Clean, Green and Smart

Best Practices

West Coast Corridor Coalition

June 2009
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Introduction

The West Coast Corridor Coalition was launched in November 2001 by transportation policy leaders in California, Oregon, Washington, and Alaska to address the looming challenge of goods movement in the Pacific states.

The region was absorbing a 40 percent share of U.S. port-related freight, which was growing at a record pace. The fact that each major West Coast port was located in a large urban area compounded the goods movement challenge by combining metro traffic with long haul and regional freight.

The purpose of the West Coast Corridor Coalition was three-fold:

1. To encourage freight systems approaches rather than a project-level focus in making major infrastructure investments.
2. To share best practices on freight operations.
3. To develop a common voice on the national role played by the West Coast in moving U.S. imports and exports, and the need for national support for this role.

Five years into the Coalition’s work, a co-equal priority had emerged: Growing evidence of global climate change – the increasing frequency of extreme weather events – and transportation’s inescapable part as a source of this environmental risk and impact.

This new priority did not replace the Coalition’s original mission, but added a new and necessary element to the work program. Moreover, since goods movement and personal travel rely largely on the same transportation system, impact the same environment, and would potentially benefit from many of the same new technologies and practices, both aspects of transportation need to be addressed where they are intertwined.

To maximize its capacity for an effective response, the Coalition in 2007 combined two committees: ITS (Intelligent Transportation Systems) and Environment. The intent was to gain leverage on the challenge by harnessing advances in information technology that could empower advances in vehicle and environmental technology.

A commitment was made by the Committee and the Coalition to gather in a Best Practices Manual the most promising innovations and initiatives dealing with transportation-related impacts on the environment and climate change. The Manual would be issued periodically in hard copy, continuously updated on line, and broadly disseminated to policy makers, opinion leaders, and the interested public. A specific best practice would appear as the featured case study in each “issue” of the Manual.

The document before you is the first compilation of West Coast best practices serving the goals of “Clean, Green and Smart.” Our thanks to the outstanding practitioners who provided their research findings and practical experience.
Along the way, we picked up generic insights as well. For example:

- There is a role for research, evaluation, and information dissemination in all phases of applying an innovation. This need does not cease with initial deployment; indeed, failure to continue evaluation could result in chronic under-deployment. Research can help innovations reach their full potential by alleviating barriers and accelerating deployment through public awareness and incentives for widespread adoption.

- At a time of major federal investment in infrastructure, innovative investments that:
  1. rely on a uniform national standard to be effective;
  2. are necessary to meet federal requirements; or
  3. create highly leveraged benefits relative to cost,
are particular candidates for inclusion in federally-funded investment.

The purpose of the Best Practices Manual is to offer an extensive menu of proposed initiatives and currently deployed projects that can reduce the environmental footprint of the transportation system by: (1) applying new fuel, drive-train, and other technologies, and/or (2) making the system more efficient in ways that reduce its required level of resource consumption relative to a given amount of goods movement or personal travel.

Each initiative or project is presented in the following format:
- Concept – a captioning phrase
- Description – what it does, how it works
- Specifics – operational experience, relevant data-points
- Status – proposed or deployed – and on what timeline
- Financing – actual or potential
- Contact – name, title, phone, and e-mail information of principal sources

The Manual is designed to be inclusive in its range of topics while not engaging in the promotion of untested ideas, to qualify descriptions with current status information, and to provide contact information that can be used by anyone seeking to perform due diligence on a specific innovation. With this disclaimer, the Manual seeks to be as comprehensive as possible in offering a full roster of ideas that can move the transportation system toward being “Clean, Green and Smart.”

The Manual is intended to reach a wide spectrum of transportation researchers, policymakers, operational managers, system users, media and the interested public. Its goals are to serve as a clearinghouse for innovations, provide a continuous update of information, support the networking of researchers with each other and the private sector, and raise the level of awareness among all parties who can help facilitate the process of adopting new technologies and systems in transportation.

May each reader find the Manual a valuable source of information that can become part of the action agenda for your agency or organization.
Advisory Board Roster
Clean, Green and Smart Project

Part of the Best Practices Manual process has been to recruit outstanding professionals for an Advisory Board that serves two functions: to keep the project current on status updates and the flow of experience from the field, and to provide peer review so that the Manual covers content in the most widely accessible and technically accurate manner. Those named below have agreed to serve on the Advisory Board, which will be continuously involved in content updates and periodically convened by e-mail, teleconference, and videoconference.

Mark Aggar, Transportation Program Manager, Microsoft Corporation
Lynn Averbeck, ITS Program Manager, Oregon DOT
Rob Bertini, Metropolitan Policy Center, Portland State University
Pete Briglia, Associate Director, Transportation Northwest Regional Center, University of Washington
Bruce Carr, Director of Strategic Planning, Alaska Railroad
Christina Casgar, Goods Movement Policy Manager/Freight Systems Developer, San Diego Association of Governments
Sarah Catz, Director, Center for Urban Infrastructure, UC Irvine
Billy Conner, Director, Transportation Research Center, University of Alaska – Anchorage
Gregg Dal Ponte, Administrator, Motor Carrier Transportation Division, Oregon DOT
Jeff Doyle, Alternative Fuels Corridor Project Manager, Washington State DOT
Genevieve Giuliano, Director, METRANS Policy Center, USC
Matt Hanson, Goods Movement Systems Developer, Caltrans
Hau Hagedorn, Research Director, Oregon Transportation Research & Education Consortium
Melissa Hewitt, ITS Project Consultant, Kimley-Horn Associates
Amy Keiter, Oregon State Economic & Community Development Department
Felix Kramer, Founder, Cal-Cars (The California Cars Initiative)
Greg Larson, Director, Office of Traffic Operations Research, Caltrans
Barbara Lewis, Office Chief, Innovative Finance, Caltrans
Bill Legg, State ITS Operations Engineer, Washington State DOT
Wes Lum, Chief, Office of Safety Innovation, Caltrans
JD Margulici, Associate Director, California Center for Innovative Transportation
Ed McCormack, Civil & Environmental Engineering, University of Washington
James Misener, Executive Director, California Partners for Advanced Transit and Highways (PATH)
Nancy Nihan, Director, Transportation Northwest Regional Center, University of Washington
Tom O’Brien, Director, Center for International Trade & Transportation, CSU Long Beach
Mike Onder, Information Technology Systems Program Manager, FHWA
Jeff Ottesen, Director of Program Development, Alaska DOT
Larry Orcutt, Chief, Division of Research & Innovation, Caltrans
Janet Ray, Corporate Communications, AAA Washington
Stephen Ritchie, Director, Institute of Transportation Studies, UC Irvine
Caroline Rodier, Senior Research Manager, Transportation Sustainability Research Center, UC Berkeley
Steven Schladover, Research Engineer, California Partners for Advanced Transit and Highways (PATH)
Susan Shaheen, Co-Director, Transportation Sustainability Research Center, UC Berkeley
Elizabeth Stratton, Freight Policy and Project Manager, Washington State DOT
Dale Tabat, Manager, Truck Freight Programs & Policy, Washington State DOT
Tom Turrentine, Director of the Electric Vehicle Center, UC Davis
Jim Whitty, Manager, Transportation Operations,
   Office of Innovative Partnerships & Alternative Funding, Oregon DOT
Jerry Wood, Director of Transportation, Gateway Cities Council of Governments
Susan Zielinski, Managing Director, SMART, University of Michigan
1. Transportation Systems Analysis

**Goods Movement Benefits:**

- Targets investments in freight infrastructure based on severity of congestion and ability of specific improvements to enhance system performance.

- Enables motor carriers to reduce emissions and enhance efficiency of operations through "smart" supply chain logistics.

**Personal Travel Benefit:**

- Enables more effective deployment of Bus Rapid Transit (BRT) as an alternative to personal automobile use.

**Transportation System Benefit:**

- Enables measurement of current vehicle emission levels to evaluate feasibility and rate of progress in attaining greenhouse gas reduction targets.
**Concept:**

**Truck Freight Performance Measurement**

**Description:** This research tests the viability of using commercially available GPS-based data to track truck performance within the central Puget Sound region. The data is used to monitor truck speeds and system reliability as performance measures that can be applied to guide freight investment decisions and track project effectiveness.

**Specifics:** The Washington State Department of Transportation (WSDOT) and the TransNow Regional Center at the University of Washington are analyzing the data to assess how state investments in freight highway projects affect system performance.

WSDOT has identified a number of ways this research can help, such as:
- Prioritizing truck freight bottlenecks in the Central Puget Sound region by quantifying delay at each bottleneck.
- Measuring travel times and trip reliability between origins and destinations; for example, from port to warehouse district or from food distribution center to the urban core.
- Analyzing the benefits of freight projects by measuring their “before and after” performance to determine whether, and by how much, they reduce travel time and increase trip reliability for trucks.

Other potential uses for truck freight data include:
- Developing truck travel-speed adjustment factors for loop data collectors by comparing GPS data for trucks and cars.
- Providing real-time truck travel information on WSDOT’s Web.
- Verifying the truck-trip travel times, origins and destinations currently used in state and regional freight models.
- Providing input for air quality models and safety studies.

**Status:** Researchers are receiving data inputs and will use the data that has been collected to evaluate zone-to-zone travel time and reliability. The pilot project will extend through 2010 and a final report will be provided to the state legislature.

**Financing:** The Washington Legislature, with support of the Washington Trucking Association, funded this project.

**Contacts:**
Edward McCormack  
Research Assistant Professor  
TransNow, University of Washington  
Phone: 206-543-3348  
edm@u.washington.edu

Dale Tabat  
Truck Policy and Project Manager  
Washington State Department of Transportation  
Phone: 360-705-6990  
tabatd@wsdot.wa.gov
Concept: **Bottleneck Capacity Analysis**

**Description:** This project examines traffic behavior in freeway bottlenecks. Using data from at least 50 weekdays in a minimum of 20 bottleneck sites in San Diego and elsewhere, the project intends to calculate average time gaps and lane flow ratios from traffic counts and lane occupancy data.

From this research, better planning, design, and management of freeway systems can result by assessing and predicting the bottleneck capacities of certain freeways.

**Specifics:** Traffic counts and lane occupancy data will be gathered using loop detectors, which are typically available at bottlenecks in the San Diego area, and videotapes to ensure a manual count accompanies the loop detectors. From these data, statistical analysis techniques will be used to identify relationships among traffic variables.

**Status:** Deliverables at the end of the project include a final report, a workshop presentation, and an implementation package consisting of the written descriptions of capacity analysis procedures.

**Financing:** California Department of Transportation (Caltrans)

**Contacts:**
James H. Banks  
Professor, College of Civil and Environmental Engineering  
San Diego State University  
Phone: 619-594-7051  
banks@mail.sdsu.edu

Hassan Aboukhadrijeh  
Caltrans Project Manager  
Phone: 916-654-8630  
haboukha@dot.ca.gov
Concept: Integrated ITS Planning for Goods Movement

Specifics: The Gateway Cities Council of Governments, representing cities on the I-710 and I-605 corridors serving the Ports of Long Beach and Los Angeles, commissioned Kimley-Horn and Associates to coordinate a stakeholder working group that would explore ITS applications in support of improving air quality and reducing congestion caused by port-related truck and rail traffic passing through the region, with the goal of minimizing environmental and community disruption while maintaining the economic vitality of a trade gateway.

The stakeholder group was remarkably diverse, including railroads, trucking companies, freight expediters, warehouse and logistics companies, AAA California, federal, state and regional transportation agencies, the ports, and individual cities.

Status: Kimley-Horn filed its “Gateway Cities ITS Integration Plan for Goods Movement” in August 2008. The following objectives were identified for further research and implementation:

- Complete the detection and communication infrastructure on major roadways in the region, supporting ITS-based information to be shared with trucks, dispatchers, rail operators, public agencies and individual roadway users regarding levels of congestion on I-710, I-605 and key “allowable truck route” arterials.

- Collect anonymous truck-specific performance data on speeds, idling, fuel consumption, acceleration, and deceleration, to determine both the functionality of the system for goods movement and environmental effects of congestion.

- Establish a freight-focused traveler information system specific to the Gateway region that would provide drivers and dispatchers with real-time dynamic routing based on truck-experienced delays on freeways and arterials, turnaround times at terminals and queue delays at terminal gates.

- Assess drayage times for container pick-up at the ports and use this information for drayage advisories and to develop a real-time container scheduling system that “has the potential to improve air quality, reduce congestion, and improve the bottom line” for trucking companies and freight railroads.

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Integrated ITS Planning  
for Goods Movement  
(continued)

- Examine the potential to apply dynamic congestion pricing (variable tolling) to major routes as a demand management tool in support of an optimal daily distribution of activity levels for port-related goods movement.

- Apply technology-based detection methods to truck safety checks, given the lack of land for building new inspection stations and the potential for a quicker, more reliable and less labor-intensive truck safety credentialing process.

**Financing:** Gateway Cities Council of Governments, California Department of Transportation, and Federal Highway Administration funded the initial phase of plan development. GCCOG has received federal funds to begin the next phase – plan implementation.

**Contacts:**
Jerry Wood  
Professional Engineer  
Director of Transportation and Engineering, Gateway Cities Council of Governments  
Phone: 562-663-6850  
jerry@jrwoodconsultant.com  

Melissa Hewitt  
Professional Engineer  
Kimley-Horn and Associates, Inc.  
Phone: 818-227-2790  
melissa.hewitt@kimley-horn.com
Concept:

**EPA SmartWay Supply Chain Analysis**

**Description:** Enabling goods-movement companies to assess the environmental footprint of their operations can help them develop supply chain strategies – management techniques and technologies – that increase the amount of cargo moved per gallon of fuel on a fleet-wide basis.

**Specifics:** SmartWay “packages” existing EPA programs and agreements with over 640 partners including rail carriers and most of the top trucking operators, shippers, logistics firms and suppliers. SmartWay is endorsed by the American Trucking Associations.

These programs, with ongoing refinements and updates, allow operators to measure their “climate change footprint” across transport modes and to model and forecast emission reductions based on applying new technology, strategy and modes.

A variety of logistics strategies are available, include load-matching (coordinating loads with other fleets), more efficient routes (“triangular” routing), off-peak delivery schedules, and utilizing inter-modal (rail) transport for moving long-haul freight to regional distribution centers.

SmartWay originated in climate change concerns, which created the need for a multi-modal CO2-footprint model related to goods movement. Inseparable from this impact measure was the demand from both government and industry for efficiency ratings and optimization of supply chain operations. Concern over climate change required industry to inventory, benchmark, and achieve improvements. In this situation, industry welcomed a government role in developing a consistent, global methodology. EPA focused on an approach that built analyses from activity “modules” provided by shippers and carriers. This development of standards based on industry feedback is called the Charter Partner approach. The product is adaptable to commercial software packages that can be used to guide logistics decisions. Companies that participate become SmartWay certified.

**Status:** SmartWay assists participants with demonstrations of advanced fuel systems and other technologies, including SmartWay certification of trucks and other vehicles. Actively participating firms become SmartWay-certified by developing “green” supply chains based on specific operational review and redesign. Industry partners are required to develop a three-year program and monitor its progress.

**Financing:** Participants are eligible for a range of financial incentives including loan guarantees and access to public-private capital. After companies have made initial outlays, the benefit of “green supply” chains is not only environmental; it is economic, expressed in more efficient operations and reduced purchases of resource inputs.

**Contact:**
Shan Hoel
TransGroup — SmartWay partner, Seattle
Phone: 206-577-4803
shan.hoel.hq@transgroup.com
Concept:  
“Green” Performance Measures for Transportation Systems

Description: Evaluate transportation system impacts on greenhouse gases, air pollution, and community quality of life by including “green” metrics in transportation data collection and evaluation.

Specifics: The Portland Transportation Archive Listing (PORTAL) regional transportation data archive was established at Portland State University in 2004 to improve understanding of the metro region’s transportation system performance.

The primary data sources for PORTAL are 600 loop detectors on metro-area freeways that stream data to servers at 20-second intervals. The loops measure vehicle count, detector occupancy (a surrogate for traffic density), and average speed in each lane. These data are combined with incident, variable message sign, bus timing, and weather data. Currently computed performance measures are vehicle miles traveled, vehicle hours traveled, travel time, and delay.

PORTAL is now augmenting these measures of transportation performance with measures that assess the environmental, economic and social sustainability of Portland’s freeway system.

Environmental measures include traffic-generated carbon monoxide, nitrogen oxides, hydrocarbons, and carbon dioxide, which contributes to climate change. Economic and social measures include the cost of delay and personal mobility in terms of person-hours and person-miles of travel.

Status: The PORTAL database is being applied as a policy tool to help assess various design, operational and behavioral factors that affect the level of vehicle travel; the efficiency of peak-hour and off-peak hour traffic flow; and the level of fuel use and related pollution impacts.

The usefulness of the database for these purposes increases with a longer period of data collection that enables measurement of the impacts of events and trends. Accuracy of the new measures will increase as analytical algorithms are refined to convert measured data into assessments of key indicators.

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Green” Performance Measures for Transportation Systems
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Financing: Oregon Transportation Research and Education Consortium (OTREC) funding sources include a federal Urban Transportation Center grant and matching funds from the four Oregon university members of OTREC, the Oregon DOT, and public and private project partners.

Contacts:
Robert Bertini  
Civil and Environmental Engineering  
Portland State University  
Phone: 503-725-4249  
bertini@pdx.edu  

Alexander Bigazzi  
Civil and Environmental Engineering  
Portland State University  
Phone: 503-725-4285  
abigazzi@pdx.edu  

Hau Hagedorn  
Research Program Manager, OTREC  
Portland State University  
Phone: 503-725-2833  
hagedorn@pdx.edu  

Web site:  
http://portal.its.pdx.edu/
Concept: Loop Detector-Based Vehicle Tracking to Evaluate System Performance

Description: RTREID (Real-time Vehicle Re-identification) is a cost-effective, real-time vehicle tracking system that utilizes existing ILD (inductive-loop detector) technology. The system provides accurate corridor travel time as well as anonymous vehicle path information. The flexibility of the system application to square and round single loop configurations allows RTREID to be free of site-specific calibration and transferability issues.

Specifics: Vehicle re-identification has emerged due to its substantial potential for effective implementation of ATMIS (Advanced Transportation Management and Information Systems). In studies of vehicle re-identification, the main stress falls on travel information, travel time estimation, and origin-destination estimation. RTREID has been developed in response to these data needs, and is designed to be implemented in real-time with existing detection technology.

RTREID is an ILD-based vehicle tracking system that re-identifies vehicles by matching inductive vehicle signatures generated via advanced detector cards. The change in inductance resulting from passage of a vehicle over a loop detector makes it possible to measure an inductive vehicle signature, which ideally is unique to that vehicle.

Advantages of employing an ILD-based system include tracing vehicles individually across multiple detection stations without privacy concerns, relatively inexpensive deployment, reproducible vehicle signatures, less complexity of analysis, and fewer market penetration problems.

Computational resources in traffic operations and the bandwidth of field communication links are often quite limited. Therefore, RTREID adopts a relatively simple data compression and transformation technique that could be integrated with a section-based freeway traffic performance measurement system. The same research group developed RTPMS, an advanced surveillance system. RTPMS was successfully deployed as a core module in a simulated real-time environment using peak-period traffic data collected along a 6.2 mile corridor on the I-405 Freeway in Irvine, California. Coverage spanned six detector stations to form five continuous sections.

The studies also indicate that the next-generation RTREID-2 is capable of accurately providing individual vehicle tracking information and performance measurements such as travel time and speed in a congested freeway corridor, utilizing data obtained from both homogenous and heterogeneous loop detection systems.

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Loop Detector-Based Vehicle Tracking to Evaluate System Performance (continued)

**Status:** The RTPMS is currently undergoing a real-time implementation phase that consists of installation of a wireless communications infrastructure on 18 detector stations along the I-405 northbound freeway, followed by a system shakedown operation. In addition to the mainline detector stations, on-and-off ramp detector locations will be included in the system. Data transmission is performed over wireless cards. Currently, the status and IP data are updated in the RTPMS database at UC Irvine’s Institute of Transportation Studies. RTPMS is being tested and modified for stability to ensure smooth data transmission from the field units.

The final step in evaluation of the performance of RTPMS is setting up wireless communication along the I-405 north corridor between State Route 133 and Red Hill Avenue in Irvine. Completion of the implementation phase will yield online real-time travel performance measures generated by RTREID-2.

The ultimate goal is deployment of the system in multiple freeway and arterial corridors to provide network-wide coverage and advanced traffic surveillance. This will facilitate the development of freeway origin-destination and route performance models. While implementation of the RTPMS requires an effort, its potential should readily outweigh its cost in providing state-of-the-art measures of traffic performance using existing inductive loop detector infrastructure.

**Financing:** California Department of Transportation

**Contacts:**
Stephen G. Ritchie  
Director, Institute of Transportation Studies  
University of California, Irvine  
Phone: 949-824-4214  
sritch@uci.edu

Shin-Ting (Cindy) Jeng  
Postdoctoral Scholar, Institute of Transportation Studies  
University of California, Irvine  
sjeng@uci.edu
Concept:
Deployment Strategy for Integrated Bus Rapid Transit (BRT)

Description: Bus Rapid Transit (BRT) is different from traditional transit service by incorporating many rail transit features. It also differs from traditional rail due to flexibility and the possibility for incremental deployment. However, there is a lack of careful systematic analysis on when each BRT element should be implemented. Absent such a framework, deployment will be determined by the tradeoff between the costs, ease of implementation (physical constraints and institutional issues), and resultant benefits.

Specifics: One of PATH’s (Partners for Advanced Transit and Highways) ongoing research projects is developing a planning framework to determine a set of optimal combinations of BRT attributes given budgetary, institutional, and other types of constraints. A related issue is integrated deployment of advanced technologies. In almost all BRT deployments, ITS and bus technologies have been applied to BRT in less than a fully integrated manner.

For example, the current bus data communication system has not yet considered many BRT features. Therefore, many of the add-on functions and features cannot be integrated with the current bus system. Another example, a transit bus instrumented with advanced communication systems (ACS), signal priority systems, and bus arrival information functions is often equipped with three separate positioning systems.

Moreover, data collected by advanced location and communication systems are not integrated, and data collected from one system often cannot be used by the other systems. Few application tools are available to take advantage of the significant amount of data collected by new technologies. This non-integrated approach to add-on technologies increases the cost of the BRT system and the non-integrated systems complicate maintenance and reduce the reliability of the overall system.

Status: NBRTI (National Bus Rapid Transit Institute) at UC Berkeley proposes to conduct research on planning and deployment strategies for integrated BRT systems. This proposed study will summarize the needs, issues and options related to BRT planning, design, technology implementation, operation, and maintenance. The study will then investigate the cost / benefit implications of these options and develop a systematic methodology for phased deployment and integrated implementation of BRT technologies. The output of this research will provide transit agencies and BRT-interested professionals with critical information and decision-support tools for the planning, design and implementation of a BRT system.

Contact:
Wei-Bin Zhang
California PATH and National Bus Rapid Transit Institute (NBRTI)
Institute of Transportation Studies
University of California at Berkeley
wbzhang@path.berkeley.edu
Concept: “Fully Featured” Bus Rapid Transit (BRT) Corridor Development

Description: In 1994, the Lane Transit District (LTD, Lane County, Oregon) began efforts to develop a fully featured bus rapid transit (BRT) system. After conducting an Urban Rail Feasibility Study in 1995, BRT was determined to be the cost-effective mode for the Eugene-Springfield region. The BRT corridor development concept became an important piece in the analysis of how to meet statewide transportation goals during the 2001 Regional Transportation Plan (RTP) update. The project received approval from the Metropolitan Planning Organization (MPO), LTD Board, Eugene and Springfield City Councils, and the Lane County Board of Commissioners. Shortly thereafter, LTD set to work incorporating as many light rail elements as possible while planning for potential corridors and developing operational details.

Specifics: LTD began operation of a four-mile BRT corridor in January 2007 and is on schedule to begin operation of a second, seven-mile corridor in late 2010. Named the EmX (Emerald Express), the BRT service features 10-minute frequencies, ADA accessible raised platforms, stations spaced every 1/3 mile, level boarding, and off-board fare collection. Over 50 percent of the length of the corridors consists of dedicated lanes. In general, LTD incorporates “green” designs at each station with native vegetation. The 63-foot articulated vehicles have a rail-like appearance, doors on both sides, emerald green exterior, and a unique layout with inward facing raised seating and on-board capacity for three bicycles.

The first corridor provides a four-mile trunk line connection between the downtown transit centers of the cities of Eugene and Springfield. It serves the University of Oregon and Sacred Heart Medical Center, two of the largest employers and participants in LTD’s Group Pass Program. Because over 90 percent of riders along the corridor have pre-paid types of fare media and monthly bus passes, LTD does not yet collect fares. LTD staff has determined that the high cost to purchase and install fare box machines at the stations will not result in revenue gains until the second corridor is ready for operation. That EmX corridor will allow a one-seat ride from downtown Eugene to a new regional hospital and mall in Springfield.

Status: Ridership on the first EmX corridor has grown steadily. The corridor replaced Route 11, which had an average of 2,660 weekday riders during the fall and spring of 2006.

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Since operation of EmX began, the first corridor has an average of 5,000 weekday riders in 2007, and an average of 6,000 weekday riders in 2008. With the success of the first corridor, which has more than doubled ridership of the previous regular service, the International Transportation Development Program (ITDP) nominated LTD for a Sustainable Transportation Award in January 2008.

Developers and city staff anticipate that over time, commercial and high-density residential growth will align along the corridors. A pilot project sponsored by the Federal Transit Administration (FTA) for vehicle magnetic guidance will inform service design and implementation for future corridors.

**Financing:** FTA funded the first four-mile corridor for a total of $24M (20 percent local match) and the second, seven-mile corridor for a total of $41.3M (7 percent local match, 13 percent state match).

**Contact:**
Tom Schwetz
Director of Planning and Development
Lane Transit District
Phone: 541-682-6203
tom.schwetz@ltd.org
2. Traveler Information Integration (TII)

Goods Movement Benefits:

- Provides motor carriers and drivers with comprehensive information on travel conditions for efficient trip planning and on-road performance.

- Provides personal travel information that encourages drivers to avoid congested routes and times and to utilize transit, reducing the volume of private vehicles on highways and arterials during peak hours when regional freight deliveries are most at risk of delay.

Personal Travel Benefit:

- Empowers commuters and other travelers with information on the full range of options for car sharing, ridesharing, smart parking, and easy connection to transit.

Transportation System Benefit:

- Enables all system users to utilize a wider range of options in making trip decisions, thereby minimizing time loss and fuel consumption related to congestion and other delay factors.
**Concept:**

**I-5 Corridor Traveler Web Site**

**Description:** A single Web source that provides detailed traveler information for Washington, Oregon, and California. The Web site allows truckers and motorists to make informed decisions prior to the start of a trip as well as making adjustments during the trip.

**Specifics:** The site compiles listings and information for truckers and motorists in the tri-state I-5 corridor on rest areas, local weather, truck stops, truck permits and trucker restrictions and highlights the 511 phone line for current traffic information in Washington, Oregon, and Northern California.

**Status:** The Web site is live and provides traveler information. However, based on input from state trucking associations, truck drivers, and truck transport operators, the site could provide additional information. Initial discussions are underway on improvements.

The unified Web address should provide truck drivers and truck transport operators with information on roadway and traffic conditions, weather conditions, rest area and truck stop services and parking availability, and interstate permitting. Web site information should include accident, incident and weather alerts, and construction activity currently or forecast as causing delay or detours; a status map of available parking along the corridor provided by both state and private resources, potentially including a reservation system; truck stop and rest area services and amenities; and permitting for each state in the corridor, including the possible development of a single permit for all three states.

**Financing:** Washington State DOT developed and hosts the traveler information website. No additional financing is available for improvements.

**Contact:**
Dale Tabat
Manager, Truck Freight Program & Policy
Washington State Department of Transportation
Phone: 360-705-6990
tabatd@wsdot.wa.gov

**Web site:**
www.wsdot.wa.gov/partners/TIO/default.htm
Concept: Freight Travel Alert Notification System

Description: Freight shippers and carriers sign up for e-mail alerts of roadway conditions and emergency notifications for areas they select. The messages are tailored to provide specific information useful to freight transportation users.

Specifics: In 2007, the Washington Department of Transportation (WSDOT) developed an e-mail alert system to communicate information on road closures, construction impacts, and emergency conditions that impact the freight community. The Freight Notification System began with over 900 subscribers from trucking companies, shippers, retailers, wholesalers, government, and private companies. By the time of the I-5 closure in December 2007 and the I-90 closure in February 2008, the subscriber list had grown to nearly 3,000. With the addition of the Washington and American Trucking Associations, the system has over 3,400 subscribers and can reach an estimated 10,000 contacts through the freight notification system.

Freight messages are sent several times a week to provide road conditions, construction updates, overweight and flammable cargo restrictions, and information on safe and legal detours for trucks. This technology provides reliable real-time information that helps ensure safe and efficient mobility of freight.

Status: WSDOT has received significant positive feedback from shippers and carriers on the usefulness of this notification system. During the I-5 closure of 2007 in particular, WSDOT was praised for its effective communication. Specifically, the email updates were identified as the most helpful tool for freight companies, followed by information on the WSDOT Web site and Webcam reports. Users have asked that a similar notification system be used in other states.

Contact: Vickie Sheehan
Communications Manager
Freight Systems Division
Washington State DOT
Phone: 360-705-7904
shehav@wsdot.wa.gov

To sign up for freight alerts, go to:
https://service.govdelivery.com/service/user.html?code=WADOT
Concept:
**Truck Smart Parking Strategy Analysis**

**Description:** An existing shortage of private and public parking for trucks has been intensified by federal rules limiting driving shifts and mandating rest periods. In the search for scarce parking spaces, drivers become fatigued and more trucks are parked illegally on ramps and shoulders, creating safety hazards. The solution is to expand capacity and improve information about available truck parking.

**Status:** In response to the shortage of truck parking, the federal surface transportation funding act (SAFETEA-LU) authorizes a Truck Parking Facilities Pilot Program. This is a four-part project that builds on previous research by California PATH (Partners for Advanced Transit and Highways) titled, “Strategies for Linking Trucking and Smart Parking Technologies.”

The second PATH project includes a problem evaluation with expert interviews, data analysis of the truck parking problem, funding opportunities to address the capacity needs, interviews to understand institutional barriers to implementing truck parking solutions in California, and workshops to brief stakeholders on the problem and develop alternative deployment strategies.

There are five key research areas: First, the study addresses concerns about truck parking by reviewing the literature and conducting expert interviews with CHP (California Highway Patrol) personnel and motor carriers. ITS (Intelligent Transportation System) solutions are then recommended.

Second, researchers conducted expert interviews with Caltrans’ Office of Goods Movement, Planning, and Traffic Operations, the Division of Research and Innovation, the CHP, Federal Motor Carrier Safety Administration, the National Transportation Safety Board, the American Trucking Associations, and motor carrier firms. As part of these interviews, electronic commercial vehicle operator screening is considered. The intent is to identify institutional barriers delaying ITS solutions to the parking problem, and identify steps to overcome those barriers.

Third, a behavioral analysis of 200 or more truckers at the Port of Oakland and other locations will be conducted to assess trucker perceptions of current conditions, and responses to ITS solutions such as a reservation system.

(continued on next page)
Truck Smart Parking Strategy Analysis (continued)

Fourth, interviews were conducted with experts from parking technology companies (Clancy, Denso, ParkingCarma, Quixote, etc.) on providing parking information to truckers by CB-radios, changeable message signs, mobile phones, on-board computers, parking sensors, PrePass commercial transponders, and/or traveler information radios.

Finally, a preliminary site analyses will be conducted to identify suitable locations to apply ITS technologies, including rest stops in Stockton and north of Sacramento. A field test will be organized with rest stop operators, technology vendors, and trucking firms to test the technologies.

Financing: SAFETEA-LU authorizes $25 million for the establishment of a Truck Parking Pilot Facilities Program.

California has received $4.5 million from that source and Caltrans has indicated it wants to work with Oregon and Washington to enhance truck Smart Park initiatives on the West Coast. Moreover, this effort could also be linked to the three-state Interstate 5 Alternative Fuels Corridor initiative (see page 87).

Contacts:
Susan Shaheen
Co-Director, Transportation Sustainability Research Center
University of California, Berkeley
Phone: 510-665-3483
sashaheen@tsrc.berkeley.edu

Caroline Rodier
Senior Researcher, Transportation Sustainability Research Center
University of California, Berkeley
Phone: 510-665-3524
caroline@tsrc.berkeley.edu
Concept: 
New Mobility Hub Networks – an Integrated VMT Reduction Strategy

Description: Create networks of “New Mobility Hubs” that allow people to move from point of origin to destination in the most efficient way, through software development that makes servers more powerful than in the past.

New Mobility Hub Networks link different modes of transport, including buses, trains, streetcars, clean-fuel taxis and car-share or bike-share vehicles, to provide convenient, practical door-to-door trips that the user finds preferable to traditional use of a single-occupancy vehicle.

Specifics: A range of innovations can link different modes of transportation services, IT technologies, and designs and infrastructures to provide integrated urban transportation choices enabling users to select the best mode for each purpose.

Transportation systems can be designed to make travel by bus and rail transit, car-sharing and bicycle-sharing, and walking all as easy and efficient as possible, with emphasis on seamless connectivity among modes of travel. Modal transfer can be facilitated through real-time arrival, departure, availability and access information at public kiosks, via cell phone and through electronic signage.

Where practical, augment these transport amenities with satellite offices (remote work stations), day care, cafes, shops, entertainment, restrooms and showers. For the user, New Mobility Hub Networks connect a full range of transport with other services, products and technologies. For the developer, Hubs have the virtue of being scalable and thus adaptable to retrofits and expansions of existing sites, especially those that are or could be activity nodes.

The concept originally developed from integrated “Mobil Punkt” work in Bremen, Germany in the late 1990s under the leadership of Michael Glotz Richter, who continues to be an active project partner.

Status: Joint concept development by the lead co-partners (see Financing, below) is currently underway. Other participating entities, including Toronto, Ontario, are serving as sites for pilot projects and field testing of concepts. Corporations including Royal Dutch Shell, Cisco, Cherokee, and GoLoco have participated in visioning sessions on the meaning of the New Mobility for their companies and globally.

Financing: The University of Michigan SMART (Sustainable Mobility and Accessibility Research and Transformation) Program catalyzes hub network projects and partnerships in cities. The Ford Motor Company Sustainable Business Development Program has provided funding.

Contact:
Susan Zielinski
Managing Director, SMART
University of Michigan
Phone: 734-763-1190
susanz@isr.umich.edu
Concept:
Safety Roadside Rest Area (SRRA) Hot Spots

Description: To meet the increasing demand for Internet access by the traveling public, this project investigated providing travel-related information to the public by kiosk, laptop computers, personal data assistants, and cell phones. Such information might include transportation and safety advisories, including emergencies, road conditions, and road closures, tourist information on local attractions and services such as parks, museums, hotels, and restaurants, and historical information on the region.

Status: The California Department of Transportation (Caltrans) has partnered with the Great Valley Center (GCV) to launch a field operational test of wireless Internet and Internet kiosks at two rest areas (Phillip S. Raine and Enoch Christoffersen) along State Route (SR) 99. Caltrans has developed recommendations for the state based on study findings.

The objectives of this field test and related Wi-Fi technologies include improving traveler safety, reducing traveler delays, promoting tourism of local natural, cultural, and historical resources, and contributing to California’s economic development. This project is a research evaluation of the field test, including institutional, user, and financial analyses.

Contact:
Susan Shaheen
Co-Director, Transportation Sustainability Research Center
University of California, Berkeley
Phone: 510-665-3483
sashaheen@tsrc.berkeley.edu

Caroline Rodier
Senior Researcher, Transportation Sustainability Research Center
University of California, Berkeley
Phone: 510-665-3524
caroline@tsrc.berkeley.edu
Concept: Ridesharing

Description: Carpooling and vanpooling reduce commute costs, save time through access to HOV lanes, and relieve pollution and congestion by reducing vehicle-miles traveled. Carpools are usually based on privately-owned vehicles, vanpools on vans that are rented or supplied by employers, non-profit agencies or government.

Many public transit agencies and community transit providers offer ride-matching services, connecting travelers with similar schedules and routes. At least one private company (Microsoft) has gone farther to develop commute compatibility profiles focused on ride-matching at a person-to-person level. This can be combined with personal paging on a mobile phone call to inform participants in “virtual” carpools of pre-screened persons who are planning a trip at the same time.

Status: In 2006 and 2007, Innovative Mobility Research (IMR) joined with the 511 Regional Rideshare Program to develop and implement an online survey of the use of 511 for ridesharing purposes. 511 is a free phone and Web service in the Bay Area that provides real-time information on traffic conditions, incidents and driving times, public transit schedules, routes and fares, carpool and vanpool referrals, bicycling, and other transportation information.

The survey results were used to determine the effectiveness of 511 in encouraging individuals to switch from driving alone to using commuter alternatives, particularly carpooling and vanpooling.

In March 2009, King County Metro (Seattle) and the Washington State Department of Transportation began development of an updated Ridesharing application that provides ride-matching services in the Pacific Northwest tri-state area of Washington, Oregon, and Idaho.

King County Metro originally partnered with Puget Sound transit agencies in 2001 on the development and implementation of one of the first online vanpool and carpool ride-matching services available in the country. It was subsequently expanded in 2005 to cover the entire state of Washington and again in 2007 to cover Boise and Ketchum, Idaho.

The new application will provide improved and expanded matching capability:
- Map-based origin-destination and along-the-route matching.
- New types of rides – commute, dynamic (same day), one-way, one-time, long distance.
- Customizable matching for private groups or special events (soccer team, wedding, church, school).

(continued on next page)
Ridesharing
(continued)

• Ability to enter and maintain multiple trips by re-using selected matching information.

Branding the Ridesharing Web site with the look and feel of a company or organization:
  • Ability to manage a Guaranteed Ride Home program online.
  • Ability to run reports about employee participation and show effects of reduced trips and vehicle miles traveled.

Provision of Commute Program Management Tools:
  • Ability for employers to create and promote transportation incentives.
  • Ability to track commuter participation through calendar registration.

Longer term, the project is exploring opportunities to enhance the system with technologies to optimize rider/driver matching in real time and integrate the requesting of riders/drivers with existing calendaring tools.

The go live date for the new application is January 2010.

Financing: By the sponsoring agencies for the Bay Area and Northwest programs.

Contacts:
Susan Shaheen
Co-Director, Transportation Sustainability Research Center
University of California, Berkeley
Phone: 510-665-3483
sashaheen@tsrc.berkeley.edu

Park Woodworth
Manager, Para-transit / Rideshare Operations
King County Metro Transit
Phone: 206-263-4494
park.woodworth@kingcounty.gov

Mark Aggar
Director, Environmental Technology Strategy
Microsoft Corporation
maggar@microsoft.com

Web site: RideshareOnline.com
Concept: Carsharing

Description: Carsharing offers an alternative to owning or leasing an auto. It allows people to rent cars on a daily or even hourly basis, paying only for the time they use the car and the mileage they drive. The operators of the Carsharing service provide vehicle maintenance, repair, and insurance.

The environmental benefits of Carsharing result from the behaviors that are encouraged by its use – more careful consideration of the need, duration and distance of auto trips, and of alternative modes including public transit, biking, and walking.

Specifics: Members of a Carsharing program pick up and return vehicles at shared-use lots that are located throughout an urban region or concentrated around public transit stations, employers, or activity centers. Typically, the member makes an advanced reservation, gains entrance to the vehicle with a card or key, and drives away. When finished with the trip, the Carsharing member returns it to its home parking space, locks it, and leaves it for the next user.

This efficient use pattern has a clear benefit in reduced parking demand at residential locations and participating public transit stations and member employer sites. It provides incentives for more thoughtful vehicle use, which creates energy savings and air quality benefits.

One specific application of Carsharing is to facilitate public transit use through “station car” programs that facilitate transit access for users whose final destination would otherwise be located too far from the endpoint of the transit route. These users complete the final leg of their trip in station cars.

Carsharing is also a “natural” match to driver populations willing to test advanced technology vehicles. A decade ago, CarLink I was launched to allow employees of the Lawrence Livermore National Laboratory access to 12 compressed natural gas Honda Civic autos for use between a public transit station and work. Other participant members could pick up the cars at the station and use them on evenings and weekends. Scheduling technology and vehicle tracking systems were employed.

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Carsharing (continued)

CarLink I resulted in a net reduction of about 20 vehicle miles per commuter per day. CarLink II, launched in 2001, introduced more advanced vehicle access, reservation, and tracking technologies. At the conclusion of the research phase in July 2002, the project transitioned to the Carsharing provider Flexcar to manage as a commercial enterprise (in 2007 Flexcar and Zipcar merged and the operation is now known as Zipcar).

**Status:** As of July 2008, 19 U.S. Carsharing programs claimed 279,174 members sharing 5,838 vehicles. Canada’s 14 organizations shared 1,667 vehicles among 39,664 members. This initial deployment represents a fraction of the potential if program design and public policy successfully address barriers to program expansion (see Automobile Smart Parking, page 31).

**Financing:** Carsharing is a new mode and would benefit from sustained public policy support that fosters its viability. For example, provision of dedicated parking spaces and exemption from taxation levied on conventional car rentals could greatly aid expansion of this concept.

**Contact:**
Susan Shaheen
Co-Director, Transportation Sustainability Research Center
University of California, Berkeley
Phone: 510-665-3483
sashaheen@tsrc.berkeley.edu
Concept:
Automobile Smart Parking

Description: Advanced parking systems and technologies are used to assist drivers in locating available parking places, thereby reducing time loss, street congestion, distance traveled and fuel consumed by drivers trying to park their vehicles. They often assist in electronic payment as well.

Specifics: Drivers can be informed of parking lot location, capacity, and spaces available by dynamic displays on electronic message signs or by Internet or mobile phone. Automated payment systems can allow for seamless transactions that enhance trip efficiency. Information on space availability can enhance efficiency in using existing capacity, while strengthening the economics of parking operations.

Parking availability – or its scarcity – in specific locations influences the mode travelers use to commute and make other trips. Where parking is restricted intentionally as a demand management tool to encourage public transit use, knowledge of space availability can help strengthen the link between policy goals and an informed public response.

Status: An effort known as SFpark is underway in San Francisco to deploy a smart automobile parking system that employs dynamic pricing. The project is part of USDOT’s Urban Partnership Agreement (UPA). An evaluation of this large-scale effort is being conducted throughout San Francisco as part of the UPA.

Financing: Smart parking capability creates market-based systems that have the potential to pay for themselves by increasing utilization rates, and thus improving the economics of operating parking facilities. By optimizing use of existing capacity, smart parking can also reduce the need to add new parking infrastructure.

Contact:
Susan Shaheen
Co-Director, Transportation Sustainability Research Center
University of California, Berkeley
Phone: 510-665-3483
sashaheen@tsrc.berkeley.edu

Caroline Rodier
Senior Researcher, Transportation Sustainability Research Center
University of California, Berkeley
Phone: 510-665-3524
caroline@tsrc.berkeley.edu
Concept: Transit Smart Parking

Description: Parking is scarce at heavily used public transit stations, and adding parking spaces is resisted as an added cost for transit operations which require a public subsidy. Transit Smart Parking can expand effective parking capacity, transit ridership, and revenues.

Specifics: In 2004 researchers at UC Berkeley, the California Department of Transportation (Caltrans), the Bay Area Rapid Transit (BART) District, California Partners for Advanced Transit and Highways (PATH), and private partners launched a field test of Smart Parking at the Rockbridge BART station in Oakland, where parking demand is high. Observational research revealed that the free lot would fill by 7:30 a.m., after which more than 30 cars would cycle through the lot looking for parking and then leave.

Traffic sensors were impeded in the station’s reserved lot to relay real-time information to message signs on the major in-bound route to alert drivers to parking availability. The same information was provided by phone and Internet so drivers could either make an advance reservation or drive directly to the space and phone in a reservation.

Status: Before-and-after surveys and focus groups evaluated travel effects, economics, and technology in the field test. A key finding: Commuters are particularly receptive to smart parking systems linked to transit, where real-time information can be critical to meeting a departure schedule. Survey analyses indicated a potential market for a daily paid parking service to attract new riders with relatively high incomes, high auto availability, and variable work schedules or locations. If this service were available, 28 percent of survey respondents said they would use BART more often.

The next phase of this research is a pilot program in San Diego that will deploy smart parking along five COASTER rail transit stations in the region.

This three-year pilot applies concepts from the Smart Parking field operational test at the Rockridge BART station for the San Diego COASTER commuter rail system. These concepts include variable message signs alongside highways approaching COASTER stations to alert drivers of traffic conditions ahead and available parking spots at each station, smart cards or vehicle-based transponders to expedite payment transaction time for parking, and a shuttle service between privately and publicly-owned parking structures around COASTER stations. A commercial deployment strategy will follow implementation and evaluation of the pilot project.
Transit Smart Parking
(continued)

**Financing:** The Rockbridge and COASTER projects will evaluate the assumption that the cost of sensors and data transmission and the cost of additions to capacity would be offset by parking revenues and increased transit ridership.

**Contact:**
Susan Shaheen  
Co-Director, Transportation Sustainability Research Center  
University of California, Berkeley  
Phone: 510-665-3483  
sashaheen@tsrc.berkeley.edu

Caroline Rodier  
Senior Researcher, Transportation Sustainability Research Center  
University of California, Berkeley  
Phone: 510-665-3524  
caroline@tsrc.berkeley.edu
Concept: Public Transit EasyConnect

Description: This effort focused on providing bicycles, electric bicycles, and Segway Human Transporters (self-balancing electric vehicles) for shared use at public transit stations to bridge the “last mile” between public transit stations and employers. The low-speed modes were used for commuting and day use throughout the workday.

The project team included the California Department of Transportation (Caltrans), the Bay Area Rapid Transit (BART) District, California PATH, Contra Costa Centre, Contra Costa County, 511 Contra Costa, the Metropolitan Transportation Commission (MTC), the Bay Area Air Quality Management District (AQMD), and private partners – Air Products & Chemicals, Inc., Millennium Partners, Segway LLC, Giant Bicycle, and eLock Technologies.

Specifics: EasyConnect was field tested at the Pleasant Hill BART station between 2005 and 2007. This location was chosen because of its proximity to Contra Costa Centre, a planned business and residential development and a “transit village.”

Fifteen businesses paid $150 per vehicle per month to join EasyConnect. Employees could use their choice of personal transport vehicle after a short training course. Conventional and electric bicycles and Human Transporters were donated to the program. Users could park them at work and use for travel to off-site meetings, for errands or lunch, and return them to the BART station or an employer storage facility at night.

Status: Contra Costa Centre has assumed management of the program, which is now called “Green Fleet.”

Financing: Transportation Demand Management (TDM) coordinators, together with area employers, typically fund such programs. In some cases, advertising generates additional revenue.

Contact:
Susan Shaheen
Co-Director, Transportation Sustainability Research Center
University of California, Berkeley
Phone: 510-665-3483
sashaheen@tsrc.berkeley.edu

Caroline Rodier
Senior Researcher, Transportation Sustainability Research Center
University of California, Berkeley
Phone: 510-665-3524
caroline@tsrc.berkeley.edu
3. Intelligent Transportation Infrastructure (ITI)

**Goods Movement Benefit:**

- Supports technology development that enhances the capability of motor carries to provide trip planning, travel conditions and safety information “in the cab” for access by drivers.

**Personal Travel Benefit:**

- Supports technology development that enhances collision avoidance capability and real-time access to driver information on traffic conditions.

**Transportation System Benefit:**

- Deploys information technology to expedite the traffic flow of trucks, buses and autos on highways and arterials under all conditions of congestion level and incident response.
Concept: Vehicle Infrastructure Integration (VII) a.k.a. IntelliDriveSM

Specifics: Vehicle Infrastructure Integration (VII) is a flow of information and a roadway infrastructure that enables transportation to function as an integrated system. A key attribute is the widespread availability of data collection by vehicles as traffic data probes. This creates the potential for continuous and ubiquitous information on traffic conditions, roadway conditions, incidents (including hazards) and accidents, pinch-points and choke-points.

Such information provides the basis for comprehensive diagnoses of system performance that could be of major assistance in transportation planning, including management architecture to develop infrastructure and schedule maintenance on the basis of real-time information of highway conditions.

At the individual level, the same capability translates into trip planning capacity. VII also has important safety applications in collision avoidance through inter-vehicle cooperation at intersections and in general traffic flow. On-board VII can provide downstream traffic information to automatically enable timely vehicle deceleration prior to arriving at a point of reduced traffic flow. Related to this is traffic smoothing through merge assistance, Cooperative Adaptive Cruise Control, and transit signal priority. Computer simulations using vehicle probe data can determine the optimal “set speeds” for smoothest traffic flow.

VII can also shorten the gap between vehicles to increase throughput and save fuel. VII-equipped vehicles — cars, buses and trucks — could be clustered in managed lanes and truckways. A recent test of truck platooning on a dedicated truckway used DSRC-based communication combined with sensors and automatic control of engine, brakes and transmission to shorten separations between trucks to as close as three meters. The following truck achieved 10-15 percent fuel savings while the lead truck saved 5-10 percent due to reduced aerodynamic drag. With passenger vehicles enabled by adaptive cruise control, a current experiment is measuring how comfortable drivers will feel with reduced gaps in vehicle spacing enabled by cooperative adaptive cruise control, which has the potential to significantly increase vehicle throughput.

Generally, safety is seen as the critical application of VII, followed by improved mobility based on communication between vehicles and between the vehicle and the roadside.

Status: VII was initiated by USDOT in 2004. There are several similar programs in Europe and Japan. The 2005 ITS World Congress in San Francisco showcased these capabilities, including a collision avoidance demonstration. In 2007 Caltrans met with USDOT to see how to accelerate VII nationally.

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Vehicle Infrastructure Integration (VII) a.k.a. IntelliDriveSM (continued)

Five layers are required for successful VII: ITS services, information management, a communications network, communication nodes, and a transportation system. VII is based on the interactions among them.

Recent progress on smart phones combines a computer, GPS and telephone “shrunk” into a small package. Since May 2008 a device has been available as an after-market product that enables VII, and privacy safeguards are being put in place for cell phones that can be tracked locationally.

Along with smart phones, the other major VII technology is DSRC — Dedicated Short-Range Communications. A national DSRC spectrum was adopted in 1999 due to lobbying by ITS America. DSRC is based on a network of roadside boxes that have instantaneous connectivity of the kind required for collision avoidance. Research is underway on the best strategy for deploying DSRC – performance and network design, density variations required by transmission range, integration with other systems such as Wi-Fi in delivering information to fast-moving cars.

Technology, commercial considerations of deployment, and politics are all involved. Capability, marketability and acceptability must all be there. A key requirement is to achieve consensus on wireless communications technology and standards. Implementation is a major challenge due to multiple levels of government and diverse priorities among public and private sector entities. Yet implementation delivers the largest benefits at high levels of market penetration where “network effects” are achieved.

Cell phones support VII services that relate to slowly changing situations like traffic conditions but not to safety features like collision avoidance and green light enabling at intersections. DSCR technology is required for such time-critical functions.

Caltrans has partnered with Savari, which built a DSRC interface between the car and the roadside using Bluetooth and the mobile phone as aftermarket devices that consumers could buy without waiting for auto manufacturers to install. On-board DSRC is a desirable approach and Savari is working on meeting the national standard.

Financing: The broad-scale questions about VII are how it will be deployed and how it will be financed, including the kind of connection fees cell phone and Wi-Fi service providers would charge, and who would pay for the integration of DSRC roadside and on-board units with Traffic Management Centers (TMCs).

Contact:
Steven Shladover
Research Engineer, PATH (Partners for Advanced Transit and Highways)
UC Berkeley Institute for Transportation Studies
Phone: 510-665-3514
steve@path.berkeley.edu
Concept:

IntelliDrive℠

Safety Applications – USDOT / NHTSA Project

Description: Roadway transportation activity experiences six million crashes per year, 41,000 fatalities in 2007, and associated economic costs of about $250 billion. In addition to fatalities and injuries, traffic crashes account for 25 percent of all congestion, creating nearly $20 billion per year in related cost.

Environmental costs in unproductive fuel consumption and carbon emissions of motor vehicle in accident-related congestion have not been calculated but are significant.

These impacts suggest a stark and compelling need to develop and implement new, more aggressive safety solutions for the U.S. transportation system. Among the most promising approaches is Intellidrive℠, formerly known as Vehicle Infrastructure Integration (VII).

IntelliDrive℠ combines advanced technologies in wireless communications, on-board computer processing, vehicle-sensors, GPS navigation, smart infrastructure, and others — that enable vehicles to identify threats and hazards on the roadway and communicate this information to give other drivers alerts and warnings.

At the core of IntelliDrive℠ is a networked environment supporting very high speed transactions among vehicles (V2V), and between vehicles and infrastructure components (V2I) or hand-held devices (V2D) to enable numerous safety and mobility applications.

This capability to identify, collect, process, exchange, and transmit real-time data provides drivers with a greater situational awareness of the events, potential, threats, and imminent hazards within the vehicle’s environment. Supported by technologies that intuitively and clearly present alerts, advice, and warnings, drivers can make better and safer decisions. When further combined with automated vehicle-safety applications, IntelliDrive℠ technology enables the vehicle to respond and react when the driver does not.

Potential applications of IntelliDrive℠ include:

- Vehicle-to-vehicle (V2V). When a vehicle brakes suddenly, a notice is transmitted to the surrounding vehicles, enabling them to either warn drivers to stop or automatically apply the brakes if a crash is imminent.

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IntelliDrive™ Safety Applications – USDOT / NHTSA Project (continued)

- **Vehicle-to-infrastructure (V2I).** A vehicle in an accident could transmit incident data — time of incident, type of crash, severity — through a roadside infrastructure device to system operators who then broadcast regional warning that alerts to drivers to slow down. Simultaneously, incident data could be transmitted directly to emergency dispatchers for emergency response.

- **Vehicle-to-others (V2D).** A car turning right may be able to send an alert to a bicyclist’s cell phone or device on the bike and avoid a potential collision.

**Status:** The USDOT has conducted extensive research on the effectiveness of vehicle-based collision countermeasures for rear-end, road departure, and lane change crashes. Field operational tests (FOT’s) of collision warning systems have shown measurable benefits in reduction of crashes. However, the systems have inherent shortcomings that reduce their effectiveness such as misidentification of stopped cars and out of path obstacles for rear-end collision warning systems, and map errors and misidentified lane markings for road departure crash warning systems.

The U.S. DOT’s National Highway Traffic Safety Administration (NHTSA) and Research and Innovative Technology Administration are exploring enhancements in vehicle-to-vehicle (V2V) communications that could improve collision-warning systems over the next four to six years and beyond. This research is intended to enhance current and future automotive safety systems such as adaptive cruise control, Emergency Electronic Brake Lights (EEBL) and intersection collision avoidance.

Many of these applications are being developed today without V2V communications. The potential for improved performance over the existing autonomous systems could enhance current safety systems and enable new safety applications to save lives and reduce injuries.

The primary objective of this joint initiative between U.S. DOT and members of the automobile industry is to determine if certain applications that utilize Dedicated Short Range Communications (DSRC) can improve upon and/or enable the performance of vehicle-based systems.

**Financing:** USDOT, NHTSA, and automobile manufacturers.

**Contact:**
Greg Larson
Chief, Office of Traffic Operations Research, Division of Research and Innovation, Caltrans
Phone: 916-657-4369
greg.larson@dot.ca.gov
Concept:
 IntelliDrive℠ Safety and Mobility Applications – SafeTrip-21

Description: SafeTrip-21 is a U.S. DOT initiative to find transformative ways of using existing technology to enhance safety and mobility. The initiative seeks to explore the potential of extending this capability as far as possible in ways that do not require deployment of DSRC (dedicated short-range communication), which requires major hardware investment along roadways. The intent of SafeTrip-21 is to take the wireless communication revolution on the road and into the car to provide the traveler with more route options, modal choices and a safer trip, and to enable pedestrians and bicyclists to send out information about their location and position.

The “connected traveler” would be enabled to access information before and during a trip so the trip may be taken efficiently and safely. Safety, speed, predictability, green footprint – all these can be the focus of “best route” advisories customized into the information profile each driver wants. Such travel information would be provided through a cell phone or other consumer handheld device, such as an aftermarket navigation unit.

Specifics: SafeTrip-21 is leveraging existing technologies to empower people who use the system and those who manage the system. Smart phones will have GPS chips that will provide congestion information on routes that have sensors – and those that don’t. Among possible applications is dynamic route guidance. The consumer information device would “tell” the traveler about road conditions, route alternatives and modal choices (car, bus, rail transit). The device would also send and receive signals regarding vehicle positions (V2V communication) to enhance travel safety.

Under SafeTrip-21, California PATH is combining its existing research test-bed with the San Francisco Bay Area’s roadway infrastructure and Silicon Valley’s ongoing revolution in wireless and personal computing. The goal is to develop applications - tell me about my trip, tell me about my road, watch out for me – that PATH will implement and evaluate.

SafeTrip-21 project partners include the U.S. DOT, Caltrans, private industry (primarily Nokia, NAVTEQ and Nissan), centers at the Institute of Transportation Studies, University of California Berkeley – California Center for Innovative Transportation (CCIT) and California PATH – and the American driver.

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**IntelliDrive℠ Safety and Mobility Applications – SafeTrip-21**  
(continued)

One project premise is that the multi-band, multi-applications environment that underpins SafeTrip-21 will create in consumers the desire and in the United States market the penetration to widely deploy SafeTrip-21 devices.

**Status:** In the next year or so in Bay Area, a series of applications known as “Group-Enabled Mobility and Safety” (GEMS) will be tested. One aim of GEMS is to provide a gateway device – a cell phone with web browser – that can bring multiple communications frequencies to match with the “correct” application, be it safety or mobility, that enables the “connected traveler.”

The “GE” in GEMS means vehicles are engaged in a cooperative use of communications with other vehicles and pedestrians. GEMS supports the connected traveler by providing mobility and safety information. PATH research will determine what information to provide and by what enabling hardware applications in a system for drivers. In one GEMS application, the UC Berkeley, California PATH, and University of Utah research teams are working with NAVTEQ to develop an Internet-based dynamic routing system delivered on a consumer handheld device such as a cell phone. The system aims to provide travelers with alternative routes that can avoid traffic jams and reduce commuting delays. Based on the Map24 interactive map platform provided by NAVTEQ, the screen shot shows a Web page with five alternative routes from downtown Mountain View to the Oakland International Airport, ranking them on real-time traffic information.

Modal shift is enabled through providing transit and parking information through mobile phones and electronic signs and by allowing travelers on the San Francisco Peninsula to access transit information in real-time while they are in motion.

**Financing:** U.S. Department of Transportation

**Contact:**
James Misener  
Executive Director, PATH (Partners for Advanced Transit and Highways)  
UC Berkeley Institute for Transportation Studies  
Phone: 510-665-3612  
misener@path.berkeley.edu

JD Margulici  
Associate Director, CCIT (California Center for Innovative Transportation)  
UC Berkeley Institute for Transportation Studies  
Phone: 510-642-5929  
jd@calccit.org
Concept:
IntelliDriveSM
Mobility Applications – Mobile Millennium Project

Description: Volunteers are invited to participate in the Mobile Millennium traffic pilot, a free public traffic-information system that uses the power of communication to provide the public with real-time traffic conditions.

Avoiding traffic congestion can save time, gasoline, greenhouse gas emissions, and stress. Mobile Millennium is a public-private research partnership that aims to address these key societal issues by providing drivers with current traffic information where and when they can use it to make informed travel decisions that keep traffic flowing.

Status: Researchers use anonymous speed and position information gathered by GPS-equipped cell phones, fuse it with data from static traffic sensors, and broadcast traffic information back to the phones. Data is gathered only from locations that are statistically significant for traffic information. This careful targeting minimizes bandwidth usage by collecting only traffic-relevant data, and equally important, is privacy-aware.

The larger the number of people using it, the better the system will work. Mobile Millennium encourages potential participants to “become an Early Adopter of this cutting-edge, developing technology. Download the free software to your phone and tell your friends. Be a Part of Next-Gen Technology?”

This is an active research project that will be updated regularly based on participant feedback on product-specific issues people are having with the software, including:
- Will it work on my phone?
- How can I install it on my phone?
- How do I look at traffic on my phone?
- How can I get audio traffic reports on my phone in real time?
- When will arterial (side street) information become available?

Mobile Millennium is trying to provide drivers with intelligent choices based on information that is “out there” but not currently available to consumers. It does this by combining Navteq/Nokia-based detection, commercial (taxi cab, etc.) vehicle tracking, and cell phone reports from “virtual lines.”

Financing: The Mobile Millennium traffic information system is provided to users for free jointly by Nokia, Navteq, and UC Berkeley, in partnership with the California and U.S. Departments of Transportation.

Contact:
JD Margulici
Associate Director, CCIT (California Center for Innovative Transportation)
UC Berkeley Institute for Transportation Studies
Phone: 510-642-5929
jd@calccit.org

Web site:
http://traffic.education.edu
Concept:
Strategic Framework for New Technology Adoption

Description: VII / IntelliDriveSM and alternative fuel vehicles are outstanding current examples of promising innovations that require a strategic approach to technology development and user acceptance. Innovation deployment will be impacted by the extent to which this approach is utilized.

Specifics: Experience has shown that the following principles should be followed to support widespread adoption of innovative technologies:

- Design in response to need: Technology developers are often tempted to create all-purpose “problem-solvers” that maximize the number of functions and applications. But this can create devices so complex that they impede user access to critical functions. Developers should instead focus on the key function and simplify the user interface that provides access to that function.

For example, mobile phone users seeking route information for a “smart and safe” trip must page through several screens to reach the navigation system with traffic information. This may be too complicated and slow for users seeking accurate, reliable real-time information. Far preferable would be a single safety-relevant icon and/or a voice interface “pushed” to the driver that addresses the upcoming situation.

- Provide trustworthy information: Technology does not automatically change behavior. People must be willing to make the behavioral changes required to use a new technology. They need to know what is available and how they can access it, or it will not be adopted. A transportation technology must make a difference in the “quality of trip” – or travelers will not bother to learn how to use the system.

For example, public willingness to make trips in alternative fuel vehicles is crucially dependent on information about travel distances versus vehicle range, refueling station locations and the cost and availability of refueling. When people leave their homes they need to have certainty if they are to make decisions about new types of driving experiences. This requires clear, easy-to-access information developed through the deliberate networking of multiple participants who are building facilities and capacity.

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Strategic Framework for New Technology Adoption
(continued)

- **Work through partnerships of government, universities, business, and consumers to connect missing links in technology deployment:** The private sector will move rapidly when it sees a business case; for example, the pace of mobile phone development since 2007. When this happens, a ubiquitous infrastructure can be deployed without taxpayer costs. Government doesn’t move this fast but has the power to set standards and create requirements. Another partner is university centers that cooperate and coordinate to combine research and experience.

CCIT (California Center on Innovative Transportation) is a deployment entity that bridges the private sector, public agencies and academia. CCIT seeks to be an “early identifier” of promising technologies and of agencies willing to champion innovations. It also focuses on technologies to enable capabilities that exist but are not connected.

CCIT works through the “push” of project assistance for new technology that can be developed by universities and adopted by the private sector, and by the “pull” of encouraging vendors to propose innovative demonstration projects that put technologies on the map for government agencies.

An outstanding example of CCIT strategy is the Cal-France project, a major advance that used mobile phones as data probes and created the algorithms to convert complex data into tools that generated results for VII / IntelliDrive℠. The work done by CCIT and UC Berkeley researchers has advanced the technologies to a new level, helping to create an innovation that has a high potential for deployment.

California PATH (Partners for Advanced Transit and Highways) focuses on bridging the “last mile” from research to deployment. PATH’s mission is to accelerate the rate of new technology implementation and adoption. PATH conducts applied prototype-oriented research and serves as a “knowledge champion” for technical experts in overcoming institutional hurdles such as intellectual property (IP) licensing, sole source contracting, and lack of an interface between the public sector and private users in developing performance standards for technology.

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Strategic Framework for New Technology Adoption

TSRC (Transportation Sustainability Research Center) focuses on alternative fuels and vehicles, and sustainable solutions including those based on intelligent transportation systems.

TSRC conducts behavioral, economic, and technical studies as well as deploying technology applications in the field to develop "green" market pathways for promising new technologies that connect transportation system users with innovative products and services beneficial to both society and the environment.

CCIT, PATH, and TSRC are part of the Institute of Transportation Studies, University of California, Berkeley. Caltrans is supporting the activities of these entities through a model based on field tests, prototypes, pilots, and deployment of research results.

Contacts:
Larry Orcutt
Chief, Division of Research and Innovation
California Department of Transportation
Phone: 916-654-8877
larry_orcutt@dot.ca.gov

JD Margulici
Associate Director, CCIT
(California Center for Innovative Transportation)
UC Berkeley Institute for Transportation Studies
Phone: 510-642-5929
jd@calccit.org

James Misener
Executive Director, PATH
(Partners for Advanced Transit and Highways)
UC Berkeley Institute for Transportation Studies
Phone: 510-665-3612
misener@path.berkeley.edu

Susan Shaheen
Co-Director, Transportation Sustainability Research Center
University of California, Berkeley
Phone: 510-665-3483
sashaheen@tsrc.berkeley.edu
Concept: **Active Traffic Management (ATM)**

**Description:** Active Traffic Management is the use of multiple aspects of Intelligent Transportation Systems (ITS) in real-time applications. ITS in turn is the application of information technology to transportation.

**Specifics:** Any situation in which the transportation system is characterized by variable conditions is a candidate for Active Traffic Management. Prime examples include: ramp metering, tolls adjusted for traffic conditions (congestion pricing), variable speed limits to ease the impact of congestion or incident response, and signal synchronization to enhance throughput and traffic flow.

Ramp metering adjusts green light intervals for congestion levels. Congestion pricing adjusts tolls for peak-hour and off-hour capacity. Variable speed limits mitigate the disruptive compaction of traffic as it approaches congestion or incidents. Signal synchronization can be adjusted on a time-related basis or with electronic detection of actual traffic.

While each of these applications occurs on a site-specific basis, system-wide coordination is required for optimal results from the combination of ramp metering, congestion pricing, variable speed limits and signal synchronization.

The last-named of these is a particular challenge because, unlike the others, it is arterial and street-based, requiring the cooperation of a large number of separate municipalities. Metropolitan planning organizations are the natural entities to take the lead.

Synchronization of traffic signals will become more important as the federal stimulus package funds highway projects whose construction can be mitigated in part by better signal coordination.

**Status:** Transportation Northwest (TransNow) at the University of Washington and the Oregon Transportation Research & Education Consortium (OTREC) at Portland State are among the entities developing field-data based algorithms to design and refine traffic models. In Seattle, the Puget Sound Regional Council is taking the lead in arterial signal synchronization, which requires cooperation among many municipalities.

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Active Traffic Management (ATM)
(continued)

**Funding:** Improved signalization requires sustained funding. An example is Kansas City, Missouri, which makes $1.5 million per year available for this purpose. In California, Proposition 1B (goods movement investment) includes signalization among activities qualified for funding.

**Contacts:**
- Nancy Nihan
  Director, Transportation Northwest
  University of Washington
  Phone: 206-543-8255
  nihan@u.washington.edu

- Peter Briglia
  Associate Director, Transportation Northwest
  University of Washington
  Phone: 206-685-1795
  briglia@u.washington.edu

- Yinhai Wang
  Assistant Professor, Civil & Environmental Engineering
  University of Washington
  Phone: 206-616-2696
  yinhai@u.washington.edu

- Hau Hagedorn
  Research Program Manager, Oregon Transportation Research and Education Consortium (OTREC)
  Portland State University
  Phone: 503-725-2833
  hagedorn@pdx.edu
Concept: Cascade Gateway / Border Congestion Relief Program

Description: The goal of the FHWA Truck Border Congestion Relief (TBCR) Program is to identify and assist international land border states in implementing innovative solutions to address land border travel-time delay and facilitate trade and travel without compromising the vital mission of securing America’s borders.

Specifics: The selection of the Cascade Gateway project for FHWA’s TBCR program gives the Washington State Department of Transportation (WSDOT) priority access to innovative financing for border-related projects. The goal of the overall project is to provide real-time traveler information to relieve congestion and maximize the efficient use of transportation and border security resources in the Cascade Gateway system.

The project will utilize real-time traveler information to relieve congestion and maximize the efficient use of transportation and border security resources at the four Western Washington/ British Columbia border crossings. When implemented, the project will strengthen operation of the individual crossings as a single border-crossing system.

The proposed project consists of three main elements:

- Expand the Cascade Gateway cross-border Advanced Traveler Information System.
- Pursue public-private partnerships to develop a fiber optic backbone stretching approximately 80 miles along the I-5 cross-border corridor.
- Foster regional, bi-national partnerships and explore other opportunities for innovative financing as allowable under federal and state law to construct priority projects within the Cascade Gateway cross-border corridor.

Relieving congestion by providing border-crossing wait-times, travel conditions, and corridor-segment travel-time information to travelers and goods-carriers before and during their trip.

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Cascade Gateway / Border Congestion Relief Program (continued)

Specifically:
- Optimize distribution of cross-border travel demand.
- Support dynamic destination-based re-routing.
- Improve interagency communication in incident response and during resumption of traffic flow conditions.
- Support compatibility with privately-developed applications.
- Facilitate compatibility and integration of transportation information systems across the border.
- Identify opportunities for public-private development of improved traveler information products; for example, extending the high bandwidth fiber on the I-5 corridor from Everett north to the border.

Status: WSDOT's Cascade Gateway project was one of three selected by USDOT in June 2008 under the TBCR program. An agreement was signed in January 2009.

WSDOT is developing a project work plan for completion by summer 2009. WSDOT will work with USDOT to: 1) set a project schedule; 2) pursue a comprehensive planning process for ITS and border congestion relief programs; 3) establish performance objectives for Cascade Gateway project elements; and 4) secure funding for project implementation.

Financing: The TBCR program currently receives no funding and there is currently no budget for the Cascade Gateway project. The WSDOT Northwest Region / Mount Baker area will rely on its current planning budget to proceed with developing a work plan for this program. Additional funding will be needed for other project elements such as ITS design and identifying financing for project implementation. The project agreement provides an opportunity for WSDOT to request additional funds from USDOT.

Contact:
Todd Carlson
Assistant Regional Administrator
Washington State Department of Transportation
Phone: 360-757-5980
carlsont@wsdot.wa.gov
Concept:  
**Adaptive Transit Signal Priority (ATSP)**

**Description:** Transit signal priority (TSP) is an operational strategy that facilitates the movement of buses through signalized intersections. It has been identified as a critical technology for deployment of Bus Rapid Transit (BRT) and improvement of traditional transit services by reducing total travel time, enhancing the reliability of transit service and thus increased ridership. Despite these advantages, TSP has not seen widespread deployment for two reasons: the concern of traffic operation authorities that frequent TSP operations will deteriorate the performance of signal control optimized for traffic flow, and the capital cost for outfitting buses with the TSP system.

California PATH Program, in partnership with Caltrans and San Mateo Transit Authority (Samtrans), are conducting a research program to investigate an Adaptive Transit Signal Priority (ATSP) concept that uses real-time GPS position, bus movement information and historical bus travel behavior data to predict bus arrival time at an intersection. This provides much longer lead time to allow the traffic controller to be ‘adaptive’ to the bus arrival as well as the traffic situations, making it possible to distribute the impact over several control cycles.

In order to allow the signal priority system to better accommodate bus signal priority calls while minimizing the impact to the other traffic and maintaining the coordination among signals, a signal priority algorithm that is based adjustable cycle length signal control scheme must be explored.

**Status:** PATH, in collaboration with Caltrans and San Mateo Transit District (Samtrans), have coordinated research and developed ATSP by equipping buses with Global Positioning Systems (GPS) that monitor bus movements and predict bus arrival times. This will be tested in this two-year research project.

First-year research seeks to improve and refine the ATSP system to make it suitable for large-scale implementation. The second year is dedicated to field tests, installing the system at multiple intersections along El Camino Real and on several buses. From these tests, the impacts of the system will be evaluated through data analysis and interviews with personnel from Samtrans and city traffic authorities.

**Financing:** Caltrans, PATH, and Samtrans

**Contacts:**
Alexander Skabardonis  
Director, California PATH  
Phone: 510-642-9166  
skabardonis@ce.berkeley.edu

Wei-Bin Zhang  
Research Engineer, PATH  
Phone: 510-665-3515  
wbzhang@path.berkeley.edu
4. Cleaner Fuels and Engines

Goods Movement Benefits:

• The shift to cleaner diesel, natural gas and hybrid power enables freight rail and road operators to achieve fuel cost savings and emission reduction that protects their economic viability while maximizing permitted areas of operation.

• The use of cleaner engines and fuels in personal vehicles reduces levels of air pollution and greenhouse gas emissions that can otherwise risk placing regions in air quality non-attainment status, with consequent restrictions on commerce and transportation funding.

Personal Travel Benefit:

• The shift to hybrid and electric vehicles enhances air quality while removing consumer vulnerability to gas price swings and the economic risk of large dollar outflows to foreign oil suppliers.

Transportation System Benefit:

• Energy security is enhanced by using domestically produced power while progressing toward achievement of greenhouse gas reduction targets.
Concept: Zero-Emission Vehicles (ZEVs)

Description: Awareness of the connection between use of petroleum-based motor fuels, greenhouse gas emissions, and global climate change has led to the concept of zero-emission vehicles as a technology and policy goal.

Climate is a huge and complex system with enormous momentum. Some climate change will continue regardless of how fast we act. This change will be expressed in the increasing frequency of extreme weather events that are more variable and more unpredictable.

The global human population is getting ‘richer’ in the sense of using more technology. At the same time, human subsistence populations need more energy for basics such as food and water. We will inevitably need to consume more energy. We are gaining in our technology but not in environmental impacts because of ever-rising demand, especially for transportation equipment and use.

The auto industry is experiencing tremendous growth in China, India and Russia. An additional 180 million vehicles are forecast to be added by 2020, bring the world total to 1 billion. Oil provides 96 percent of transportation energy.

For the U.S., there is also the issue of energy security. We produce 10 percent of world oil and consume 25 percent of it, resulting in the outflow of $500 million to $1 billion a day, reliance on unstable foreign sources, and the prospect of “peak oil” in the face of surging oil demand from developing nations.

This suggests the U.S. has come to what Intel CEO Emeritus Andy Grove calls a Strategic Inflection Point (SIP). He says, “We can move to new heights if we recognize we are at a SIP on oil – or toward decline if we do not. We need a sense of urgency and a World War II level of industrial response.”

Today the U.S. in a “great race” on transportation technology. The national goal is to move our entire society toward energy efficiency for quality of life. The organizational goal is to be an eco-innovator who contributes to a sustainable mobile society.

While the goal is “Zero Emission Vehicles,” there is in fact no technology that is truly zero in emissions. It is important to realize that all the energy we use on earth came from the sun in the form of extraction of carbon from the atmosphere. The variable is a matter of cycle time. Fossil fuels may require 100 million years or more to take form, while bio-fuels require one to five years. If we could power our vehicles by solar electricity and wind, the cycle time for transportation energy could be reduced to a single day.

The objective is to achieve this short energy cycle with a transportation system that maintains access, mobility and flexibility while costing no more, and ultimately less. This can be done if we begin to electrify our ground transportation system.

Electricity as fuel for transportation is a disruptive change. We have never

(continued on next page)
Zero-Emission Vehicles (ZEVs) (continued)

developed an alternative fuel for vehicles – but this time there is no turning back. Global climate change is the driving factor in policy change. The transition is inevitable and urgent. It involves huge challenges. We are blazing new ground in a perfect storm.

Specifics: Movement toward ZEVs as a dominant part of the U.S. vehicle fleet depends on a combination of requirements and incentives:

• Carbon reduction targets are being widely adopted at the national and state level. Experts including Dan Sperling, Director of the UC Davis Center for Transportation and a CARB member, believe greenhouse gas reduction mandates should be written so they are narrow, targeted and specific, with firm target.

• Carbon content of fuels. A widely cited goal is to reduce CO2 output 70 percent by 2050. Improvements in internal combustion engine (ICE) technology have the potential to contribute 30 percent of this 70 percent through a strategy that engineers label “reduce, reuse, recycle” of CO2 and other pollutants. In the U.S., individual vehicle performance is crucial because our dispersed pattern of development means reduced CO2 from transportation will not come primarily from using transit.

Another strategy to reduce carbon content and oil dependency is “energy diversity,” including bio-fuels to the extent they result in CO2 reduction.

California has 10,000 gas stations, 120-130 compressed natural gas stations that are public, and six E85 ethanol stations. The greatest problem in constructing alternative fuel stations is local and state regulation by fire marshals, air quality districts, and the water resources board.

Fire marshals approval would continue to be a challenge for electric vehicle recharging stations, especially if they require high power levels. If charging can be done at 110 volts and 1.5 kwh, fire safety is enhanced. Moreover, that level of power is the preferred charging level for cars.

• De-carbonized electricity generation. Of the 70 percent reduction sought in CO2 output, 40 percent depends on “clean” electricity production. Electricity is significantly reliant on a 19th century fuel – coal. Today, 70 percent of electric power generation is carbon-based, 20 percent is nuclear and 10 percent is hydro. The goal is to de-carbonize through using renewable energy sources including wind and solar to the greatest extent possible.

A July 2007 study by the National Resources Defense Council and the Electric Power Research Institute estimated that if the U.S. vehicle fleet were electric and powered entirely by coal-fired plants, CO2 output would be 25 percent lower than for a fleet of gas-powered autos.

Further gains rely on de-carbonizing (continued on next page)
Zero-Emission Vehicles (ZEVs)

(continued)

electricity generation by integrating solar, wind, and other renewables and using the electricity they generate to power for zero-emission capable vehicles.

A low-carbon fuel mix is a major goal at Southern California Edison, which purchases one-sixth of the nation’s wind power and 90 percent of its solar power. Solar is the perfect partner with a home “battery” that stores energy for domestic use. This technology ties in with auto-related developments to create scalable market conditions for both power and vehicles.

The problem of solar and wind is that energy generation is dependent on weather conditions and thus intermittent. As a result, current technology requires a fossil fuel (NG/Diesel) backup. This could be ameliorated by the availability of widely distributed electrical energy storage.

Quebec Hydro, hydropower generates 97 percent of its 41 million megawatts. The utility is developing wind power as the complement and is moving toward mandatory carbon reductions. The reason for this strategy is that hydropower is a perfect complement to wind, since under windless conditions hydro can be used to fill in the deficit in real time.

Financing: Electric vehicles – hybrids, plug-ins, and extended range – are popular when energy costs for internal combustion engines are high. Cost drives the search for energy efficiency. When gas is expensive, companies take a close look at fleet management and initial deployment of alternative-fuel vehicles.

Gas prices of $4 a gallon reduce the hybrid payback period from 70-10 years to 5-7 years. Will the electric vehicle market go from zero to something enormous? Not without policy and direction and incentives. A current example comes from the Energy Administration and Toyota: As economic slowdown dropped average gas prices in the U.S. from $4.10 in July 2008 to $1.90 in March 2009, the average length of time to sell a Toyota Prius rose from 1.6 days to 76.6 days (48 times longer). The increase for a Camry hybrid was from 4.6 days to 156.2 days (34 times longer) – compared to an increase from 28.1 days to 84.1 days (3 times longer) for a gas powered Camry.

In response to this impact, experts including Dan Sperling and Andy Grove advocate a tough form of regulatory intervention: Put a price floor under gasoline to eliminate the risk that price drops will dislocate the market for hybrid and electric vehicles. Others emphasize making clean energy vehicles competitive by technology advances that bring down clean energy costs rather than seeking to make dirty energy expensive.

Contacts:
Daniel Sperling
Director, Institute of Transportation Studies
University of California, Davis
Phone: 530-752-7434
dsperling@ucdavis.edu

Mark Duvall
Transportation Program Director
Electrical Power Research Institute
Phone: 650-855-2591
mduvall@epri.com
Concept:  
**California Clean Mobility Partnership (CCMP)**

**Description:** The CCMP is a three-year (2007-2010) public-private collaboration to promote research and development of advanced vehicle technologies, alternative fuels, and intelligent transport systems.

**Specifics:** UC Berkeley, UC Irvine, and Toyota have joined in collaboration with key strategic partners to establish and implement a unique capability that: 1) incorporates the social and technical research required to address California goals for alternative fuels and vehicles; and 2) represents populations and trends in both southern and northern California.

The project is supported by: 1) grant funds made available under state legislation through the California Air Resources Board’s “Alternative Fuel Incentive Program”; and 2) the provision of vehicles, vehicle monitoring and data mining, emission testing facilities, and technical support by Toyota.

The CCMP Phase I research will analyze, assess, and inform the technical and market challenges and opportunities for plug-in (PHEV) and fuel-cell (FCHV) hybrids. Research elements include:

- Placing the vehicles in real-world settings and studying various aspects of their performance, usage, and driver response.
- Developing test certification procedures for the next generation of dual-fuel vehicles.
- Quantifying the grid impacts associated with extensive deployment of electric-drive vehicles. Modeling the impact of PHEV and FCHV deployment on future-year air quality.

The CCMP program has six key elements: Household Placements Analysis, PHEV Certification, Energy and Economic Analysis, Urban Air Quality Assessment, Utility Grid Interaction, and Education and Outreach Message Development.

The methodology for the social research involves placing conventional hybrid vehicles, PHEVs, and FCHVs into households in northern and southern California on a rotating basis of four weeks for each of the three vehicles. The behavioral response to the vehicles and fueling will be surveyed via questionnaires and interviews.

**Status:** At present, the social research effort has cleared all major contractual and human-subject requirements, project vehicles are being tested and equipped with GPS and telematics technology, and the initial group of drivers are being screened for participation. First placements of vehicles are expected to begin in April 2009 and to continue for a minimum of one year in both northern and southern California.

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California Clean Mobility Partnership (CCMP)
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The following elements of technical research have been completed: 1) two rounds of test certification research in collaboration with the ARB El Monte Laboratory, Toyota, Horiba, and the Japan National Traffic Safety and Environmental Laboratory; 2) compilation of the initial analysis of grid impacts, in collaboration with Southern California Edison; and 3) initial results from the air quality simulation performed in collaboration with the California Energy Commission, the ARB, and the South Coast Air Quality Management District.

Financing: State of California funds authorized by the Legislature through AB 1118.

Contacts:
Susan Shaheen
Co-Director, Transportation Sustainability Research Center
University of California, Berkeley
Phone: 510-665-3483
sashaheen@tsrc.berkeley.edu

Tim Lipman
Co-Director, Transportation Sustainability Research Center
University of California, Berkeley
Phone: 510-642-4501
telipman@tsrc.berkeley.edu
Concept: High-performance Batteries

Description: Batteries are in many ways the technology that will make or break the effort to produce Zero-Emission Vehicles (ZEVs). Advances in battery capability have been described as the “holy grail” on which all else depends in determining the pace and degree of movement toward electric vehicles. “The battery is the key to technological and commercial success of plug-in electric hybrids (PHEVs). Today we can say the necessary requirements will be met,” believes Fritz Kalhammer of Kalhammer Electrochemical and Energy Technology. Those involved in the EV effort closely monitor progress on battery technology.

Specifics: EPRI – The Electric Power Research Institute – is the major source of battery performance parameters. Batteries must be durable to handle charge-depleting and charge-sustaining modes. Each involves its own electrochemical impacts and configurations.

Nickel plate batteries, the most mature technology, are high-energy but have safety problems with deep discharge, which can cause “thermal runaway” on cathodes.

Lithium-ion batteries can meet medium-range power density and energy density requirements, with a 15-year battery life. Expect lithium ion installation first in conventional hybrids and then in plug-in vehicles. Lithium titanate offers even higher performance at high cycles.

Iron phosphate batteries are the safest and have excellent power but low voltage that could impede their use in plug-in vehicles. A possible solution is to use another phosphate such as manganese.

It is difficult and costly to design 300-400 miles of electric vehicle range to compete with the internal combustion engine (ICE). Each key capability – cost. life, power, range – have different “best” answers, so trade-offs are required to optimize total performance.

Status: The current research direction is to de-emphasize high storage capacity for hybrid vehicles and focus on plug-in vehicle requirements, which are evolving from high-power systems to high-energy systems.

The key criteria for a plug-in hybrid electric vehicle battery are: the power/energy density tradeoff, the packaging of usable energy, and cost/affordability. Batteries can be compared on a cell, module, or pack basis.

Installing the largest possible battery in a car puts less stress on it. This makes sense for long use life. Shorter time frames favor smaller batteries due to lower initial cost. The type of vehicle that is built largely is a function of battery weight, which ranges between 60 and 120 kilograms (130 – 260 lbs.). Battery integration into vehicles is a relatively neglected area.

Lithium ion has advanced so rapidly it has become the technology of choice due to high energy density compared to
High-performance Batteries
(continued)

alternatives such as lead acid nickel cyanide. At the same time, its price has dropped due to 15 years of commercialization in personal electronics. Other promising technologies are further out.

There are issues with lithium ion. Lifecycle performance is not well understood. One criterion of technology selection is how well the cells function together. To this point, battery power has depended on bundling small cells but future development must take a path toward larger cells. Prismatic or rectangular cells may pack better and cool better than today’s cylindrical cells.

Nissan’s focus is advanced battery development. Its engineers believe the key to packing power, energy and density into a lithium ion battery half the size of a conventional battery is “lamination,” a thin structure that facilitates layout flexibility in the vehicle. Technical tasks remain, including insulation of the lamination film.

Large-format cell development is crucial to bringing down costs. As size is scaled up, there will be a manufacturing issue. Storage of concentrated energy is unstable, and getting the heat out of larger cells is a safety issue. Lithium ion is efficient in charging and discharging but is very sensitive to over- and under-charging. It generates heat that must be dealt with as part of cost-effective thermal management to assure safety at a system level.

The latest major development in lithium-ion batteries comes from research by Gerbrand Ceder and Byongwoo Kang at the Massachusetts Institute of Technology. They focused on the speed with which the ions are able to enter and leave the electrodes, which governs how fast a battery can be charged and recharged.

By finding a way to make the surface of the electrodes glassy rather than crystalline the researchers created a medium that acts as a super-capacitor, conducting ions swiftly to the battery core. The result is a material that, in experimental batteries, was able to charge and discharge in a few seconds.

Lithium ion is the current technology of choice, but there may be future evolutions beyond it. In the words of Dan Sperling, Director of the UC Davis Center for transportation, “Keep pressing forward on battery research. Recognize that lithium ion is just one step.” Emerging battery technologies involve advanced materials.

Financing: In February 2009, the Obama administration announced $2 billion in grants from the Recovery and Reinvestment Act for development of advanced batteries to support the goal of putting 1 million American-made plug-in hybrid vehicles on the road by 2015.

Nations such as China and Japan view batteries as a critical technology, and their governments are making investments based on this. Most battery capability is in Asia because that is where personal mobile devices are made. Battery costs follow a less steep
Moore’s Law decline than transistors but greater technical efforts could accelerate the rate of decline.

OEM’s (original equipment manufacturers) learned during the 1990s that batteries are expensive and may require subsidies. There are cost and volume “thresholds of production” for economies of scale. The R&D business case doesn’t always pencil out when gas prices are low.

The key ingredient in consumer affordability is that fuel savings are larger than battery costs at mass production price levels. A new plant with a 500,000 unit annual capacity for hybrid auto (HEV) batteries can be constructed in about two years. Not as much is known about plug-in (PHEV) battery production but the timeline should be similar. None of the big manufacturers are currently developing pure electric vehicle (EV) batteries.

Contacts:
Mark Duvall
Transportation Program Director
Electrical Power Research Institute
Phone: 650-855-2591
mduvall@epri.com

Andrew Frank
Professor, Department of Mechanical and Aeronautical Engineering
University of California, Davis
Chief Technology Officer, Efficient Drivetrains, Inc.
Phone: 530-752-8120 / 707-678-2700
aafrank@ucdavis.edu
Concept: Hybrid Electric Vehicles (HEVs)

Description: A robust and resilient energy system requires sources of energy to be substitutable for each other in generating power. This is the case in stationary grids, which can utilize electricity generated from many different sources. But it has not been the case in transportation. The dual-fuel car that uses electricity first and gasoline when needed would change this.

Eighty percent of US motorists drive an average of less than 40 miles a day. This means they could use hybrids with a 40-mile electric capability. The electric power infrastructure can handle 50 million dual-use vehicles that charge in the off-peak. Use of such vehicles would cut U.S. gasoline use in half. This would not only slash our oil imports but change the dynamics of world oil markets.

Given the role of transportation in generating CO2 emissions, no serious carbon reduction strategy is possible without clean vehicle technology, and the automobile is perhaps the most amenable type of vehicle to “go electric.”

Specifics: New enabling technologies are timely, notably the advent of the hybrid electric vehicle (HEV) which is neither an internal combustion engine (ICE) nor an all-electric vehicle (EV). It may be some time before we have a pure EV. The technology time sequence is likely to be ICE – HEV – PHEV – EV.

Status: HEV offerings from major manufacturers are burgeoning. Notable examples in a wide-ranging field include:

Toyota — The Prius arriving in dealer showrooms during spring 2009 is the third-generation of this best-selling electric-gas hybrid. Officially it is rated at 50 mpg, up from 46 mpg on the previous model. But at a recent Toyota press event, journalists were invited to compete for achieving the best mileage on a 33.8-mile course. Using common-sense techniques the winners like avoiding jackrabbit starts and using full electric power for a mile at a time, the winning team logged an amazing 94.6 mpg.

Nissan — In July 2007, Nissan introduced the hybrid Altima in California and other ZEV states. Fuel consumption and acceleration are better than in a standard Altima. Nissan’s long-term goal is to start globally massive sales of ZEVs in 2010-2012. Nissan will also sell advanced batteries to other OEMs.

Honda — Dubbed the Prius-fighter due to its similar appearance, the Honda Insight is aimed at a different market. It is “targeted toward thrifty eco-sensitive types,” says Alex Taylor of Fortune magazine. The Insight scores in the low 40s in miles per gallon and prices start just under $20,000.

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Hybrid Electric Vehicles (HEVs) (continued)

**Ford** — The Ford Escape, celebrating the sale of over 100,000 vehicles, shares with the Toyota Prius the distinction of being among the early generation hybrids. It has participated in numerous test projects including plug-in conversion (see below) and has a 30 mile blended electric range with 120 mpg. The Escape has been a valuable test bed for battery development and the discovery that it’s not just a matter of putting a larger battery in a conventional car; all systems on the vehicle must be designed around the electric power train.

The new 41-mpg Ford Fusion hybrid is getting rave reviews for its gas-electric output of 191 horsepower, its 52-mpg rating on mixed city-highway driving, and its price of about $25,000 with applicable federal tax credit. After driving the Fusion, auto reviewer Dan Neil of the Los Angeles Times wrote, “So, somebody invented the car of the future and didn’t tell us?”

The Fusion’s Sanyo-supplied battery is 30 percent smaller and 23 percent lighter than the Escape battery and supplies enough power to propel the Fusion at speeds up to 47 mph all-electric – key to the car’s high in-city mileage. One technical advance in the Fusion is a variable-voltage converter that reduces heat loss during high-output.

Ford intends to follow the Fusion and Mercury Milan hybrids with a by battery-powered van in 2010 and a “family” of hybrids by 2012.

**GM** — The Chevy Volt is designed around the 40 mile per day average for U.S. motorists. It is capable of providing pollution-free commuting while consuming about $1 worth of electricity to plug in a wall socket at 110/120 volts for eight hours or 220/240 volts for three hours. When a trip exceeds 40 miles, a 1.4 litre four-cylinder gas engine fires up to power a 53-kw AC generator that relieves the battery pack as the source of electricity. The generator doesn’t fully recharge the pack, since that can be done at one-sixth the cost by plugging in. But the hybrid mode does provide extended capability to relieve “range anxiety.”

In addition to the Chevy Volt due next year, GM, which already sells eight hybrids, said 26 of the 33 cars it will market in 2015 won’t run on gasoline alone.

**Chrysler** — In September 2008 Chrysler unveiled a Town & Country minivan and a Jeep Wrangler based on an electric motor, a battery and a 1-liter gasoline generator installed in an existing vehicle platform. The vehicles can travel 40 miles on battery power before the generator kicks in to add another 360 miles of range. They come with front-wheel, rear-wheel, and all-wheel drive. Eight new hybrids or electric vehicles have been promised by 2015.

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Hybrid Electric Vehicles (HEVs)
(continued)

Financing: Hybrid development must surmount two major hurdles. The first is the basic challenge of putting a new and somewhat more expensive platform on the market in competition with conventional ICE vehicles. Toyota said last year that it was finally making money on the Prius after nearly a decade of production – this despite the fact that the car was scarce relative to demand and commanded a premium price during much of its sales history. Executives at other automakers acknowledge that they lose money on every hybrid sold. The market economics are hugely affected by the pump price of gasoline (see Zero-Emission Vehicles, Financing section).

The next hurdle is huge uncertainty surrounding the future of major auto manufacturers, especially but not only in the U.S. Indeed, most major nations subsidized parts of their auto industry long before recent assistance to GM and Chrysler by the U.S. government. But with state intervention comes state control. Soon after GM’s CEO was displaced by an administration-selected manager, talk was heard in Washington, D.C. that the Chevy Volt was “too expensive” to compete in the marketplace.

The root problem is that government bailout money may not be patient money due to taxpayer and political demands for quick results. This works against the ability to make long-term investments. But a countervailing force is that government is more sensitive than industry to climate change impacts and therefore more committed to responses that address this issue. Sensing the situation, Michigan Governor Jennifer Granholm in Newsweek magazine for April 13, 2009, made a strong case for the proposition that “Even as automobiles go electric, Michigan wants to build them.”

Contacts:
James Boyd
Vice-Chair, California Energy Commission
Phone: 916-654-3787
melliott@energy.state.ca.us

Daniel Sperling
Director, Institute of Transportation Studies
University of California, Davis
Phone: 530-752-7434
dsperling@ucdavis.edu

Felix Kramer
Founder, CalCars
Phone: 650-599-9992
fkramer@calcars.org

Bill Reinert
National Manager, Advanced Technology Group
Toyota Motor Company
bill_reinert@toyota.com

Jonathan Lauckner
Vice President, Global Program Management
General Motors Corporation

Nancy Gioia
Director, Sustainable Mobility Technologies & Hybrid Vehicle Programs
Ford Motor Company
**Concept:**

**Plug-in Hybrid Electric Vehicles (PHEVs)**

**Description:** PHEVs (Plug-in Hybrid Electric Vehicles) are coming along at the same time as HEV (hybrid electrics). HEVs can be re-engineered to become PHEVs.

Plug-ins could cost less to build than conventional hybrids because it is possible to downsize the liquid-fuel engine and simplify the transmission. Recharging permits a smaller, lighter, cheaper electrical unit and reduces CO2 emissions 25 percent below a conventional hybrid.

All-electric vehicles (EVs) require a high-powered charge – but not PHEVs, which can use 110-volt power straight from the wall. On average, vehicles are parked 21+ hours a day. They can be recharged with 10-15 kwh, which can be done in 6-10 hours. Charging time is not an issue because the PHEV is a dual-fuel vehicle that can be operational if either fuel is available.

**Specifics:** According to knowledgeable sources, a reduction in annual output of CO2 of up to 1 billion tons can be achieved by a shift to EVs. To get there will require execution by vehicle manufacturers, electric utilities and other players. This will take innovation and collaboration.

Remaining challenges for a PHEV include the cost of a high-capacity battery versus an internal combustion engine, user access to recharging, and the CO2 intensity of electricity generation. To put the matter in perspective, PHEVs can use batteries one-third to one-fourth the size of batteries in a pure EV. Thus the same world battery production capacity would serve up to four times as many PHEVs as EVs, displacing a proportionally greater amount of gas and oil consumption.

**Status:** PHEVs can become zero-emission vehicles if three areas are addressed: use of gasoline and /or bio-fuels in auto technology, smart grid development using solar and wind, and a widely distributed 110 volt plug-in infrastructure.

Auto technology: PHEVs are dual-fuel as a back-up but they allow movement toward zero emissions by use of solar, wind, renewables and non-corn ethanol, in a 90/10 ratio between electricity and liquid fuel. The full benefit requires a smaller ICE so there is room for a large electric battery. This combination should deliver performance equal or superior to a conventional car. A key hardware technology is a mechanical, continuously variable transmission that is lighter and more efficient than an electric motor.

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Plug-in Hybrid Electric Vehicles (PHEVs) (continued)

In 2010, major Japanese, European and American and car companies will be offering PHEVs. “Urban EVs” that meet short-range travel needs should also be developed. Smaller, neighborhood vehicles can be made by a variety of manufacturers while only a few can build full size EVs.

California’s energy plan commits the state to PHEV development. In 2005, the state’s Energy Commission took the unprecedented step of endorsing a specific technology – PHEVs – and establishing a research and public education center at UC Davis with an annual appropriation of $120 million from utility taxes.

Professor Andy Frank of UC Davis has been working on the PHEV for 35 years. Batteries, electric motors, a reliable mechanical Continuously Variable Transmission (CVT), and computers were the “missing links” when he began in 1972. Frank built the first PHEV in 1993. In the years that followed he made PHEVs out of mainline Detroit SUVs and passenger cars. All the cars Frank modified perform better than stock, providing 60 miles of all-electric range and, when sustaining the battery charge in hybrid mode, double the fuel economy of a conventional vehicle.

Google launched an initiative in 2007 to convert HEVs to PHEVs. The company found a “compelling interest” in PHEVs due to improvement in gas mileage and reduction in greenhouse gases. At the Google campus, a parking structure with 1.5 megawatts of solar panels on the roof and plug-ins enables employees to charge their cars during the workday.

Google employees’ 74-124 mpg experience is a real-world test. The company has had professional drivers cover a 2,000-mile segment of unique situations in a PHEV Prius conversion that achieved up to 93.5 mpg, and major car companies say they can do even better.

Smart grid: PHEVs can be seamlessly integrated with utilities and the power grid. A coalition to accelerate use of electricity and replace gasoline covers 37 states and three Canadian provinces. It involves collaboration among manufacturers, national labs and research institutes.

The eastern part of Canada has the electrical infrastructure needed for PHEVs. Every parking space is equipped with a 110 volt, 1.5 kw waterproof outlet used for engine block heating in the winter time. This plug can also serve as a battery charger for PHEVs. The cost of this infrastructure is obviously modest since it was installed simply for the convenience of the general public.

In moving toward an all-electric ground transportation system, efficiency has the highest near-term leverage because of the amount of time needed to build clean generation facilities.

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Plug-in Hybrid Electric Vehicles (PHEVs) (continued)

A recent event organized in Washington, D.C. by Plug-In America revealed a high level of bipartisan interest in questions such as: How much demand will PHEVs place on the grid? Will it be ready? How can PHEVs make the grid smarter? What policies are required to make this happen?

A study by the Pacific Northwest National Laboratories concluded that the existing grid can support 80 percent of the current fleet of light-duty autos in North America if they became PHEVs today. This use level would require giving increasing attention to plugging into a greener grid. Car companies are talking to electric utilities just as they have talked to the oil companies over the years.

To do their part, utilities need to make changes that are as profound as those for automakers. Today’s grid works but is not smart. As a result it is a product that utilities can’t inventory. Ways to store electricity haven’t been developed, and so power is unidirectional – sent to the consumer on demand, on a real-time basis. But the PHEV is not only a transportation vehicle, it is also a device that can store energy and feed it back to the grid. This technology is not expensive, especially if the power level required is held to 1.5 kwh 110 volts.

The smart grid will be a “switch yard” based on two-way sensors, advanced metering and distributed computing, connected to end-use devices that communicate with each other to optimize electricity use and draw power from the most available source in short real-time intervals.

Plug-in infrastructure: Connecting electric cars to a charging grid is essential. This can be simple and easy to use. But it will not be simple to build if it is required to support fast-charging, battery-swapping, and home/business recharging, all of which are being considered.

As the transportation system moves “beyond oil” to electricity, vehicle recharging capability needs to be part of new building design in cities, including residential high-rises and commercial office buildings as well as private residences. Retrofitting of recharge capability, especially in homes, will also be widely required.

There is need to integrate support facilities for electric vehicles as a design element in urban development. People who can recharge their cars at work as well as home will be more efficient if they don’t have to waste time and mental energy on the next recharge and such access will cause EV adoption rates to accelerate, helping to meet greenhouse gas reduction targets.

The City of San Jose is planning to install a large number of “smartlets” for charging electric vehicles. These will be attached to “smart” street-light poles with sensors that regulate the required light intensity.

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Plug-in Hybrid Electric Vehicles (PHEVs)

In the 1990s Southern California Edison (SCE) installed a large number of 240-volt outlets for inductive charging that can now be used by PHEVs with the right infrastructure. Today’s technology developed by the solar industry allows two-way transfer and storage of energy between the battery and the grid. This relates to “net zero energy” homes – a California standard for 2020. Thus PHEVs and EVs can become the energy storage system that has been the dream of electricity suppliers for the last century, without the utility having to pay for the storage capacity.

SCE estimates that if PHEVs are charged at night, there is currently enough capacity for 4 million such vehicles in Southern California. In Northern California, smart cars can follow the energy profile of wind farms. These applications will be enabled in part by “smart meters”- computer systems that manage as well as record energy use.

It is even possible PHEV owners could save money by selling power back to the grid. When the PHEV user allows his battery to be used at times of grid peaking, rather than a cash payment it may be “smart” for the grid manager to simply exchange expensive energy for lower-cost energy. This approach would allow the PHEV battery to be charged essentially for free while the utility saves peaking charges and, ultimately, additions to peak capacity.

Smart charging using a “smart garage” allows the ultimate application of vehicle-to-grid (V2G) power exchange. V2G creates the “cash-back” vehicle as a source of energy to the grid through “smart charging” based on grid response. V2G combined with improved efficiency in the grid could remove peak pricing power and neutralize fuel costs for the PHEV user. Phase I is to use the existing grid. Phase II is to integrate renewable sources.

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Plug-in Hybrid Electric Vehicles (PHEVs) (continued)

Google’s PHEV fleet has demonstrated vehicle-to-grid power exchange with PG&E. “We have demonstrated the swing in taking a charge from the grid and giving it back,” says Dan Reicher, Director of Climate Change and energy initiatives for Google.

If you can store energy in your car, the electric utility can store energy in your garage as part of a distributed energy system. The grid must become smarter to balance supply and demand, in a two-way interaction with consumers who become part of the smart grid.

A PHEV and home energy charging can minimize cost and maximize control for customers by giving them “intelligent charging.” Related to this is “roaming charging.” Wherever the vehicle goes it has a “charging identity.” The smart grid and smart meters vary around the country but plug-in technology should be standardized so PEVs are able to charge even if communication with a utility fails due to remote location or other cause.

Financing: Government subsidies could help in adding plug-in locations at parking lot spaces, parking meters and elsewhere to provide both conventional deductive or special inductive charging. Similar incentives could be provided by utilities to subsidize or provide charging outlets in residential garages.

Contacts:
Tom Turrentine
Director, PHEV Center
University of California, Davis
Phone: 530-752-6500
tcurrentine@ucdavis.edu

Felix Kramer
Founder, CalCars
Phone: 650-599-9992
fkramer@calcars.org

James Boyd
Vice-Chair, California Energy Commission
Phone: 916-654-3787
melliott@energy.state.ca.us

Daniel Sperling
Director, Institute of Transportation Studies
University of California, Davis
Phone: 530-752-7434
d sperling@ucdavis.edu

Ed Kjaer
Director of Electric Transportation
Southern California Edison

Andrew Frank
Professor, Department of Mechanical and Aeronautical Engineering
University of California, Davis
Chief Technology Officer, Efficient Drivetrains, Inc.
Phone: 530-752-8120 / 707-678-2700
aaf frank@ucdavis.edu
Concept: Hybrid Conversions / Retrofits

Description: The goal is to convert the world vehicle fleet as fast as possible, using the full range of tools. There are currently about 100 PHEVs (Plug-in Hybrid Electric Vehicles) in the world. How might we build 10 million PHEVs in four years? The car companies are finally getting to it but there are ways to move faster by working on the entire existing fleet, replacing 10-15 percent a year through retrofit and a smaller fraction through new vehicles.

Specifics: The challenge of achieving a meaningful volume of dual-fuel vehicles can be met by unleashing the distributed infrastructure of auto repair shops to perform conversions. Andy Frank of University of California, Davis, and Hamid Arasto of Illinois Institute of Technology have shown this can be done.

Status: In a 20,000-mile test of a large Chevy pickup, Andy Frank has had no failures of any system components and plans beta tests beginning with fleets. The goal is a 50 percent improvement on mileage, with a 100-mile range as a hybrid. “We are at 33 percent and expect getting to 40 percent soon.” Frank reports.

Manitoba Hydro used Hymotion 5 with a lithium ion 5kwh battery to turn Prius into a PHEV operating at temperatures down to -44F with the norm between -13F and +5F. Cold conditions make the engine kick in far more frequently, and more fuel is used to operate the emission systems than the engine.

Performance held up but fuel consumption was high – 40 - 45 mpg versus 150-200 mpg in June. Gas mileage of the Prius PHEV is like normal Prius mileage at low temperatures and like a PHEV conversion at higher temperatures because the electric unit operates more as it gets warmer.

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Hybrid Conversions / Retrofits
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**Financing:** Government could provide a 50% tax credit for conversion costs. The SBA can help guarantee loans to retrofitters. What is the cost of doing conversions? How does it compare to the total the cost of not doing conversions? Government needs to help get front-end costs down. After that, many experts believe the market viability of conversions will carry itself.

There is a “black hole” at US EPA, California EPA, and California ARB with regard to retrofits. This shouldn’t be the case given that reduction in fuel consumption means a proportional reduction in CO2 emissions.

**Contact:**
Andrew Frank
Professor, Department of Mechanical and Aeronautical Engineering
University of California, Davis
Chief Technology Officer, Efficient Drivetrains, Inc.
Phone: 530-752-8120 / 707-678-2700
aafrank@ucdavis.edu
Concept: 
Public Awareness / Acceptance / Adoption of Green Vehicles

Description: In the adoption of green vehicles, a crucial part of the challenge is on the market and consumer side rather than on the technology side. A precondition for movement toward a new transportation technology is satisfying real-world customer expectations and patterns of usage. The customer will make a rational choice on both economics (payback periods) and patterns of use (driving habits) before purchasing an electric vehicle or alternative fuel vehicle.

Specifics: The internal combustion engine has been central to our lifestyle since the 1920s. Self-expression and individual freedom have unfolded as a central theme crucially linked to the auto. Giving up the car is the last change people will make – but they may be willing to change how their car operates.

We are witnessing a convergence of forces that creates a paradigm shift and enables the world to move forward. From a consumer standpoint, the new technologies need to work “just like the old ones.” Electricity and the automobile are partnered to shape American life over the last century. Now, they are partnering to shape the future.

“We are at a remarkable moment when all factors have come into play for the first time and have caught public attention,” says Dan Reicher of Google. Jim Boyd, Vice-Chair and lead commissioner for fuels policy on the California Energy Commission, believes “there is a convergence in California of government policy and public attitudes. This is the right issue at the right time.”

Steve Specker, CEO of the Electric Power Research Institute (EPRI) says: “Looking into the far future, I am an optimist. Looking at the next decade, I am a realist. There are tough issues to tackle. Looking at today, I am an activist. We need to continue to move consumer awareness and acceptance of EVs ahead.”

Lessons learned about market deployment of hybrids and electrics tell us that research on travel behavior is relevant. Consumer research tells us niche markets (i.e., the Prius) provide strong customer identity. Other key ingredients to EV and alternative fuel vehicle adoption include regulatory initiatives, financial incentives, retail practices, and infrastructure.

Electric cars can either be seen as an adjustment people avoid making, or an opportunity for consumer involvement. Ed Kjaer, Director of Transportation for Southern California Edison (SCE), sees a shift underway from the “passive customer” to the “informed customer” who understands cause and effect in the energy system, to the “empowered customer” who is an active player in a distributed energy system.

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Public Awareness / Acceptance / Adoption of Green Vehicles  
(continued)

Kjaer envisions a time when the smart grid links to a smart meter, a connected home, and a PHEV. “Customers will be able to control their energy load through a rich menu of information and technology devices that tell them how much they are using and strategies to reduce it.”

One important tool to help “make a market” is through economies of scale that drive prices down and make EVs competitive is fleet purchases by government and major companies. Fleets are a key enabler. They drive market solutions that will support mass solutions.

Status: SCE has the largest EV fleet in the nation – 260 vehicles, with 12 million miles of travel. The State of California’s Zero Emission Vehicle mandate has resulted in much cleaner vehicles across its fleet, validating the boldness of the law. The City of San Jose is committed to replace its fleet with alternative fuel vehicles.

Government has a role to play – in this case to support technologies that enable consumers to “go green.” In the corporate sector, decision-making on fleet purchases by FedEx, UPS, USPS is the subject of a dissertation by Kevin Nesbit at UC Davis.

The Transportation Sustainability Research Center (TSRC) at UC Berkeley has examined response to EVs, gasoline-electric hybrid vehicles, and hydrogen fuel cell vehicles from a behavioral perspective. The research has been done in close collaboration with Toyota, Nissan, and Mercedes Benz. Studies have focused on behavioral response to these vehicles over time and in fleet settings (e.g., carsharing).

Financing: A widely varied mix of government, university, and auto industry and electric utility sources.

Contacts:
Tom Turrentine  
Director, PHEV Center  
University of California, Davis  
Phone: 530-752-6500  
turrentine@ucdavis.edu

Ed Kjaer  
Director of Transportation Programs  
Southern California Edison

Susan Shaheen  
Co-Director, Transportation  
Sustainability Research Center  
University of California, Berkeley  
Phone: 510-665-3483  
sashaheen@tsrc.berkeley.edu

Tim Lipman  
Co-Director, Transportation  
Sustainability Research Center  
University of California, Berkeley  
Phone: 510-642-4501  
telipman@tsrc.berkeley.edu
Concept: Cleaner Diesel – West Coast Collaborative

Description: A variety of tools can be utilized to reduce diesel emissions relative to goods movement needs. While not strictly an “alternative propulsion technology,” cleaner diesel can significantly change the way these power systems operate and perform.

Specifics: Diesel engine emissions contribute to ozone (“smog”), air toxics, and fine particulates that are associated with heart and lung disease, asthma, and other adverse health effects including lung-cancer from long-term exposure. A particular concern is asthma in children, who are more susceptible due to their more rapid breathing rate. Because of these effects, most Western states have made diesel emission reduction a public health priority.

The West Coast Collaborative is a partnership among all levels of government, the private sector, and environmental groups along the West Coast whose goal is to strategically reduce diesel emissions by focusing on the most polluting engines and applying the most cost-effective use of funds to reduce air pollution and improve public health.

Status: Collaborative partners are implementing specific programs for large-scale, regional diesel emission reduction focused on locomotive and truck engine idling; port shoreline engine retrofits, on-shore power (cold ironing), and ship-based emission reduction; cleaner fueling infrastructure for ports, rail and trucks; and construction equipment retrofits and cleaner fuels for large-scale highway projects (in partnership with Federal highways’ congestion mitigation and air quality program.

Financing: Since June 2004, US EPA has granted over $14 million in funding, leveraging over $40 million from Collaborative partners to implement over 90 projects along the West Coast. The Collaborative has over 1,000 partners and has reached out to Canada and Mexico to address reduction of diesel emissions.

The health benefits from diesel emission reduction outweigh program costs by an estimated 13-to-1 ratio. For every federal dollar the Collaborative spends on the effort, partners contribute one to ten times that amount. The 2009 American Recovery and Reinvestment Act includes $300 million in grant funding for cleaner diesel programs. Each state will be awarded about $1.75 million, or 30 percent of total funding, to create work plans for the program. The remaining 70 percent — $156 million — will be distributed through a competition whose categories include deployment of EPA-certified clean diesel technologies, emerging clean-diesel technologies, and clean diesel financing programs based on low-cost revolving loans or other tools to finance fleet reductions of diesel emissions.

Contact:
Peter Murchie
U.S. Environmental Protection Agency
Phone: 503-326-6654
murchie.peter@epa.gov

Web site: www.westcoastcollaborative.org
Concept:
Cleaner Diesel – Cascade Sierra Solutions

Description: Cascade Sierra Solutions (CSS) is a non-profit organization that works in partnership with the West Coast Collaborative to reduce fuel use and emissions from heavy-duty diesel engines. CSS operates in Washington, Oregon and California with a primary focus on the Interstate 5 corridor.

Specifics: Diesel engine emission control technologies include:

- Oxidation catalyst – converts pollutants into harmless gases by means of oxidation.
- Particulate filters – permit gases to pass through but trap particulates.
- Exhaust gas recirculation, catalytic reduction, and traps – reduces or converts NOx.
- Fuel additives – serve as catalysts for reductions in particulates and hydrocarbons.
- Low-viscosity lubricants – reduce engine, transmission and drive train friction.
- Alternative diesel fuels – can reduce emissions, used solely or in combination.

Idle reduction — On-board systems such as APU’s (Auxiliary Power Units) provide heating, cooling, and electricity to the cab without requiring the diesel engine to idle at rest stops or overnight. Truck plazas with a ground source can allow trucks to draw power for these purposes.

Improved aerodynamics — An entire range of retrofits can reduce drag on both the tractor and trailer by a variety of fairings and other add-ons that cut air resistance and air turbulence. These features are built into newer trucks.

Tire inflation and configuration — An automatic tire inflation (ATI) system on drive and trailer wheels can generally pay for itself in just over two years by decreasing fuel consumption and the risk of tire failure due to under-inflation. Also, single wide-base tires save fuel by reducing vehicle weight, rolling resistance and aerodynamic drag.

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Clean Diesel –
Cascade Sierra Solutions
(continued)

Status: Through partnerships including the West Coast Collaborative and the National Diesel Emissions Reduction Program, and through its Outreach Centers, Cascade Sierra Solutions helps raise awareness in the trucking industry of technologies that reduce emissions and fuel consumption, and save money. CSS also takes an active role in helping the industry make the capital investments required to apply these technologies (see next section, “Bridge to a Better Future” Vehicle Exchange Program).

Financing: Many trucking fleets and truck owners do not have the initial capital to invest in upgrades. CSS seeks to overcome this barrier by coordinating available incentives, assisting with grant and tax credit applications, offering federally funded rebates and other incentives, and offering affordable leasing and financing options. Use of each tool is based on demonstrating an attractive return on investment to the trucking company owner.

Contact:
Sharon Banks
President, Cascade Sierra Solutions
Phone: 503-302-0900
sharon@cascadesierrasolutions.org

Web site:
www.cascadesierrasolutions.org
Concept: “Bridge to a Better Future” Vehicle Exchange Program

Description: Cascade Sierra Solutions (CSS) proposes to take recent-vintage used trucks that no longer meet California’s stricter emission requirements, recondition them for improved fuel economy and exhaust control, and sell them at reasonable prices to Northwest operators so they can retire older trucks. The exchange will reduce diesel pollution by 80 percent, greenhouse gas emissions by 16 tons, and fuel consumption by 1,200 gallons per truck per year.

Specifics: By national law, all diesel truck engines built before 2007 need to be upgraded or replaced by 2016. Port drayage is a special concern because it typically relies on older trucks to make short hauls in dense urban areas. By state law, Southern California ports must retire pre-2004 trucks immediately. Prior to this exchange program, these trucks were simply being destroyed. The program enables Northwest ports to get 500 of their most polluting (pre-1994) trucks off the road and replace them with refurbished California trucks leased to currently eligible Washington operators.

Status: CSS has applied to the California Air Resources Board (CARB) for a policy ruling that authorizes the program. CARB has held off until at least May 2009 in setting guidelines due to a lack of state funding for purchase of older trucks.

Financing: A public-private partnership coordinated by Cascade Sierra Solutions includes U.S. Environmental Protection Agency, the West Coast Collaborative, Washington state, municipal and port agencies, and private financing. The intent is to offer qualified applicants operating leases at $350-450 per month, $100 of which will be invested in an interest-bearing account to be used for down-payment by the lessee on purchase of a 2007 or newer truck when required.

Contact:
Sharon Banks
President,
Cascade Sierra Solutions
Phone: 503-302-0900
sharon@cascadesierrasolutions.org

Web site:
www.cascadesierrasolutions.org
Concept: Cleaner Diesel - American Trucking Associations

Description: The American Trucking Associations (ATA) recognizes and endorses the following steps to reducing diesel emissions per ton-mile of goods movement:

(1) Engine upgrades and retrofits (for specifics, see Cascade Sierra Solutions).

(2) Setting fuel economy standards and limiting maximum speeds. The ATA supports national fuel economy standards for trucks. A truck traveling at 75 mph consumes 27 percent more fuel than at 65 mph. The ATA has endorsed setting a national speed limit of 65 mph and installing speed governors on new trucks that limit speeds to 68 mph.

(3) Utilizing more productive truck configurations and combinations. Because of a truck’s frontal mass and rear eddies of air, aerodynamic refinements significantly affect fuel use, as does proper tire inflation, especially on rear axles where more than half of fuel consumption is required.

(4) A more controversial strategy is focused on the fact that a smaller number of large trucks moves a given cargo volume with less fuel than a larger number of small trucks. Constraints on this shift include weight limitations and safety concerns.

(5) “Smart driver” skills related to fuel efficiency begin with selecting an engine that has the proper torque – more important than horsepower to get the truck moving. Other skills include proper shifting between gears without going to a higher rpm, and gearing to maintain a given speed with minimal fuel use or even by coasting, avoiding overuse of compression brakes and the resulting need to accelerate to regain speed, and reducing idling time through use of alternative power units (APUs) and automatic engine shut-off.

(6) Truck rest area and parking design is not mentioned by the ATA but could help. During rest periods, drivers often idle their engines to provide heat or air conditioning for the sleeper compartment, to keep the engine warm in cold weather, or to provide electrical power for vehicle appliances. Reducing or eliminating engine idling would be enabled by providing alternative power, ideally by plug-in electrical outlets.

Status: The American Trucking Associations has recommended the above steps to its members – operators and drivers – through its Web site and other communications.

Financing: Funding for engine upgrades is limited. Fuel saving and the efficiencies will actually save operator and driver expenses.

Contact: American Trucking Associations
Concept: Cleaner Diesel – Freight Rail Locomotives

Description: Recent improvements in diesel engine design approach breakthrough levels with 90 percent less particulate emissions and 50 percent less nitrogen oxides (NOx) than 20 years ago. New regulations will take NOx to a 90 percent reduction. Related to this are cleaner fuels, including ultra-low sulfur and bio-diesel that sharply reduces CO2 emissions.

Specifics: Advances in diesel technology apply to railroad locomotives as fully as to trucks. Indeed, in two regards, the importance of “greening” freight rail power may be even greater than for road vehicles.

First, the larger the platform, the more flexibility exists in installing new propulsion systems. Just as large trucks can accommodate power train and fuel system options not easily installed in light-duty vehicles, so railroad locomotives have the most flexible space layouts for new systems.

Next, rail is recognized as the most efficient and least polluting mode for moving long-haul freight, with a substantial advantage per ton-mile over highway freight movement. The economics have been recognized by large trucking firms, which have become freight railroads’ best customers. Freight is shipped to regional centers by rail and delivery within the regions is made by truck.

To fully capture the inherent cost and environmental advantage of rail requires applying the full range of advanced diesel engine technology to freight locomotives.

Status: The two dominant builders of heavy freight rail engines are Electro-Motive and GE. BNSF railroad recently purchased 200 GE engines that burn 20 percent less fuel than their predecessors. Electro-Motive cites advances in its latest-generation 4500 horsepower road engines of 25-45 percent reduction in NOx and 40-60 percent reduction in particulates. ElectroMotive also offers a midrange power unit with claimed fuel savings up to 25 percent and emission levels below current federal guidelines.

Railpower Hybrid Technologies builds EcoMotive, a selection of yard-and-road switching engines with up to 2800 horsepower based on “battery-dominant” and “genset” technologies. The latter includes liquid-cooled “choppers” that provide higher tractive effort in lower speed ranges. In 2007, EcoMotive received a EPA Clean Air excellence award.

Railpower also offers EcoCrane, the first container cargo handling technology based on use of “plug-and-play” hybrid power at ports. The crane uses battery pack energy to lift container freight and reclaims the energy as the container is lowered.

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Cleaner Diesel — Freight Rail Locomotives
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**Financing:** Acquisition of cleaner diesel locomotives is primarily a business decision by long-haul, short-line, and site-specific (ports, rail yards) freight railroads negotiating purchase agreements with manufacturers.

**Contact:**
- Electro-Motive Diesel, Inc.
  Phone: 800-255-5355
- RailPower Hybrid Technologies Corp.
  Phone: 814-835-2212
  mailto:info@railpower.com

Web sites:
- [www.EMDiesels.com](http://www.EMDiesels.com)
- [http://railpower.com](http://railpower.com)
Concept:
Hybrid Electric and Natural Gas Trucks

Description: There is a high level of interest in green technology for vehicles, and none I potentially greener than large vehicles. Trucks and SUVs should be a top priority because they use more fuel, and they can accommodate larger batteries. Further, the success at ports with “cold ironing” makes truck stops early candidates for plug-in recharging capability.

Most hybrid vehicles combine an internal combustion engine (ICE) as the main power source and various secondary power and energy storage modes, including electric and hydraulic systems. Dual power systems enable the capture of energy otherwise lost during braking and use it to boost the main engine, enabling more efficient operation.

Because of their larger size and more flexible layout capacity, truck platforms are more amenable than autos to dual-source hybrid power systems and to storage capacity for alternative fuels such as liquefied natural gas (LNG), compressed natural gas (CNG) and hydrogen.

Specifics: Offerings in this field are burgeoning. Among notable examples:

Cummins Westport offers an LNG system for heavy trucks to combine the advantages of low-carbon, low-emission fuel and a price advantage of up to 25 percent – $1.97 per DEG vs. $1.62 per gallon in a March 2009 example. LNG fuel capacity is equivalent to 33 to 112 diesel equivalent gallons.

Natural gas is composed primarily of methane, which burns more cleanly than gasoline because it has more hydrogen and less carbon. Use of natural gas reduces NOx emissions 33 percent and greenhouse gases 20 percent below the same engine in a gas-powered mode, according to a 2007 US EPA and California ARB certification. Cummins plans to meet new 2101 EPA standards by combining exhaust gas recirculation, particulate filters, selective catalytic reduction (SCR) and high pressure direct injection.

Kenworth is installing the 450 hp Westport ISX-G 15-litre engine as a factory-installed option in its ”time-proven workhorse,” the T800 heavy truck. Kenworth says the result is lower
Hybrid Electric and Natural Gas Trucks

(continued)

fuel costs and reduced emissions without sacrificing horsepower or torque. Also Kenworth has the Cummins/Westport ISL-G 8.9L 2010 EPA complaint engine as a factory option in the T800SH and the T470 configurations. This product is offered with LNG or CNG fuel systems.

Kenworth also offers the T270 Class 6 and T370 Class 7 hybrids. These medium-duty trucks combine a PACCAR PX-6 300 hp gas engine with a 340-volt battery pack. The hybrid system includes an integral transmission-mounted motor-generator and a dedicated power management system to switch between the two modes of operation.

In slower traffic the parallel hybrid power system, developed with Eaton, acts as an electric motor utilizing power from the battery pack. “Regenerative braking” is used to generate and store electricity, which provides almost 60 horsepower with 310 ft/lbs of torque. Electrical power is then used to assist the diesel engine during acceleration. An electric power “take-off” option allows energy to be drawn from the batteries for off-engine operation.

Coca-Cola Corp. bought 120 of the initial run of hybrids in April 2008 and reported the vehicles increased fuel efficiency by 32 percent while reducing emissions by 37 percent.

Freightliner offers a hydraulic hybrid walk-in van chassis, a hybrid electric motor home chassis, and a hybrid electric commercial bus chassis. They combine a diesel ICE and an electric motor driven by lithium ion batteries. An “energy management system” selects the most efficient mode at each point of operation. Freightliner notes that constant battery recharging through operation of the diesel engine and by regenerative braking results in “no need to plug into an electrical source to recharge batteries.”

Preliminary test results on the van chassis showed a 50-70 percent improvement in fuel economy in stop-and-go traffic, compared to all-diesel power with an automatic transmission. The vehicle can operate as a hybrid or in an engine-off, all-electric mode. Options including idle-off and air brakes provide 8-9 percent of the fuel economy gains. The platform is certified for EPA 2010 emission requirements.

Electric Vehicles International (EVI) offers a light truck with 170 – 240 horsepower based on an LNG / CNG / gas powered ICE plus lithium phosphate or lead acid batteries. It also offers a 2-person all-electric utility vehicle with a 40-mile range, 35 mph maximum speed and 1500 kg (3300 lb) cargo capacity on a flatbed. 

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Hybrid Electric and Natural Gas Trucks
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**EV Power Systems** is focusing on trucks, which consume more power than autos. Their basic rule is, don’t change the power train or emission controls. Design the retrofit so it is transferable. EV’s equipment fits behind the transmission and looks like a GM dual-kit system with the casing removed. It is based on intercepting a signal from the pedal to the control panel.

**Balqon** in 2007 began work on the prototype of the world’s most powerful short-range heavy-duty electric truck. Funded by the Port of Los Angeles and the South Coast Air Quality Management District, the truck is now in use at the Port and is capable of hauling a fully loaded 40-foot container with zero emissions. Performance includes a top speed of 40 mph, a maximum range of 60 miles empty and 40 miles loaded, and a full-charging time of 3-4 hours. In 2009, the Port placed an order with Balqon for five on-road electric drayage trucks and 20 electric container terminal tractors.

**The Northwest Hybrid Truck Consortium** is a project of the West Coast Collaborative to purchase 10 of the cleanest hybrid diesel-electric utility trucks available. These trucks will produce nearly 40 percent fewer greenhouse gas emissions and up to one-third fewer soot and smog related emissions by shutting off their engines and using battery power in the field. The new hybrid technology could also add up to 60% in fuel economy. The project is among the first to apply this technology to utility fleet vehicles.

The consortium was formed by King County (Seattle), Washington in 2005 and now includes the entire Central Puget Sound region. The Consortium is working with WestStart-CALSTART, a non-profit that has developed a hybrid truck commercialization strategy with truck manufacturers, technology companies and fleet operators.

**Financing:** The following are examples of hybrid economics drawn from above sources:

**UPS** is beginning to test a new technology for its delivery trucks. An assembly of pumps, tanks and high-pressure hydraulic fluids replace the transmission so that during acceleration the truck burns no gas. Instead, hydraulic fluid stored in a high-pressure tank powers a pump motor that turns the truck’s axle. When the truck is running at steady speed, the diesel engine re-pressurizes the fluid, as does the capture of kinetic energy when the truck is braking.

Kenworth — The company estimates that a hybrid truck can cost $40,000 more than a conventional unit with similar specifications, but that premium will be paid off in four to five years by reduced fuel consumption of up to 50 percent in the utility version. Estimates are based on gas mileage of 10 mpg for its medium-duty hybrids versus 6 mpg for a gas-only counterpart.

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Hybrid Electric and Natural Gas Trucks  
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Balqon — The drayage model is priced at $208,000 while the yard hostler is $189,000. Purchase of these vehicles is funded as part of a $1.5 million, five-year Technology Advancement Program (TAP) as part of the Clean Air Action Plan of the Ports of Los Angeles and Long Beach.

UPS — The UPS technology was developed by US EPA scientist Charles Gray. After studying his work, UPS concluded the technology would add about $7,000 to the $40,000-50,000 base cost per truck. But EPA said savings could be as much as $50,000, with CO2 reductions of 30% or more. After reviewing this analysis, UPS decided to proceed with test deployment.

Contacts:
Wayne Elson  
U.S. Environmental Protection Agency  
Phone: 206-553-1463  
elson.wayne@epa.gov

Tony Brown  
Environmental Protection Agency  
Phone: 206-553-1203  
brown.anthony@epa.gov

Cummins Westport  
Phone: 604-264-4734 / 213-324-6498  
sales@westport.com  
dwright.hanson@cummins.com

Kenworth Truck Co.  
Phone: 425-828-5000 / 323-278-4103  
BobFry@inlandkwla.com

Freightliner Custom Chassis Corp.  
Phone: 800-545-8831

Electric Vehicles International (EVI)  
Art Robins, VP – Operations  
Phone: 877-435-1999  
arobins@evi-usa.com

The Northwest Hybrid Truck Consortium project leverages $250,000 from US EPA with $1.5 million from members of the Consortium.

Web sites:
http://LNGtrucks.westport.com
http://freightlinerchassis.com
http://www.evi-usa.com/
Concept:  
**Sustainable Transportation Energy Pathways (STEP)**

**Description:** An almost total reliance of the U.S. transportation system on oil is increasingly at odds with considerations of energy security, long-term energy supply, national balance-of-payments, and greenhouse gas impacts on global climate change. Alternative forms of energy appear to be an inevitable element in sustainable transportation. Yet, each potential alternative involves technology development, vehicle and infrastructure deployment, and consumer acceptance.

**Status:** STEP is a four-year outreach and research program intended to address the logistical, operational, and technical problems associated with an alternative fuel-based economy.

The main objectives are to develop methods, theories, and tools for consistent, and transparent comparisons of alternative energy and vehicle pathways, and to apply these tools to compare four pathways based on hydrogen, electricity, bio-fuels and fossil fuels.

The hydrogen pathway is the most advanced, due to a research and outreach and research program (2003-2006) that addressed logistical, operational, and technical issues associated with the transition to a hydrogen-based system. Four research tracks were covered: analysis and design of fuel distribution infrastructure; economic and environmental analyses; market analyses and forecasts for infrastructure and vehicles; and pathways and scenarios. To achieve results in each track, there were five tasks completed.

The first task was vehicle demand analysis – purchasing behavior, regional characteristics, response to vehicle fueling schemes, timing, and potential niche markets for hydrogen fuel cells in auxiliary power units (APUs), heavy duty transit, internal combustion engine (ICE) vehicles, and fleet purchases.

The second task was a design analysis of hydrogen fuel distribution infrastructure (cost, operational issues, technology) This was the principal activity of the whole program. Key research areas included infrastructure network, interaction with electricity systems, real-life capacity, logistics, transport constraints (right of way and sitting).

Based on this analysis, a hydrogen business and policy strategy was adopted by major stakeholders as the basis for transition to a hydrogen economy. Reports were published describing this strategy.

The fourth task was estimating the cost, energy requirements, and environmental impacts of hydrogen pathways. Air pollutant and greenhouse gas emissions and lifecycle costs characterize this analysis.

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Sustainable Transportation Energy Pathways (STEP) (continued)

The goal was to study the policy implications and value propositions of a hydrogen economy.

The fifth task included potential special projects such as hydrogen production technologies and infrastructure sitting technologies. Research conducted under the Hydrogen Pathways Program summarizes the hydrogen tract including investigation of electricity/hydrogen systems, the impact of alternative policies, infrastructure development strategies, and regional transition case studies.

The bio-fuels pathway will explore the work of California Biomass Collective at the University of California, Davis, including the analysis of bio-refinery production systems, environmental and land-use impacts, infrastructure strategies, and vehicle analysis.

The electricity track includes production methods, time-of-day charging impacts, and total grid capacity. Research will also be done on consumer behavior and preferences for electric drive attributes, including all-electric vehicle range and charging times.

The fossil fuels track addresses petroleum-based fuels as the dominant form of transportation energy, and the potential for sources, including coal with carbon sequestration, oil shale, and tar sands.

In a separate but related research project, Caltrans, PATH and Mercedes-Benz Research and Development North America, Inc. are studying the processes involved in operating hybrid fuel-cell electric vehicles in a fleet setting, including support for a fueling infrastructure.

The study will use Mercedes-Benz’s “F-Cell” vehicle equipped with a hybridized fuel cell and a battery power system coupled with an electronic motor/power controller propulsion system.

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Sustainable Transportation Energy Pathways (STEP)
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The project will include “ride-n’-drive” clinics in Sacramento and Richmond, California with approximately 100 participants at each site. Caltrans and PATH will arrange focus groups to assess the response to hydrogen cars and infrastructure. Additional focus groups will be arranged with carsharing participants and a plan for a next phase “pilot program” will be developed.

Financing: The hydrogen pathway program was funded by auto companies (General Motors, Honda, Toyota, Nissan, and Subaru), Caltrans, government agencies (USDOT, EPA, DOE, Natural Resources Canada), and energy companies (BP, Chevron, Shell Hydrogen, ConocoPhillips, ExxonMobil, PG&E, TOTAL, Sempra Energy, Indian Oil, Air Products, and Petrabras). The ongoing program is funded by the same group of companies and agencies.

Contacts:
Joan Ogden
Director, Sustainable Transportation Energy Pathways (STEP)
University of California, Davis
Phone: 530-752-2768
jmogden@ucdavis.edu

Daniel Sperling
Director, Institute of Transportation Studies
University of California, Davis
Phone: 530-752-7434
dsperling@ucdavis.edu

Susan Shaheen
Co-Director, Transportation Sustainability Research Center
University of California, Berkeley
Phone: 510-665-3483
sashaheen@tsrc.berkeley.edu

Timothy Lipman
Assistant Research Engineer, Transportation Sustainability Research Center
University of California, Berkeley
tlipman@strc.berkeley.edu
Concept: **Algae as a Bio-Fuel**

**Description:** A group of researchers and investors believe fast-growing strains of algae could hold the key to the future of the bio-fuel industry.

**Specifics:** Algae multiplies rapidly, contains large amounts of vegetable oil, can be grown in brackish and saline environments that support almost no other commercial activity, and does not have a competing use as a foodstuff when used as a fuel.

**Status:** Allied Minds, a Boston-based private investment firm that specializes in licensing university research, has teamed with University of Washington biology professor Rose Ann Cattolico to launch start-up company AXI to create fast-growing strains of algae for use as a bio-fuel.

A number of operators in the bio-fuels industry think algae reactors could produce far higher yields than soybeans or corn, making bio-fuels commercially viable while avoiding the economic and moral issues involved in “food for fuel” uses.

Allied Minds Vice President Erik Rabins says the intent is for AXI to become the primary supplier of algae strains for the algae-to-biofuel industry, using Cattolico’s method to improve the growth rate and energy productivity of virtually any strain of algae. AXI, formerly Voltan Biofuel, won the award for the best clean-tech idea at UW’s Center for Innovation and Entrepreneurship 2008 competition.

Other Seattle-area firms are pursuing related breakthroughs. Bionvitas is focused on producing micro-algae in high volumes; Indenture, on algae-to-fuel conversion; Blue Marble Industry on marine algae harvest methods. The region’s largest firm, the Boeing Company, says algae could become one of the most promising sources of jet bio-fuel for the aviation industry.

**Financing:** University research and private funds.

**Contact:**
Rose Ann Cattolico
Professor of Biology, University of Washington
Director, Cattolico Laboratories
Phone: 206-9363 / 206-543-1627
racat@u.washington.edu
Concept: Interstate 5 Alternative Fuels Corridor

Description: About 95 percent of U.S. transport relies on petroleum-based fuels. Hybrid and alternative fuel vehicles are being developed but a limited retail market for purchasing the fuels they require is a constraint on the purchase of these vehicles.

In 2008, Washington, Oregon and California launched a three-state effort to explore the possibility of developing state-owned land at highway rest areas in the Interstate 5 corridor as sites that would offer incentives for service station operators to sell alternative fuels. Knowledge of this intent was a factor in the USDOT designation of I-5 as a “Corridor of the Future” in 2007.

Specifics: In August 2008, the three state DOTs filed an application with the Federal Highway Administration (FHWA) to qualify the I-5 alternative fuels corridor as Special Experimental Project (SEP) Number 15 in the category, “Explore Alternative and Innovative Approaches to Overall Project Development Process.”

As part of the application, a waiver was requested to remove a prohibition on the use of land within the right-of-way of a federal highway for “automotive service stations” or other private commercial operations and lift certain restrictions on the use of safety rest areas (SRAs). SEP-15 approval would have been the most direct course to obtaining the waiver.

The National Association of Truck Stop Operators (NATSO) saw the pilot project as a competitive threat and urged FHWA to deny the waiver. A well-organized interest group, NATSO had successfully lobbied Congress to repeal part of the previous transportation appropriations bill that contained the authority and program to allow truck electrification projects.

In November 2008, the states filed a project description with FHWA that emphasized the intent to minimize competitive issues. The filing said the proposal would exclude conventional fuel sales in all locations, and would not provide sites in areas that already had “an established retail distribution network” for alternative fuels. It excluded motor vehicle repair, lodging, and sale of alcoholic beverages from co-located commercial services.

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**Interstate 5**
**Alternative Fuels Corridor**
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It promised full input from local businesses near each site. It stressed that the project was transitional to a new fuels era rather than a permanent presence in the marketplace.

**Status:** In January 2009, the states were informed by USDOT of a compromise solution to approve the project as part of the Interstate Oasis Program, whose guidance principles can be amended through the Federal Register. A 30-60 day public comment period was set for February and March. USDOT stated its intention to make the revisions in the Oasis program necessary to approve the project after this process was complete.

**Contacts:**
Jeff Doyle  
Director, Public/Private Partnerships,  
Washington State DOT  
Phone: 360-705-7023  
doylej@wsdot.wa.gov

James Whitty  
Director, Office of Innovative Partnerships and Alternative Funding  
Oregon Department of Transportation  
Phone: 503-986-4284  
jim.whitty@odot.state.or.us

Barbara Lewis  
Office Chief, Innovative Finance  
Division of Budgets, California Department of Transportation  
Phone: 916-653-8344  
barbara.lewis@dot.ca.gov
Concept: Alternative Fuels Corridor Economic Feasibility

Description: In support of the tri-state effort, the Office of Public/Private Partnerships of the Washington State Department of Transportation (WSDOT) commissioned PB Consultants to evaluate the economic feasibility of an alternative fuel corridor in the Washington portion of I-5. PB delivered its final report to WSDOT on January 23, 2009.

Specifics: Using data based on industry experience for 2007, the consultants developed an economic model of the typical gas station. They found that a typical station annually sold $4.1 million in gasoline at a 6 percent profit margin ($233,000) while the convenience store at the station generated $1.4 million in revenue at a 31 percent margin (440,000). Average annual operating costs for the combined facility were $533,000 including credit card fees. Thus, net revenues averaged $230,000. The cost to open a retail gas station averaged $2.0 – 2.4 million depending on location.

These costs and cash flows were used to model a lease-based transaction between the operator and the state, based on cost-sharing of site development and risk-sharing on cash flow outcomes. Financial models were also adjusted for specific types of alternative fuels including ethanol, biodiesel, electricity, and hydrogen (compressed natural gas was not part of the analysis). The analysis evaluated the degree to which supply chain constraints on each fuel type would affect cost competitiveness and availability of product.

A crucial factor impacting consumer willingness to rely on a network of alternative fueling stations is spacing – the ability of the I-5 corridor to provide a sufficient number of stations to ensure that drivers can use the corridor for extended trips outside urban areas. The study’s “station spacing analysis” used 350 miles as a reference point for gasoline-powered vehicles and set biodiesel at 400 miles, ethanol at 250 miles, hydrogen at 120 – 300 miles, and electric vehicles at 60 – 200 miles.

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Alternative Fuels Corridor Economic Feasibility (continued)

I-5 in Washington State spans 275 miles, which means in most cases an alternative fuel vehicle could traverse the state with one fueling event. The need for some redundancy is counterbalanced by the fact that “the stations contemplated in this study are not meant to compete with existing or future stations on non-state owned land. As such, a limited number of stations in more rural locations is preferable” – assuming a larger concentration of wholly private stations in urban areas.

The study found specific rest area sites based on a “conservative” limit of 120 miles between facilities. Then the study described the infrastructure features of each type of fueling and its relation to other on-site retail services, which were deliberately constrained to minimize direct competition with commercial gas stations and truck stops.

**Status:** The Washington State study will be combined with parallel research efforts in California to create a comprehensive picture of requirements and optimal design features on an alternative fuels corridor covering the entire length of Interstate 5.

**Financing:** The study examined the probable degree of required state and private participation in developing and operating the network. It assumed an alternative fuel station would need a 15 percent annual internal rate of return (IRR). Where modeling showed an IRR below this level, the state could make an up-front contribution to capital costs of station development. Where the IRR was projected above 15 percent, the state could collect a fixed percent of revenue as part of the rent paid by the operator for use of state land.

PB Consulting projected bio-fuels stations would reach positive cash flow in 5 – 6 years while electric and hydrogen stations would require 8 – 10 years to become profitable. The strongest profit performance for reaching an IRR above 15 percent was projected to be an “all-fuels” station that provided bio-diesel, ethanol, electric and hydrogen refueling. This finding especially fits the profile of a small network of stations located on state land.

The study concludes by reviewing the challenge of gaining a consensus from governments with permitting authority, service providers with profitability goals, and consumers with reliability needs.

**Contact:**
Jeff Doyle  
Director, Public/Private Partnerships,  
Washington State DOT  
Phone: 360-705-7023  
doylej@wsdot.wa.gov
5. Law & Regulation (L/R)

Goods Movement Benefit:

• Expedites motor carrier regulation procedures through automated, interoperable information technologies.

Personal Travel Benefit:

• Provides drivers with tradeoff choices between cost and travel time through use of “value pricing” – variable tolling related to level of congestion.

Transportation System Benefit:

• Provides a basis for adequate long-term system funding covering infrastructure maintenance and capacity investments by basing taxation of actual level of system use rather than type of fuel use.
Concept: Seamless Weigh Station Preclearance of Trucks

Description: Create a national policy for truck transponders used in preclearance systems so any regulatory compliant truck can be weighed-in-motion and signaled to proceed past open weigh stations without stopping. Congress can act to mandate transponder interoperability across jurisdictions to allow for seamless freight movement on major highway and trade corridors such as Interstate 5.

Specifics: Many states operate weigh station preclearance systems utilizing high-speed weigh-in-motion scales, automatic vehicle identification equipment and on-board transponders that serve as two way communication devices between the roadside and the truck, providing the functional equivalent of an electronic license plate for trucks to transmit and receive signals as they approach weigh stations.

These systems save motor carriers time and the cost of fuel by eliminating millions of unnecessary stops. They save states money by increasing weigh station capacity without a need to expand static platform scales, allowing better management of the growing stream of truck traffic and helping states enforce safety regulations by screening trucks to determine which need inspection. Preclearance systems also contribute to reduced vehicle emissions affecting human health and climate change.

Some states see so much value in preclearance that they provide transponders at no cost to truck operators who regularly stop at weigh stations. But restrictive policies create interstate inefficiencies that force regulatory compliant trucks to stop at weigh stations because preclearance system providers in some states do not allow other states to read and interact with the transponders they have issued.

The PrePass preclearance program used in 28 states is run by a public-private partnership called HELP Inc. – Heavy Vehicle Electronic License Plate. HELP has a restrictive policy that prevents its transponders from being enrolled in any other system, such as Oregon’s Green Light or the NORPASS system used in Washington, six other states and two provinces. This limitation is despite the fact that Green Light and NORPASS have both stated that they would freely allow Prepass transponders to enroll and operate in their respective systems.

As a result, regulatory compliant motor carriers with a PrePass transponder get a red light as they approach Oregon Green Light or Washington NORPASS weigh stations. Their only recourse is to return their Prepass transponder to Prepass and obtain a free Oregon
Seamless Weigh Station
Preclearance of Trucks

Green Light transponder that can be enrolled in any system, including Prepass.

Moreover, all states, including California, that are under contract with PrePass are prohibited from accessing and sharing information regarding precleared trucks for safety or other enforcement purposes with other states or with operators.

Despite some marketing claims, trucks with transponders in states that access the bypass event data are not subject to increased regulatory scrutiny? For example, in the Green Light system ODOT simply records the same license plate information it manually records each time a truck pulls into a weigh station. Transponder-equipped trucks actually get less scrutiny than other trucks. One of the main reasons ODOT uses the Green Light system is to identify safe and legal carriers and allow them to continue uninterrupted. As a result, ODOT can concentrate on trucks that may need more attention.

Status: The U.S. DOT’s Commercial Vehicle Information Systems and Networks program (CVISN) was designed to ensure that states deploy interoperable systems. But the Federal Motor Carrier Safety Administration (FMCSA) has not addressed the impasse over transponders.

The June 26, 2000, edition of Transport Topics covered this issue. It quoted Mike Onder, Information Technology Systems Program Manager for USDOT: “They market to [trucking] that this information is private. When they sign up with a state, they agree [the state] won’t get access to the data. That goes against the CVISN architecture. PrePass is hurting interoperability.”

The magazine also quoted Jeff Secrist, CVISN Coordinator, Federal Motor Carrier Safety Administration: “(Truckers) want to be able to travel unencumbered nationwide without coping with different preclearance programs. From a safety perspective, there’s a major benefit in sharing information . . . so that unsafe vehicles can’t travel between states. HELP - PrePass doesn’t allow other systems to have access to its data. And that means it can’t be compliant.”

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Seamless Weigh Station Preclearance of Trucks
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FMCSA has the ability to require that states comply with all legitimate data requests to support driver hours-of-service enforcement efforts and it can make such compliance a condition for states to continue to be eligible to receive federal grant dollars from the Motor Carrier Safety Assistance Program.

Whether a state has made use of such data in regulatory enforcement is not the question. The question is whether state and federal investigators who have historically made legitimate use of such data should be increasingly denied such data.

Absent FMCSA exercising clear authority, there are two other alternative courses of action to achieve seamless preclearance for trucks.

Alternative 1 – Federal legislation enacted by Congress with the following provisions:

1) Declare that transponders must be freely interoperable among jurisdictions and preclearance systems that weigh and identify U.S. trucks should be integrated, consistent with the CVISN program.

2) Clarify that states and their authorized employees may enroll, at the request of a carrier, any interoperable transponder for legitimate regulatory purposes and use transponders for such purposes, including the receipt of signals that link its unique identifier to a motor carrier’s records.

3) Declare that weigh station records, whether collected electronically or manually, must be available for states’ legitimate regulatory enforcement purposes.

Alternative 2 – Utilize technology advancements to retire transponders as the basis of vehicle identification, replacing them with Radio-frequency Identification (RFID) chips and/or license plate readers. These would be used in combination with roadside reader boards to communicate weigh station bypass decisions to drivers approaching an open scale, thus achieving the goals of seamless preclearance and authorized record-keeping. (Such an approach would retain provisions of the above legislation relating to these goals).

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Seamless Weigh Station
Preclearance of Trucks
(continued)

The vehicle license plate has long been a unique identifier. By shifting from manual to electronic license plate readers, states could utilize sophisticated optical character recognition plate-reading ability that can digitize alpha-numeric characters into a database.

Another tool that can be used simultaneously is the RFID chip attached to the plate for verification. RFID is employed globally for cargo container identification. With RFID, the element of communication back to the driver necessary for preclearance operations would need to be addressed by addition of a roadside reader board.

Financing: The proposed legislation outlined above as Alternative 1 creates no significant cost issues. States and carriers are already paying for transponders. Moreover, interoperability may bring down unit costs through standardization of transponder design.

Alternative 2 would obsolete a substantial investment in transponders and AVI devices, and would require new investment in replacement technology. If preclearance is license plate-based, motor carriers would have added costs, but some states might achieve offsetting personnel cost savings and/or cost avoidance opportunities by replacing manual plate reading with electronic reading.

Contacts:
David McKane
Green Light Manager
Motor Carrier Transportation Division
Oregon Department of Transportation
Phone: 503-373-0884
David.J.McKane@odot.state.or.us

Anne Ford
Administrator, Commercial Vehicle Services
Washington State Department of Transportation
Phone: 360-705-7341
forda@wsdot.wa.gov

Stan Norikane
Data Weigh-in-Motion
California Department of Transportation
Phone: 916-654-5651
stanley_norikane@dot.ca.gov
Concept: Single Source Multi-State Overweight / Oversize Permitting

Description: WASHTO – the Western Association of State Highway and Transportation Officials – has teamed with twelve western states to provide regional single-trip overweight/oversize permits.

Specifics: Washington and Oregon, together with Arizona, Colorado, Idaho, Louisiana, Montana, Nevada, New Mexico, Oklahoma, Texas and Utah have entered into an agreement that authorizes the issuance of the Western Regional Permit.

This permit may be issued by the entry, origin, destination or pass-through state if the cargo does not exceed prescribed size and weight and is operating on the routes listed. The member states have developed a list of special conditions within each state that apply to the operation of the envelope vehicle. This list must accompany all regional overweight/oversize permits.

Status: The program is active.

Financing: The state of issuance will collect the fees for all member states in which the vehicle is permitted for travel. These fees can be paid by credit card, cash, cashiers check or other guaranteed funds.

Contacts: Each state’s contact can be found at:
www.wsdot.wa.gov/NR/rdonlyres/C43BCA33-4F74-43C4-B10F-9AD745168744/0/Permit_Brochure.pdf
Concept: Inductive Signature-based Commercial Vehicle Classification System

Description: This research study by the University of California - Irvine yielded (1) the development and prototype implementation of a new high-fidelity inductive loop sensor called the Blade; and (2) a groundbreaking commercial vehicle classification system based on vehicle “signatures” obtained from the Blade inductive sensor technology.

The Blade couples with advanced signature-based inductive loop detector cards to yield detailed vehicle signatures that show distinct wheel spikes that indicate the location of axle assemblies.

Using advanced numerical analysis methods, these signatures were used to provide accurate and comprehensive classification of commercial vehicles. The detail of classification is unprecedented, due to the system’s ability to profile individual components of multi-unit vehicles by their axle and, more importantly, body configuration. This detail provides the potential to yield useful insights on travel behavior and the impacts of different commercial vehicle types associated with various industrial activities.

The unique configuration of Blade inductive sensors also allows accurate inductive signature data to be recoverable even in stop-and-go situations where acceleration and deceleration effects can potentially distort signature data and affect surveillance accuracy.

Specifics: This study solved the problem of obtaining reliable inductive signature data under adverse traffic conditions, such as those found in peak freeway congestion periods and in arterial streets heavily influenced by intersection delays.

Where previously vehicle inductive signatures would be irreversibly distorted by acceleration or deceleration effects, they are now corrected and usable. This is essential in freeway applications, where there has been tremendous interest in obtaining accurate performance measures that have not been previously available under peak congestion periods when the vehicle signature quality degrades due to acceleration-deceleration distortion. Correction is achieved by applying the SPRINTS transformation model developed through Blade research, and paves the way for accurate traffic performance measurements to reveal accurately the severity of congestion and delay experienced on freeways as well as arterial networks.

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Inductive Signature-based Commercial Vehicle Classification System

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Until now, the classification system that best combines reliability and detail is the axle-based FHWA scheme F using automated vehicle classifiers. However, this system still leaves a void in the comprehensive understanding of commercial vehicle travel behavior and impacts, due to their inherent heterogeneity. The newly developed classification system yields a more detailed axle classification scheme with axle classification accuracy of ninety-nine percent shown on an independent test data set.

More importantly, the new system introduces body unit classification schemes consisting of nine drive-unit body configurations and ten trailer-unit body configurations, revealing detailed information regarding the function of the drive and trailer units of each commercial vehicle.

Status: In the study, many of the nine classes were under-represented in the model development data set. Hence, the real-world heterogeneity of vehicles within those classes may not be well represented, and could result in high rates of misclassification. This suggests that the commercial vehicle classification system will require further calibration with a larger and more comprehensive data set before implementation.

The results obtained from this study indicate remarkable potential for providing enhanced commercial vehicle profile analysis through the implementation of this system. Such information is critical to reveal exposure rates and travel behavior of specific commercial vehicle types to evaluate the multi-faceted impacts of commercial vehicle impacts.

The Blade inductive sensors used in this study are a prototype surface-mounted version, which has limited operational lifespan suitable only for research purposes. The specifications for a permanent version of the inductive sensors are currently being developed to allow Blade to be functionally deployed on the roadway to provide the benefits of enhanced commercial vehicle surveillance that were demonstrated in this research study.

Financing: California Department of Transportation, University of California Transportation Center

Contacts:
Stephen G. Ritchie
Director, Institute of Transportation Studies
University of California, Irvine
Phone: 949) 824-4214
s Ritchie@uci.edu

Yeow Chern Andre Tok
Postdoctoral Scholar, Institute of Transportation Studies
University of California, Irvine
ytok@uci.edu
Concept: Highway User Taxation Based on Miles Driven (VMT)

Description: The total context of concern about basing highway financing on a motor fuel tax includes imported oil costs, energy security, greenhouse gases, and “peak oil,” with the implied need for conservation. Policy is conflicted, since it both relies on and seeks to reduce the use of petroleum-based fuels. Thus, there is national interest in a mileage-based tax.

Specifics: The Transportation Commission chairs of California, Oregon, and Washington recently co-signed a letter to members of Congress urging that federal law encourage states to develop alternative methods of highway funding such as vehicle miles traveled (VMT) fees.

“We ask Congress to confirm the feasibility of a VMT-based fee system by mandating the federal government to fully explore a transition from the gas tax to a funding system tied more directly to road use and impact on the road system,” the chairs wrote. They noted that fluctuating fuel prices and reduced fuel consumption make fuel taxes an unreliable and unsuitable funding source.

The trio called upon Congress to “set an aggressive timetable” for completion of a new VMT-based fee system “through well funded research and development efforts to identify the best option for system design and technology.”

The three Transportation Commission chairs are John Chalker of California, Gail Achterman of Oregon, and Dan O’Neal of Washington. They are the top policymakers on transportation in the three states and they collaborate as the West Coast Transportation Commission.

VMT fees are a centerpiece recommendation in a report just released by a bipartisan national Transportation Finance Commission and U.S. Transportation Secretary Ray LaHood has said he favors VMT fees as a substitute for the gasoline tax, which is proving insufficient to fund roads.

The day after LaHood spoke in favor of the road use tax, White House Press Secretary Robert Gibbs said a VMT “is not and will not be the policy of the Obama administration.”

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Highway User Taxation Based on Miles Driven (VMT)

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It is not clear whether the cause of this internal dispute can be resolved by treating VMT fees as a phased-in source of revenue rather than as an immediate replacement for the gas tax.

The chairs’ letter outlines the results of the Oregon pilot program in which nearly 300 vehicles driven by volunteer citizens were equipped with GPS-based units and charged for miles traveled. “This test demonstrated the mileage fee raises substantial revenue in a way that is relatively simple to pay, collect and administer - without revenue erosion for fuel efficiency,” they noted.

A similar project in the Puget Sound area that deducted fees from prepaid accounts showed that such a fee “directly impacts travel decisions and reduces congestion, while raising transportation revenue” the letter says.

The chairs believe a key conclusion from these two studies is that a VMT fee serves to advance several priorities simultaneously: reducing congestion, reducing emissions, encouraging the use of alternate modes, and identifying a sustainable long-term funding methodology.

Status: The three states envisage a multi-state effort in the Interstate 5 corridor to take the concept further towards implementation.

During 2006-07, a trial program in Portland equipped about 300 cars with passive receivers of satellite signals and a mileage reader, similar to a toll transponder reader that transmits a wireless communication to a database where mileage fees are applied. Drivers of these vehicles were taxed 1.2¢ per mile driven – equivalent to the state’s 24¢ gas tax on a car averaging 20 miles per gallon.

In addition to national concerns, the Oregon experiment is motivated in part by an intention to “be aggressive in terms of looking at electric cars and hybrids and plug-ins and all these options, and at the same time continue to invest in our roads and infrastructure,” according to Governor Ted Kulongoski’s office spokesman Rem Nivens. Governor Kulongoski proposes expansion to $5,000 of Oregon’s already substantial tax credit for purchase of electric vehicles. Combined with federal subsidies, this would allow Oregonians to save up to $12,500 on the purchase of an all-electric car. Success of these incentives would accelerate declines in gas tax revenue.

The Governor has proposed requiring installation of mileage-counting devices only in new vehicles and charging mileage only on Oregon roads.

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Highway User Taxation Based on Miles Driven (VMT)
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Drivers from outside the state would be charged the gas tax. However, the interstate aspect (especially given that Portland is a bi-state metro area) immediately raises the question of a federal policy that would affect manufacturers nationally. This prospect is increased by the fact that the states of Ohio, Pennsylvania, Colorado, Rhode Island, Minnesota, and Texas have also expressed interest in phasing out the gas tax and replacing it with a tax on miles driven.

Financing:
Oregon has acknowledged that it would not be able to make the change without assistance from the federal government or a consortium of states. Oregon DOT has made a proposal to Congress that the next federal transportation authorization bill should set a six-year timetable to complete development of a mileage-based highway user tax system that would be implemented in the following six-year cycle.

This commitment would include funding to identify and design the best system and operating technology. The ODOT proposal calls for working groups within USDOT and an independent oversight body. The proposal also would give the USDOT Secretary authority to require on-board equipment in new vehicles to speed the transition to the new tax.

A sensitive political issue, notwithstanding apparent technical solutions, is assuring the privacy of trip information. Another important issue, as noted above, is whether the new tax would entirely replace or partly supplement motor fuel taxes for freight and/or personal vehicles.

Contacts:
John Chalker  
Chair, California Transportation Commission  
Phone: 916-654-4245

Gail Achterman  
Chair, Oregon Transportation Commission  
Phone: 503-986-3450

Dan O’Neal  
Chair, Washington State Transportation Commission  
Phone: 360-705-7070

James Whitty  
Director, Office of Innovative Partnerships and Alternative Funding  
Oregon Department of Transportation  
Phone: 503-986-4284  
Jim.Whitty@odot.state.or.us

Lynn Averbeck  
Project Director, Office of Innovative Partnerships and Alternative Funding  
Oregon Department of Transportation  
Phone: 503-731-4663  
Lynn.Averbeck@odot.state.or.us
Concept:
Distance and Congestion-Based Dynamic Pricing

**Description:** Vary highway user toll by a combined calculation based on distance traveled and level of congestion measured on a real-time basis.

**Specifics:** The San Diego Association of Governments has developed a nationally recognized application of variable tolling/value pricing on Interstate 15. Every few minutes, the automated system recalculates the toll rate based on the level of traffic in the I-15 corridor to make sure traffic flows freely in the Express Lanes.

**Status:** When another eight miles of Express Lanes opened recently on I-15, a new distanced-based dynamic pricing system was also launched. Under this state-of-the-art system, transponder-equipped FasTrak customers accessing the Express Lanes pay a toll based on the distance they travel in the lanes and a rate per mile for their entry location, adjusted for level of congestion.

The toll rate posted on signs located just before each of the entrances to the Express Lanes will state the minimum toll drivers can expect to pay if they enter the facility, regardless of their eventual exit location. The signs also will advise on one or more possible fares for longer trips to upcoming freeway interchanges.

If traveling to a destination somewhere between the first possible exit point and the next major freeway interchange, the traveler can expect to pay a toll that falls between the minimum and the toll to go all the way to the interchange.

The new FasTrak system is the most advanced in the world. A sophisticated identification system based on individual transponders tracks where and when each vehicle enters and exits the lanes, automatically calculates the toll, and flags violators for enforcement by the California Highway Patrol.

The eight miles of added Express Lanes on I-15 will have new conveniences including multiple entrances and exits, and an upgraded “dynamic tolling” system. Direct access ramps – another new feature – allow users to enter and exit the Express Lanes from the transit stations along I-15. The transit stations provide parking for carpoolers/vanpoolers and transit riders.

San Diego built strong support for the toll lanes by using part of the revenue for improved transit service, creating a win-win for three constituencies: drivers willing to pay a toll to save time in an express lane, drivers using general-purpose lanes that became less crowded, and transit riders who gained service improvements paid for by auto tolls.

**Contact:**
Derek Toups
Project Manager
Associate Regional Planner, San Diego Association of Governments
Phone: 619-699-1907
dto@sandag.org
Conclusion

It is axiomatic that if the best of what is being done anywhere were being done everywhere, the system it serves would function well. The findings offered here describe best practices and best concepts. At the moment, they are far from universally applied.

The “Clean, Green and Smart” project is about the power of connection - not only connection among technologies, strategies and policies but connection among people who believe in an open-source environment to identify, develop and implement innovations.

A network such as this, with its vast range of content, can only be held together by the intelligence, energy and commitment of its participants. Working separately in specific areas of effort, we are united by an intention to make a major contribution that will help reconcile human mobility with environmental survival. The goal is to create a partnership between the planet and its people, applied through the unique West Coast spirit that combines high technology with high quality of life.

The intent of this document is to describe a specific path by which each of us may participate in building such a legacy. In the words of Chief Justice Oliver Wendell Holmes, Jr., “Each of us must be part of the great issues of our time, at the peril of being judged not to have lived.” Thus the legacy is not only for the collective future but is personal history for each of us.

In our time, perhaps the greatest service we can perform is to connect large and complex bodies of knowledge with the sense of possibility about a preferred future – and then to provide a critical path for moving in that direction.

By combining creativity with discipline, the intent is to offer a “Clean, Green and Smart” Best Practices Manual structured for effectiveness and impact so that its contribution to our individual and collective legacy is solid and secure. If so, we will have done part of the necessary work.