen gas stored at 5,000 psi (350 bar). The vehicle emits only water vapor and oxygen-depleted air as exhaust from its tailpipe.

Depending on how the hydrogen is made initially, there can be “upstream” emissions associated with the use of the vehicle. However, even if the hydrogen fuel is made directly via the reforming of natural gas, criteria pollutants and greenhouse gases are reduced relative to conventional vehicles. Recent estimates suggest that greenhouse gases can be reduced by 20 to 40 percent with hydrogen made from natural gas, and up to 95 to 100 percent if hydrogen is made from wind, solar, and some types of biomass power sources.

Drivers of the UC Berkeley F-Cell vehicle are participating in a training session on vehicle operation prior to using it, and some drivers will receive additional training for hydrogen refueling. The vehicle will initially be refueled at the AC Transit hydrogen refueling facility in nearby Richmond (see photo next page) per agreement with the transit agency and Hydrogenics Inc., as well as in Oakland per agreement with AC Transit and ChevronTexaco Corp., and at UC Davis.

In addition to providing DaimlerChrysler and the U.S. DOE with “real-world” operational experience with the vehicle, PATH researchers will be conducting various travel-behavior studies related to the use of the vehicle. This continued on next page
research is primarily be funded by the California Department of Transportation (Caltrans). As part of one study, PATH researchers are using the UC Berkeley vehicle and two F-Cell vehicles operated by Caltrans to gauge user experiences with the vehicle and the hydrogen refueling process. Various user acceptance surveys, "ride-and-drive" clinics, and focus groups are being planned for the summer.

PATH researchers hope to use their experience with the F-Cell vehicle to extend a recently completed Caltrans/PATH grant that explored the potential for using intelligent transportation systems (ITS) to maximize access to early hydrogen refueling infrastructure. This exploratory project, conducted in 2005, was titled "Integrated Hydrogen and Intelligent Transportation Systems Evaluation for the California Department of Transportation." (UCB-ITS-PRR-2005-34)

Key findings from the study include the following:
1) several states are competing with California to develop hydrogen infrastructure and vehicle deployment plans (in particular New York and Florida);
2) the U.S. Department of Transportation is conducting significant hydrogen-related activities under the new Research and Innovative Technology Administration (RITA) division;
3) the California Hydrogen Blueprint Plan includes several references to Caltrans as a key partner in hydrogen projects, particularly related to hydrogen station siting and incorporation of hydrogen vehicles in government fleets; and
4) there are several interesting concepts for integrating hydrogen powered vehicles and ITS to help facilitate the introduction of these vehicles.

With regard to this last finding, PATH researchers hypothesize that ITS can provide an important means for vehicle drivers to locate and find refueling locations and maximize the usefulness of the vehicles. Given an initial sparse hydrogen infrastructure and with early hydrogen-powered vehicles at least somewhat range-limited, this concept could be an important enabling mechanism. ITS could also be used by vehicle operators to reserve and pre-purchase fuel, thus providing hydrogen station owners with greater certainty with regard to the level and timing of demand. This could help to maximize the throughput of the stations and reduce fuel costs.

We would like to acknowledge the Division of Research and Innovation at Caltrans for their support of the project UCB-ITS-PRR-2005-34 "Integrated Hydrogen and Intelligent Transportation Systems Evaluation for the California Department of Transportation", Timothy E. Lipman, Susan Shaheen, November 2005, 63 pp.

The key PATH researchers involved in the F-Cell vehicle-related projects are Timothy Lipman (teli@berkeley.edu), Asst. Research Engineer with ITS-Berkeley, and Susan Shaheen (sasha@path.berkeley.edu), Asst. Research Engineer and Policy and Behavioral Research Program Leader with California PATH.
The VII California demonstration in the 2005 ITS World Congress Innovative Mobility Showcase has been selected, along with 17 others, from a field of 70 nominees for "Best of ITS" for 2006. The category for this finalist status is "Research and Innovation". The VII California effort is a Caltrans- and Metropolitan Transportation Commission (MTC)-led effort to build a Vehicle-Infrastructure Integration or VII testbed (see Intellimotion article "Vehicle-Infrastructure Integration (VII) and Safety: Rubber and Radio Meets the Road in California" Intellimotion Volume 11 Number 2, 2005) in Northern California. California PATH, supporting Caltrans, and Parsons Brinkerhoff Farradyne, supporting MTC are key partners to VII California and to this successful demonstration. Other partners in the demonstration included DaimlerChrysler Research Technology North America and the Volkswagen Electronics Research Laboratory.

To achieve this successful demonstration required a fast track implementation right on the heels of results from evolving research and development. To guide the effort, a Concept of Operations was prepared that established the partner's expectations of the target California VII system including the initial World Congress milestone. Those developed and shown for the World Congress demonstration included:

1. Vehicles as Traffic Probes – The vehicles send raw location, time, speed and direction information to roadside equipment (RSE) which pass the data along to a central processing center where it is used to create timely and accurate real-time traveler information.
2. Travel Time Data to Vehicles – The central processing center sends accurate and up-to-date link travel times to the RSE and then the vehicle for use in real-time dynamic routing.
3. Incident Information to Vehicles - The central processing center transmits real-time incident information to the RSE and then the vehicle, which can be programmed to present this information to the driver in accordance with installed equipment and selected options.
4. In-Vehicle Signage – In-vehicle signing refers to the display (and annunciation, where necessary) of available roadside sign information inside the vehicle. This information would be transmitted via RSEs. The information can describe features about the local area such as speed limits or services that are provided in the near vicinity.
5. OEM Specific Application – Encrypted message set specific to Original Equipment Manufacturer (OEM) requirements, passed between vehicle, RSE and a private center.

As implemented for the 2005 ITS World Congress, the initial VII California provided for the communication of data from equipment located on-board participating vehicles to roadside units deployed at selected locations via Dedicated Short Range Communication (DSRC) radios, an activity led by PATH. From there, the data was communicated to several locations, including the 511/TravInfo® Travel Information Center through a message server and the appropriate addressing schemes; here, PATH was instrumental in developing the underlying network architecture and transport to interface with existing architectures. Next, data from the 511/TravInfo® TIC is also communicated back to the roadside units, through them to the participating vehicle on-board equipment, and then provided to the driver through audio and visual displays, such as shown right from Volkswagen.

The ultimate goals of the VII California program are to:
- Better manage the safety and productivity of the surface transportation system;
- Benefit from the synergy of public sector, auto industry, and other private sector innovations;
- Build upon California’s already considerable existing infrastructure investments.

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Evaluation of the Bay Area Incident Response System (BAIRS), Michael Mauch, Koohong Chung, Soyoung Ahn, Alexander Skabardonis, 67 pp, UCB-ITS-PRR-2006-1


Global Warning Signal Integration as a Tool for Work Zone Safety and Efficiency, Theodore E. Cohn, Joseph E. Barton, Daniel S. Greenhouse, Kent B. Christianson, 74 pp, UCB-ITS-PRR-2006-03

Opportunities for Improved Intermodal Connectivity at California Airports, Xiao-Yun Lu, Geoffrey D. Gosling, Jing Xiong, 135 pp, UCB-ITS-PWP-2006-1


Traffic Management System Performance Using Regression Analysis, David Levinson, Wei Chen, 43 pp, UCB-ITS-PWP-2006-3

Effectiveness of VMS Using Empirical Loop Detector Data, Hong Huo, David Levinson, 25 pp, UCB-ITS-PWP-2006-4


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Technical and logistical activities were co-managed by California PATH and Parsons Brinkerhoff Farradyne in very productive partnership that included guidance from Caltrans and MTC. And certainly, it was a demonstrated success. In a very short time, the VII California partnership formed, planned and conducted a very successful demonstration that portends a significant future for VII in California.

The two other finalists in the Research and Innovation category are:
- General Motors for “Vehicle to Vehicle Communication”
- Motorola for “VII and Motorola”

It is noteworthy that PATH provided some of the fundamental research that led to the General Motors demonstration.