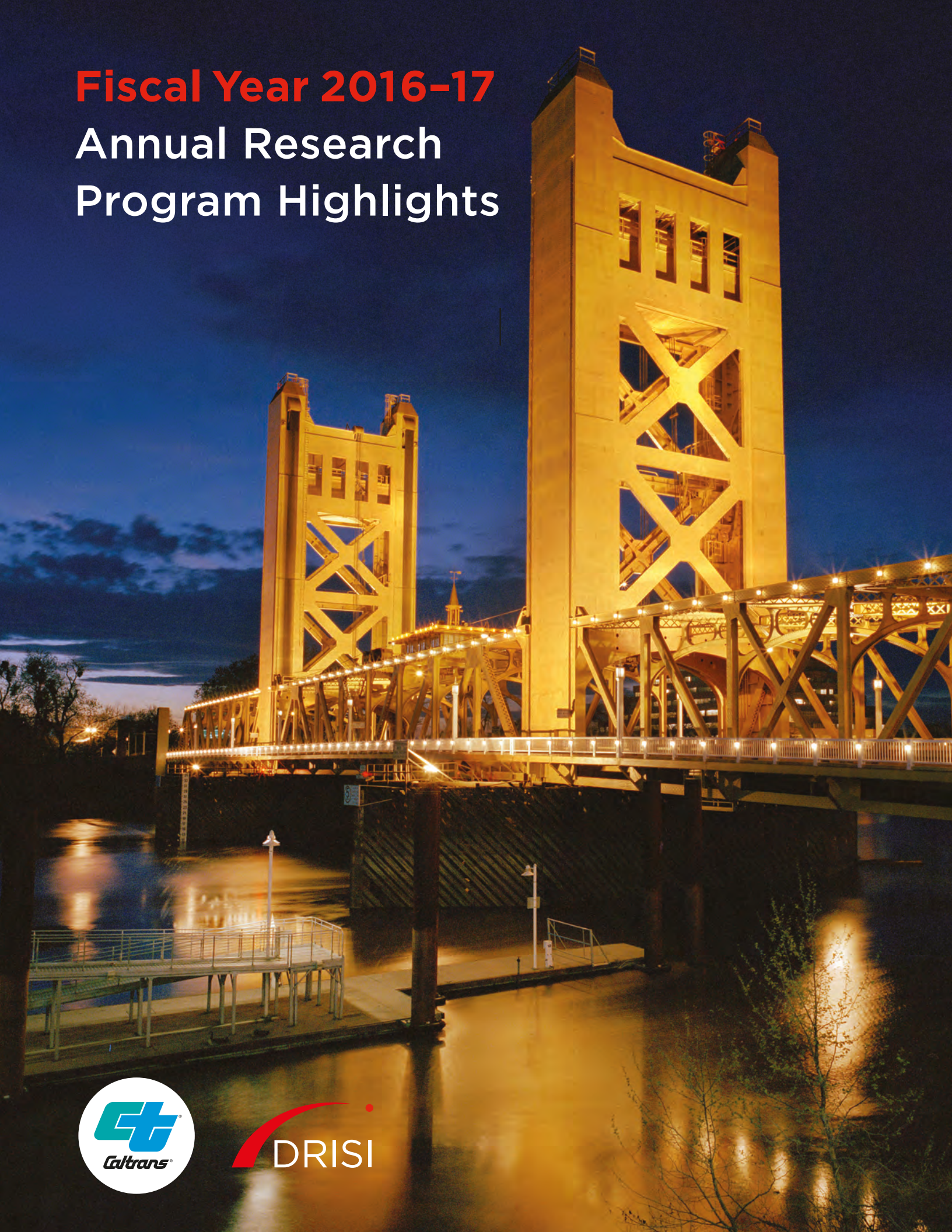
Fiscal Year 2016–17
Annual Research Program Highlights



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Caltrans Research Program

Fiscal Year 2016–17

Annual Research Program Highlights

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For more information:

California Department of Transportation
www.dot.ca.gov

Division of Research, Innovation and System Information
www.dot.ca.gov/research

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Caltrans Division of Research,
Innovation and System Information

Division Chief's Message

I am pleased to introduce the Division of Research, Innovation, and System Information's (DRISI) FY 2016–17 Annual Research Program Highlights. This report covers the 12-month period ending June 30, 2017, during which DRISI continued to build upon a robust research program, adding staff to better support the California Department of Transportation's growing need for knowledge and solutions, institutionalizing DRISI's recently developed Research Prioritization Methodology (RPM) to make informed funding decisions that align research outcomes with the Caltrans strategic goals, evaluating the performance of our research portfolio with a transparent measure of implementable outcomes, and improving DRISI's expansive network of research partnerships.

DRISI implemented the RPM for the spring 2017 research selection process of developing the FY 2017–18 research portfolio of funded projects. The selection process was fiscally constrained with the cumulative research project budgets exceeding available funding. The RPM provided objective measures of the alignment of anticipated research outcomes with the Caltrans strategic goals and thus facilitated the selection of those projects that had the greatest potential to "move the needle." DRISI will continue to use and refine the RPM based on this successful pilot.

DRISI reports annual performance of the research portfolio in the Caltrans Mile Marker publication. Baseline performance was established in 2015 for three broad categories of research: Caltrans functional research, sponsored University Transportation Center (UTC) research, and sponsored national research. The goal is to measure whether a research effort produced an implementable outcome. The 2015 baselines were set at 50%, 20%, and 10%, increasing 5%, 4%, and 2% per year until the 2020 targets of 75%, 40%, and 20% are achieved. DRISI research produced implementable results exceeding the FY 2016–17 interim targets by 6%, 4%, and 13%.

DRISI leveraged opportunities to build and expand Caltrans' network of research partnerships, renewing existing sponsored research center agreements with the University of California and building new connections with the UC Institute of Transportation Studies to support California Senate Bill 1 (SB1) funded research. SB1 was also the conduit to working with the newly created California State University System Transportation Consortium. DRISI formalized Caltrans support for three new United States Department of Transportation UTCs led by California-based universities. Sponsored UTC research has been an important and productive component of the DRISI research portfolio.

I hope that as you read this Research Program Highlights report, you're motivated to become involved in Caltrans' research activities, including engaging on a national level with the American Association of State Highway and Transportation Officials or the Transportation Research Board (TRB).

Jim Appleton, Chief
Division of Research, Innovation and System Information

Accomplishments and Innovations

Caltrans pursues groundbreaking approaches to deliver a safe, sustainable, and integrated transportation system for all Californians. Guided by Caltrans' mission and vision, DRISI is focused on developing innovative transportation solutions and disseminating transportation-related knowledge across Caltrans.

Shaping the Future of Transportation with PATH

Caltrans helped establish Partners for Advanced Transportation Technology (PATH) at the University of California, Berkeley in 1986. Since then PATH has collaborated with Caltrans to explore and prepare for emerging new transportation technologies that hold promise to improve traveler safety, reduce traffic congestion, encourage alternative transportation modes, and facilitate the movement of goods and services. These new technologies also help improve air quality and reduce greenhouse gas emissions and the detrimental impact of transportation on land use and sprawl.

In partnership with Caltrans, PATH conducts leading-edge research, develops new ITS technologies and applications, and conducts controlled experiments and field operational tests to highlight the benefits and risks of further deployment. Its programs are supported through public, private, and academic partnerships with the goal to educate students, transportation practitioners, and Caltrans staff about emerging ITS technologies and the operational benefits they can offer. PATH has become an internationally recognized research program in Intelligent Transportation Systems (ITS) with a focus on improving transportation safety, system performance, and sustainability in California through the application of advanced ideas and technologies. With this shared vision for California, Caltrans and PATH continue to work closely together to achieve Caltrans' mission and strategic goals.

One of the focus areas for Caltrans is the development of connected vehicles (CV). CV technology enables cars, trucks, buses, pedestrians, and bicyclists to communicate with each other and with roadside infrastructure to share important safety and mobility information. The roadside infrastructure consists of traffic signals, toll booths, freeway ramp meters, work and school zones, and other types of infrastructure. CV technology uses the national Dedicated Short-Range Communication (DSRC) protocol for safety applications because it is reliable, fast, secure, and resistant to interference.

The National Highway Traffic Safety Administration reports that 2017 had about 37,000 fatalities and 2.5 million serious injuries resulting from vehicular crashes. CV technology has the potential to address up to 80% of the scenarios that result in these incidents. With vehicle-to-infrastructure (V2I) communications, CV technology offers safety applications that inform, alert, and if necessary, warn drivers of potentially hazardous situations before the driver is aware of them. Similarly, under vehicle-to-vehicle (V2V) applications, CV technology enables vehicles to communicate with each other to identify threats and hazards with a 360-degree awareness and then issue warnings to drivers to take preemptive actions to avoid or mitigate crashes.

The outcome of CV technology coincides with Caltrans' strategic goals of improving safety and mobility on California roadways. CV technology will help reduce highway incidents, provide reliable, timely, and accurate information to drivers, enable vehicles to communicate with traffic signals to eliminate unnecessary stops, and allow traffic managers to better assess transportation system performance and manage the transportation system in real time.

To develop and evaluate applications in the V2I area, Caltrans, with the technological expertise of PATH, developed a CV test bed in Palo Alto, California, on State Route 82, also known as El Camino Real. The test bed, two miles long and spanning 11 intersections, provides an operational environment where traffic signals and equipped vehicles nearby can communicate through DSRC connectivity. To view the test bed, visit *http://caconnectedvehicletestbed.org/index.php.*

The test bed unlocks the potential for developing various V2I applications, such as Red-Light Violation Warning and Transit Signal Priority.

- Crashes caused by running red lights are some of the most serious in terms of injuries and fatalities. Red-Light Violation Warning is the primary V2I safety application at intersections. The signal phase information is broadcast to approaching equipped vehicles. The vehicles compare the information with the current dynamic state of the vehicle (speed, distance to intersection, and braking status) and determine whether the driver is likely to run the red light. If so, a warning is issued in time for the driver to avoid entering the intersection.

- Transit Signal Priority is a critical technology for bus rapid transit systems. It has the potential to reduce bus intersection delays and improve service schedule adherence by extending green lights to allow buses to pass through an intersection or providing an early green to reduce wait times. Caltrans and PATH are working with transit bus operators located near the test bed to develop and test this application.

In the V2V area, Caltrans and PATH are investigating the benefits of cooperative adaptive cruise control (CACC), which is an extension of conventional adaptive cruise control for light passenger vehicles and trucks. CACC uses V2V communications so that the vehicle has information not just on the vehicle immediately in front (through sensors) but also on a leading vehicle or vehicles further in front. Other key parameters, such as position, velocity, and acceleration, are also shared via V2V communication. CACC can enhance the overall operation of the freeway corridor, even with market penetrations as low as 20%. More information about this project, visit *https://path.berkeley.edu/research/connected-and-automated-vehicles/cooperative-adaptive-cruise-control.*

California connected vehicle test bed

Cooperative adaptive cruise control

Partial Automation for Truck Platooning

The Federal Highway Administration (FHWA) awards grants under its Exploratory Advanced Research (EAR) Program for research projects that have potential for transformational changes and revolutionary advances in highway engineering and intermodal surface transportation in the United States. A recently completed EAR Program supported a truck platooning research project led by Caltrans and PATH. The results of earlier studies conducted by Caltrans and PATH indicated that truck platooning could improve safety, mobility, emissions, and energy efficiency.

Caltrans sponsored the grant application at the request of the Gateway Cities Council of Governments and the Los Angeles Metropolitan Transportation Authority, who are seeking ways to increase truck throughput, reduce congestion, and mitigate environmental impacts (primarily air quality) near large ports in their region. The results of the project are intended to lead to technology enhancements for the dedicated truck lanes to be piloted on I-710 and then adopted more broadly in the entire Southern California region.

Caltrans and its key technical partners, including PATH, Volvo Technology of America, and Cambridge Systematics, were successful with their application and received a grant to develop and test a driver-assist system that enables truck platooning operations. The project successfully developed and demonstrated closely spaced, three-truck platoons by integrating commercially available Adaptive Cruise Control (ACC) systems with high-speed V2V communications.

The project first obtained input from major truck fleet operators to identify trucking industry needs that could be served by applying Cooperative Adaptive Cruise Control (CACC) for truck platooning. Outreach was conducted both locally in Southern California near the I-710 corridor and nationally. Based on the needs identified, the researchers defined concepts for truck platoon operations and performed computer simulations to understand the theories' relative strengths and weaknesses to hone the project research and development strategy.

Electronically coupled Volvo trucks modified by UC Berkeley PATH showing truck platooning operations at a 2017 Caltrans demonstration on the I-110 near the Port of Los Angeles

Volvo provided PATH three trucks to add V2V communications to the factory-installed ACC systems. The combination of truck-to-truck communications with ACC creates a CACC system with greater capability than just ACC alone. The high-speed communication enables the trucks to "talk" to one another and coordinate braking and acceleration. This communication allows trucks to safely follow each other more closely and accurately, giving them the capability to speed up and slow down as a unit. Through a series of testing and development cycles, the CACC technology was improved to the point where it could be safely operated and used in tests on state highways. The project team then explored four potential benefits of heavy truck platooning:

- Increased throughput by reducing gaps between vehicles
- Reduced fuel consumption due to improved aerodynamics
- Emission reductions from reduced fuel consumption
- Safety improvements due to high-speed communication and coordinated maneuvering

The project team also investigated commercial vehicle driver acceptance of the truck CACC system, primarily the comfort level while driving with smaller than normal gaps between vehicles.

The results of the tests and experiments were then modeled and used as inputs in computer simulations to reassess the benefits, which were presented to stakeholders and the broader public. Three public truck-platooning demonstrations were held. The first was at the ITS America Annual Meeting in San Jose in 2016. The second was in March 2017 in collaboration with the Gateway Cities I-710 project. The final demonstration was held in September 2017 in the Washington, DC area for FHWA staff and other local agencies.

The results from project experiments and computer simulations showed that trucks using CACC systems could be operated in a coordinated fashion and that the space between trucks could be safely reduced. Tighter spacing and coordinated truck operations have the potential to reduce fuel use, criteria pollutants, and greenhouse gases in the range of 5% to 14%. The results from the truck development and testing in computer simulations show that significant increases in freight throughput can be achieved, increasing the number of trucks and the freight they carry per lane per hour. Furthermore, when enough vehicles (both trucks and automobiles) are using CACC, general traffic flow will improve, making highway operation more efficient.

For more information, visit *https://path.berkeley.edu/research/connected-and-automated-vehicles/truck-platooning*.

Transport Canada fuel reduction experiment

Research Program Administration

DRISI manages a balanced, comprehensive portfolio of projects to address the research and operational needs across Caltrans. The division seeks to take advantage of strategic collaboration opportunities by identifying public, academic, and private partnering solutions for conducting research. These partnerships leverage the dollars invested in present and future public infrastructure.

The objective of DRISI's research program is to efficiently administer research tasks from idea to product for customers in Caltrans' programs and districts. To accomplish this, DRISI funds research in six categories:

- Caltrans functional research
- University transportation centers
- National research program
- State research support partnerships (research centers)
- Technology transfer and implementation
- Roadside safety research (crash testing)

In FY 2016–17, DRISI managed a $24.9 million research program to deliver research results and products that address transportation challenges across California. The program supports researching new knowledge areas, developing technologies that turn findings into practical applications, and transferring these technologies and innovations into practice through dissemination, demonstration, training, and adoption. Funding for the research program comes from two sources: the State Planning and Research (SP&R) federal program and the State Highway Account (SHA).

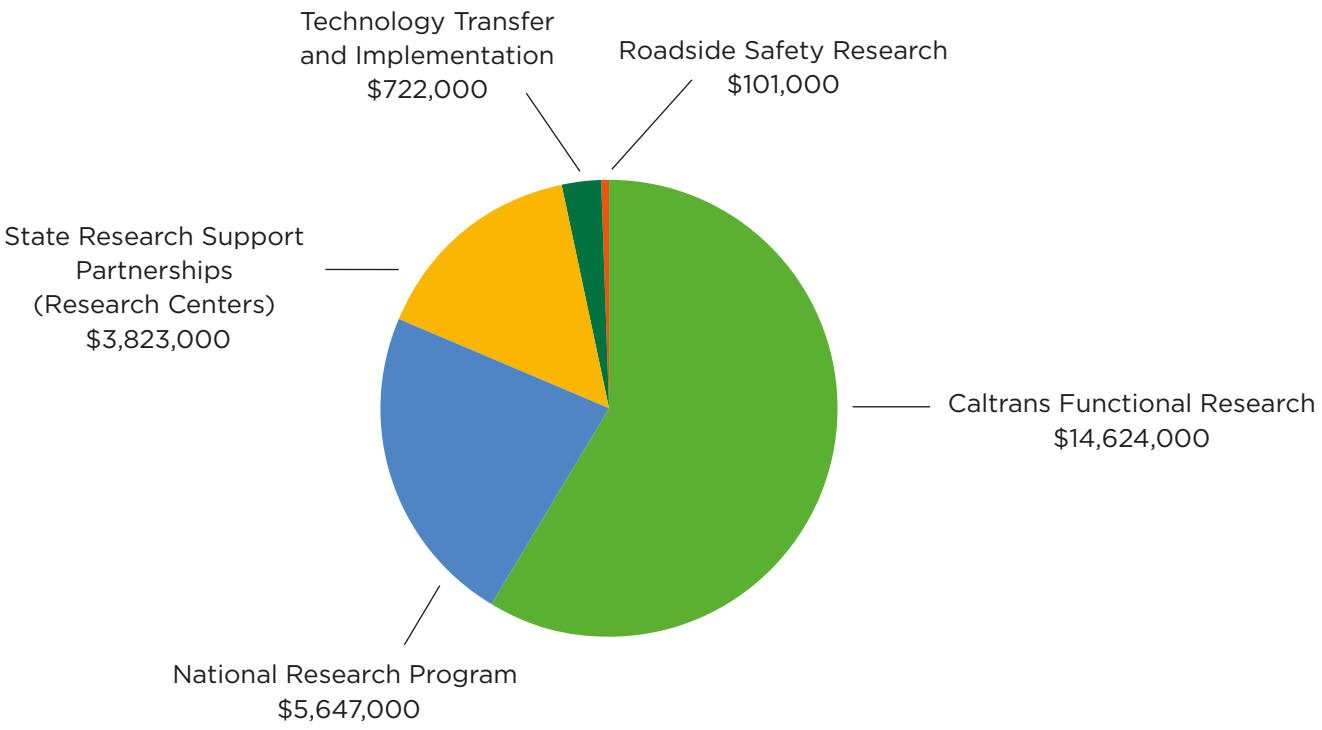
The SP&R provided $22.8 million ($19.4 million in federal funds and $3.4 million in matching state funds). This federally mandated program sets aside 2% of California's apportionments from these federal programs to fund planning and research activities:

- National Highway Performance Program
- Surface Transportation Block Grant Program
- Highway Safety Improvement Program
- Congestion Mitigation and Air Quality Improvement Program
- National Highway Freight Program

The SHA, which is funded through state gasoline and diesel fuel taxes, motor vehicle fees, and truck weight fees, provided $2.1 million. The purpose of the SHA is to fund highway-related projects and purchases, including construction and maintenance, acquisitions, equipment, surveys, services, investigations, and planning and research.

The following graph shows the breakdown of the research program into major areas of focus.

Allocation of FY 2016–17 Research Funds



Total FY 2016–17 funding
$24.9 million

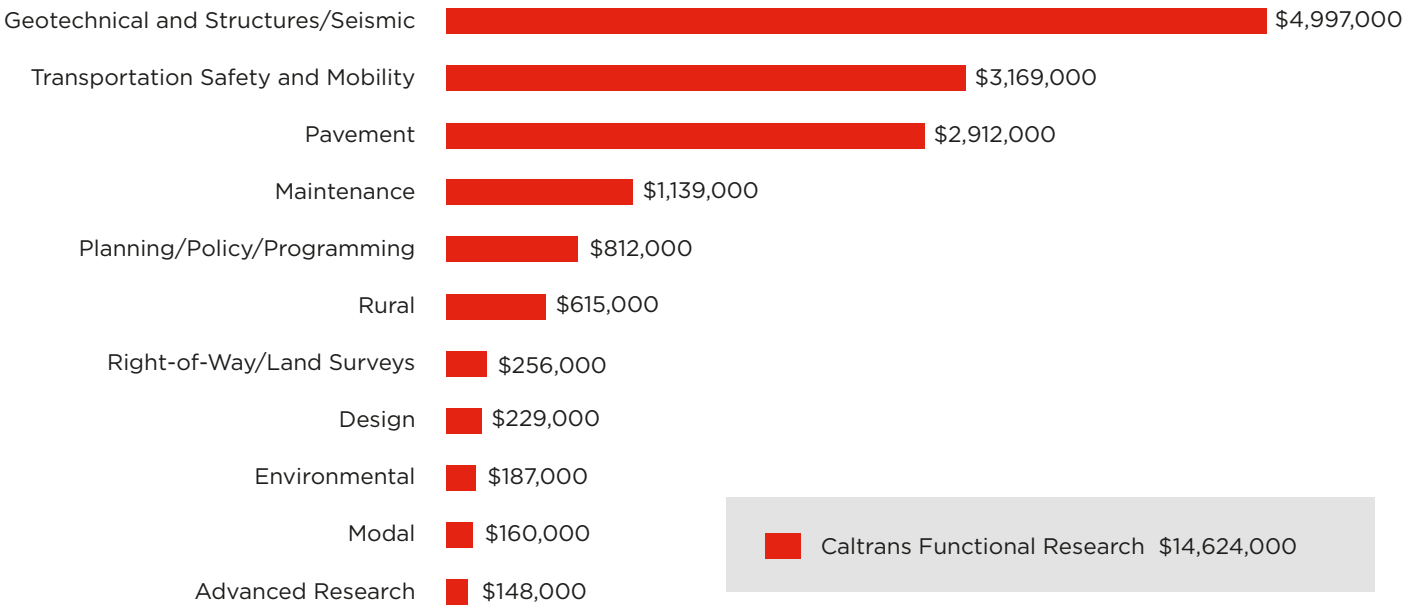
FUNDING CATEGORIES

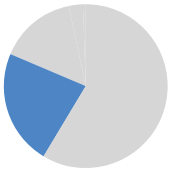
Caltrans Functional Research | $14,624,000

The Caltrans functional research portfolio includes transportation research that addresses the areas of construction, design, environment, geotechnical/structures, maintenance, multimodal transport, pavement, planning, policy, programming, right-of-way, rural concerns, and transportation safety and mobility. Tasks are selected through the process described in the "Research Program Development" section and grouped by functional areas to align with Caltrans' core programs. In FY 2016–17, DRISI managed 260 research tasks covering various functional areas, of which 62 reached completion. For a summary of all research tasks underway in FY 2016–17, see the "Research Task Summary."

The following graph shows the breakdown of research by functional area.

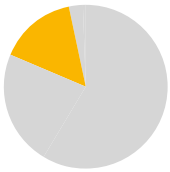
Distribution of Caltrans Functional Research by Research Area





National Research Program | $5,647,000

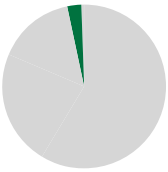
Caltrans partners with national transportation organizations, including the TRB and the National Cooperative Highway Research Program (NCHRP). Caltrans benefits from national research efforts through leveraging research conducted at the national level and by serving on committees and panels that identify critical transportation issues, recommend project selection, and guide implementation. More information about these national programs is on page 15–16. In FY 2016–17, Caltrans staff actively participated on 134 highway, 3 freight, 3 airport, and 1 transit cooperative research project panels (see Appendices 2–5).



State Research Support Partnerships (Research Centers) | $3,823,000

DRISI partners with university-based research centers to deliver research results and products. Each research center offers specialized technical expertise and state-of-the-art facilities, equipment, and materials. More information about the following research centers is on pages 17–19.

- Advanced Highway Maintenance and Construction Technology Research Center (AHMCT)
- Pacific Earthquake Engineering Research Center Lifelines Program (PEER)
- Partners for Advanced Transportation Technology (PATH)
- University of California Pavement Research Center (UCPRC)



Technology Transfer and Implementation | $722,000

Promoting the implementation of research results into Caltrans routine practice requires multichannel, sustained technology transfer. DRISI uses various tools and methods to encourage the adoption of research results and products. These efforts include communication and engagement with DRISI customers and stakeholders.

Research products are the mechanism by which Caltrans is encouraged to make changes to business practices, with the goal of improving organizational effectiveness and efficiency. The research products are categorized by one or more of the following:

- New or improved technical standard, plan, or specification
- New or improved manual, handbook, guidelines, or training
- New or improved policy, rule, or regulation
- New or improved business practice, procedure, or process
- New or improved tool or equipment
- New or improved decision support tool, simulation, model, or algorithm (software)
- Processed data/database
- Evaluation of new commercial products to determine if they meet Caltrans' needs

DRISI uses various methods to communicate research results and products. Activities include:

- Conferences and forums
- Demonstrations and training
- Meetings, presentations, and webinars
- Research events and workshops
- Support of products during initial stages of adoption

Print and web-based publications and materials include:

- **Annual Research Program Highlights reports** showcase activities and completed research. *www.dot.ca.gov/research/researchreports/index.htm*
- **Final reports** document the executed methodology, detailed findings, and technical analysis of the research tasks. *www.dot.ca.gov/research/researchreports/dri_reports.htm*
- **Preliminary Investigation reports** provide a comprehensive overview of historical and existing national and international research and best practices for defined research needs. *www.dot.ca.gov/research/researchreports/preliminary_investigations/index.htm*
- **Research Notes** give an overview of research in progress to a general audience. Released at the beginning of a research task, the notes describe the need, methodology, goal, benefits, milestones, and next steps. *www.dot.ca.gov/research/researchreports/current_research/index.htm*
- **Research Results** communicate to a general audience what was accomplished with the research. They summarize the need, goal, methodology, outcome, and benefits. *www.dot.ca.gov/research/researchreports/technical_summaries.htm*

Roadside Safety Research | $101,000

DRISI's Roadside Safety Research group evaluates the crash worthiness of safety technology, such as barriers, guardrails, crash cushions, bridge rails, sign supports, and other hardware. It conducts full-scale crash tests on roadside safety hardware designs developed by Caltrans to ensure that these designs comply with applicable crash performance criteria. The group also evaluates the crash worthiness of proprietary hardware developed by others to ensure that it is acceptable for use on state highways. The group provides support to Caltrans Legal Division in tort liability cases by conducting crash tests and delivering technical assessments and expert witness testimony.

University Transportation Centers

University transportation centers (UTC) are internationally recognized centers of excellence that are fully integrated within institutions of higher learning. The UTC program is administered by the U.S. Department of Transportation (U.S. DOT). The program advances transportation technology and expertise through research, education, and technology transfer; provides a critical transportation knowledge base outside of the U.S. DOT; and addresses the workforce needs for the next generation of transportation leaders.

DRISI works in partnership with UTCs to identify, research, and develop solutions for California's transportation challenges.

In FY 2016–17, although no new funding was provided to UTCs due to the cycles of the federal grant application and funding processes, DRISI continued to engage in research during the fiscal year with these five UTCs for projects initiated in prior years. More information about these organizations is on pages 20–21.

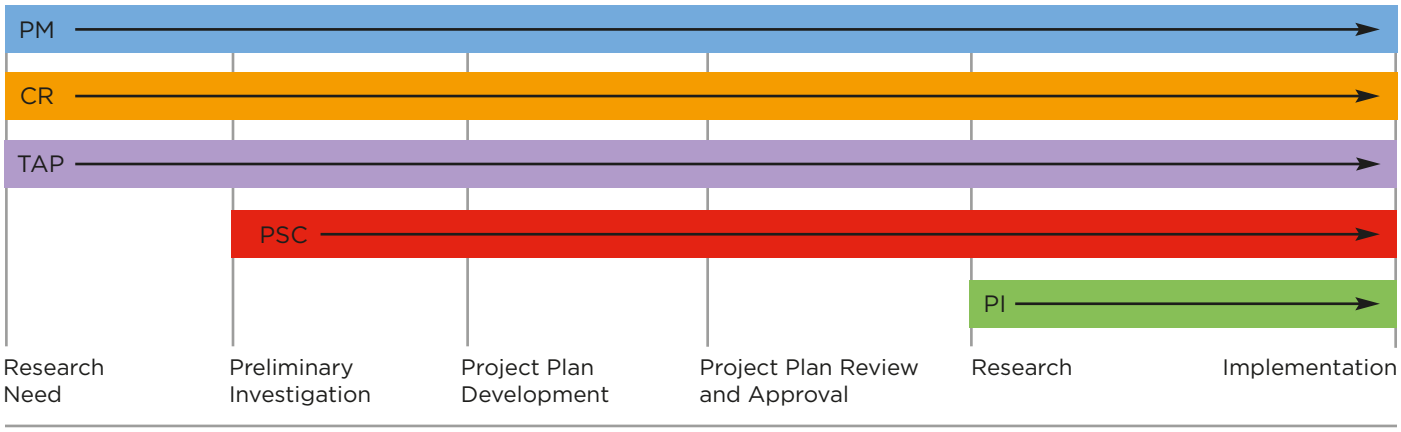
- METRANS Transportation Center
- Mineta National Transit Research Consortium
- National Center for Sustainable Transportation
- University of California Center on Economic Competitiveness in Transportation
- University of California Transportation Center

RESEARCH PROGRAM DEVELOPMENT

DRISI engages the Caltrans Executive Board and three levels of committees in identifying research needs, selecting research projects, and deploying and implementing research products. The Executive Board provides strategic direction and identifies department-level research priorities. The Research and Deployment Advisory Committee (RDAC) recommends research and funding and actively sponsors the deployment and implementation of the resulting research products. The RDAC can include district directors, deputy district directors, and headquarter division chiefs, who might also lead one of the program steering committees (PSC). The PSCs adopt an agenda for a multiyear integrated research program. Each PSC has at least one technical advisory panel (TAP), which includes experts from the various divisions and districts. The TAPs act in an advisory role to the PSC.

In coordination with customer representatives and PSC leads, DRISI project managers propose new research projects. The PSCs and DRISI management review the proposals in March. PSC leads prioritize their respective proposals in March, and the RDAC recommends the portfolio in April.

Research Process and Roles



Project Manager (PM)
DRISI staff member with full authority and responsibility, delegated by the appropriate office chief, to manage projects and produce the intended results on schedule and within budget. The PM keeps the project sponsors, customers, stakeholders, and end users satisfied by managing the approved project, from the initial problem statement to a deployable product.

Customer Representative (CR)
A representative from one of Caltrans' program areas who is actively involved in the research effort and the PSC and acts as a champion for the final research product.

Technical Advisory Panel (TAP)
Each TAP has a vital role in evaluating research needs, providing recommendations for continuing and new projects, developing and ranking project plans and requests for preliminary investigations, and identifying opportunities for deployment and implementation of research products.

Program Steering Committee (PSC)
Each PSC has an essential role in generating new research projects, developing program-level research priorities, and supporting the deployment and implementation of research products.

Principal Investigator (PI)
Contractor or researcher responsible for conducting the research and the completion of the contract obligations.

National Research Programs

Caltrans partners with national transportation organizations and benefits from leveraging research conducted at the national level.

Transportation Research Board

TRB, the major national multimodal transportation research organization, brings practitioners and researchers together to solve critical transportation problems. With more than 200 standing committees, almost every transportation mode and topic is represented. Each committee proposes research, shares research findings, sponsors special activities, and provides a forum for transportation professionals to discuss current and future transportation issues.

The TRB's major sources of revenue are state departments of transportation, federal agencies, other transportation organizations, and TRB self-generated revenue. With a contribution of $505,490 in 2017, Caltrans was able to leverage $33 in research-related activity for every $1 invested.

This beneficial investment in TRB enables Caltrans to:

- Have a voice in setting national research priorities and agendas
- Access user-oriented research
- Avoid duplication of research efforts
- Support the uniform, practical, and common-sense application of transportation research results
- Develop a more informed and forward-thinking workforce
- Improve customers' experiences by accelerating the development and implementation of solutions to problems that affect transportation planning, design, construction, operation, and maintenance
- Retain employees by offering stimulating and professionally rewarding opportunities to participate in efforts that help improve the nation as a whole

National Cooperative Research Programs

The National Cooperative Research Programs address research on safety, planning, design, construction, operations, and maintenance at the national level. This research includes developing and evaluating new technologies and techniques. The programs also foster sharing best practices among states.

Caltrans leaders work with the following national research programs:

- National Cooperative Highway Research Program (NCHRP)
- Transit Cooperative Research Program (TCRP)
- National Cooperative Freight Research Program (NCFRP)
- Airport Cooperative Research Program (ACRP)

In 2017, the NCHRP selected 37 new projects for funding, of which 14 were important to Caltrans. Caltrans staff is currently serving on 17 of the new project panels. As project panel members and a member of the Special Committee on Research and Research Advisory Council, Caltrans is able to influence national projects to directly benefit California.

Transportation Pooled Fund Program

When significant or widespread interest is shown in solving transportation-related problems, several federal, state, regional, and local transportation agencies, academic institutions, foundations or private firms might jointly fund research, planning, and technology transfer activities. The Transportation Pooled Fund (TPF) program combines resources to support transportation research studies.

State Research Support Partnerships

DRISI partners with university-based research centers to deliver research results and products. Each research center offers specialized technical expertise and state-of-the-art facilities, equipment, and materials.

Advanced Highway Maintenance and Construction Technology Research Center

The AHMCT Research Center is located at the University of California, Davis. Its mission is to improve the safety, mobility, and reliability of California's highways, achieve lean operations, and minimize environmental impacts while considering life-cycle assessments, sustainability, and cost-benefits. AHMCT uses advanced robotics, automation, sensing, networking, and information technologies in completing applied research that supports Caltrans in the areas of highway and civil infrastructure construction, maintenance, and operations.

Because Caltrans' first of five goals is safety and health, much of the research performed at AHMCT focuses on or has a strong safety element. Recent research efforts have sought to automate traditionally labor-intensive tasks to get maintenance and construction workers away from live traffic lanes. To accomplish this, a mix of evaluating available commercial systems and original research is undertaken. AHMCT determines whether a commercial system provides value to Caltrans in terms of safety, mission support, cost savings, and operational efficiency. When suitable commercial systems are not available, AHMCT conducts applied research to develop systems and equipment to meet Caltrans' needs and specifications. AHMCT also supports Caltrans by completing preliminary investigation reports that are generated prior to undertaking new research and hosting peer exchange workshops that bring knowledge to Caltrans staff from subject matter experts at federal, state, and local entities.

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ahmct.ucdavis.edu

Pacific Earthquake Engineering Research Center Lifelines Program

The PEER Lifelines Program, located at UC Berkeley, is a partnership between lifeline providers that share a common interest in improving the response to seismic hazards. The multi-institutional research and education center focuses on developing performance-based earthquake engineering methods and design tools to better characterize potential threats due to severe ground shaking, fault rupture, soil liquefaction, and tsunami inundation.

California, located at the boundary of the Pacific and North American tectonic plates, has the greatest seismic risk exposure of any state in the country. About 13,000 Caltrans–owned bridges and a roughly equal number of local agency–owned bridges face seismic risk. Caltrans' priority is to ensure that the roadways and bridges are safe and can support emergency response and regional recovery efforts. To achieve these goals economically, accurate characterization of potential threats is necessary. Some locations are more vulnerable than others because of their proximity to active faults or poor soil conditions. PEER Lifelines develops statistical models that characterize various earthquake-related hazards to improve the understanding of where these high-risk locations are and how large the seismic demands might be. These models are then incorporated into Caltrans planning and design procedures to advance cost-effective mitigation strategies.

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peer.berkeley.edu

Partners for Advanced Transportation Technology

California PATH is an internationally recognized research program in Intelligent Transportation Systems (ITS) that focuses on improving transportation safety, system performance, and sustainability in California through the application of advanced technologies and concepts. The added benefits of its research into areas such as transportation system management, vehicle connectivity, and vehicle automation also include reduced energy consumption, better land-use management, and improved transportation equity for all users, as well as strengthening California's economic vitality.

PATH conducts leading-edge research, developing new ITS technologies and applications and performing controlled experiments and larger field operational tests to illustrate the benefits and risks of further deployment. PATH implements its research program through public, private, and academic partnerships that also educate students, transportation practitioners, and Caltrans staff about ITS technologies and the operational benefits they offer.

PATH also assists Caltrans and other California transportation agencies in understanding how the adoption of emerging transportation technologies can assist the state in attaining its ambitious public policy goals of improving safety and facilitating the movement of people, goods, and services, while also mitigating the adverse impacts of transportation, such as greenhouse gas emissions.

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www.path.berkeley.edu

Sustainable Transportation Energy Pathways

Focused on the future roles of alternative fuels and vehicles, the current UC Davis STEPS program is a four-year (2015–18) multidisciplinary research consortium. Sponsored through a private-public collaboration, STEPS promotes the transition to a sustainable transportation energy future by generating the theory, tools, and methods to compare promising alternative energy sources. The program addresses the uncertainty that governments and the private sector face in developing new fuel-vehicle pathways, highlighting the necessity of a comprehensive approach in reducing oil use and greenhouse gas emissions. STEPS disseminates knowledge and tools to industry, government, the environmental NGO community, and the general public. STEPS researchers host webinars and annual workshops for consortium members to collaborate on sustainable vehicle and energy solutions and inform industry planning and government policy with timely and sophisticated science-based analysis.

California put forth the Hydrogen Highway Initiative in 2004, resulting in a partnership between Caltrans and the UC Davis to research the use of hydrogen for transportation applications. Since then, other alternative fuel types (electricity, natural gas, and biofuels) have shown both promise and practicality. The STEPS comparative analysis provides Caltrans a full research portfolio of these alternative fuel types and the potential impacts and challenges to public-sector entities and policy makers. Additionally, the findings produced by STEPS researchers have helped Caltrans staff obtain a greater understanding of how alternative fuels are changing the transportation landscape for both Caltrans and the society at large.

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steps.ucdavis.edu

University of California Pavement Research Center

UCPRC is a major component in the statewide pavement program, focusing on improving the durability and management of pavements. UCPRC is multidisciplinary, addressing the areas of pavements, structures, materials, mechanical, environmental, transportation, geotechnical, and chemistry, with research programs at both UC Davis and UC Berkeley. Its goals include implementing mechanistic-empirical design, incorporating recycling and sustainability, developing quieter pavements, enhancing construction practices and project delivery, and implementing smoothness.

California's economy depends on the ability to move goods rapidly and without damage. California's traveling public expects a safe and efficient transportation network. As resources become limited, Caltrans must find ways to maintain and improve its extensive pavement infrastructure. UCPRC provides expertise in areas that Caltrans requires to maintain this critical transportation infrastructure.

LEARN MORE

www.ucprc.ucdavis.edu

University Transportation Centers

In FY 2016–17, five California-led UTCs worked in partnership with DRISI to support the research needs of Caltrans and the state of California, primarily in the areas of mass transportation, rail, traffic operations, and transportation planning. The UTCs are fully integrated within institutions of higher learning that advance the state of the art in transportation research and technology and cultivate the next generation of transportation professionals.

Mineta National Transit Research Consortium

MNTRC, led by the Mineta Transportation Institute at San José State University, provides expertise on alternative fuels, safety and security, public policy, finance, workforce development, livable communities, environmental sustainability, economic competitiveness, new modes, and other critical factors essential to sustainable mobility. MNTRC primarily supports the research needs of Caltrans' divisions of Rail and Mass Transportation and Transportation Planning. Consortium members include:

- Bowling Green State University
- Grand Valley State University
- Howard University
- Penn State University
- Rutgers, The State University of New Jersey
- University of Detroit Mercy
- University of Nevada, Las Vegas
- University of Toledo

University of California Transportation Center

UCTC, led by the University of California, Berkeley, focuses on environmental sustainability, economic competitiveness, and livability and the connections between them. UCTC primarily supports the research needs of Caltrans' divisions of Rail and Mass Transportation and Transportation Planning. Consortium members include:

- University of California, Davis
- University of California, Irvine
- University of California, Los Angeles
- University of California, Riverside
- University of California, Santa Barbara

Affiliate members include:

- California Polytechnic State University, San Luis Obispo
- California State Polytechnic University, Pomona
- California State University, Sacramento
- California State University, San Bernardino

METRANS Transportation Center

METRANS, led by the University of Southern California, is a two-member consortium that includes California State University, Long Beach. METRANS conducts an integrated, multidisciplinary program of research aimed at increasing the economic competitiveness of large metropolitan areas through improved transportation system performance, addressing passenger and freight across all surface transportation modes. METRANS primarily supports the research needs of Caltrans' divisions of Rail and Mass Transportation, Transportation Planning, and Traffic Operations.

National Center for Sustainable Transportation

NCST, led by the University of California, Davis, addresses the U.S. DOT's strategic goal to advance environmentally sustainable policies and investments by asserting national leadership in reducing carbon emissions from transportation systems while supporting climate adaptation activities and continued mitigation of air pollution and other environmental impacts. NCST primarily supports the research needs of Caltrans' Division of Transportation Planning. Consortium members include:

- California State University, Long Beach
- Georgia Institute of Technology
- University of California, Riverside
- University of Southern California
- University of Vermont

University of California Center on Economic Competitiveness in Transportation

UCCONNECT, led by the University of California, Berkeley, promotes economic competitiveness, pursuing projects to reduce congestion, improve highway operations, and enhance freight movement. UCCONNECT primarily supports the activities of Caltrans' divisions of Rail and Mass Transportation, Transportation Planning, and Traffic Operations. Consortium members include:

- University of California, Irvine
- University of California, Los Angeles
- University of California, Riverside
- University of California, Santa Barbara

California State Polytechnic University, Pomona is an affiliate member.

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Research Task Summary

The Research Task Summary lists selected research tasks completed in FY 2016–17 and scheduled to be completed in FY 2017–18 or 2018–19 that highlight the breadth of the research program. Tasks are arranged by functional program areas, with transportation pooled funds (TPF) listed separately, in ascending order by task end date. For tasks appearing in bold, a Research Results summary document is included in this report on the page number indicated.

Research tasks completed in FY 2016–17

Research tasks scheduled to be completed in FY 2017–18 or 2018–19

Advanced Research

Task ID	Task Title	Task Manager	End Date	Page #
2536	Clean, Green and Smart Corridor Development: MCOM Advance Adoption of Alternative Fuel Commercial Vehicles	Hanson, Matt	8/31/16	-
2962	**A Cooperative V2V Alert System to Mitigate Vehicular Traffic Shock Waves**	**Siddiqui, Asfand**	**4/30/17**	**36**
2911	Evaluating Deployability of Cooperative Adaptive Cruise Control (CACC) to Form High-Performance Vehicle Streams	Siddiqui, Asfand	1/1/18	-
2623	Partial Automation for Truck Platooning	Hanson, Matt	3/31/18	-
2772	AASHTO Rep to SAE DSRC Technical Committee	Gwynne, Gloria	4/30/18	-
2950	Maintenance, Operations, and Enhancement of DSRC Communications Infrastructure	Siddiqui, Asfand	4/30/18	-
2910	Early Opportunities to Apply Automation in California Managed Lanes	Siddiqui, Asfand	8/31/18	-
2909	Technical Support for Connected Vehicle Pilot Deployment "One California Deployment Support"	Siddiqui, Asfand	4/29/19	-

Advanced Research TPF

Task ID	Task Title	Task Manager	End Date	Page #
2061	Support for Research and Deployment of System Ops Applications of VII, TPF-5(206)	Siddiqui, Asfand	12/31/18	-

Construction

Task ID	Task Title	Task Manager	End Date	Page #
2524	Validating the Effects of Collaborative Partnering on Major Capital Projects	Chung, Haniel	8/1/16	-
2982	Sustainable Mitigation of Stormwater Runoff Through Fully Permeable Pavement	Provost, Lee	9/15/17	-
3097	Developing an Interactive Machine Learning–based Approach for Sidewalk Digitalization	Tyner, Patrick	11/15/17	-

Crosscutting

Task ID	Task Title	Task Manager	End Date	Page #
2856	Policy Forums	Azevedo, Christine	9/30/17	-
2857	Research in Action On-line Engagement	Azevedo, Christine	9/30/17	-
3007	Mapping and Improving the Delivery Process of Highway Pavement Rehabilitation Projects	Provost, Lee	10/1/17	-

Design

Task ID	Task Title	Task Manager	End Date	Page #
3259	Trees on Non-Recoverable and Non-Transversable Slopes: Survey of State Practice	Ali, Akber	7/24/17	-
2997	Richmond–San Rafael Bridge Access Improvements Evaluation	Mizuno, Bradley	9/30/17	-
2761	Performance Measures for Roadside Features	Ikram, Hamid	9/30/18	-
2896	Highway Soil Compaction and Safety for Storm Water Treatment BMPs	Loebs, Nathan	11/13/18	-
3106	Effective Utility Encasement Criteria and Methods	Ali, Akber	3/31/19	-

Design TPF

Task ID	Task Title	Task Manager	End Date	Page #
2943	Containment Release from Storm Water Culvert Rehabilitation Technologies: Understanding Implications to the Environment and Long-Term Material Integrity, TPF-5(339)	Ali, Akber	2/28/18	-
2294	Enhancements to the FHWA-FST2DH Two-Dimensional Hydraulic Model, TPF-5(248)	Chung, Haniel	11/7/18	-

Environmental

Task ID	Task Title	Task Manager	End Date	Page #
3074	The Environmental Effects of New Mobility Services	Azevedo, Christine	3/31/17	-
2978	**Using Non-Invasive Genetics to Compare How a California Freeway Affects Gene Flow in a Disturbance-Averse Versus a Disturbance-Tolerant Species**	**Bisrat, Simon**	**6/30/17**	**38**
2724	Develop a Tidewater Goby Survey Method Using Environmental DNA	Bisrat, Simon	12/31/18	-

Environmental TPF

Task ID	Task Title	Task Manager	End Date	Page #
1578	FHWA Traffic Noise Model: Version 3.0 Software and Training, TPF-5(158)	Bisrat, Simon	6/30/17	-
1579	Tire/Pavement Noise Research Consortium, TPF-5(135)	Bisrat, Simon	9/1/17	-
2776	Underwater Noise Attenuation Experimental Methods, TPF-5(323)	Bisrat, Simon	12/31/17	-
2538	Near Road Air Quality Research, TPF-5(284)	Bisrat, Simon	6/30/19	-

Equipment

Task ID	Task Title	Task Manager	End Date	Page #
2738	Evaluation of Equipment Production and Procurement Practices	Benouar, Azzeddine	3/31/17	-
2737	Fleet Replacement Model Evaluation and Refinement	Benouar, Azzeddine	6/30/17	-
3085	Continued Evaluation of the TowPlow Trailer System	Baumeister, Larry	1/12/18	-

Equipment TPF

Task ID	Task Title	Task Manager	End Date	Page #
1132	Development of Maintenance Decision Support System (MDSS), TPF-5(054)	Baumeister, Larry	10/31/17	-

Executive

Task ID	Task Title	Task Manager	End Date	Page #
3000	Road Charge White Paper	Williams, Scott	2/28/18	-
2780	Road Charge Pilot Demonstration Program	Williams, Scott	3/31/19	-

Executive TPF

Task ID	Task Title	Task Manager	End Date	Page #
2620	Western Road Usage Charging Consortium (WRUCC), TPF-5(288)	Williams, Scott	3/31/18	-

Geotechnical/Structures

Task ID	Task Title	Task Manager	End Date	Page #
2933	Simulation of Liquefaction-induced Damage of the Port of Long Beach Using the UBC3D-PLM Model	Benouar, Azzeddine	9/1/16	-
2934	**Development of an Economic Framework to Evaluate Resilience in Recovering from Major Port Disruptions**	**Provost, Lee**	**9/1/16**	**40**
2342	**Effects of Superstructure Creep and Shrinkage on Column Design in Post-Tensioned Concrete Box-Girder Bridges**	**Sikorsky, Charles**	**12/31/16**	**42**
2111	**Geophysical Methods for Determining the Geotechnical Engineering Properties of Earth Materials**	**Owen, Bill**	**3/31/17**	**44**
2532	Assessment of Soil Arching Factor for Retaining Wall Pile Foundations (Phase I)	Sikorsky, Charles	5/31/17	-
2346	Controlling Temperature and Shrinkage Cracks in Bridge Decks and Slabs	Lee, Peter	7/1/17	-
2605	Reusable Instrumented Test Pile, Phase 2	Shantz, Tom	10/31/17	-
2572	Anchorage Zone Reinforcement of Post-Tensioned Box Girder Bridges	Lee, Peter	11/1/17	-
3017	Development of Guideline for Generation, Selection, and Adjustment of Ground Motions	Hipley, Pat	11/30/17	-
2557	Compliance Crash Testing of a Manual for Assessing Safety Hardware (MASH) 2009 Test Level 4 Side Mounted Bridge Rail	Her, Vue	12/31/17	-
3023	LFD and LRFD Capacity of Steel Pin and Hanger Assembly	Sikorsky, Charles	1/31/18	-
3053	Bridge Strong Motion Instrumentation	Hipley, Pat	2/28/18	-
2784	Pacific Earthquake Engineering Research Center (PEER) — Lifeline Partnership 3	Shantz, Tom	8/31/18	-
2781	Post-Tensioned Box-Girder Deck Replacement Method	Lee, Peter	9/30/18	-
1805	Corridor-Scale Landslide Hazard Mapping: Conversion of CGS Hazard Maps	Roblee, Cliff	12/31/18	-
1780	Generation-2 Bridge Fragility Relationships — Production Analytical Components	Roblee, Cliff	6/30/19	-
3032	Development and Crash Testing of a MASH TL-3 Bridge Railing Transition	Vedenoff, Jean	6/30/19	-
3033	Development and Crash Testing of a Steel Post-and-Beam Bridge Railing, ST-75, in Compliance with MASH 2016, Test Level 4, for Use in California	Whitesel, David	6/30/19	-

Geotechnical/Structures TPF

Task ID	Task Title	Task Manager	End Date	Page #
2489	Passive Force-Displacement Relationships for Skewed Abutments, TPF-5(264)	Sikorsky, Charles	12/31/17	-
2298	Evaluation of Seismic Performance of Earth Retaining Structures, TPF-5(276)	Shantz, Tom	6/30/18	-
2768	Validation of Tsunami Design Guidelines for Coastal Bridges, TPF-5(307)	Buendia, Robert	12/31/18	-

Maintenance

Task ID	Task Title	Task Manager	End Date	Page #
2990	Field Testing of the Snowplow Driver Assistance System	Baumeister, Larry	5/23/17	-
2981	Introducing Resilience into the State Transportation Network	Williams, Scott	9/15/17	-
2732	Evaluation of Devices for Improving Traction Control in Winter Conditions	Mizuno, Bradley	9/30/17	-
2748	Determination of in Situ Precast Concrete Girder Compressive Strength	Baumeister, Larry	12/31/17	-

Maintenance TPF

Task ID	Task Title	Task Manager	End Date	Page #
2842	Western Maintenance Partnership, TPF-5(312)	Unck, Justin	6/30/19	-

Modal

Task ID	Task Title	Task Manager	End Date	Page #
2969	**A Comparative Analysis of High-Speed Rail Station Development into Destination and Multi-Use Facilities**	**Tyner, Patrick**	**2/28/17**	**46**
2860	**Rail and the California Economy**	**Azevedo, Christine**	**4/1/17**	**48**
2964	**Designing a Transit-Feeder System Using Bikesharing and Peer-to-Peer Ridesharing**	**Lao, Kayo**	**4/30/17**	**50**
2521	Dynamic Transit Trip Planner Interactive Transit Station Information System	Mizuno, Bradley	12/29/17	-
2664	Bus Rapid Transit Toolbox: Assessing Person Throughput to Measure Transportation Impacts for BRT Projects	Mizuno, Bradley	12/29/17	-
3124	Trajectory Data Mining for Performance Measurement of Public Transportation Systems	Chow, Stan	12/31/17	-
3135	Analysis of Comprehensive Multimodal Shared Travel Systems with Transit, Rideshare, Carshare and Bikeshare Options	Lao, Kayo	2/28/18	-
2663	Development and Demonstration for Integrated Dynamic Transit Operations System	Loebs, Nathan	5/31/18	-
2998	Aviation Weather Information - Web Portal Implementation (Integration of Aviation AWOS with RWIS (AWOS/RWIS), Phase 3)	Clark, Melissa	6/30/19	-

Pavement

Task ID	Task Title	Task Manager	End Date	Page #
2693	**Development of Recommended Guidelines for Preservation Treatments for Bicycle Routes**	**Holland, Joe**	**6/30/17**	**52**
2702	Results from Visual Inspection and Laboratory Testing for ASR in Existing Concrete Cores from Bridges and Pavements in California	Stafford, Patrice	9/16/17	-
2706	Document PaveM Traffic Updating Processes	Wang, Yue	9/16/17	-
2674	Performance Models for Seal Coats in PaveM	Holland, Joe	9/30/17	-
2675	Update Project Level Asphalt Surface Design	Holland, Joe	9/30/17	-
2723	Effects of Pavement Roughness on Freight Movement	Holland, Joe	9/30/17	-
2667	Standard Materials Library and Guidance	Yang, John	10/3/17	-
2668	Improved ME Design Algorithms and Reliability Approach	Yang, John	11/30/17	-
2671	Performance-Related Specifications for Rubberized Asphalt Binder	Yang, John	11/30/17	-
2672	Support for Superpave Implementation	Yang, John	11/30/17	-
2673	Simplified Performance-based Specifications for AC Long-Life Projects	Yang, John	11/30/17	-

Pavement, continued

Task ID	Task Title	Task Manager	End Date	Page #
2677	Binder Replacement in High RAP/RAS Asphalt Mixes (Phase 2: Accelerated Pavement Testing and Field Monitoring)	Yang, John	11/30/17	-
2686	Evaluate Traffic Speed Deflection Measurement	Holland, Joe	11/30/17	-
2687	New Life Cycle Cost Optimization Models for PaveM	Holland, Joe	11/30/17	-
2688	Evaluate APCS Data Collection and PaveM Engineering Configuration	Holland, Joe	11/30/17	-
2689	Update PaveM Engineering Configuration	Holland, Joe	11/30/17	-
2690	Update Guidance and Calculations for Life Cycle Cost Analysis	Holland, Joe	11/30/17	-
2691	Validation of Greenhouse Gas Emissions from Pavement Deflection	Holland, Joe	11/30/17	-
2703	Improved Smoothness and Distress Models and Benefits Equations for PaveM	Wang, Yue	11/30/17	-
2704	Evaluate Composite Pavement Performance and Decision Trees	Holland, Joe	11/30/17	-
2705	Algorithms for Grouping Segments into Projects in PaveM	Wang, Yue	11/30/17	-
2707	Improved Guidance and Specifications for Full-Depth Reclamation	Yang, John	11/30/17	-
2708	Microcracking for Cement Stabilized Layers: Phase 1 Lab Testing and Modeling	Holland, Joe	11/30/17	-
2709	Microcracking for Cement Stabilized Layers: Phase 2 HVS and Field Testing	Holland, Joe	11/30/17	-
2710	Quieter Pavement Long-term Monitoring	Wang, Yue	11/30/17	-
2713	Evaluate Early Age and Premature Cracking for PaveM and LCCA	Wang, Yue	11/30/17	-
2718	Environmental Life Cycle Assessment Updates and Applications	Holland, Joe	11/30/17	-
2719	Updated Greenhouse Gas Emission Calculations in PaveM	Holland, Joe	11/30/17	-
2722	Evaluate Linear Reference System	Nokes, Bill	11/30/17	-
2878	Development of Improved Guidelines and Designs for Bonded Concrete Overlays on Asphalt Pavements (BCOA)	Wang, Yue	11/30/17	-
3024	Increasing Crumb Rubber Usage by Using Small Amounts of Crumb Rubber Modifier in Hot Mix Asphalt	Holland, Joe	11/30/17	-
3206	Complete Early Age and Premature Cracking Evaluation	Wang, Yue	6/30/19	-
3209	Life Cycle Assessment for Alternative Strategies to Reduce Greenhouse Gas	Bisrat, Simon	6/30/19	-
3210	Fast Model for Energy Consumption Due to Pavement Structural Response	Holland, Joe	6/30/19	-

Pavement TPF

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2258	Technology Transfer Intelligent Compaction Consortium (TTICC), TPF-5(233)	Chung, Haniel	7/3/17	-
3028	National Road Research Alliance (NRRA), TPF-5(341)	Holland, Joe	12/31/18	-

Planning/Policy/Programming

Task ID	Task Title	Task Manager	End Date	Page #
2851	Business Establishment Survival and Transportation Level of Service	Tyner, Patrick	8/1/16	-
2854	Traffic Volume and Aggregate Economic Activity: Implications for Taking the Pulse of the U.S. Economy	Chung, Haniel	9/1/16	-
2932	**Investigations of the Effect of Humid Air on NO_X & PM Emissions of a CNG Engine**	**Gwynne, Gloria**	**9/1/16**	**54**
2937	Route Choice Characteristics of Owner-Operated Trucks in Southern California Freeways	Nokes, Bill	9/1/16	-
2641	Infill Dynamics in Rail Transit Corridors; Challenges and Prospects for Integrating Transportation and Land-Use Planning	Azevedo, Christine	9/15/16	-

Planning/Policy/Programming, continued

Task ID	Task Title	Task Manager	End Date	Page #
2850	**Untapped Opportunities: Assessment of Organizational Strategies to Improve Border Coordination in California at the U.S. and Mexico Border**	**Azevedo, Christine**	**9/30/16**	**56**
2968	Transportation Data Trends and Best Practices	Chursenoff, David	9/30/16	-
2976	**The Effect of State and Federal Housing Policies on Vehicle Miles of Travel**	**Williams, Scott**	**9/30/16**	**58**
2797	Impacts and Future of the California Fuel Tax Swap of 2010	Williams, Scott	11/30/16	-
2640	**Spatial Dynamics of Warehousing and Distribution in California**	**Tyner, Patrick**	**12/31/16**	**60**
2792	**Industrial Land and Jobs Study for the San Francisco Bay Area**	**Tyner, Patrick**	**12/31/16**	**62**
2939	Developing Affordable Housing Guidelines Near Rail Transit in Los Angeles	Chursenoff, David	12/31/16	-
2891	The Nexus Between Infrastructure and Accessibility	Lao, Kayo	1/31/17	-
2974	The Impact of Residential Location, Lifestyles and Emerging Technologies on the Travel Behavior and Vehicle Ownership of Young Adults ("Millennials") in California	Monson, Tyler	3/15/17	-
2979	**Deployment of Sustainable Fueling/Charging Systems at California Highway Safety Roadside Rest Areas**	**Williams, Scott**	**3/15/17**	**64**
2980	**Biking in Fresh Air: Consideration of Exposure to Traffic-Related Air Pollution in Bicycle Route Planning**	**Williams, Scott**	**3/15/17**	**66**
2862	**Potential Greenhouse Gas Emissions Reductions from Optimizing Urban Transit Networks**	**Bisrat, Simon**	**3/31/17**	**68**
2941	The Decline in Inter- and Intra-Urban Mobility and Its Impact on Passenger Travel	Williams, Scott	3/31/17	-
2967	OHV Fuel Tax Study	Williams, Scott	3/31/17	-
2983	Affordable Housing in Transit-Oriented Developments: Impacts on Driving and Policy Approaches	Williams, Scott	3/31/17	-
2852	Professional Planner Workforce Development Training Program	Law, Frank	4/1/17	-
2973	**Tracking Land Use Changes That Support Sustainable Mobility**	**Lao, Kayo**	**4/1/17**	**70**
2961	Managing Pedestrian and Car Interactions	Provost, Lee	4/30/17	
2963	Long-distance Travel in the California Household Travel Survey (CHTS) and Social Media Augmentation	Williams, Scott	4/30/17	-
2985	**Enabling Demand Modeling from Privately Held Mobility Data**	**Williams, Scott**	**4/30/17**	**72**
2993	**The Equity Impacts of California's County Transportation Sales Taxes**	**Williams, Scott**	**4/30/17**	**74**
2918	The Effectiveness of State and Local Incentives on Household Ownership of Alternative Fuel Vehicles — A SEM Analysis	Azevedo, Christine	6/30/17	-
2919	Toward Accurate and Valid Estimates of Greenhouse Gas Reductions from Bikeway Projects	Hunt, Harold	6/30/17	-
3142	Framework for Developing Economic Competitiveness Measures for the California Sustainable Freight Action Plan	Tyner, Patrick	7/15/17	-
2965	Identifying and Analyzing the Relative Advantages and Disadvantages of Public-Private Partnerships and Traditional Delivery for Transport Projects	Williams, Scott	7/31/17	-
3081	Evaluating Freight Efficiency Metrics	Tyner, Patrick	9/30/17	-
3073	The Economic Benefits of Placemaking: Transportation Implications	Williams, Scott	10/31/17	-
3088	The Adoption of Shared Mobility in California and Its Relationship with Other Components of Travel Behavior	Lao, Kayo	10/31/17	-
3089	Truck Choice Modeling: Understanding California's Transition to ZEV Trucks Taking into Account Truck Technologies, Costs, and Fleet Decision Behavior	Monson, Tyler	10/31/17	-
3092	Development and Application of an Integrated Health Impact Assessment Tool for Transportation Plans in Sacramento County	Provost, Lee	10/31/17	-

Planning/Policy/Programming, continued

Task ID	Task Title	Task Manager	End Date	Page #
3133	Managing the Impacts of Freight in California	Monson, Tyler	11/30/17	-
2886	Shifting from LOS to VMT as the Measure of Transportation Impacts: Evaluating Prospects for Implementing Senate Bill 743	Tyner, Patrick	12/31/17	-
3118	Caltrans Future of Mobility White Paper	Monson, Tyler	1/31/18	-
3143	Developing Markets for Zero-Emission Vehicles in Goods Movement	Provost, Lee	1/31/18	-
3123	Evaluating Economic Mobility and Resilience of Multimodal Freight Operations in a Connected Vehicle Environment	Tyner, Patrick	2/28/18	-
3132	Caltrans Freight Program Assessment Initiative	Tyner, Patrick	2/28/18	-
3136	Bicycle Infrastructure and Business District Changes	Kwong, Jerry	2/28/18	-
3138	Who's in the Driver's Seat? The Division of Car Use in Auto-Deficit Households	Williams, Scott	2/28/18	-
3122	A Cost Allocation Model for Horizontal Supply Chains	Law, Frank	3/30/18	-
3090	Development of a Freight System Conceptualization and Impact Assessment (Fre-SCANDIA) Framework	Monson, Tyler	3/31/18	-
3116	Caltrans Benefits of Research White Paper — Deakin	Azevedo, Christine	4/30/18	-
3244	Economic Competitiveness, Definitions, and Metrics	Monson, Tyler	6/14/18	-
3091	Life Cycle Assessment for Complete Streets: Framework and Pilot Studies	Williams, Scott	6/30/18	-
3093	Understanding the Distributional Impacts of Vehicle Policy: Who Buys New and Used Alternative Vehicles?	Williams, Scott	6/30/18	-
3095	Evaluating the Need for Policy Interventions: Will On-Demand Ridesharing Services Enhance Sustainability and Mobility?	Williams, Scott	6/30/18	-
3121	Goods Movement Trainings/Academy	Monson, Tyler	6/30/18	-
3125	Sustainable and Affordable Housing Near Rail Transit: Refining and Expanding a Scenario Planning Tool	Williams, Scott	6/30/18	-
2833	Transit-Oriented Development and Commercial Gentrification: Exploring the Linkages	Williams, Scott	9/30/18	-
3014	Shared-Mobility Policy Framework and Workshop	Lao, Kayo	9/30/18	-
3144	Panel Study of Emerging Transportation Technologies and Trends in California (Phase II)	Tyner, Patrick	10/31/18	-
2931	Developing Statewide Sustainable Communities Strategies Monitoring System for Jobs, Housing, and Commute, Phase II	Lao, Kayo	12/31/18	-
3025	Understanding Modal Access/Egress for California High-Speed Rail Stations	Tyner, Patrick	6/25/19	-
2922	Updating Heavy Duty Equipment Emissions Prototype, Phase 2	Tyner, Patrick	6/30/19	-

Planning/Policy/Programming TPF

Task ID	Task Title	Task Manager	End Date	Page #
2847	**State Responses to Energy Sector Developments, TPF-5(327)**	**Tyner, Patrick**	**8/31/16**	**76**
2782	Toolkit for the Deployment of Alternative Vehicle and Fuel Technologies, TPF-5(331)	Tyner, Patrick	3/30/18	-

Research Support

Task ID	Task Title	Task Manager	End Date	Page #
2680	Operate FWD and Profiler Calibration Centers	Holland, Joe	9/30/17	-
2681	Maintain Heavy Vehicle Simulator Equipment	Holland, Joe	9/30/17	-
2682	Maintain Laboratory and Field Testing Equipment Capability	Holland, Joe	9/30/17	-

Research Support, continued

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2683	Maintain Laboratory Testing AMRL Certification	Holland, Joe	9/30/17	-
2684	Provide Advice to State Government on Pavement Technology	Holland, Joe	9/30/17	-
2685	Advanced Pavement Research for Long-Term Future Needs	Holland, Joe	9/30/17	-
2654	Crash Testing Support 2013-2018	Jewell, John	4/10/18	-
3064	Crowdsourcing Innovation at Caltrans	Turner, Loren	6/30/18	-
2958	AHMCT Research Deployment Support for 65A0560	Unck, Justin	9/30/18	-
2921	Application of a Project Prioritization Framework to the 2016 SHOPP	Turner, Loren	12/31/18	-
2858	STEPS 2015-2018: Sustainable Transportation Energy Pathways (STEPS3)	Iacobucci, Lauren	2/28/19	-

Research Support TPF

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1938	Transportation Research Program Management Database, TPF-5(181)	Retanan, Joel	2/28/18	-

Right of Way and Land Surveys

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2996	Research and Support for MTLS Data Management and Visualization	Lofton, Arvern	9/30/16	-
2729	Expanding Mobile Terrestrial Laser Scanning (MTLS) Capability and Capacity Throughout Caltrans	Lofton, Arvern	2/14/18	-

Rural

Task ID	Task Title	Task Manager	End Date	Page #
2927	Responder Study Phase 3: Testing and Support	Clark, Melissa	9/30/18	-
3111	Automated Safety Warning System Controller Phase IV: Deployment Support	Campbell, Sean	12/31/18	-
3213	Advanced Camera Lowering Device for ITS Field Maintenance	Campbell, Sean	12/31/18	-
1754	COATS Phase VII	Campbell, Sean	1/31/19	-
1748	Professional Capacity Building for Communication Systems — Phase IV	Perez, Jose	6/30/19	-

Rural TPF

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2916	WeatherShare Phase IV — Inclement Weather Testing	Campbell, Sean	12/31/17	-
1760	Rural Traveler Information Needs Assessment and Pilot Study Phase III: Bordering States Rural Coverage, TPF-5(241)	Campbell, Sean	2/28/18	-
2649	Aurora Program: Aurora Road Weather Information (ARWI) Systems, TPF-5(290)	Clark, Melissa	6/30/19	-

Seismic

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2756	**Probabilistic Seismic Damage Assessment for Sub-standard Bridge Columns**	**Lee, Peter**	**12/31/16**	**78**
2755	**Nonlinear Time History Analysis of Ordinary Standard Bridges**	**Sikorsky, Charles**	**6/30/17**	**80**
2544	Seismic Performance of Bridge Superstructure in Accelerated Bridge Construction	Lee, Peter	8/14/17	-

Seismic, continued

Task ID	Task Title	Task Manager	End Date	Page #
2861	A Comprehensive Set of Testing Protocols for Buckling-Restrained Braces Applied to Bridges	Lee, Peter	11/30/17	-
2881	Next-Gen Monitoring and Evaluation of California Bridges	Lee, Peter	11/30/17	-
2522	Cyclic Performance Characterization of Large Diameter Steel Reinforcing Bars and Mechanical Couplers	Kartoum, Allaoua	1/31/18	-
2539	Experimental Validation of Interaction of MSE Abutments with Superstructures Under Seismic Loading	Sikorsky, Charles	1/31/18	-
2744	Numerical Assessment of Liquefaction-Induced Ground Deformations and Loading Mechanisms	Sikorsky, Charles	1/31/18	-
2880	Development of Performance-based Seismic Design Guidance for Ordinary Bridges	Sikorsky, Charles	1/31/18	-
2561	Seismic Assessment of Cut and Cover Tunnels — Large Scale Tests	Sikorsky, Charles	4/30/18	-
2879	Development of a Validated Methodology for Seismic Analysis and Design of Standard and Pile Supported Retaining Walls	Wang, Gary	5/31/18	-
2994	Seismic Behavior of Grade 80 RC Bridge Columns — Phase 1	Noureddine, Issam	6/29/18	-
2757	Bridge System Research for Accelerated Bridge Construction (ABC)	Lee, Peter	7/1/18	-
2883	Ductile Behavior of Reinforced Concrete Arch Ribs — Plastic Hinging Under High-Compressive Axial Loads	Mosaddad, Bahram	7/1/18	-
2882	Modeling of Friction Concave Isolators' Performance Based on Updated Testing Protocols	Kartoum, Allaoua	8/31/18	-
2751	High-Strength Steel Reinforcement in Critical Regions of Earthquake Resistant Bridges	Noureddine, Issam	12/31/18	-

Strategic Planning TPF

Task ID	Task Title	Task Manager	End Date	Page #
2900	Develop and Support Transportation Performance Management Capacity Development Needs for State DOTs, TPF-5(326)	Azevedo, Christine	10/30/18	-

Transportation Safety and Mobility

Task ID	Task Title	Task Manager	End Date	Page #
2535	Coordination of Freeway Ramp Meters and Arterial Traffic Signals Phase IIA — Site Selection and Simulation Development	Aboukhadijeh, Hassan	9/28/16	-
2839	Travel Time Detector Installation and Integration on US 50 in District 3	Slonaker, John	10/14/16	-
2977	**Simulation of Ridesourcing Using Agent-Based Demand and Supply Regional Models: Potential Market Demand for First-Mile Transit Travel and Reduction in Vehicle Miles Traveled in the San Francisco Bay Area**	**Monson, Tyler**	**12/31/16**	**82**
2912	Cell Transmission Model–based Optimal Signal Control Strategies in Urban Networks	Chung, Haniel	1/30/17	-
2450	Strategies for Reducing Pedestrian and Bicyclist Injury at the Corridor Level (SMART), Phase 2	Kwong, Jerry	1/31/17	-
2876	A Unified Framework for Analyzing and Designing Signals for Stationary Arterial Networks	Chung, Haniel	1/31/17	-
2975	**Warehousing and Distribution Center Facilities in Southern California: The Use of the Commodity Flow Survey Microdata to Identify Logistics Sprawl and Freight Generation Patterns**	**Tyner, Patrick**	**3/31/17**	**60**
2445	**Field Test of Coordinated Ramp Metering**	**Aboukhadijeh, Hassan**	**4/28/17**	**84**
2959	Traffic Predictive Control	Provost, Lee	4/30/17	-

Transportation Safety and Mobility, continued

Task ID	Task Title	Task Manager	End Date	Page #
3001	**Sustainable Operation of Arterial Networks**	**Perez, Jose**	**4/30/17**	**86**
2808	**Performance Analysis and Control Design for On-ramp Metering of Active Merging Bottlenecks**	**Slonaker, John**	**6/30/17**	**88**
2770	Experimental Studies of Traffic Incident Management with Pricing, Private Information, and Diverse Subjects — Second Year	Clark, Melissa	7/31/17	-
2984	Congestion Reduction Through Efficient Empty Container Movement	Tyner, Patrick	8/14/17	-
2531	Automated Video Incident Detection (AVID) System	Slonaker, John	9/30/17	-
2899	Identify the Data Requirements for Safety Screening to Identify High Collision Concentration Locations	Kwong, Jerry	9/30/17	-
3041	Support for Challenge Area Work Zone	Mizuno, Bradley	9/30/17	-
2817	Development of Micro-Wireless Sensor Platforms for Collecting Data of Passenger-Freight Interactions	Gwynne, Gloria	10/4/17	-
3096	Evaluating the Environmental Impact of Traffic Congestion in Real Time Based on Sparse Mobile Crowdsourced Data	Provost, Lee	10/31/17	-
2652	Adaptive Coordination Algorithm for Arterial Traffic Signals	Slonaker, John	12/31/17	-
2837	Assist in the Development and Testing of the Connected Corridors I-210 Pilot Project (In-house Research)	Slonaker, John	12/31/17	-
2995	Connected Corridor Research for I-210 Corridor Management	Slonaker, John	12/31/17	-
2452	Pedestrian Safety Improvement Program Development, Phase 2	Kwong, Jerry	1/31/18	-
3134	Safe Operation of Automated Vehicles in Intersections	Siddiqui, Asfand	2/28/18	-
3139	Investigation of Multimodal Crashes Using Full Bayesian Multivariate Spatial-Temporal Models	Kwong, Jerry	2/28/18	-
3140	Control and Management of Urban Traffic Networks with Mixed Autonomy	Perez, Jose	2/28/18	-
2464	Trip-Generation Rates for Smart-Growth Land-Use Projects (related to Task 2626)	Gwynne, Gloria	3/31/18	-
2465	Affordable Housing Trip-Generation Strategies and Rates	Lao, Kayo	4/30/18	-
3094	Automated Vehicle Scenarios: Simulation of System-Level Travel Effects Using Agent-based Demand and Supply Models in the San Francisco Bay Area	Monson, Tyler	5/15/18	-
2646	An Evaluation of Signalized Intersection Safety Using Centracs System	Gwynne, Gloria	5/31/18	-
3068	Congestion-Responsive On-ramp Metering: Before and After Studies Toward Statewide Policy	AbouKhadijeh, Hassan	5/31/18	-
2447	Field Test of Variable Speed Advisory for Freeway Traffic Control	AbouKhadijeh, Hassan	6/15/18	-
1546	C1 Loop Detector Reader	Kwong, Jerry	6/30/18	-
2926	Evaluating the Performance of Traffic Detection Devices — Continuation of Task 1559	Retanan, Joel	6/30/18	-
3109	Modeling and Control of HOT lanes Phase II	Siddiqui, Asfand	6/30/18	-
3137	Travel-Demand Nowcasting	Chow, Stan	6/30/18	-
3112A	Bicycle and Pedestrian Infrastructure and Volume Data System for the California State Highway System	Loebs, Nathan	7/1/18	-
2765	MCOM Truck Smart Parking, I-5 Corridor Smart Truck Parking: Linking California, Oregon, and Washington State with Integrated Truck Traveler Information	Hanson, Matt	8/31/18	-
3182	Hand-held Diagnostic Controller for ITS Field Maintenance Phase II	Campbell, Sean	8/31/18	-
2906	Traffic Accident Surveillance and Analysis System (TASAS) and Injury Data Base Development	Ikram, Hamid	9/30/18	-

Transportation Safety and Mobility, continued

Task ID	Task Title	Task Manager	End Date	Page #
3078	Yellow LED Border on Pedestrian Signal	Retanan, Joel	9/30/18	-
2660	Coordination of Freeway Ramp Meters and Arterial Traffic Signals Phase IIB — Field Operational Test	AbouKhadijeh, Hassan	12/31/18	-
2970	Vision-based Sensor System for Site Monitoring: Wrong-Way Driving, Phase 1	Slonaker, John	12/31/18	-
3009	Smart Truck Parking Buildout	Hanson, Matt	3/31/19	-
2304	Evaluating Alternative Design of Geometric Configuration for High-Occupancy Vehicle Facilities in California	Perez, Jose	6/30/19	-

Transportation Safety and Mobility TPF

Task ID	Task Title	Task Manager	End Date	Page #
2306	Traffic Signal Systems Operations and Management, TPF-5(258)	Clark, Melissa	12/30/17	-
0797	Evaluation of Low-Cost Safety Improvements, TPF-5(099) (ELCSI PFS) and TPF-5(317)	Loebs, Nathan	12/31/17	-
1057	Roadside Safety Research Program, TPF-5(114)	Jewell, John	6/29/18	-
2318	Highway Safety Manual Implementation, TPF-5(255)	Kwong, Jerry	6/30/18	-
2954	Self-Deicing LED Signals, TPF Solicitation No. 1403	Kwong, Jerry	9/30/18	-
0373	High Occupancy Vehicle / Managed Use Lane, TPF-5(029) now TPF-5(322)	Perez, Jose	6/30/19	-
3066	Midwest States Pooled Fund Crash Test Program, TPF-5(193)	Whitesel, David	6/30/19	-
3067	Roadside Safety Research for MASH Implementation, TPF-5(343)	Jewell, John	6/30/19	-


California
6465

Fiscal Year 2016–17
Research Results

For this report, DRISI selected a variety of research tasks that highlight elements of the research program. The research results are organized by topic area and provide a high-level summary of the research need, goal, methodology, outcome, and benefit. These documents were produced with the collaboration of the participants of the tasks.

You can download the summaries from *www.dot.ca.gov/research/researchreports/technical_summaries.htm.* For more information about a specific task, contact the task manager listed.

DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Mitigating Traffic Jams Caused by Shock Waves

Vehicle-to-vehicle communication uniformly distributes traffic across multiple lanes and eliminates upstream shock-wave formations

Advanced Research

APRIL 2018

Project Title:
A Cooperative V2V Alert System to Mitigate Vehicular Traffic Shock Waves

Task Number: 2962

Start Date: May 1, 2016

Completion Date: April 30, 2017

Product Category: New or improved decision support tool, simulation, model, or algorithm (software)

Task Manager:
Asfand Siddiqui
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WHAT WAS THE NEED?

As the number of vehicles on freeways increases, it is necessary to use the existing infrastructure more efficiently. With uncoordinated traffic, the highway capacity is not optimally distributed. At some locations, vehicle density can be high, while other sections can experience gaps, and if vehicles do not change lanes at an opportune time, traffic can build up in a particular lane. Unexpected driver actions during heavy traffic can trigger a shock wave—as vehicles slow down in response to the action, even briefly, a temporary overload can occur, causing the formation of a shock wave upstream. The unexpected stop-and-go traffic exacerbates congestion. Congestion caused by shock waves could be reduced by using vehicle-to-vehicle (V2V) communication to provide downstream drivers with velocity and lane-switching recommendations to more uniformly distribute vehicles along highways.

WHAT WAS OUR GOAL?

The goal was to extend a V2V communication protocol to mitigate traffic shock waves and redistribute vehicles to more efficiently use highway capacity.

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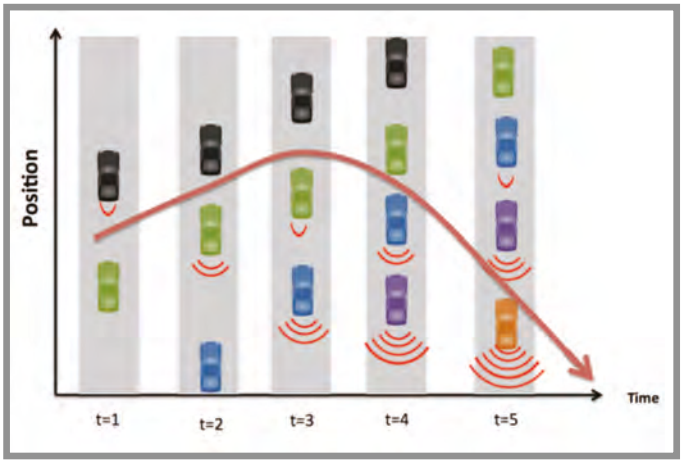
Mitigating Traffic Jams Caused by Shock Waves

WHAT DID WE DO?

Caltrans, in partnership with UCCONNECT extended the Density Redistribution through Intelligent Velocity Estimation (DRIVE) protocol to use multiple lanes to address shock waves and efficiently distribute traffic. DRIVE-EX is a connectionless protocol that relies on traffic information from downstream to access traffic conditions ahead in a vehicle's current lane and immediate adjacent lanes, broadcasting messages when a vehicle slows down or the velocity falls below a threshold. It assumes that a vehicle is equipped with optic sensors to determine which lane it occupies. The researchers experimented with different shock-wave scenarios, such as a reduction of lanes due to an accident or road work, and also evaluated mixing autonomous and human-driven cars.

WHAT WAS THE OUTCOME?

Simulation results show that DRIVE-EX improves traffic flow in various scenarios that can cause shock waves. Vehicles are able to adapt to traffic conditions beyond the line of sight and perform optimal lane changes. When a vehicle decreases its velocity, a message is broadcasted to neighboring vehicles and to those further downstream. The vehicle following in the same lane as the slowed-down vehicle either adapts its velocity or switches to an adjacent lane based on recommendations from the DRIVE-EX protocol. The system coordinates the lane change with vehicles in the target lane, and vehicles following in the departed lane abstain from changing lanes for a predetermined period of time.



Formation of a shock wave on a one-lane road over time, from left to right. The leading vehicle slows down for some reason, and the vehicles that follow must adapt their speeds to not crash into the lead vehicle.

WHAT IS THE BENEFIT?

DRIVE-EX provides vehicles with the ability to notify other vehicles about upstream traffic disturbances in advance of being directly impacted. The information gives downstream drivers more reaction time, reducing hard-braking maneuvers followed by accelerations, as is common in shock-wave scenarios, and can help coordinate lane switching. The protocol redistributes traffic within a lane and across multiple lanes to mitigate shock waves and maintain traffic flow. Smoothing traffic flow reduces overall travel time and increases average velocity.

LEARN MORE

To view the complete report:
www.dot.ca.gov/hq/research/researchreports/reports/2017/CA17-2962_FinalReport.pdf

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Research Results

Are Highways Barriers to Genetic Diversity Among Different Species?

To date, State Route 49 in Northern California has not impeded movements of the disturbance-tolerant coyote and the disturbance-averse gray fox

Environmental

FEBRUARY 2018

Project Title:
Using Noninvasive Genetics to Compare How a California Freeway Affects Gene Flow in a Disturbance-averse versus a Disturbance-tolerant Species

Task Number: 2978

Start Date: October 1, 2015

Report Date: April 1, 2017

Product Category: New or improved manual, handbook guidelines, or training

Task Manager:
Simon Bisrat
Senior Environmental Planner
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WHAT WAS THE NEED?

According to the Federal Highway Administration, the nation's highways extend for over four million miles and have ecological effects on about 20% of the country. The 2012 Moving Ahead for Progress in the 21st Century Act identifies the need for state and metropolitan agencies to reduce wildlife-related automobile hazards, decrease wildlife mortality, and improve habitat connectivity. Traffic noise, volume, and illumination can change behavior patterns and distribution. Highways in particular can act as barriers to wildlife movement, fragmenting and isolating populations, causing an increased risk of extinction over time due to loss of genetic diversity and inbreeding depression. The degree to which highways affect wildlife can depend on a species' ecological characteristics and a highway's features. Knowledge of how California highways impact wildlife with differing behavioral responses to disturbance helps Caltrans and other transportation agencies undertake mitigation activities that maintain connectivity across highways to reduce the threat of extinction.

WHAT WAS OUR GOAL?

The goal was to examine to what degree a highway's characteristics and traffic flow restrict the movement and affect the gene flow of wildlife species with differing tolerances for disturbance.

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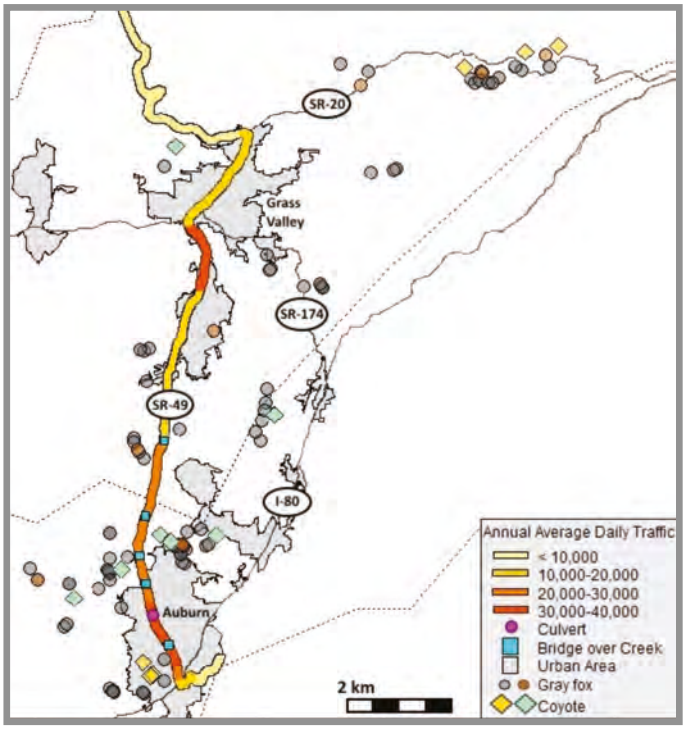
Are Highways Barriers to Genetic Diversity Among Different Species?

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the National Center for Sustainable Transportation, studied the movements of coyote and gray fox along three sections of State Route (SR) 49 between the cities of Auburn and Grass Valley in the Sierra Nevada foothills. Initially constructed during the Gold Rush, the two-lane undivided highway, traveled by 2,000–40,000 vehicles daily, based on 2015 traffic volumes, traverses a mixture of urban, suburban, and rural areas. The two species are similar in their reproductive phenology, dispersal timing, territoriality, and diet, but differ in their sensitivity to habitat. Coyotes can thrive in many habitats, including urban settings, while gray foxes tend to restrict themselves to mid-elevation scrublands. To determine whether SR 49 was a barrier to gray fox and coyote movements, the researchers collected fecal and road-kill tissue samples of 19 coyotes and 90 gray foxes over a 10-month period. Of these, 14 and 57 were unique coyote and gray fox genotypes, respectively.



Map of study area and annual average daily traffic volumes along SR 49 with locations of where samples were collected. Within each species, the different colors indicate membership in one of two different genetic clusters.

WHAT WAS THE OUTCOME?

Genetic clusters for both species were found on each side of SR 49, suggesting that at least some coyotes or gray foxes have crossed the highway under bridges, through culverts, or over the road surface during times of low traffic. Alternately, SR 49 could be a barrier to coyote and gray fox movement but there is a lag between initial reduction of gene flow and detection of population structure. The results differ from a study along U.S. 101 in Southern California in which coyotes were able to cross the highway but could not breed successfully due to territorial conflicts. More available habitat flanks SR 49 to promote reproduction and reduce signals of population isolation, however future increases in traffic volume and loss of habitat due to continued urban development might eventually reduce wildlife connectivity and genetic flow.

WHAT IS THE BENEFIT?

Knowledge of how California highways impact wildlife with differing responses to human disturbance helps transportation agencies plan mitigation activities that benefit multiple species. By broadening studies to include sections of high, moderate, and low traffic volumes, transportation agencies can target highway stretches that create the greatest barrier to wildlife movements to restore population connectivity. Highways running through important wildlife habitats should be monitored as human disturbance increases so that action can be taken to diminish barrier effects before genetic diversity among populations is affected.

LEARN MORE

To view the complete report:
https://ncst.ucdavis.edu/wp-content/uploads/2015/09/NCST-Caltrans-TO-015-Schreier-Noninvasive-Genetics_FINAL-July-2017.pdf

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Research Results

Minimizing the Economic Damage of Major Port Disruptions

Determining appropriate resilience tactics can greatly reduce business interruption losses regionally and nationally

Geotechnical/ Structures

MARCH 2018

Project Title:
Development of an Economic Framework to Evaluate Resilience in Recovering from Major Port Disruptions

Task Number: 2934

Start Date: August 15, 2015

Completion Date: September 1, 2016

Product Category: New or improved decision support tool, simulation, model, or algorithm

Task Manager:
Lee Provost
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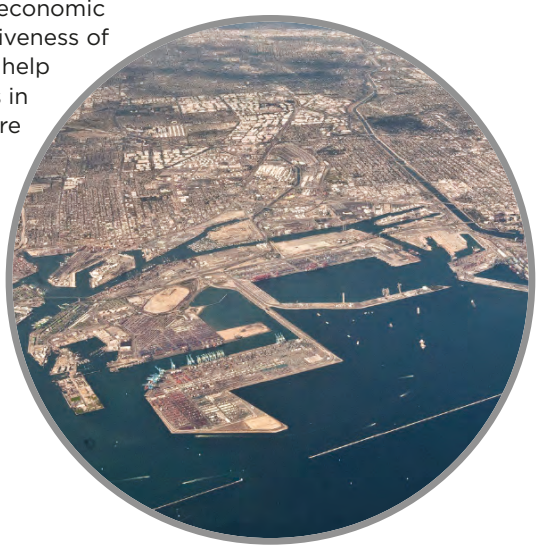
WHAT WAS THE NEED?

California's ports play a vital role in the state's and nation's economy, and a major port disruption can reverberate across the entire economy, affecting or even shutting down regional and national supply chains. For example, extended downtime at the Port of Los Angeles marine oil terminals can lead to an operation stoppage at petroleum refineries who are then unable to meet their customers' needs, resulting in shortages to other sectors as the decreased production trickles down the supply chain. Ports are generally successful in quickly recovering from small disruptions, but much less resilient to large, extended disruptions. A number of port disruptions have taken place in recent years stemming from various causes, such as labor disputes, natural disasters, and technological accidents. Many studies have estimated the direct and indirect impacts of disruptions, but few studies have factored in the possible forms of resilience that could mute these losses and provide a more rapid recovery. In the event of a port disruption, a methodology is needed that extends beyond the immediate damage to ships or port facilities and evaluates the economic ripples caused by the curtailment of imports and exports to determine which measures to implement to speed up the resumption of activities.

WHAT WAS OUR GOAL?

The goal was to develop an economic model to evaluate the effectiveness of various resilience options to help ports and related businesses in the supply chain recover more rapidly from major disruptions.



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WHAT DID WE DO?

Caltrans, in partnership with the METRANS Transportation Center, incorporated various supply-side and customer-side resilience strategies into The Enormous Regional Model (TERM) to quantify their contributions to reduce the economic consequences of a major port disruption. TERM is a multi-regional computable general equilibrium model that can measure distinct regional impacts as well as the associated regional spillover effects. The researchers simulated two disasters with different magnitudes and durations at California seaports: a tsunami generated by distant seismic activity causing a two-day shutdown, and a severe local earthquake creating extensive damage. They then assessed the potential effects of the various resilience tactics to reduce economic losses.

WHAT WAS THE OUTCOME?

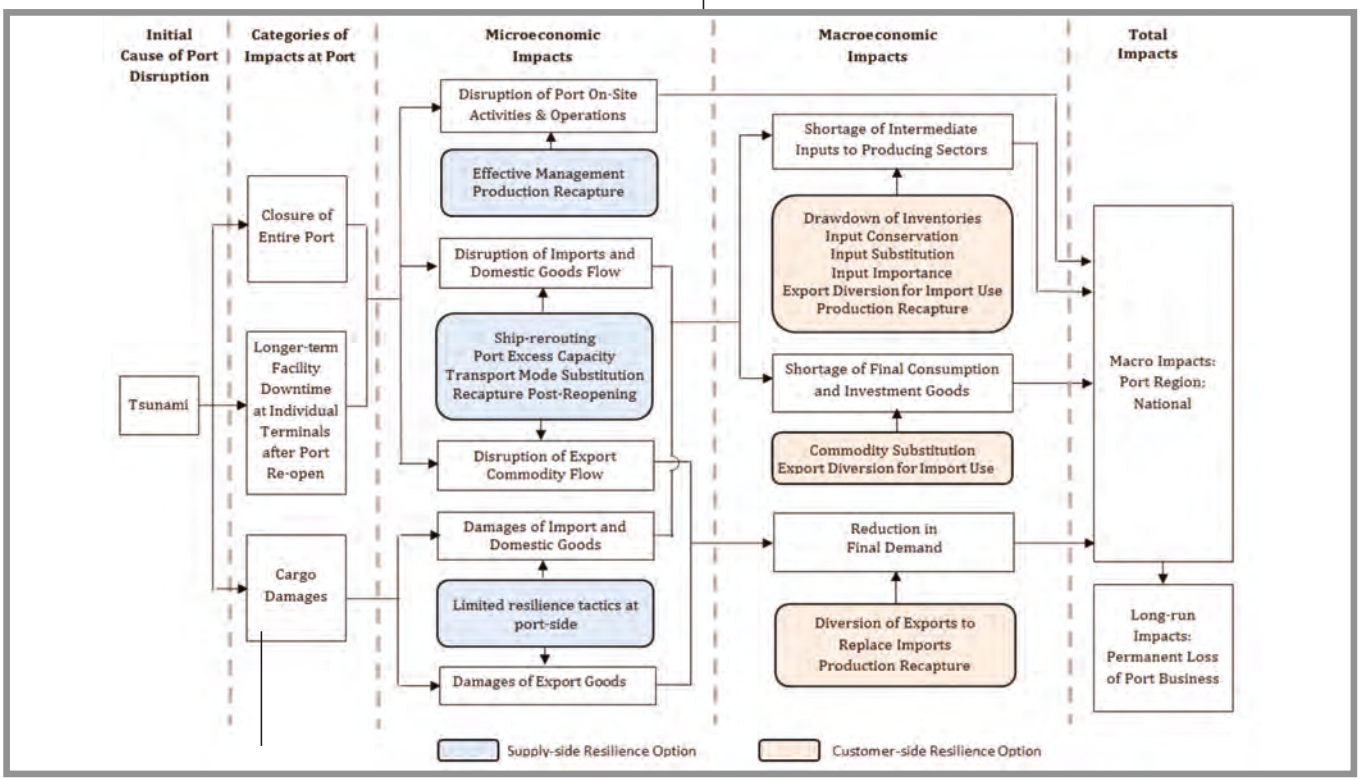
The lower-bound tsunami scenario could result in a gross domestic product (GDP) loss of $650.1 million and an employment loss of seven thousand jobs. The combined effects of various relevant resilience tactics have the potential to reduce the economic damages by about 97%. The upper-bound scenario could cause GDP losses of over $12 billion in California and $16 billion at the national level. However, resilience measures can reduce these impacts by about 75% for California and about 89% for the nation. Resilience tactics can be applied at several levels. For example, ports can use excess capacity in undamaged facilities, and ships can be rerouted to other ports. Diverting goods intended for export to address import shortages and recapturing lost production by working overtime when normal port operations resume can help reduce business interruptions.

WHAT IS THE BENEFIT?

Port disruptions have far-reaching regional and national economic impacts. Resilience tactics can greatly reduce business interruption losses. The modeling framework developed provides a means to assess the economic impacts of a major port disruption and the ability of potential strategies to mitigate losses and speed up the resumption of port activities. The model also provides insights into investment decisions on protecting ports from and enhancing their resilience to natural and man-made disasters.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2016/CA16-2934_FinalReport.pdf



Analytical framework of estimating total economic impacts of a port disruption with implementation of resilience measures

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Research Results

Predicting Superstructure Creep and Shrinkage in Post-tensioned Concrete Box Bridges

New recommendations increase the accuracy of displacement-induced column design forces due to creep and shrinkage and reduce costs

Geotechnical/ Structures

JANUARY 2018

Project Title:
Effects of Superstructure Creep and Shrinkage on Column Design in Post-Tensioned Concrete Box-Girder Bridges

Task Number: 2342

Start Date: June 1, 2012

Completion Date: December 31, 2016

Product Category: New or improved decision support tool, simulation, model, or algorithm (software)

Task Manager:
Charles Sikorsky
Research Program Manager
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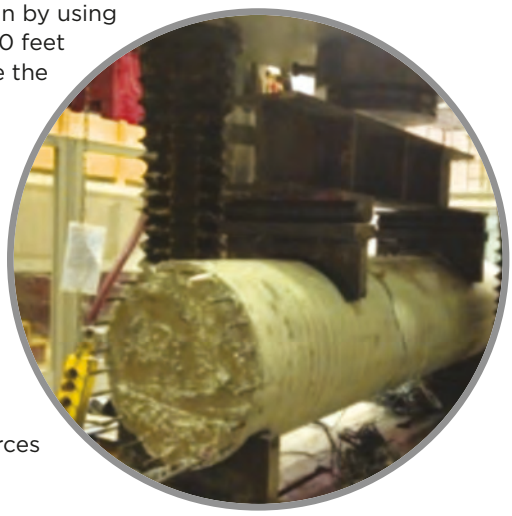
WHAT WAS THE NEED?

Cast-in-place post-tensioned (CIP PS) concrete box-girder bridge frames are widely used in California. During construction and after they are placed in service, creep and shrinkage cause the superstructure to shorten, which in turn produces time-dependent forces on the columns. These forces must be accurately estimated to ensure satisfactory performance and produce a cost-effective design. Accurately estimating these forces is challenging due to their dependence on parameters, such as strain rate and concrete relaxation. Because conservative estimates of these parameters are used in design, the displacement-induced column forces are typically overestimated, resulting in larger column and foundation sizes and increased construction costs. Unnecessarily larger columns increase the lateral forces induced by movements of the superstructure, thereby exacerbating the design problem. Caltrans has adopted a simplified method that is based on a joint and bearing design approach, which includes creep and shrinkage effects in column design by using a strain rate of 0.63 inches per 100 feet of superstructure length. Because the simplified method is deemed to produce relatively large column forces, further verification was needed to improve the design calculations.



Testing a reinforced concrete beam

WHAT WAS OUR GOAL?

The goal was to evaluate and improve the accuracy of the simplified method to estimate column displacement-induced forces due to creep and shrinkage in CIP PS box bridges.

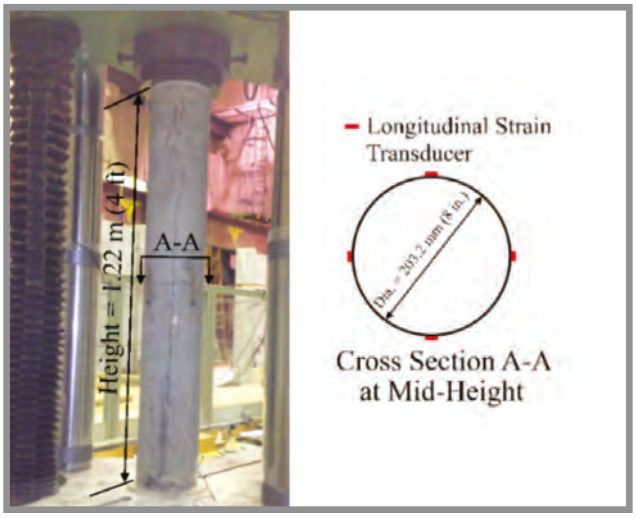
Predicting Superstructure Creep and Shrinkage in Post-tensioned Concrete Box Bridges

WHAT DID WE DO?

Caltrans, in partnership with the Iowa State University Department of Civil, Construction and Environmental Engineering, selected eight representative CIP PS box bridge frames of various lengths, configurations, and prestress amounts to investigate time-dependent effects. Using finite element models (FEM), the researchers evaluated the range of expected shortening strain rates of the superstructure due to dead load, prestress, creep, and shrinkage and compared the corresponding forces induced in the columns to those estimated with the current simplified method. They also experimentally quantified concrete relaxation with respect to its beneficial effects on displacement-induced column forces. Based on the finite element analysis results, the researchers developed four alternative approaches to more accurately calculate the displacement-induced column forces. Similar to the Caltrans simplified method, two approaches (1a and 1b) used the FEM creep and shrinkage strains for each frame type—short-, medium-, and long-span—and the average of the eight frames, respectively, to calculate forces. Whereas the column forces were calculated using the FEM total strains for each frame type and the average of the eight frames, respectively (approaches 2a and 2b).

WHAT WAS THE OUTCOME?

The research identified the inaccuracies of the simplified method in the estimated superstructure strain rate and in accounting for the concrete relaxation phenomenon in columns and developed rational design recommendations to incorporate the time-dependent effects and obtain good estimates for the column design forces. Superstructure shrinkage contributed most to the shortening strain rate of the superstructure, column top lateral displacement, and the associated base shear force compared to the corresponding effects due to dead load, prestress, and creep. Among the four alternative approaches examined, approach 2b, which is based on total strain, most closely matched the corresponding FEM results. However, the researchers recommend approach 1b because it considers creep and shrinkage strains separately, like the Caltrans simplified method. The mean and standard deviation for the ratio of forces calculated by approach 1b to the FEM were reduced to 1.49 and 0.3, respectively, compared to the Caltrans simplified method values of 2.43 and 0.94.



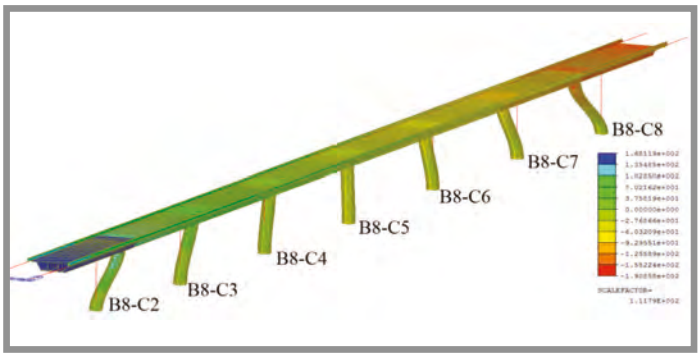
Concrete relaxation test on a column and the corresponding observed axial displacement and stresses as a function of time

WHAT IS THE BENEFIT?

The recommendations improve the Caltrans simplified method, increasing the accuracy of calculated column design forces with appropriate consideration to strain rate, concrete relaxation, and the effects of column flexural cracking, resulting in an appreciable reduction of column displacement-induced forces. The revised estimates support the use of more economical column and foundation designs, reducing the construction cost of CIP PS box frames.

LEARN MORE

To view the complete report:
www.researchgate.net/publication/316939972_Effects_of_Superstructure_Creep_and_Shrinkage_on_Column_Design_in_Posttensioned_Concrete_Box-Girder_Bridges



Elevation view of a California long CIP PS box frame with the FEM longitudinal displacement results (in millimeters)

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Research Results

Using Geophysical Methods to Determine Geotechnical Properties for Transportation Projects

New reference describes cost-efficient geophysical methods to aid engineers in measuring in situ physical properties of soil and rock

Geotechnical/ Structures

FEBRUARY 2018

Project Title:
Geophysical Methods for Determining the Geotechnical Engineering Properties of Earth Materials

Task Number: 2111

Start Date: April 1, 2013

Completion Date: March 31, 2017

Product Category: New or improved technical standard, plan, or specification

Task Manager:
William P. Owen
Senior Engineering Geologist
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WHAT WAS THE NEED?

Surface and borehole geophysical methods can measure in situ properties and structural characteristics of earth materials, such as shear modulus, bulk density, porosity, fracture orientation, depth to bedrock, and fault location. These methods provide crucial subsurface information for geotechnical design of transportation infrastructure on a more comprehensive scale than typical subsurface investigation techniques. Better understanding of the subsurface conditions can reduce costs because engineers gain a greater insight of the soil conditions, thereby reducing risk and uncertainty. However, geophysical methods are underutilized for transportation infrastructure in part because the literature on geophysical methods is either intended for novice geophysical users or specialized for particular fields. Summaries describing the engineering properties for the practicing engineer and geologist for direct transportation project application are scarce. Filling this literature gap would increase the geotechnical engineering community's knowledge base and provide a means to more efficiently distribute the cost of geotechnical site characterization and project design.

WHAT WAS OUR GOAL?

The goal was to identify and describe the appropriate geophysical methods for measuring the engineering properties of in situ soil and rock to aid roadway and structure foundation design.

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Using Geophysical Methods to Determine Geotechnical Properties for Transportation Projects

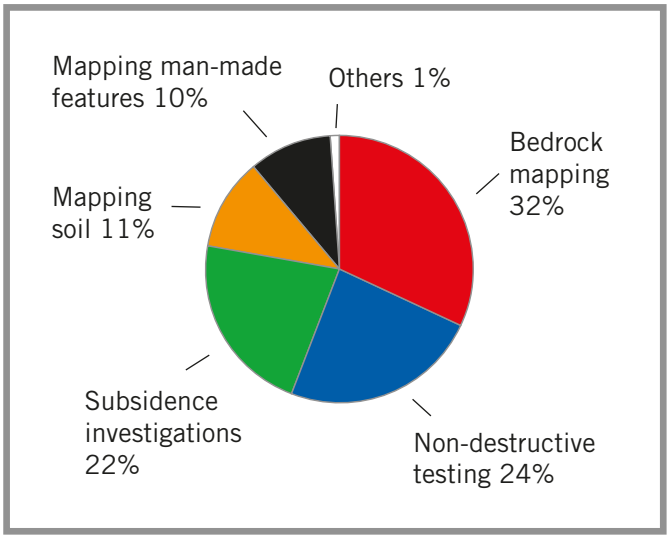
Research Results

WHAT DID WE DO?

Caltrans, in partnership with Temple University and University of California, Los Angeles, reviewed the current literature and summarized the derivation of various soil and rock properties using geophysical methods, identified accepted methods and promising techniques, recommended applications for typical Caltrans projects, and suggested areas for future research and additional avenues of application. The reference addresses issues related to the uncertainty in dynamic soil properties and highlights the importance of geophysical measurements and their potential impact on geotechnical design.

WHAT WAS THE OUTCOME?

The comprehensive reference demonstrates the wide range of capabilities available via geophysics to estimate earth material properties. The methods can guide efforts in many elements of transportation infrastructure, such as foundation design, construction of earth retaining systems, and placement of embankments. For seismic design and site characterization, seismic refraction, seismic tomography, Spectral Analysis of Surface Waves, Multichannel Spectral Analysis of Surface Waves, and borehole velocity logging provide higher quality information for shear-wave velocity than correlations from standard penetration tests. Additionally, much of the theory central to various geophysical methods form the basis for a number of non-destructive testing techniques that are applicable to many highway engineering problems.



Most common application of geophysical methods based on a nationwide survey

Although geophysical methods offer tremendous value for estimating earth material properties in transportation projects, they are not meant to replace standard drilling, sampling, and laboratory testing, but rather to provide a cost-effective approach to augment other subsurface characterization exploration efforts.

WHAT IS THE BENEFIT?

Geophysical methods can quickly provide information over a much larger area than subsurface drilling, in situ testing, and laboratory testing of acquired samples. At the planning phase, geophysics can potentially provide the preliminary information necessary for the project. In the design phase, geophysical methods can aid in tailoring drilling operations and in situ tests. During subsurface exploration, engineers can use geophysical methods to estimate the engineering properties of subsurface materials. For each phase, proper application of geophysical methods can increase information and provide appreciable savings to a project in both labor and time.

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Research Results

Integrating High-Speed Rail Stations with Intermodal Connectivity and Multi-use Facilities

Identifying the challenges, opportunities, and criteria for good station-area planning to inform the development of proposed California high-speed rail facilities

Modal

MARCH 2018

Project Title:
A Comparative Analysis of High-Speed Rail Station Development into Destination and Multi-use Facilities

Task Number: 2969

Start Date: November 15, 2015

Completion Date: February 28, 2017

Product Category: New or improved business practice, procedure, or process

Task Manager:
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WHAT WAS THE NEED?

Good station-area planning is an essential prerequisite for the successful operation of a high-speed rail (HSR) station. Good planning can also trigger opportunities for economic development surrounding the station and within the city. In 2014, San Jose adopted the Diridon Station Area Plan, setting out a 30-year vision to create a multimodal facility surrounded by new, state-of-the-art development connecting HSR, rapid transit, commuter rail, and bus services. Additionally, the availability of tracts of undeveloped or under-developed land around Diridon station, mostly in the form of surface parking lots owned by public entities, offers the potential for dense development in the station area. Some European countries have over 30 years of experience with planning and designing HSR stations. How have the long-term visions of these rail stations built adjacent to major commercial, office, and residential uses weathered fluctuating conditions, volatile real estate environments, and changing political climates? What can San Jose Diridon Station and other HSR stations learn from this accumulated knowledge?

WHAT WAS OUR GOAL?

The goal was to acquire lessons learned and best practices from successful railway stations and transit experts to develop guidelines for creating a transport node that links transit services and promotes non-vehicular modes, such as walking and biking.

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Integrating High-Speed Rail Stations with Intermodal Connectivity and Multi-use Facilities

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the Mineta Transportation Institute, reviewed the planning and design of successful intermodal transit facilities and compared European cities and stations that share similarities to San Jose in size, location, and scope. Many of the stations have been in operation for more than a decade, providing hindsight for evaluation. In addition to meeting with local San Jose planners and urban designers, the researchers interviewed transit managers from various European stations, selecting five case studies for detailed exploration on what worked well, what went wrong, whether plans needed to adjusted, and which goals did not come to fruition.

WHAT WAS THE OUTCOME?

The findings from the literature review, case studies, site analysis, and interviews with local and international professionals were compiled in a detailed report, along with recommendations for the planning and design of the Diridon HSR station. Three types of connectivity characterize successful HSR station-area planning:

- Spatial—Seamless integration of the station with its surroundings
- Intermodal—Integration of different transportation modes at the station and convenient access and transition from one mode to the other
- Operational—Good project governance and coordination and collaboration among different public sector agencies and between the public and private sectors

WHAT IS THE BENEFIT?

Examining HSR stations built over the past 30 years shows that planning is instrumental in coordinating adjacent land use, often by increasing the density and incorporating major traffic attractors, such as important public buildings, retail areas, entertainment centers, and distinctive station architecture. The most successful stations are distinguished by a seamless integration of the HSR station with its surroundings and strong intermodal connectivity that links the high-speed services to other transportation modes and services. The assembled case studies and recommendations can provide guidelines for successful planning of the San Jose Diridon station as well as other stations along the California HSR corridor.

LEARN MORE

To view the complete report:
http://transweb.sjsu.edu/project/1502.html

Connectivity Elements for Good Station-Area Planning

SPATIAL	INTERMODAL	OPERATIONAL
Central station location	Good intermodal choices and connections	Significant public sector involvement
Good integration of station with surrounding area—minimization of a barrier effect	Good level of service	Political leadership and local champions
Densification of land uses around station	Good pedestrian access to the station	Public-private partnerships
Concentration of retail, commercial, and cultural amenities	Good bicycle access to the station	Coordination of different actors
Public places and plazas for people to congregate outside and inside		Consideration of both local and regional context and complementarity
Scattering of parking structures throughout station areas		Multiphased planning
Availability of bicycle parking		Land assembly and land banking
External station building orientation		Value capture
Distinctive architecture with ample natural light		

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Research Results

Rail and the California Economy

Investigating how passenger and freight rail contributes to the state's economy today and what factors could impact these contributions in the future

Modal

MARCH 2018

Project Title:
Rail and the California Economy

Task Number: 2860

Start Date: March 1, 2015

Completion Date: April 1, 2017

Product Category: New or improved technical standard, plan, or specification

Task Manager:
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WHAT WAS THE NEED?

Rail is a fundamental component of California's transportation system and has helped define the state's history from the days of westward expansion to supporting the growth of one of the world's largest economies. With the coming high-speed rail system and record traffic in containerized freight, it is also helping to define the state's future. Although millions of passengers and billions of dollars of cargo travel on rail in California every year, a holistic overview of rail's role in the state's economy and the challenges it faces was lacking.

WHAT WAS OUR GOAL?

The goal was to investigate how the state's passenger and freight rail system contributes to the California economy and what factors could impact these contributions going forward and present the information so that it is accessible to a general audience.

This unit train of produce carries the equivalent of 125 trucks at a fraction of the cost.

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WHAT DID WE DO?

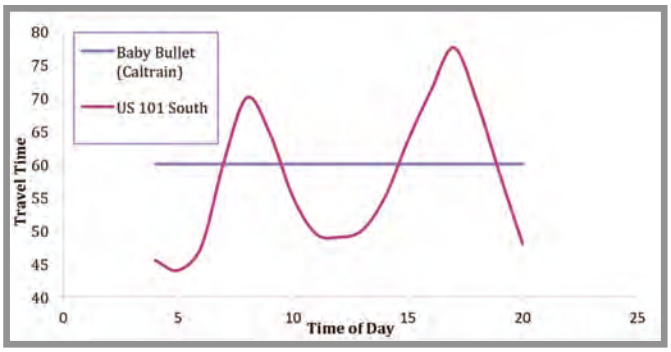
Caltrans, in partnership with the University of California, Institute of Transportation Studies, interviewed various passenger and freight transit agencies to measure rail's role in California's economy and understand the constraints that can hinder missions, investments, improvements, and expansion. The researchers focused on four major benefits that rail provides and assembled case studies to illustrate rail's contributions and obstacles.

Mobility—Provides individual passengers access to employment, and offers shippers an efficient means to move commodities in bulk.

Capacity—Transports large numbers of passengers and goods per hour using limited space on exclusive rights-of-way that are not impacted by rode closures and typically not impeded by severe weather conditions.

Agglomeration—Clusters people, firms, housing, goods, and services in a particular area, fostering collaboration, competitiveness, innovation and promoting regional economic growth.

Environmental—Conserves energy, reduces air and noise pollution, and lowers vehicle miles traveled, which decreases highway damage and the resulting maintenance costs.



Travel times between San Jose and San Francisco on US 101 compared to the Caltrain express service (Baby Bullet). At peak capacity, the Caltrain line carries the equivalent of a freeway with two lanes in each direction.

WHAT WAS THE OUTCOME?

California has one of the most diverse networks of rail in the country, ranging from lightly used branch lines in the northern interior to a heavily trafficked triple-track mainline near downtown Los Angeles. It includes intercity passenger routes, regional rail corridors, long-haul interstate freight lines, and freight short lines. Together, the network moves thousands of passengers and millions of tons of cargo per day, resulting in millions of dollars saved in freeway congestion, lost time by commuters, crashes, and pavement wear, in addition to the benefits of a moving office with the introduction of cellular connectivity. Each train boxcar can carry the cargo of two trucks at a fraction of the environmental cost, including particulate matter, nitrogen oxide, and volatile organic compounds. In some cases, public-private partnerships for infrastructure can encourage additional movement from truck to rail.

WHAT IS THE BENEFIT?

Rail is and has been a major contributor to California's economy and quality of life, moving people and goods efficiently. Providing a clearer picture of the rail network's benefits and obstacles in an easy-to-read document enables policymakers and public agencies to target future research and investment where it will be the most effective.

LEARN MORE

To view the report:
www.dot.ca.gov/research/planning/docs/Rail_CAEconomy_Book_Report.pdf

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Research Results

Bikesharing as a Transit System Feeder

A mobile app incorporates bikeshare stations to connect commuters to and from transit stops and increase public transportation ridership

Modal

MARCH 2018

Project Title:
Designing a Transit-Feeder System Using Bikesharing and Peer-to-Peer Ridesharing

Task Number: 2964

Start Date: May 1, 2016

Completion Date: April 30, 2017

Product Category: New or improved decision support tool, simulation, model, or algorithm

Task Manager:
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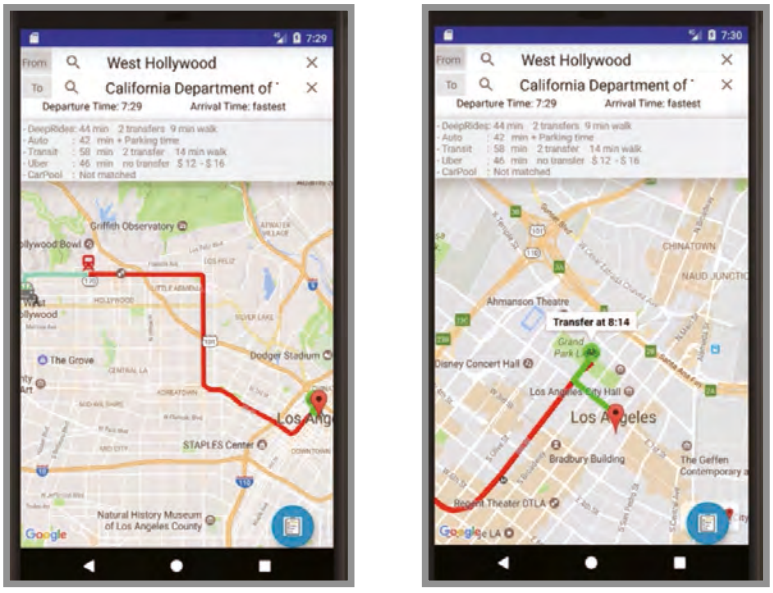
WHAT WAS THE NEED?

Public transit plays a vital role in alleviating urban congestion, but it doesn't capture its full mode share because many travelers do not have close access to a station. The first-mile, last-mile problem in terms of proximity to a transit stop keeps many commuters in their vehicles, often driving solo. When strategically placed, bikesharing services complement and enhance transit by offering travelers a convenient one-way trip to and from stations. Riders can check out a bike from the docking station and not worry about loading it on a bus or metro car or bringing it into the workplace. The bikes can extend transit coverage, linking disconnected bus and metro stops without added infrastructure costs. In a previous project, the researchers developed a mobile application for the Los Angeles Metro that suggests travel routes in real time that combine ridesourcing options and transit schedules to make public transportation more efficient and attractive. This research broadens the transportation alternatives to include bikesharing as a transit feeder.

WHAT WAS OUR GOAL?

The goal was to expand the transit-feeder mobile app to include bikesharing as one of the options to access transit stations and promote public transit use.



Recommended route (left) with the times and prices for the various options; bike transfer point (right)

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WHAT DID WE DO?

Caltrans, in partnership with the University of California Center on Economic Competitiveness in Transportation (UCCONNECT), added bikesharing locations to a recently developed transit-feeder mobile application to investigate the potential contribution biking can have on public transit ridership. Using the LA Metro Red Line and the city's newly launched downtown bikeshare system as a case study, the researchers developed algorithms to estimate and compare routes, travel time, and cost between driving to a destination or using ridesourcing or bikesharing, or a combination of the two, to connect with a transit stop. To address the ongoing fluctuating supply and demand for bicycles among stations, a redistribution program periodically rebalances the docking stations by optimally routing vans for pick up and drop off.

WHAT WAS THE OUTCOME?

The multimodal network scheme finds comprehensive optimal routes for travelers, expanding the coverage of public transit. Ridesharing and bikesharing could be effective transit feeders when properly designed and integrated into the transit system. Simulations showed that by coordinating bikesharing with metro schedules, bike usage could initially grow by 1.7%. This number can increase significantly if bus transit systems are also included, as proposed in a follow-up project. For this limited case study, the availability of bikesharing and ridesourcing options increased metro usage by about 2%. The algorithm for rebalancing bike docking stations confirmed that three vans are needed to serve 63 stations and also optimized the routing to reduce travel times, which is necessary as the bike system expands.

WHAT IS THE BENEFIT?

The expanded transit-feeder system presents alternative options to efficiently connect travelers with transit, addressing the first-last mile hurdle and making public transportation more attractive, efficient, and accessible. Including bikesharing as a transit component also promotes healthier modes of transportation and boosts biking in general as a means of transportation, encouraging infrastructure improvements to provide protected lanes and other safety measures.

LEARN MORE

To view the complete report:
http://ucconnect.berkeley.edu/sites/default/files/file_uploads/2016-TO-046-65A0529.pdf

Multimodal mobile app (left) and its system framework

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Research Results

Pavement Surface Guidelines for Bicycle Routes

Smoother pavement surface treatments improve the ride quality for bicyclists

Pavement

FEBRUARY 2018

Project Title:
Development of Recommended Guidelines for Preservation Treatments for Bicycle Routes

Task Number: 2693

Start Date: July 1, 2014

Report Date: January 15, 2017

Product Category: New or improved technical standard, plan, or specification

Task Manager:
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WHAT WAS THE NEED?

Pavement surface texture is one of several characteristics that influences ride quality, and the condition of the pavement can affect a rider's comfort and perceived safety. High levels of texture or roughness change the rolling resistance, forcing a rider to work harder, and excessive vibration can cause pain, discomfort, or concerns about safety or bicycle damage. As commuter and recreational biking increases, it is important to take into account the road quality of bike routes and roadways when repairing and resurfacing pavements. A Caltrans 2014 study addressed the impact of chip seal pavement treatments on bicycle ride quality, concentrating on a specific type of highway surface preservation treatment and recreational bike riders. This research expanded that study to include the variety of surface textures found statewide and encompass a wider range of bicycle types and riders to develop guidelines for the design and selection of preservation treatments for bicycle routes on state highways and local streets.

WHAT WAS OUR GOAL?

The goal was to develop recommended guidelines for selecting pavement surface treatments that maximize bicycle ride quality in terms of texture and roughness.

Commuter bicycle instrumented with accelerometers (red circles) at the typical mounting locations and a GPS unit on the handlebar (blue dashes).

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WHAT DID WE DO?

Caltrans, in partnership with the University of California Pavement Research Center, measured the macrotexture, roughness, and pavement distresses of different preservation treatments on 67 road sections in the California cities of Chico, Davis, Richmond, and Sacramento and in Reno, Nevada, and on a number of highway sections and county roads using instrumented cars and bicycles. The researchers then compared the results with personal surveys regarding bicycle ride quality on these road sections to explore correlations between pavement roughness and distresses, bicycle vibration, and bicycle ride quality. Models for bicycle ride quality and physical rolling resistance were also developed. The researchers also completed the long-term monitoring of pavement macrotexture for larger stone seals initiated in the first study on California state routes (SR) 1 in San Luis Obispo, 2 in Los Angeles, and 198 in Monterey to determine how much texture is reduced—or smoothed—by traffic.

WHAT WAS THE OUTCOME?

The information gathered from the measurements and models was used to produce recommended guidelines for selecting specifications for chip seals, slurry seals, and microsurfacings to improve bike ride quality. Both roughness and texture are important parameters for determining whether riders find a particular pavement section acceptable. Changes in Caltrans chip seal gradation specifications have resulted in a higher macrotexture value. Based on the two studies, 80% of riders rate pavements with macrotexture mean profile depth (MPD) values of 1.8 mm or less as acceptable, and 50% rate pavements with MPD values of 2.3 mm or less as acceptable. Most slurry seals on city streets produce high acceptability across the cities studied. Pavement texture generally tends to decrease over time due to traffic. The presence of distresses, particularly cracking, lowers the ratings that riders give to pavements.

The recommended guidelines for choosing a surface treatment specification address only bicycle ride quality. Other criteria must be considered when selecting a surface treatment specification, including motor vehicle safety in terms of skid resistance under wet conditions and the life-cycle cost of the treatment.

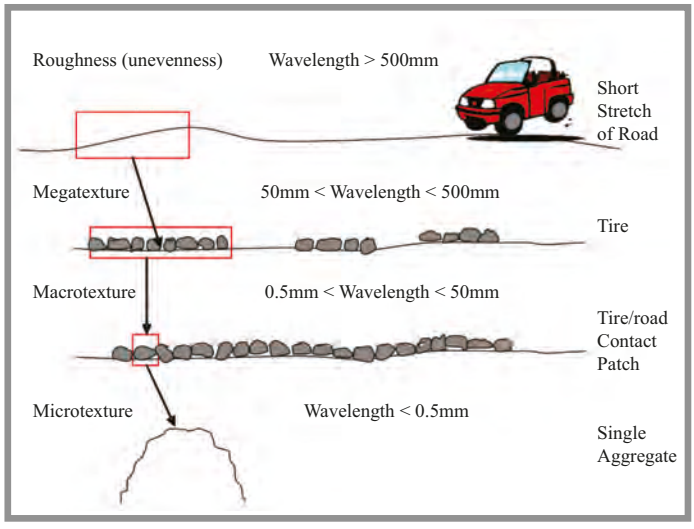
Lightweight inertial profiler with rear-mounted high-speed lasers, one in each wheel path (red circle) and GPS unit (orange circle).

WHAT IS THE BENEFIT?

Caltrans can use the recommended guidelines during the surface treatment selection process to establish and meet a high level of bicycle ride quality. The continuous improvements on ride quality encourages bicycling as a mode of transportation and recreational activity.

LEARN MORE

To view the complete report:
www.ucprc.ucdavis.edu/PDF/UCPRC-RR-2016-02.pdf



Pavement surface texture components and their wavelengths (500 mm = 1.64 ft, 50 mm = 0.164 ft or 2.0 in., 0.5 mm = 0.02 in.)

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Research Results

Lowering Natural Gas Emissions with Humid Air

A humid air system can reduce NO_X emissions of compressed natural gas engines without increasing particulate matter emissions

Planning/ Policy/ Programming

FEBRUARY 2018

Project Title:
Investigations of the Effect of Humid Air on NO_X & PM Emissions of a CNG Engine

Task Number: 2932

Start Date: August 15, 2015

Report Date: September 30, 2016

Product Category: New or improved decision support tool, simulation, model, or algorithm (software)

Task Manager:
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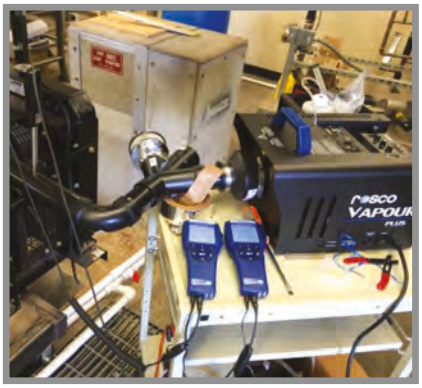
WHAT WAS THE NEED?

The transportation sector produces about 29% of greenhouse gas (GHG) emissions in the United States. The primary GHGs are water vapor, carbon dioxide, methane, ozone, and nitrous oxide. One strategy for reducing transportation-related GHG emissions is to switch to low-carbon, cleaner burning fuels, such as natural gas. Compressed natural gas (CNG) engines can potentially reduce passenger car GHG emissions by 20% to 30%, and 11% to 23% for heavy duty vehicles. Adapting existing and new CNG engines with humid air systems could also reduce NO_X emissions. Higher humidity lowers NO_X emissions, and humid air systems have been effective in reducing diesel engine emissions. Water vapor is injected into the intake air supplied for combustion. The process reduces the cylinders' temperature and raises the heat of the air-fuel mixture, which also contributes to eliminating cylinder hot spots.

WHAT WAS OUR GOAL?

The goal was to determine the feasibility of using a portable humid air system for reducing the NO_X emissions of CNG engines.



An inline four-cylinder, naturally aspirated engine with a maximum rated horsepower of 50.8 for natural gas fuel was connected to a water-cycled dynamometer equipped with automated data acquisition for engine performance tests.

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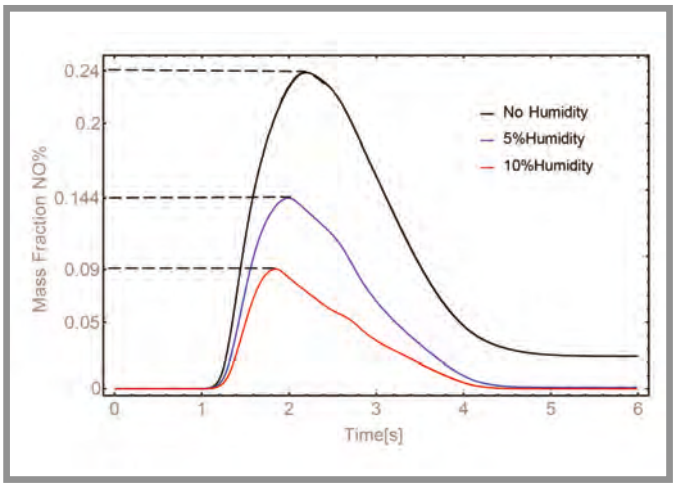

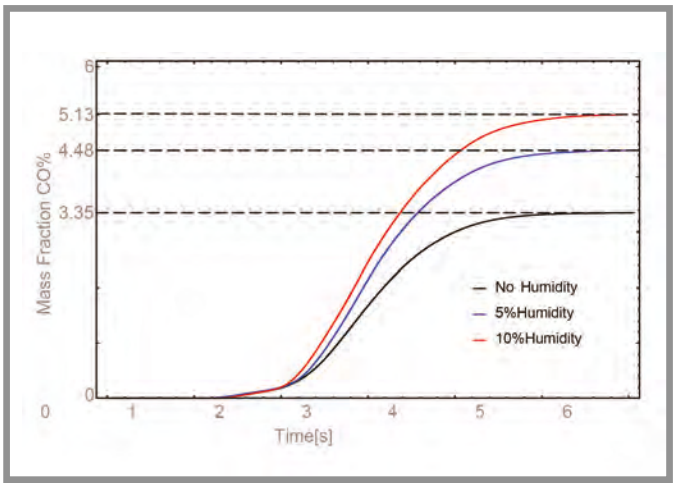

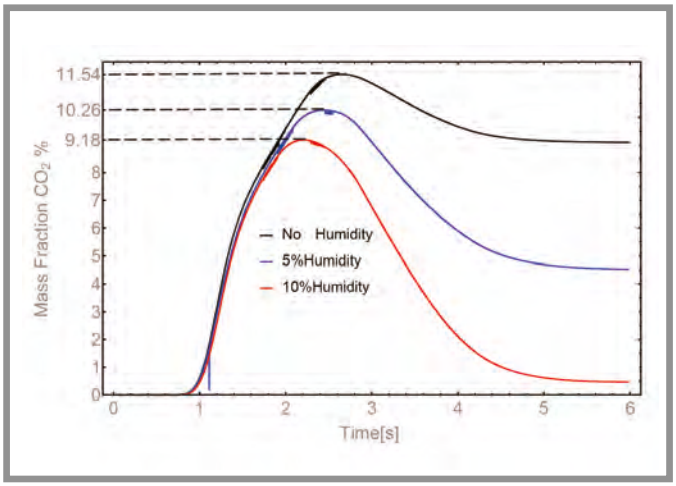

Percent variation of NO_X, CO, and CO_2 for the three cases studies

WHAT DID WE DO?

Caltrans, in partnership with the METRANS Transportation Center, quantified the effect of a humid air system on NO_X and particulate matter emissions of a compressed natural gas engine using simulations for both dry and humid air intake, ranging from 5% to 30% relative humidity. The researchers also experimented on a General Motors inline four-cylinder, naturally aspirated engine with a maximum rated horsepower of 50.8 for natural gas fuel. The engine was connected to a water-cycled dynamometer. The tests applied four different loading conditions, ranging from 5–37.5 horsepower, and three humidity levels, starting at the ambient humidity of 30% and then increasing the level to 45% and 60% relative humidity.

WHAT WAS THE OUTCOME?

The numerical results showed a 40% reduction in NO_X emissions at 10% relative humidity when compared to the emissions produced with dry intake air. At 15% and 30% relative humidity levels, emissions were reduced by 65% and 93%, respectively. The engine tests confirmed that for each 15% increase in relative humidity, the NO_X emissions dropped approximately 10%. However, at low horsepower loads, the increased humidity significantly increased exhaust particulate matter, but increasing the horsepower decreased particulates. At 37.5 horsepower, the ratios of particulate matter emitted at 45% and 60% relative humidity were near 2.0.

WHAT IS THE BENEFIT?

A humid air system could substantially reduce NO_X emissions, and at high horsepower, it could bring a compressed natural gas engine close to a zero-emission vehicle. This system has the potential to reduce NO_X emissions without increasing particulate matter emissions when applied to heavy-duty natural gas engines used for freight and mostly operating at high loading conditions.

LEARN MORE

To view the complete report:
www.metrans.org/sites/default/files/research-project/METRANS%2016-Final%20Report-Rahai-CSULB-for%20website-15-01.pdf

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Research Results

Improving Multimodal Transportation Services for California's Border Communities

Multi-agency coordination is needed to bring about better, faster, and more enduring mobility improvements in the border region

Planning/ Policy/ Programming

MARCH 2018

Project Title:
Untapped Opportunities: Assessment of Organizational Strategies to Improve Border Coordination in California at the U.S. and Mexico Border

Task Number: 2850

Start Date: February 1, 2015

Completion Date: September 30, 2016

Product Category: New or improved decision support tool

Task Manager:
Christine Azevedo
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WHAT WAS THE NEED?

In 2014, California's six land ports of entry on the border with Mexico accounted for 47 million northbound trips and $55 billion in trade from freight crossing in both directions. Growing demand at these border crossings, coupled with heightened security measures and constrained processes, has resulted in increased wait times and congestion on local roads. To address the need for a better-integrated border transportation system that reduces impacts on local communities, Caltrans launched the California Integrated Border Approach Strategy in 2013. The strategy requires strong inter-agency coordination and collaboration, which currently is hampered by issues common among metropolitan areas, including insufficient funding, divergent planning and programming processes, and differing agency mandates and priorities. The complexity of these challenges is exacerbated by the bi-national nature of border issues and the fact that no single agency nor the border communities themselves have exclusive authority to make decisions and implement change to improve conditions, and there is no formalized, collaborative strategies to implement projects that go beyond the mandate of individual agencies. The California border region needs an effective multi-institutional mechanism capable to serve as the lead coordinating entity for strategic planning, project delivery, and funding partnerships to address regional mobility.

WHAT WAS OUR GOAL?

The goal was to improve transportation services and reduce impacts of transportation-related activities on border communities by identifying strategies and coordination mechanisms that can increase funding and improve project delivery and regional mobility.

Caltrans

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WHAT DID WE DO?

Caltrans, in partnership with the University of California Center on Economic Competitiveness in Transportation (UCCONNECT), examined the mobility conditions at each California border community abutting a port of entry and the adjacent planning and agency landscape to identify the strengths, weaknesses, opportunities, and challenges facing the border region and to assess the feasibility to develop multi-agency coordination mechanisms that foster strategic planning, project delivery, and funding partnerships to meet the region's mobility and travel needs.

WHAT WAS THE OUTCOME?

Most northbound passenger trips crossing the border are for shopping, work, visiting friends and family, or medical purposes. In addition, thousands of U.S. legal residents live in Mexico and cross the border daily for these same purposes. While this concentrated traffic at the border is an economic generator for the region, it also adversely affects communities through traffic-generated air and noise pollution, declining traffic safety, congestion, and community disruption. Traffic congestion at the ports of entry often spills into surrounding California community roads, and vehicle idling during long waits at the border degrade air quality.

The study proposed several strategies and mechanisms for improving transportation conditions by sharing resources, expanding funding options, increasing coordination, and forming new institutional arrangements to deliver projects more resourcefully. To promote project success, the researchers developed a method for stakeholders to rank their preferences and also assessed the legislative status of the various strategies and institutional arrangements to determine the degree of implementation feasibility or the need for legislative action.

WHAT IS THE BENEFIT?

This research provides a framework to increase agency coordination and cooperation to improve governance and project delivery for the border region. Addressing the transportation and mobility needs surrounding the ports of entry is crucial for the region's economic prosperity and quality of life. Congestion and delays increase transport costs, fuel use, and emissions, which in turn have harmful effects on California and regional competitiveness, local community development opportunities, and public health.

LEARN MORE

To view the complete report:
www.ucconnect.berkeley.edu/sites/default/files/Border%20Study.pdf

Port of Entry	Crossing Type	Average Daily Trips	Share of Average Daily Trips	Pedestrian Average Wait Time	Private Car Average Wait Time	Freight Average Wait Time
San Ysidro	Passenger only	54,599	43%	44	91	N/A
Otay Mesa–Mesa de Otay	Passenger, Commercial	30,624	24%	22	50	39
Tecate-Tecate	Passenger, Commercial	4,407	3%	4	32	8
Calexico-Mexicali	Passenger only	23,668	18%	17	55	N/A
Calexico East–Mexicali II	Passenger, Commercial	11,064	9%	0	50	31
Andrade–Los Algodones	Passenger only	3,434	3%	4	24	N/A

Average number of daily northbound trips at the California-Mexico ports of entry and the reported wait times in minutes in 2014, according to the Border Master Plan

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Research Results

Effect of Affordable-Housing Policies on Vehicle Miles Traveled

Do current housing incentive programs promote access to transit and jobs?

Planning/ Policy/ Programming

APRIL 2018

Project Title:
The Effect That State and Federal Housing Policies Have on Vehicle Miles of Travel

Task Number: 2976

Start Date: October 1, 2015

Completion Date: September 30, 2016

Product Category: New or improved policy, rule, or regulation

Task Manager:
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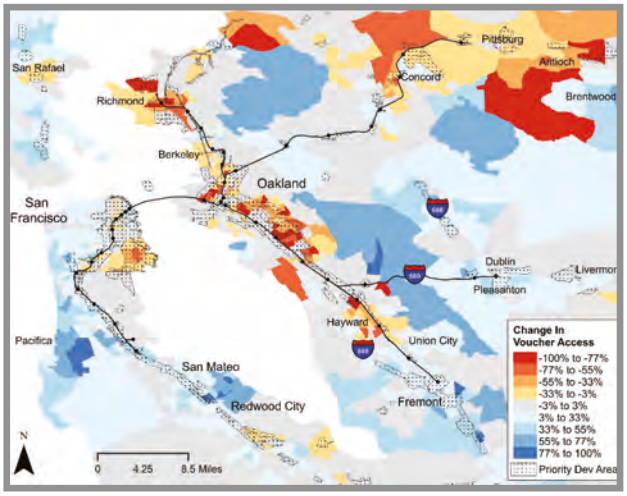
WHAT WAS THE NEED?

Integrating housing and transportation planning is a critical component of addressing emissions from the transportation sector over the long term. Spatial imbalances between the locations of jobs and housing contribute to longer commute times and commute challenges. California's Senate Bill 375 tasks metropolitan planning organizations with reducing regional per-capita greenhouse gas (GHG) emissions through changes in land use and transportation planning. A key mechanism for achieving these reductions is by promoting the construction of infill housing and transit-oriented developments (TOD) to increase the proximity and accessibility to jobs and thereby reduce vehicle miles traveled (VMT). However, jurisdictions interested in increasing density in transit-rich areas face an array of state and federal policies around housing tax credits and vouchers that act in opposition to the goals of SB 375. Supply-side housing policies tend to promote development in areas with lower employment and transit access, requiring residents to commute long distances for work. Similarly, demand-side programs, like Section 8 housing vouchers, might be concentrating low-income households in job- and transit-poor areas. This research evaluated supply and demand incentives for affordable housing and examined how these incentives can be used to help ensure that low-income families have access to transit and employment.

WHAT WAS OUR GOAL?

The goal was to examine the ability of existing and proposed affordable housing policies to align with California's sustainable transportation goals and lower VMT.



Shifting maximum voucher payouts to the ZIP code level rather than the greater metropolitan area dramatically improves voucher holders' access to jobs-rich neighborhoods, potentially reducing VMT.

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Effect of Affordable-Housing Policies on Vehicle Miles Traveled

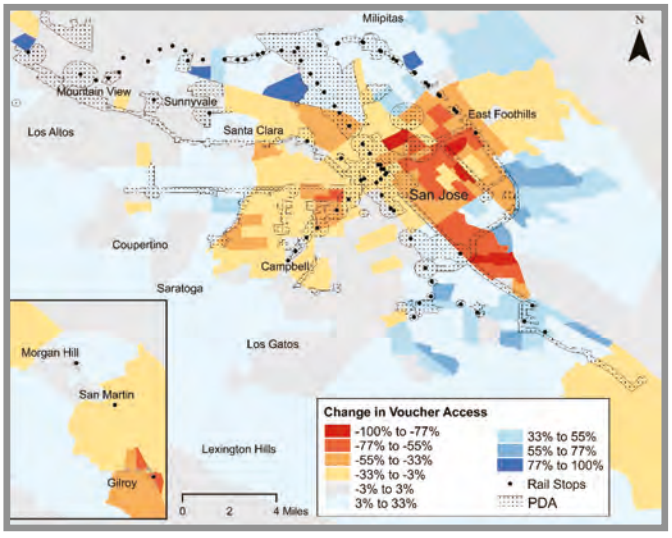
Research Results

WHAT DID WE DO?

Caltrans, in partnership with the National Center for Sustainable Transportation, evaluated how successful current incentives are at placing affordable housing near transit and quantified the cost on a per-unit or per-voucher basis of aligning state and federal housing policies with VMT-reduction goals. The researchers compiled a database of affordable housing units produced in the San Diego and the Sacramento metropolitan regions (a database for the San Francisco Bay Area already existed). A supply-side analysis examined how each funding source performs in financing housing units in communities with different socioeconomic and accessibility characteristics. For the demand-side analysis, the researchers reviewed the Section 8 program's effectiveness in each region of placing voucher recipients in jobs-accessible and transit-rich communities and then produced alternative Section 8 policy scenarios for improving accessibility. They also analyzed whether California's emphasis on promoting affordable housing in transit- and jobs-rich neighborhoods is increasing the cost of development.

WHAT WAS THE OUTCOME?

The results show that changing to "small area" fair market rents (FMR) that are determined by ZIP code improves voucher holders' access to jobs-rich neighborhoods. This benefit comes at the cost of nearly eliminating voucher accessibility in neighborhoods that are currently accessible. The modeling results indicate that affordable housing near transit stops is not significantly more expensive, but costs do increase slightly for projects in jobs-rich neighborhoods. Participation in the state's TOD housing program does not significantly impact costs.



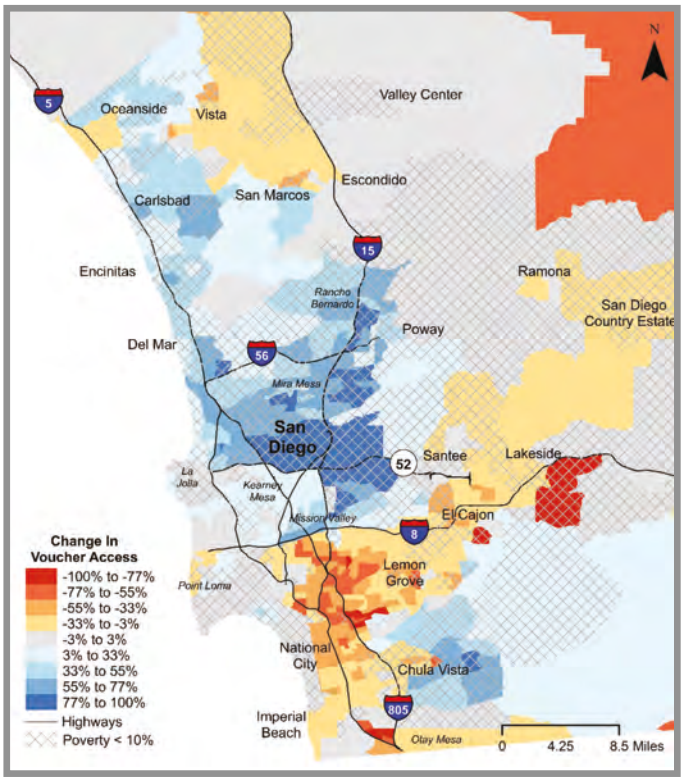
Percentage point changes in voucher accessibility when shifting from a market area FMR to a ZIP code FMR in the Santa Clara–San Jose HUD area

WHAT IS THE BENEFIT?

The results of the research serve as a guide for future reforms to state and federal housing policies aimed at bringing them in line with the goals of SB 375 and other major smart-growth legislation. This research also helps identify the spatial attributes of affordable housing placement and the relationship between affordable housing and available jobs.

LEARN MORE

To view the complete report:
https://ncst.ucdavis.edu/wp-content/uploads/2015/09/DEC3.FINAL_.Caltrans-ReportV3.pdf



In the San Diego HUD market area, voucher accessibility declines dramatically in high-poverty neighborhoods when using a ZIP code FMR.

DRISI

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Research Results

Location Patterns of Warehousing and Distribution Facilities in California

The location of WD activities affects freight demand, statewide transportation planning, land use, and emissions

Planning/ Policy/ Programming

JANUARY 2018

Project Title:
Spatial Dynamics of Warehousing and Distribution in California
and
Warehousing and Distribution Center Facilities in Southern California: The Use of the Commodity Flow Survey Microdata to Identify Logistics Sprawl and Freight Generation Patterns

Task Number: 2640 and 2975

Start Date: October 20, 2015

Report Date: March 31, 2017

Product Category: New or improved technical standard, plan, or specification

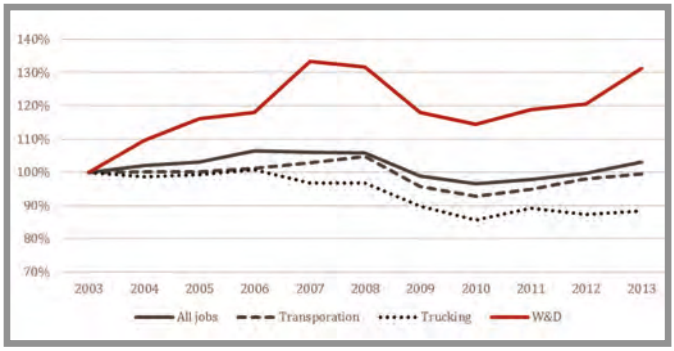
Task Manager:
Patrick Tyner
Associate Transportation Planner
patrick.tyner@dot.ca.gov

WHAT WAS THE NEED?

California's robust and dynamic economy, together with its role as an international trade gateway, generates large volumes of freight. Warehouse and distribution (WD) centers are fundamental to goods movements, and this sector has grown rapidly in recent years, with modern distribution facilities exceeding 500,000 square feet. Their location and activities influence the state's transportation system, environmental and economic well being, and land-use patterns. Changing supply chain and distribution practices and an expanding on-demand economy affect the spatial patterns of WD activities. If location patterns shift, their associated truck travel requirements also shift. One of the studies focused on the impact to Southern California due to the huge amount of cargo moved internally in the region—in 2014, Southern California had 1.2 billion square feet of WD centers, cold storage facilities, and truck terminals, accounting for almost 85% of the internal truck traffic. As express and rush deliveries become the norm, will WD logistics change to accommodate? Understanding the how, where, and why of these trends is essential for metropolitan and statewide planning and contribute to efforts to implement the California Sustainable Freight Action Plan.

WHAT WAS OUR GOAL?

The goal was to analyze the location patterns of warehousing and distribution facilities in California to assess future needs, land-use changes, and possible increases in vehicle miles traveled and the associated impacts.



Trends in the relative job growth of the entire economy and sub-sectors of transportation in California

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Location Patterns of Warehousing and Distribution Facilities in California

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the METRANS Transportation Center, analyzed the WD trends from 2003–13 using Zip Code Business Patterns data for changes in the number of facilities, locations, the extent of geographic clustering, and spatial shifts in the context of population density and employment. The researchers examined factors associated with WD location trends to forecast future transportation requirements, including rent and location constraints, access to major import and export nodes, transport facilities, demand for larger facilities, and changes in the structure of supply chains. In an associated task, National Center for Sustainable Transportation researchers analyzed the concentration of WD centers in five Southern California counties between 1998 and 2014 to identify the various aspects that contribute to the location of facilities in specific areas, such as transport costs and on-demand delivery, and how the centers affect surrounding populations, land use, and environmental conditions.

WHAT WAS THE OUTCOME?

Both studies confirmed that warehouse location patterns have remained stable over the 2003–13 decade and that location is largely a function of population and employment distribution. WD activity is concentrated in a few large metropolitan areas because they are the trade hubs and have large and diverse labor pools, numerous linked industries, and a rich supply of transport facilities. These resources would be difficult to relocate or replicate elsewhere. However, in the Los Angeles and San Francisco areas, some WD facilities are moving away from hubs and decentralizing in response to land prices, possible development constraints, and congestion. WD centers in less-populated areas will continue to cluster around high-access nodes of the highway network. Yet as the on-demand economy grows, more facilities might be placed in dense areas to shorten delivery times. For example, between 2012 and 2016, Amazon established about 21 facilities in Los Angeles and Orange counties to fulfill orders. During this period, the average distance from a facility to the Los Angeles central business district dropped from 56.52 miles to 33.9 miles.

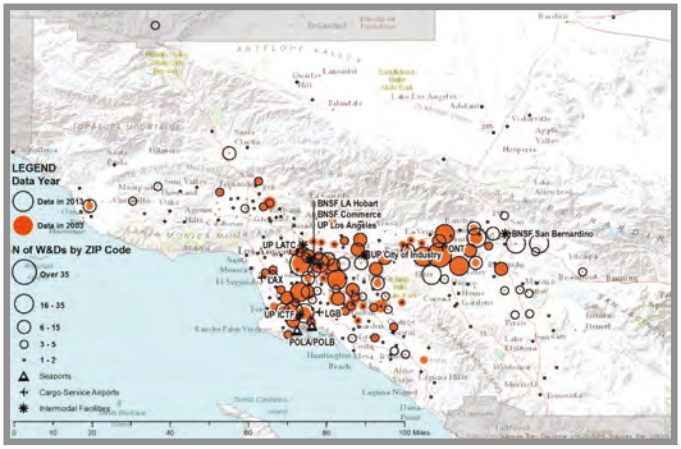
WHAT IS THE BENEFIT?

WD centers are major truck traffic generators. Understanding the freight patterns of these facilities helps visualize future trends, plan and develop appropriate measures to support an efficient freight transportation system and healthy economy, achieve sustainable goods movement, and address the impacts generated by their operations.

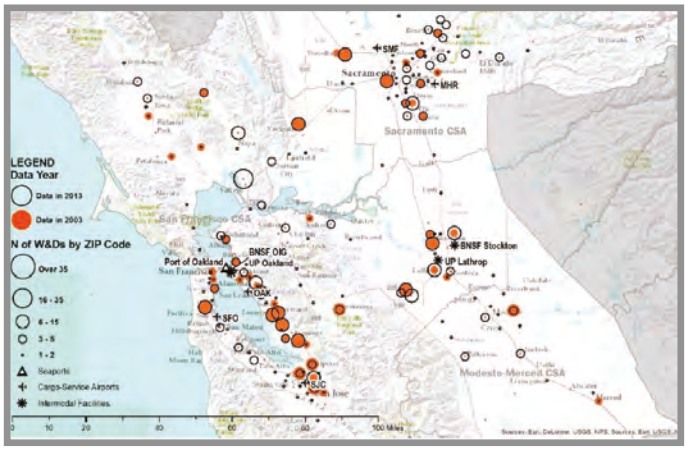
LEARN MORE

To view the complete reports:
www.dot.ca.gov/research/researchreports/reports/2017/CA17-2640_FinalReport.pdf

https://ncst.ucdavis.edu/wp-content/uploads/2015/08/NCST-Caltrans-Jaller-Warehouse-and-Distribution-Logistics-Sprawl-FINAL-July-19-2017.pdf



Distribution of WDs in 2003 and 2013 in Los Angeles



Distribution of WDs in 2003 and 2013 in San Francisco, Sacramento, and Modesto

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Research Results

Industrially Zoned Land in the San Francisco Bay Area: When Demand Outweighs Supply

Preserving industrially zoned land to improve regional goods movement and reduce greenhouse gas emissions

Planning/ Policy/ Programming

MARCH 2018

Project Title:
Industrial Land and Jobs Study for the San Francisco Bay Area

Task Number: 2792

Start Date: January 1, 2015

Completion Date: December 31, 2016

Product Category: New or improved business practice, procedure, or process

Task Manager:
Patrick Tyner
Associate Transportation Planner
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WHAT WAS THE NEED?

Industrial land is zoned to accommodate economic activity around the production, distribution, repair, and storage of goods. The location of industrial businesses and the related patterns of goods movement affect the region's ability to compete globally, provide living-wage jobs to residents, and meet greenhouse gas reduction targets. The nine-county San Francisco Bay Area region has nearly 98,000 acres of industrially zoned land. As of the late 2000s, 38% of the industrial land in some Bay Area sub-regions was already planned for office, residential, or mixed uses. Although demand from industrial businesses is steady or growing, the amount of warehouse and manufacturing space in central areas is declining, and the supply will be insufficient to meet demand by 2035, causing many production, distribution, and repair (PDR) businesses to shift their location to the region's periphery or adjacent lower-cost regions, increasing vehicle miles traveled and the subsequent emissions. This research compliments the Metropolitan Transportation Committee's 2015 *San Francisco Bay Area Goods Movement Plan*, which identifies the need for a goods movement strategy that supports global competitiveness, smarter delivery systems, and a modernized infrastructure via public-private partnerships that invest particularly in rail infrastructure and the Port of Oakland.

WHAT WAS OUR GOAL?

The goal was to analyze the demand for and supply of industrially zoned land in the San Francisco Bay Area to determine a strategy for preserving land to improve regional goods movement and reduce GHG emissions.

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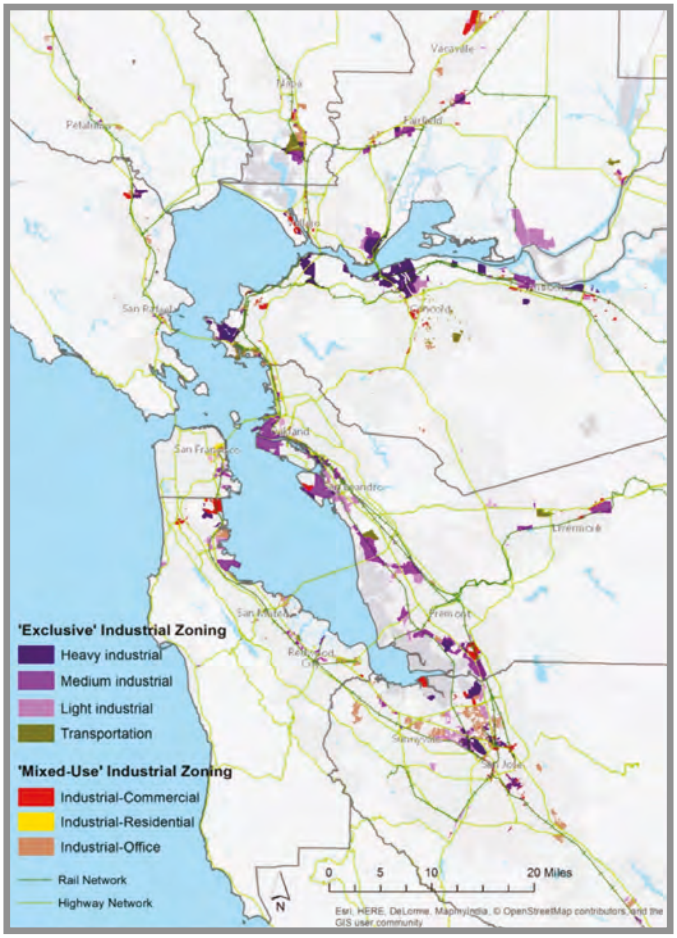
Industrially Zoned Land in the San Francisco Bay Area: When Demand Outweighs Supply

WHAT DID WE DO?

Caltrans, in partnership with the University of California Transportation Center, assessed Bay Area businesses' needs for industrial land now and in the future in terms of location, building space, and goods movement and determined the region's current supply of industrially zoned land. The researchers identified areas at risk for conversion based on demand from more profitable uses, obsolescence of industries, residential developments arising nearby, and other causes and analyzed the potential economic and transportation impacts as industrial land disappears. The study also examined the types of zoning that are most effective at preserving industrial land and its businesses.



Industrial land by zoning classification for the inner Bay Area

WHAT WAS THE OUTCOME?

Overall, the analysis suggests that the conversion of industrial land is proceeding at a slow and steady pace that is likely to accelerate in coming years due to the visions put forward in cities' general plans. By 2040, shortages of industrial land are likely to occur in the South and East Bay, with surpluses remaining in the North Bay. Several considerations can guide city decision-making about where to retain industrial land and where to convert it. This study developed criteria in terms of transportation, economy, equity, zoning, environment, and location that could enter into the decision and contribute to the process of designating priority production areas.

WHAT IS THE BENEFIT?

The location of industrially zoned land and businesses is closely linked to the availability of transportation infrastructure and has implications for vehicle miles traveled and a region's economic competitiveness. Documenting the location patterns in the greater Bay Area region also provides insights into California's other metropolitan regions. Understanding how to optimize the location of industrially zoned lands helps transportation and land-use planners determine more efficient transportation investments.

LEARN MORE

To view the complete report:
www.dot.ca.gov/newtech/researchreports/reports/2017/CA17-2792_FinalReport.pdf

To view the MTC San Francisco Bay Area Goods Movement Plan executive summary:
https://mtc.ca.gov/sites/default/files/RGM_Exec_Summary.pdf

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Research Results

Fuel, Charge, Renew: Installing EV Stations That Produce and Store Energy at Rest Stops

Renewable fueling and charging systems at highway rest areas can benefit the transportation and utility sectors and promote electric vehicle adoption

Planning/ Policy/ Programming

FEBRUARY 2018

Project Title:
Deployment of Sustainable Fueling/ Charging Systems at California Highway Safety Roadside Rest Areas

Task Number: 2979

Start Date: October 1, 2015

Report Date: September 30, 2016

Product Category:
New or improved policy, rule, or regulation

Task Manager:
Scott Williams
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k.scott.williams@dot.ca.gov

WHAT WAS THE NEED?

Plug-in electric vehicles (PEV) and hydrogen fuel cell electric vehicles (FCEV) play a key role in moving away from fossil fuel and meeting California's 2050 greenhouse gas (GHG) emission goals. To encourage adoption, more hydrogen fueling and fast-charging stations are needed in suburban areas and along interstate and state highways so that drivers can travel between communities and long distances with confidence. In tandem, the electric utility sector is increasing the amount of energy generated from renewable sources, such as wind and solar, but using renewable energy resources efficiently relies on storing energy when and where it is produced and distributing it when and where it is needed. Currently, most hydrogen fuel is produced in centralized facilities and delivered to stations, and most PEV stations are separately located, slow charging, and use electricity from the grid, typically not renewable energy. Integrating a hydrogen fueling station, fast-charging station, renewable electricity generation, and energy storage on a single site can lower infrastructure costs and accelerate the use of renewable energy in the California transportation sector. As the owner of the state's Safety Roadside Rest Areas (SRRA), Caltrans is exploring placing integrated stations at existing SRRAs because they are often near an electricity grid, well situated along highly traveled highways, and have the acreage to accommodate the facility and solar panels.

WHAT WAS OUR GOAL?

The goal was to examine deploying fueling and charging stations at existing California roadside rest areas that produce, use, and store renewable energy.

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Fuel, Charge, Renew: Installing EV Stations That Produce and Store Energy at Rest Stops

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the National Center for Sustainable Transportation, compared the short- and long-term costs and efficiencies of integrating fueling and charging stations that use local renewable energy on a single site to the current configuration of separate PEV and FCEV stations using nonlocal energy. The integrated stations function as both vehicle fueling-charging stations and distributed grid energy storage to benefit both the transportation and utility sectors. For energy storage, one system used compressed hydrogen and the other used batteries. Renewable power sources, such as solar or wind, charge PEVs directly. Fueling hydrogen is produced from electrolysis of water using excess renewable electricity. The hydrogen refuels FCEVs as needed or is stored for later use. Hydrogen can also be converted back to electricity for charging vehicles or to provide peak power to the grid. Excess renewable electricity is stored in batteries for later use, such as PEV charging, hydrogen production, or fed to the grid.

WHAT WAS THE OUTCOME?

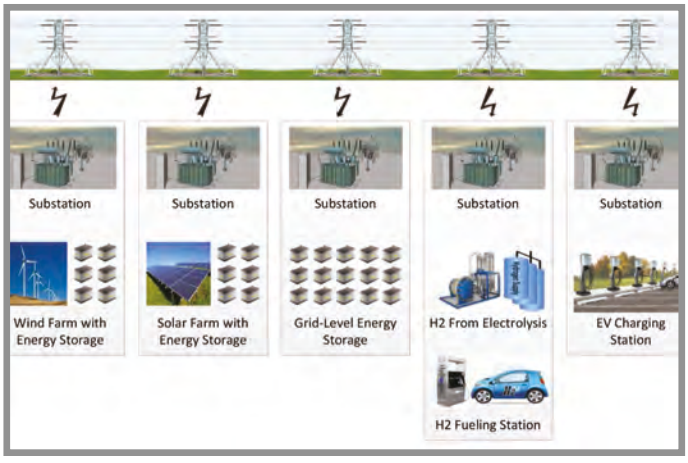
The integrated stations are more energy efficient and economically attractive than the distributed stations in terms of hydrogen fuel cost, but there was minimal difference in the cost of PEV charging based on current electricity rate schedules. Initially, distributed stations require less capital investment, but the energy costs are more sensitive to utility electricity pricing. As the market for FCEVs and PEVs develops, it is anticipated that the stations would have relatively low usage, and the integrated stations could function as distributed power generation and energy storage for the grid. Although current federal law prohibits commercial activities at SRRAs, if the fueling-charging stations are free of charge, they are not considered commercial.

WHAT IS THE BENEFIT?

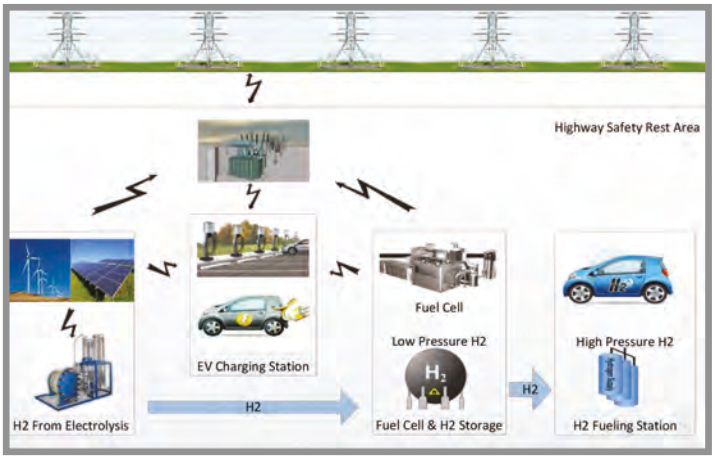
Integrating a hydrogen fueling station, DC fast-charging station, renewable power sources, and energy storage at existing SRRAs lowers the infrastructure costs associated with building multiple, separate sites, makes efficient use of land and natural resources, and feeds excess energy to the grid, benefiting both the transportation and utility sectors.

LEARN MORE

To view the complete report:
https://ncst.ucdavis.edu/wp-content/uploads/2015/09/NCST-Caltrans-Project-Report-Task-TO-016-ver4-Jan-23-2.pdf



Current setup of renewable fueling and charging stations, renewable power sources, and energy storage on different sites



Integrated H2 fueling and DC fast-charging station using hydrogen for energy storage at a SRRA

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Caltrans Division of Research, Innovation and System Information

Research Results

Incorporating Air Pollution Exposure in Bike Route Planning

Interactive app shows traffic-related air pollution for bike routes

Planning/ Policy/ Programming

MARCH 2018

Project Title:
Biking in Fresh Air: Consideration of Exposure to Traffic-Related Air Pollution in Bicycle Route Planning

Task Number: 2980

Start Date: December 23, 2015

Report Date: January 31, 2017

Product Category: New decision support tool, simulation, model, or algorithm

Task Manager:
Scott Williams
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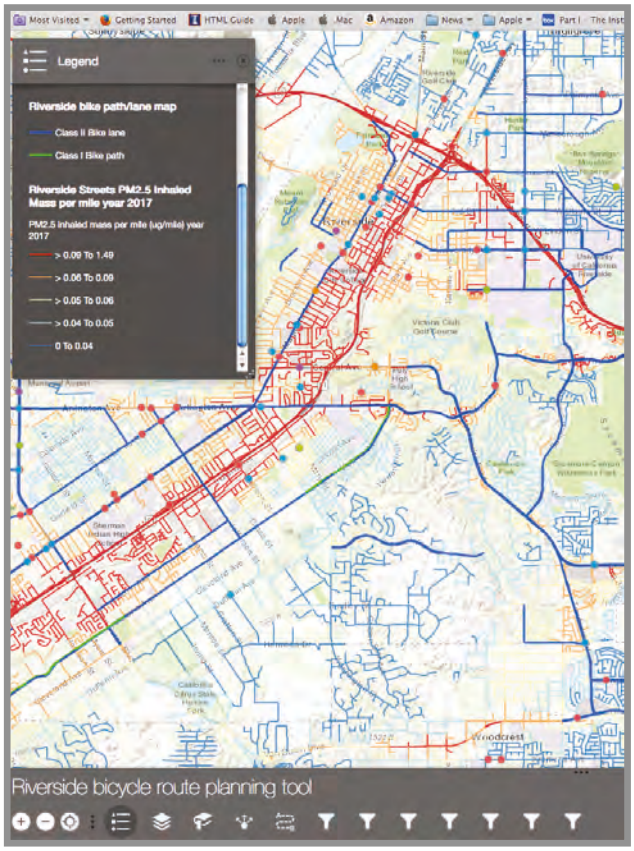
WHAT WAS THE NEED?

Local, regional, and state agencies in California are increasing bikeways to promote sustainable and multimodal transportation. In most areas, bike routes are created by adding a lane to existing rights-of-way, taking into account the roadway infrastructure, built environment, vehicular traffic volume, and safety. However, harmful vehicular exhaust is rarely considered in route planning, despite bicyclists being directly exposed and intake exacerbated by increased breathing rate. Although several factors contribute to the level of air pollution, measuring traffic activity as part of route planning to help reduce exposure to vehicle emissions improves the biking experience and promotes it as an alternative form of transportation.

WHAT WAS OUR GOAL?

The goal was to develop a method to assess exposure to traffic-related air pollution and to incorporate it as a consideration when planning bike routes.



Bicycle route planning support tool

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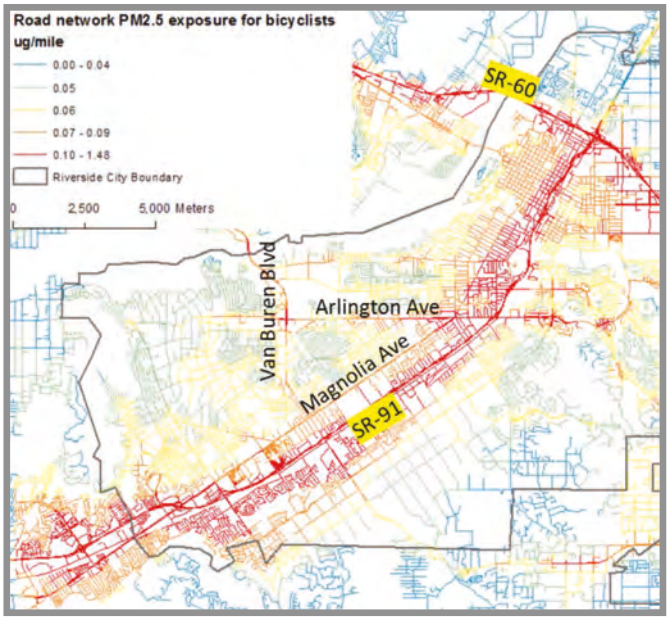
Incorporating Air Pollution Exposure in Bike Route Planning

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Riverside Center for Environmental Research and Technology, created a streamlined process for estimating the level of near-road primary fine particle ($PM_{2.5}$) concentrations by modeling traffic activity, traffic emission, and air pollutant dispersion over a year period in the city of Riverside based on 36 hourly average meteorological conditions during morning, midday, and afternoon. The researchers then weighted the 36 sets of estimated $PM_{2.5}$ concentration values by the level of bicycle activity for the different time periods and months of the year derived from the GPS dataset in the 2010–12 California Household Travel Survey and produced a city map showing the estimated level of exposure to $PM_{2.5}$ for each roadway link. Then, taking $PM_{2.5}$ exposure into account, alternative routes along the same travel corridor were compared, factoring in their connection to land uses, posted speed limit, number of lanes, road shoulder width, traffic volume, terrain and road grade, roadside parking, presence of barriers, and number of intersections. Because some of these attributes are qualitative, the researchers ranked the alternative routes by applying an equal, as well as different, weight of importance for each characteristic. The comparison results revealed that the best alternative route depends on whether exposure to traffic-related air pollution is taken into consideration and how important this factor is relative to others.



Traffic-related $PM_{2.5}$ exposure per mile for bicyclists on the Riverside road network

WHAT WAS THE OUTCOME?

The researchers developed an interactive route planning tool to enable planners and engineers to compare traffic-related air pollution as well as other attributes when designing bicycle facilities. Planners and engineers can change the order and weight of importance for the different contributing factors for a specific corridor or area. Bicyclists can also query the tool for directions along existing routes based on a variety of criteria, including exposure to air pollution and historical crash data.

WHAT IS THE BENEFIT?

Active transportation modes, such as walking and biking, are key elements of sustainable transportation systems. However, exposure to traffic-related emissions, which has been proven to contribute to health problems, such as lung and heart diseases, makes biking less appealing to travelers. This new route planning tool incorporates exhaust data to help decision-makers design healthier and safer routes to improve the biking experience and promote biking as an alternative form of transportation.

LEARN MORE

To view the complete report:
https://ncst.ucdavis.edu/wp-content/uploads/2016/10/NCST-UCR-Biking-Fresh-Air-Final-April-2017-2.pdf

To view the bicycle route planning tool:
http://arcg.is/29CESgp

Street image of the alternative route segments between UC Riverside and downtown Riverside

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Caltrans Division of Research, Innovation and System Information

Research Results

Planning/
Policy/
amming

Reducing Greenhouse Gas Emissions from Urban Transit

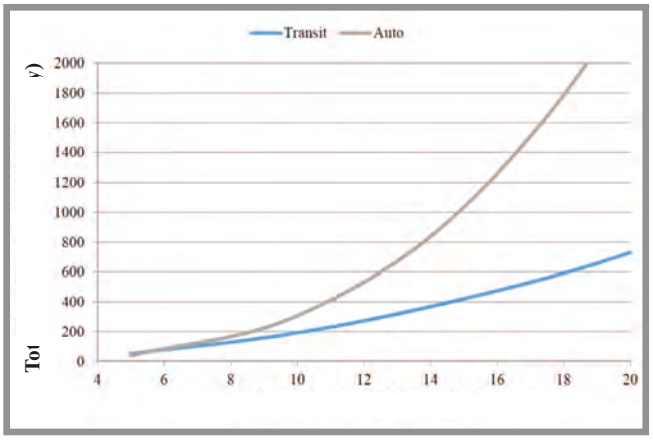
Optimally redesigning current transit systems can reduce GHG emissions without sacrificing level of service

WHAT WAS THE NEED?

Transportation produces about 28% of the total GHG emissions in the United States. Shifting automobile trips to public transit systems can lower the percentage, but public transit is also a contributor. To reduce the transit sector's emissions, efforts have focused on replacing the fleet with cleaner vehicles. To further decrease emissions, previous studies have advocated reducing transit's level of service (LOS)—providing less frequent service and decreasing the areas of coverage. However, this scenario does not consider elastic transit demand and the unintended consequence that by reducing LOS, travelers switch from relatively clean transit to faster but more polluting modes, thereby increasing GHG emissions citywide. Urban transit networks are usually hierarchical, consisting of a trunk service, such as a metro, and feeder transit that provides both local and trunk access. Capital-intensive and large-capacity transit modes are dependent on other transit options that act as feeders. All modes must be considered as part of an integrated system, and that service reductions to one component can affect the entire system. New design and operational approaches that take demand elasticity into account can reduce environmental impacts by optimizing the transit network and encouraging ridership.

WHAT WAS OUR GOAL?

The goal was to investigate methods for urban areas to reduce GHG emissions, taking into account the unintended results of transit demand elasticity and the interdependency of the entire transit network.



As an auto-only city expands in size, the emissions increase dramatically due to the longer average driving distance and larger demand. For a city that runs on transit, emissions also increase as a higher transit frequency is required, but transit generates much lower emissions.

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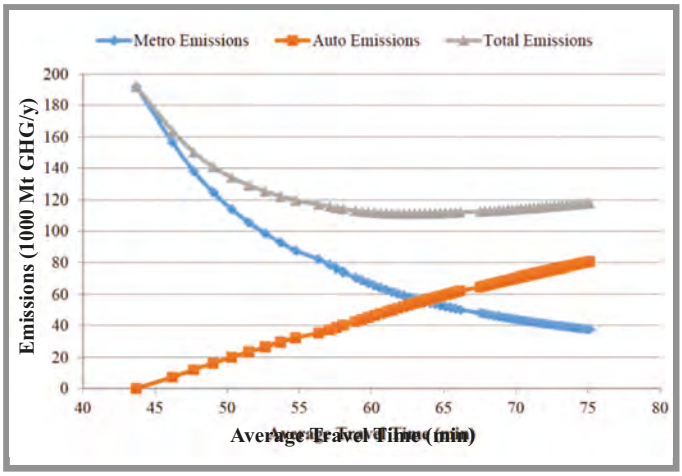
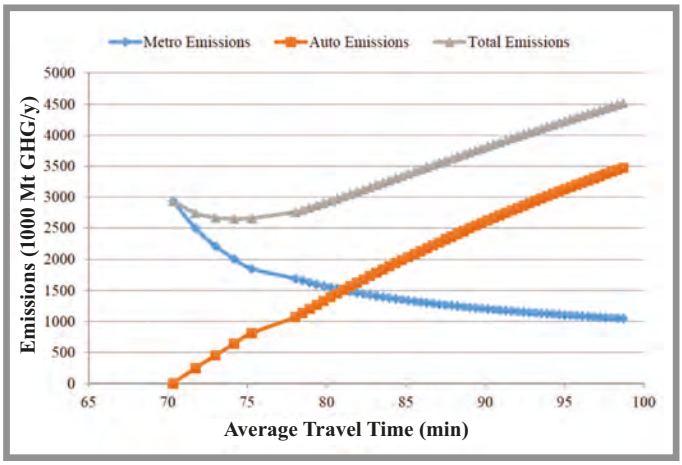
Reducing Greenhouse Gas Emissions from Urban Transit

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Institute of Transportation Studies, analyzed the effect of demand elasticity to allow for the possibility of transit users shifting to automobiles when faced with LOS reductions. The researchers quantified the relationship between GHG emissions and user travel time for cities of varying sizes, demand densities, and elasticities, and for four different trunk technologies: bus, bus rapid transit, light rail transit, and heavy rail transit. For a real-world case study, the methodology was applied to the San Francisco MUNI bus network.





How lowering LOS affects total emissions for small (top) and large (bottom) cities with high demand density. For large cities, as the metro LOS is lowered, more auto emissions are generated because transit users shift to cars and drive longer distances.

WHAT WAS THE OUTCOME?

The analytical model developed incorporates demand elasticity between transit and automobiles, the demand split between transit and walking, and the demand split within the transit system. Transit demand elasticity is a key factor in determining the magnitude of reduction, and the potential for unintended consequences increases with the size of the city. Lowering LOS could cause riders to shift away from transit to lower occupancy vehicles. Hierarchical transit systems with mass transit modes tend to be more cost and emission efficient. However, in small cities, trunk-only bus systems might produce more cost and emissions savings. Imposing an emissions budget on the entire city instead of individual transit agencies is a safer course of action to avoid unintended emission backfire and achieve emissions reductions.

WHAT IS THE BENEFIT?

Quantifying the potential tradeoffs between LOS and emissions can help transit agencies select the trunk transit technology and optimal network attributes to reduce GHG emissions and costs to both transit users and agencies. Because many current transit systems are not optimally designed, it is likely that their GHG emissions can be reduced without sacrificing LOS. An optimal system has a lower spatial availability but a higher temporal availability of bus service. Providing more frequent express bus services can increase ridership and reduce emissions.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2016/CA16-2862_FinalReport.pdf

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Research Results

To What Extent Are Local Governments Supporting Sustainable Mobility?

Cities do not uniformly include land-use strategies in their zoning codes to promote smart growth and reduce vehicle miles traveled

Planning/ Policy/ Programming

APRIL 2018

Project Title:
Tracking Land Use Changes That Support Sustainable Mobility

Task Number: 2973

Start Date: March 1, 2016

Completion Date: April 1, 2017

Product Category: New or improved decision support tool, simulation, model, or algorithm

Task Manager:
Kayo Lao
Associate Transportation Planner
kayo.lao@dot.ca.gov

WHAT WAS THE NEED?

California's 2008 Sustainable Communities and Climate Protection Act (Senate Bill 375) aims to curtail transportation-related greenhouse gas (GHG) emissions by reducing the amount of driving that Californians do to accomplish their daily activities. SB 375 specifically encourages regional land-use planning and development practices that lessen automobile reliance and sprawl. Each of the state's 18 metropolitan planning organizations (MPO) is required to include a sustainable communities strategy (SCS) to reduce driving as part of its four-year regional transportation plan. However, SB 375 explicitly upholds local government authority over land-use decisions, so implementation of an MPO's regional land-use vision depends on the voluntary cooperation of the region's member cities and counties. As California regions are now developing and approving their second round of SCSs under SB 375, to what degree are local governments adopting policies and development decisions that reflect the MPO's regional land-use vision and which factors make individual local governments more likely to cooperate?

WHAT WAS OUR GOAL?

The goal was to investigate to what extent are cities adopting strategies that support the regional land-use visions intended to reduce automobile reliance.

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To What Extent Are Local Governments Supporting Sustainable Mobility?

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the National Center for Sustainable Transportation, surveyed city and county land-use planning and community development directors in 2017 to study the extent to which local governments cooperate with regional land-use planning and the circumstances that drive such collaboration. The researchers invited all 435 cities and 39 counties located within the planning area boundaries of the state's 18 MPOs to participate, of which 180 (38%) responded. The questionnaire asked whether the jurisdiction's zoning code provides for eight strategies associated with concentrating physical development to increase accessibility and reduce automobile reliance: increased building densities; increased heights; development that is infill, mixed-use, or transit-oriented; reduced or eliminated minimum parking requirements; an urban growth boundary; and agricultural land or open-space preservation.

WHAT WAS THE OUTCOME?

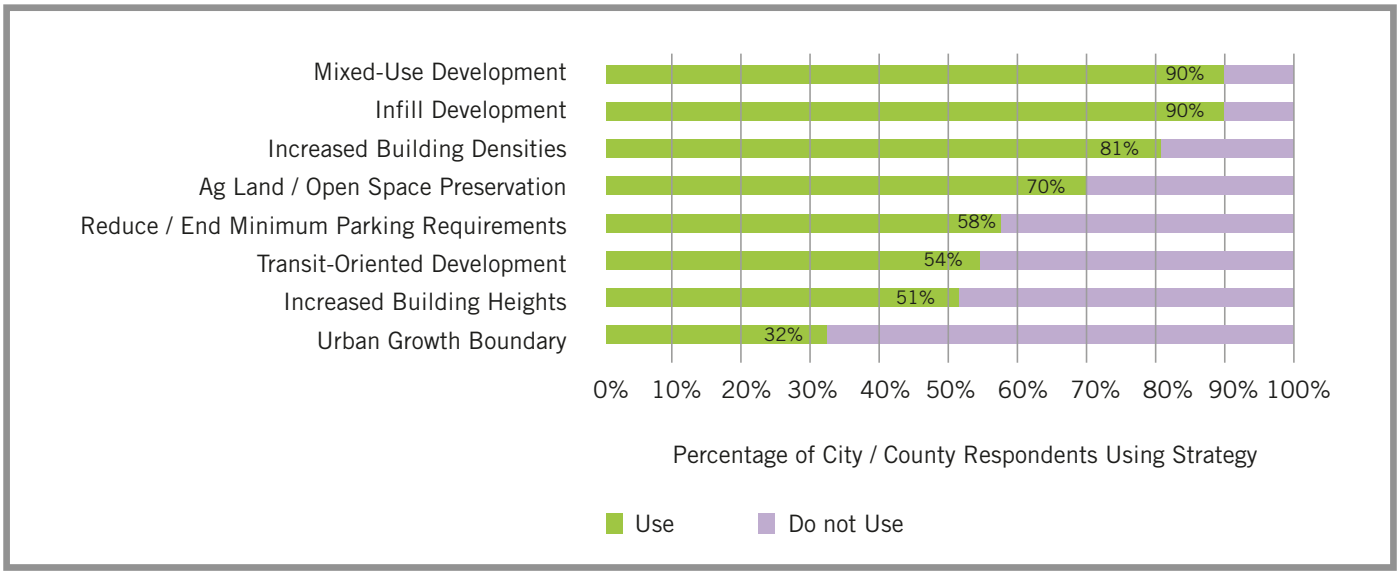
Overall, California cities have not uniformly included land-use strategies in their zoning codes to promote smart growth. Respondents had adopted on average five of the eight key land-use strategies included in the survey. Some cities reported using all eight strategies, while others used none. Local governments that report overall positive awareness of, engagement in, and satisfaction with the regional planning process tend to adopt more SB 375–favorable strategies, and the presence of Green Party voters is also positively correlated.

WHAT IS THE BENEFIT?

Given SB 375's reliance on local governments' own land-use decisions, it is essential to understand how land use in California communities is changing. This project illuminates the extent to which local governments report understanding the SCS and its land-use policy implications, and to which degree they are taking action to support it. The success of the SCS depends on voluntary local government compliance, because the MPOs have no land-use authority. The survey results inform efforts by Caltrans, along with other state, regional, and local agencies, to consider ways to encourage and facilitate implementation of regional SCSs and make transportation planning more comprehensive.

LEARN MORE

To view the complete report:
https://ncst.ucdavis.edu/project/tracking-land-use-changes-that-support-sustainable-mobility



Sustainably-oriented land use strategies in California

DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Using Privately Held Mobility Data for Travel Demand Modeling

A new methodology calibrates discrete choice models with cellular data while preserving privacy to improve travel demand forecasting

Planning/ Policy/ Programming

APRIL 2018

Project Title:
Enabling Demand Modeling from Privately Held Mobility Data

Task Number: 2985

Start Date: May 1, 2016

Completion Date: April 30, 2017

Product Category: New or improved decision support tool, simulation, model, or algorithm

Task Manager:
Scott Williams
Associate Transportation Planner
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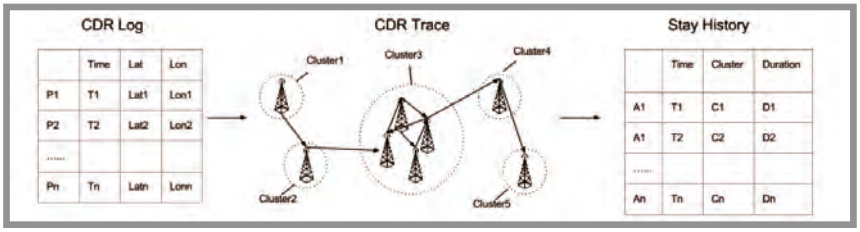
WHAT WAS THE NEED?

New mobility paradigms, such as car-sharing and on-demand transportation, and the proliferation of non-motorized modes, are changing the transportation landscape quicker than the data collected from traditional travel surveys are able to reflect. Travel demand models are an important tool for transportation planning, but tend to be infrequent and expensive to conduct, hindering public agencies to respond to rapidly evolving demand patterns. At the same time, valuable mobility data is locked in private repositories of telecoms and service providers and cannot be easily shared, whether for profit or objectives of public good. In addition to customer privacy and security issues, the lack of business models for data-centric private-public partnerships, immaturity of data marketplaces, and technical bottlenecks have impeded access.

Travel demand modeling techniques can be enhanced by leveraging the passively collected location data generated by mobile devices. For example, in the San Francisco Bay Area, on average, a mobile phone accesses the network every 1.2 minutes, generating records that encode rich information about the spatial and temporal nature of the trip, such as travel speed and proximity to road and transit infrastructure. By developing a method to extract this private-sector data without disclosing sensitive personal information and calibrating it with discrete choice models, the latency inherent in today's demand forecasting can be reduced while also providing broader coverage and more timeliness than current methods.

WHAT WAS OUR GOAL?

The goal was to build an activity-based travel demand model that incorporates choices for location, destination, time, and travel mode from passively collected cell phone data to use for transportation planning.



Call detail records (CDR) data collection

Caltrans provides a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability.

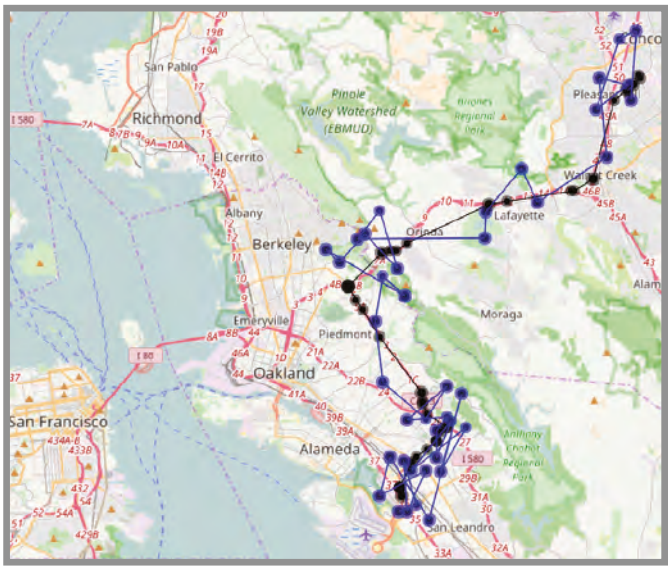
Using Privately Held Mobility Data for Travel Demand Modeling

WHAT DID WE DO?

Caltrans, in partnership with the University of California Center on Economic Competitiveness in Transportation (UCCONNECT), developed and validated a method to calibrate discrete choice models for a range of use cases, including choices in travel mode, destination, and residential location, using cell phone data. The researchers collaborated with AT&T to process the privately held cell phone data within the company's repositories using especially developed plug-in components, making it possible to produce impersonalized modeling parameters from the data without compromising AT&T's customers' privacy rights. The method detects user travel and identifies the travel mode directly from the raw call detail record logs, which include the time and the user's approximate latitude and longitude. Because the trips and travel modes are unlabeled, the call detail records are preprocessed to extract relevant trip attributes and rely on results from external routing databases to provide information on the available travel alternatives for a given trip.

WHAT WAS THE OUTCOME?

Passively collected big data sources can be used to infer a person's mode of travel mode to get to an activity. A discrete choice model based on the inferred travel mode is trained so that the model can be used for transportation planning. The discrete choice model parameters describe and explain how travelers choose the mode from a set of travel mode alternatives to predict which travel modes a traveler will take on future trips.



Each record of raw CDR logs contains the timestamp and the approximate latitude and longitude of events recorded by the data provider.

WHAT IS THE BENEFIT?

Given specific choice and geographic context, transportation planners can model a multitude of travel decisions for longer-term scenarios of evolving demographics and changing accessibility using cellular data without compromising privacy. This project enables new business models that support data flow between stakeholders in private and public sectors, paving the way for broader impacts on the transportation ecosystem. The algorithms drastically reduce the latency and costs of obtaining crucial information for models used in transportation planning practices and speed up policy analysis.

LEARN MORE

To view the complete report:
http://ucconnect.berkeley.edu/sites/default/files/file_uploads/2016-TO-48-65A0529.pdf

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Research Results

LOST in Translation: Are Local Option Sales Taxes Equitable?

The inherent regressivity of collecting sales tax to fund transportation projects can be tempered by the way the money is spent

Planning/ Policy/ Programming

APRIL 2018

Project Title:
The Equity Impacts of California's County Transportation Sales Taxes

Task Number: 2993

Start Date: May 1, 2016

Completion Date: April 30, 2017

Product Category: New or improved decision support tool, simulation, model, or algorithm

Task Manager:
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WHAT WAS THE NEED?

As state and federal fuel tax revenues for transportation continue to decline, financial responsibility has increasingly shifted to local governments. In California, 24 of the 58 counties have Local Option Sales Taxes (LOST) to fund transportation projects. Since first enacted in 1976, 76 LOST measures have appeared on county ballots, 48 of which were approved by voters. While both fuel and sales taxes are considered regressive because lower income households tend to pay a larger share of their income than higher income households, sales tax finance for transportation also means that light users of transportation systems tend to pay more per mile traveled than do heavy users.

Despite their regressive nature, LOSTs for transportation are popular politically. Voters like that the taxes are levied in small increments—often a half-cent or cent per dollar—over a large number of transactions, as well as the list of projects to be funded. And while these measures are often subject to debate when placed on the ballot, concerns over their fairness to low-income and minority communities are rarely addressed. To assess the efficiency, fairness, and political acceptability of continuing to expand the state's reliance on sales taxes for transportation in the future, information is needed to know whether these taxes benefit or harm lower income populations.

WHAT WAS OUR GOAL?

The goal was to understand the impacts of LOSTs and their expenditures across various income groups.

Frequency of words used in all 37 pro and con ballot arguments

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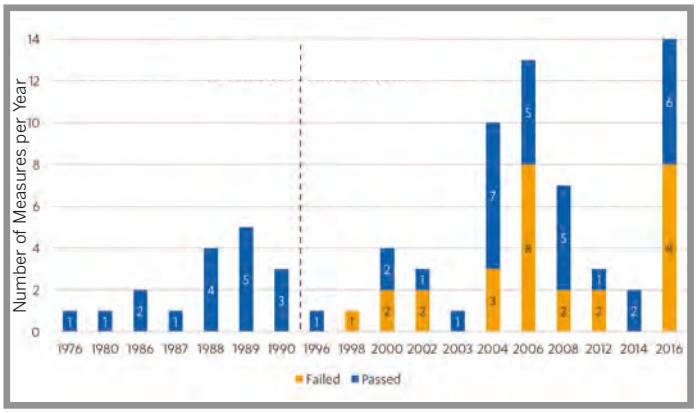
WHAT DID WE DO?

Caltrans, in partnership with the University of California Center on Economic Competitiveness in Transportation (UCCONNECT), analyzed the collection of LOSTs in California between 1976 and 2016 and the expenditure of funds to determine how they affect low-income and minority travelers and communities. The researchers examined the processes by which the LOST expenditure plans were developed, who participated in the formulation of the measures, and who voted for and against them for five case study counties: Fresno, Madera, Orange, Santa Barbara, and Santa Clara. The researchers also reviewed ballot arguments in 37 LOST measures and assessed how types of equity are used in arguments supporting and opposing LOST measures.

WHAT WAS THE OUTCOME?

While equity issues are raised in ballot arguments, they are rarely prominent. Instead, most arguments center on whether the measure's proposed projects will reduce traffic congestion as promised. Some discussions of equity attempt to persuade voters by using statistics and claims about probable policy outcomes. Other ballot arguments take a visceral, rhetorical approach, appealing to the emotions or specific group identities of voters. This duality is most evident in arguments critical of modal funding equity and spending on transit. The regressivity of LOSTs depends not only on who pays them but also on how the revenues are spent. When projects and services are funded that benefit lower income households, LOSTs effectively become more progressive.



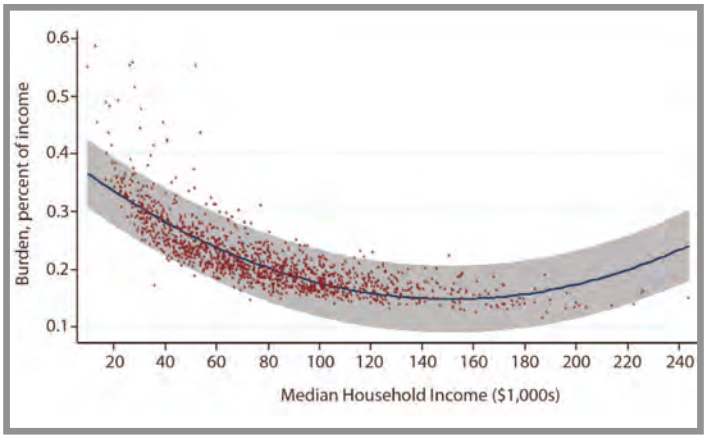
Number of LOST measures in each election, and the number of these measures passed into law by voters

WHAT WAS THE BENEFIT?

California policymakers at all levels of government are seeking ways to increase revenue for transportation programs across the state. This research helps inform future efforts by demonstrating how this increasingly significant source of transportation revenue affects economically disadvantaged and minority populations. When considering other revenue instruments in the years ahead, it is important to address the fairness and equitability of the mechanisms by which transportation revenue is collected and expended.

LEARN MORE:

To view the complete report:
www.its.ucla.edu/wp-content/uploads/sites/6/2017/05/LOST-Report_final.pdf



LOST tax burden in terms of household income

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Research Results

Energy Sector's Effect on State Transportation Systems

Addressing the impacts to state transportation infrastructure due to the expansion of energy production and development

Planning/ Policy/ Programming

MARCH 2018

Project Title:
State Responses to Energy Sector Developments, TPF-5(327)

Task Number: 2847

Start Date: December 1, 2014

Completion Date: August 31, 2016

Product Category: New or improved technical standard, plan, or specification

Task Manager:
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WHAT WAS THE NEED?

New and expanding energy sector developments—oil, natural gas, coal, wind, biofuels, and solar—are occurring in numerous states throughout the country. Hydraulic fracturing (fracking) for crude oil and natural gas is expanding in many states, including California. Along with other states, California is experiencing increased shipments of crude oil by rail and barge, with supply chains serving energy installations in one state often originating in another. California has more than 160,000 oil wells in production, with more being planned, that require truck services over rural and urban routes to move sand, pipes, water, and chemicals for drilling and maintenance.

While states, counties, and communities are realizing economic benefits from these activities, the impacts from energy development on transportation systems are immediate and extensive. Rural roads and bridges are especially vulnerable to the increased volumes of trucks, but additional demands are also being placed on rail, port, and aviation networks. State departments of transportation and other agencies are responding in numerous ways to increased truck traffic, oversized and overweight vehicles, infrastructure deterioration, and safety concerns. Because these issues are shared by numerous states, the Texas Department of Transportation (DOT) formed a pooled fund, of which Caltrans is a participant, to exchange information, experiences, and expertise to address the energy sector impacts on the transportation network.

WHAT WAS OUR GOAL?

The goal was to provide communication and information sharing among member states related to proactive and reactive responses to energy sector developments, including industry engagement, infrastructure management, funding and financing, safety, and planning and forecasting tools.

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WHAT DID WE DO?

Led by the Texas DOT, Caltrans, along with the Louisiana, Montana, North Dakota, Ohio, Pennsylvania, and Washington DOTs, surveyed transportation agencies and conducted state site visits to gather and share information on the methods, tools, and techniques being used to address energy sector development impacts on the transportation system. The California site visit was conducted in Benecia and focused on the Valero Benicia Refinery rail project, which would increase rail facilities to accommodate crude oil delivery. The member state participants met to identify and discuss research needs, technology transfer activities, best practices, and future sponsor-funded projects.

WHAT WAS THE OUTCOME?

The study compiled the member states' best practice initiatives, including forecasting methods for new energy developments and impact areas, rapid response techniques for addressing infrastructure damage, funding and financing mechanisms, and addressing safety concerns. As a result of the various state site visits and workshops, the participating states had overlapping concerns as well as differing responses to energy sector impacts.

- The states differ considerably in their approach and effort to mitigate and pay for infrastructure damage from energy sector developments.
- The states vary on how they define and address impacts from extensive trucking activities upon disadvantaged communities.
- Proposed land use changes around energy developments are significant determinants regarding the expansion of facilities, such as access to and from state highway systems, local road signage and signal timing, and at-grade rail crossings.
- In some locations, oil and gas fracking is introduced so rapidly that governments cannot act quickly enough to develop and implement appropriate mitigation strategies.
- Adequate and appropriate signage in high-activity areas is critical for safety and accessibility.
- Some energy companies are willing to partner with local and state governments to finance infrastructure and safety-related improvements.

WHAT IS THE BENEFIT?

California is an energy-producing state, with some level of activity related to natural gas, oil, biofuel, wind, solar, and nuclear. The state's refineries process approximately 1.6 million barrels of crude oil per day and supply transportation fuel in the state and to neighboring states. By participating in this pooled fund project, Caltrans gained in-depth knowledge of energy sector logistics practices, specifically for the oil industry, and developed greater awareness of energy sector impacts to California's transportation infrastructure.

LEARN MORE

To view the complete report:
www.pooledfund.org/Details/Study/576

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Research Results

Identifying Vulnerable Sub-standard Bridge Columns

Probabilistic seismic damage assessment method helps prioritize retrofitting and repairing sub-standard bridge columns

Seismic

MARCH 2018

Project Title:
Probabilistic Seismic Damage Assessment for Sub-standard Bridge Columns

Task Number: 2756

Start Date: June 1, 2011

Report Date: December 31, 2016

Product Category: New or improved technical standard, plan, or specification

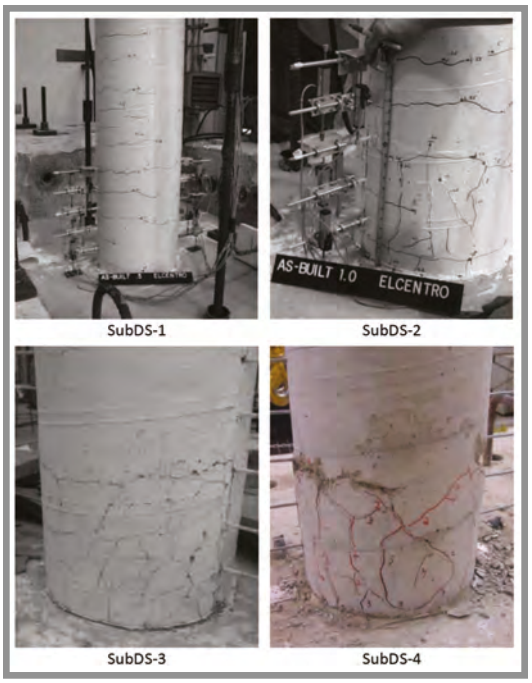
Task Manager:
Peter Lee
Research Contract Manager
Plee@dot.ca.gov

WHAT WAS THE NEED?

The condition of many bridge columns constructed prior to the 1970s and the implementation of current seismic design codes are of major concern. Sub-standard bridge columns are susceptible to brittle failure due to inadequate lateral reinforcement and slippage of column longitudinal bars spliced at the connection to the footing. It is critical that these columns be assessed to identify their deficiencies and to prioritize a retrofitting program. When making an assessment, it is also important to consider the serviceability of a bridge after an earthquake to determine whether it is sufficiently safe to remain open to traffic without repair, repairable within a reasonable period, or to be replaced. However, most seismic-performance studies have focused on methods for retrofitting and repairing the sub-standard columns and not on assessing their susceptibility to seismic damage. To help target the most vulnerable bridges, a practical method for reliability-based seismic assessment of sub-standard bridge bents was needed.

WHAT WAS OUR GOAL?

The goal was to develop a probabilistic method and tools for seismic damage assessment of sub-standard bridge columns for different earthquake return periods and damage states to help prioritize seismic retrofit and repair.



Damage states for sub-standard bridge columns

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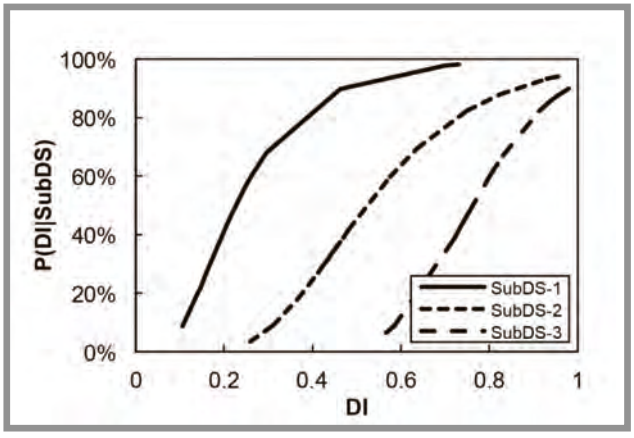
WHAT DID WE DO?

Caltrans, in partnership with the University of Nevada, Reno Department of Civil and Environmental Engineering, developed a capacity (resistance) model and a demand (load) model for sub-standard bridge bents and reliability analysis to determine the extent of the bents' seismic vulnerability.

To develop the capacity model, the researchers reviewed data from previous experimental studies of 25 bridge column models to determine the most common type of apparent seismic damage and identified four distinct states: flexural cracks in the lap-splice region but no vertical cracks (SubDS-1); minor vertical or shear cracks in the lap-splice region (SubDS-2); extensive vertical (block-shape) or shear cracks in the lap-splice region (SubDS-3); and slippage of lap-spliced bars or failure due to shear (SubDS-4). The researchers defined a response parameter in terms of displacement—a damage index—and correlated the index to the damage states using a probabilistic approach of fragility function.

To develop the demand model, the team performed extensive analytical modeling of selected single- and multi-column bents, including a practical range of the number of columns per bent, support conditions, aspect ratios, longitudinal steel ratios, lap-splice lengths, ground motion types, site classes, and earthquake return periods. The demand model was established using load distribution curves based on the fragility relationships of demand damage indices.



Capacity distribution curves

WHAT WAS THE OUTCOME?

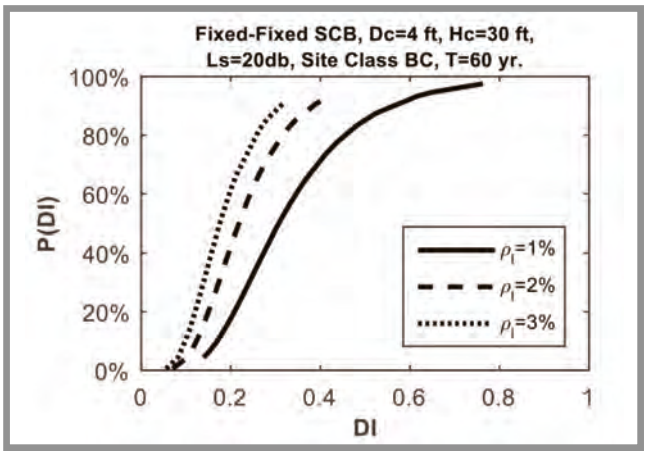
Using the distribution of the capacity and demand models, the researchers estimated the reliability against failure and other damage states, incorporating the probability of earthquake exceedance during the lifetime of the bridges and produced a relatively simple analytical approach to capture the effect of lap-spliced bars on the response of the sub-standard columns by modifying the stress-strain relationship of steel. To facilitate the application of the combined reliability charts in identifying vulnerable bridges, an illustrative example was designed.

WHAT IS THE BENEFIT?

Prior to the occurrence of an earthquake, Caltrans engineers can better identify sub-standard bridge piers that are more susceptible to seismic damage by using a probabilistic approach specific to the bridge to prioritize the retrofitting program. In the aftermath of an earthquake, engineers can assess the level of expected damage to inform the repair process and prioritize the repair program. The proposed probabilistic approach is more effective than the commonly used "all or nothing" retrofitting approach, which can be unnecessary and costly.

LEARN MORE

To view the complete report:
http://wolfweb.unr.edu/homepage/saiidi/caltrans/ProbablisticII/PDFs/FinalreportCaltra ns%20PSDA-1-18-2017.pdf



Sample of demand distribution curves

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Research Results

Nonlinear Time History Analysis Modeling Recommendations for Ordinary Standard Bridges

Nonlinear modeling and analysis more accurately determine stresses, strains, deformations, forces, and displacements of critical components

Seismic

DECEMBER 2017

Project Title:
Nonlinear Time History Analysis of Ordinary Standard Bridges

Task Number: 2755

Start Date: June 1, 2015

Completion Date: March 31, 2017

Product Category: New or improved decision support tool, simulation, model, or algorithm (software)

Task Manager:
Charles Sikorsky
Research Program Manager
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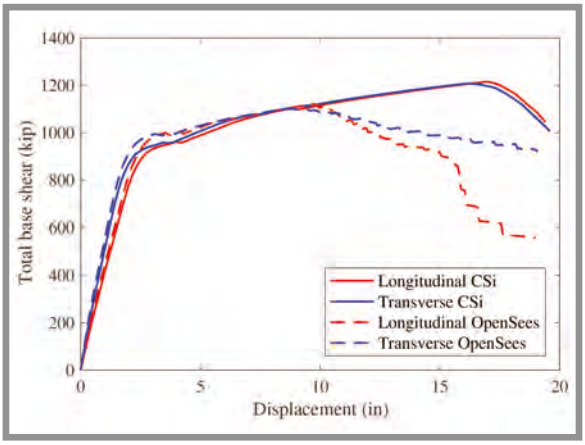
WHAT WAS THE NEED?

General-purpose finite element analysis tools, such as CSiBridge and OpenSees, have put nonlinear time history analysis (NTHA) within reach for simulating the response of ordinary standard bridges to seismic loading. These tools predict structural response more accurately than response spectrum or nonlinear static methods, but they are highly sensitive to variations in the input parameters. They can generate significantly different results due to inherent modeling assumptions and mathematical formulations of element response that are not readily apparent. Without modeling guidance and safeguards against numerical instabilities, NTHA can produce results that are incomplete, non-conservative for design, or controvert engineering judgment. To obtain an accurate representation, engineers need guidance on parameter selection and the consequences of the choices and how the behavior can differ between the widely used commercial bridge engineering applications, because mathematical models are often influenced by the capabilities of the particular computer program.

WHAT WAS OUR GOAL?

The goal was to evaluate the sensitivity of nonlinear time history response of ordinary standard bridges with respect to material properties and modeling assumptions and to assess whether CSiBridge and OpenSees produce similar analytical results.



Although nonlinear static material and section responses match, nonlinear pushover analysis results differ slightly between OpenSees and CSiBridge due to hinge element parameters and concrete ultimate strain behaviors.

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Nonlinear Time History Analysis Modeling Recommendations for Ordinary Standard Bridges

Research Results

WHAT DID WE DO?

Caltrans, in partnership with Oregon State University and the University of Central Florida, created models of four ordinary standard bridges with two-span continuous superstructures using CSiBridge and OpenSees. Two of the bridges had integral bents, and the other two had isolation bearings between the superstructure and the bent and abutments. The researchers performed NTHA for several ground motions and compared the benchmarked bridge models in the two applications. They also conducted sensitivity analysis based on the direct differentiation method available in OpenSees to quantify the effect of modeling parameters—material and element constitutive properties and link properties at the isolators and abutments—on each bridge's response. The researchers proposed guidelines and recommendations for the choice of model formulations and input parameter values, two important sources of discrepancies.

WHAT WAS THE OUTCOME?

Both CSiBridge and OpenSees correctly implement a lumped plasticity approach for analysis of simple reinforced concrete cross sections relative to the exact solution, while OpenSees correctly implements the distributed plasticity approach as well. The discrepancies that arise from the series arrangement of the elements in the lumped approach can be approximately corrected for the initial stiffness and yield force. However, larger discrepancies can be expected in the post-yield hardening and softening behaviors and the cyclic response.

When modal analysis and NTHA were performed for all bridges under the original Caltrans CSiBridge model configuration and another configuration based on simple roller boundary conditions, the modal nonlinear static and nonlinear dynamic results were nominally similar. However, the agreement in terms of trends and magnitudes depended on the abutment boundaries and the cyclic response of the column concrete.

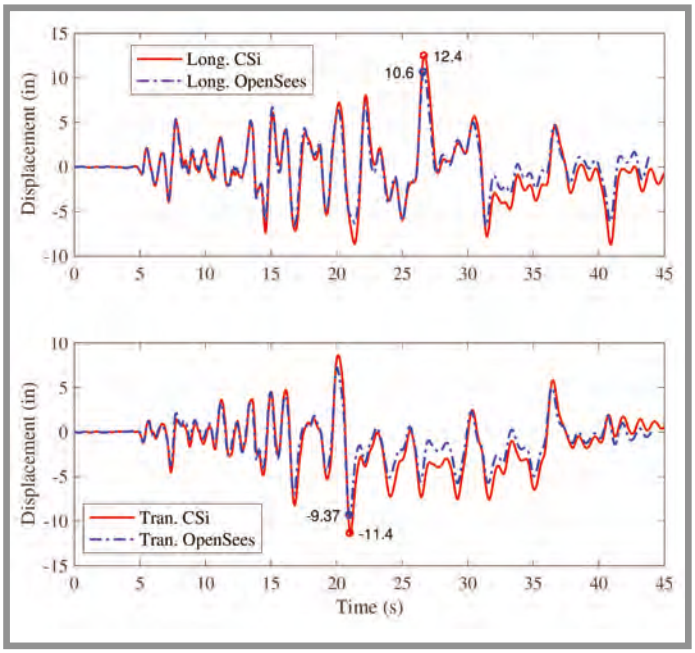
The sensitivity analyses revealed that the stiffness and strength of abutment gap models significantly influence the bridge's nonlinear static and dynamic response. Although the literature gives prominent attention to columns, reinforcing details and modeling assumptions for the columns have less influence on the response of bridges with integral bents; however, the influence is not insignificant. As expected for base isolated bridges, the stiffness and strength of the isolators influence the dynamic response. Depending on the boundary conditions at the abutments, the assumed stiffness of the superstructure can have a seemingly large influence on the bridge response, emphasizing the importance of modeling assumptions.

WHAT IS THE BENEFIT?

Reliable seismic response models are necessary to support the assessment and design of California highway bridges. Bridge designers now have an improved understanding of the sensitivity and parametric studies that relate to the inputs and models commonly selected when analyzing typical bridges, and they can obtain more reliable results using commercial software. The more complex nonlinear time history analysis provides an opportunity for performance-based engineering evaluation over the conventional linear elastic or response spectrum methods.

LEARN MORE

To view the complete report:
www.researchgate.net/publication/317339085_Nonlinear_Time_History_Analysis_of_Ordinary_Standard_Bridges



Nonlinear time history agreement for a single ground motion applied to an ordinary standard bridge between CSiBridge and OpenSees when excluding the abutment models.

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Research Results

Assessing the Impact of Public Transit, Private Ridesourcing Partnerships

Can transportation network companies fill the gap to connect commuters to public transit stations to reduce drive-alone trips?

Transportation Safety and Mobility

FEBRUARY 2018

Project Title:
Simulation of Ridesourcing Using Agent-Based Demand and Supply Regional Models: Potential Market Demand for First-Mile Transit Travel and Reduction in Vehicle Miles Traveled in the San Francisco Bay Area

Task Number: 2977

Start Date: October 20, 2015

Completion Date: December 31, 2016

Product Category: New or improved decision support tool, simulation, model, or algorithm (software)

Task Manager:
Patrick Tyner
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WHAT WAS THE NEED?

How do you transform solo drivers to transit riders? On average, people will walk up to a half mile to a transit stop or station. Running bus lines that connect to major transit stations from all neighborhoods is usually too costly, and insufficient demand can affect frequency of service. Providing park-and-ride lots is typically a short-term fix because demand quickly exceeds availability, and erecting large parking structures to create more spaces can increase the walking distance and time needed to get to the transit station. In addition, dedicating acreage to parking structures, especially in dense, urban areas, uses valuable land that could be converted to transit-oriented housing and businesses.

The rise of transportation network companies (TNC), such as Uber and Lyft, presents a new opportunity for transit agencies to get commuters to and from their closest public transportation stop. Across the country, some transit agencies are using state, local, or federal funds to test the concept of public partnerships with private TNCs to facilitate access to transit. These pilot programs have various goals, such as cost-effectively improving access to pubic transit systems, particularly for disadvantaged populations, easing congestion, or reducing greenhouse gas (GHG) emissions. However, minimal data regarding the potential demand and resulting benefits is available because the private TNCs do not want to reveal competitive information.

WHAT WAS OUR GOAL?

The goal was to apply available modeling tools and data to assess the potential of TNCs to provide first-last mile transit access service and thereby reduce vehicle miles traveled and GHG emissions.

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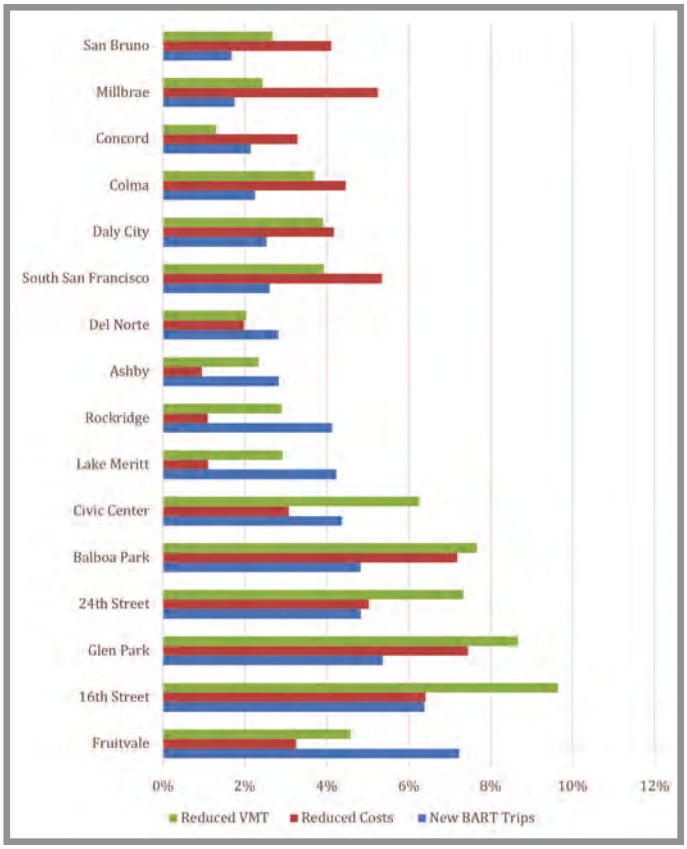
WHAT DID WE DO?

Caltrans, in partnership with the National Center for Sustainable Transportation, simulated targeting commuters who drive alone but have the possibility to take transit to work using available San Francisco Bay Area travel-demand survey data combined with BART schedules, fares, and wait and travel time, a household's distance to a BART station extracted from Google mapping, and TNC pricing structures to measure the difference in travel time and cost for travelers who switch to ridesourcing to a BART station. The researchers then calculated the potential reduction in vehicle miles traveled (VMT) by the simulated commuters. To assess equity effects, household income and auto availability were also taken into account.

WHAT WAS THE OUTCOME?

The analysis indicated that 31% of the identified solo drivers could reduce their travel time and monetary costs by using a TNC and BART. If all these motorists switched, about 40,000 new BART trips would be generated, eliminating over a half-million VMT during the morning commute. Most trips resulted in relatively high cost and VMT savings, which could be a strong motivator for behavioral change. Examining cost savings by income level and vehicle availability suggested that ridesourcing is more likely to benefit lower income households with fewer vehicles. Sensitivity analyses indicate that even with increased TNC fares and waiting times, a large number of solo driver commuters could benefit by switching to a TNC and BART. Tests of riders sharing a TNC service suggest cost savings and VMT reductions even when travel time is increased by 60%.



Potential of various BART stations to generate new trips and reduce VMT and generalized costs

WHAT IS THE BENEFIT?

Increasing transit use maximizes operating revenue and decreases congestion and greenhouse gas emissions. TNCs can compliment public transit by addressing the first-last-mile dilemma. As investments increase in piloting TNC-public transit partnerships, minimal modeling and empirical analysis are available to evaluate the successes and failures. This research produced a practical method that uses existing models and data to identify the impact of TNCs to reduce solo drivers. The analysis addresses benefits per transit station to pinpoint locations with high market potential in terms of travel time and cost savings and environmental benefits—VMT and GHG reductions. Transit and government agencies can use this methodology to estimate TNC fare subsidies to increase performance by station to achieve project objectives, such as equitable access, increased BART ridership, and reduced VMT.

LEARN MORE

To view the complete report:
https://ncst.ucdavis.edu/wp-content/uploads/2015/09/NCST-Rodier-Ridesourcing-Simulation-Final-June-2017.pdf

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Caltrans Division of Research, Innovation and System Information

Research Results

Improving Traffic Flow with Coordinated Ramp Metering

Real-time coordination of ramp meters in response to traffic condition changes can optimize highway performance during congestive periods by reducing bottlenecks

Transportation Safety and Mobility

MARCH 2018

Project Title:
Field Test of Coordinated Ramp Metering (CRM)

Task Number: 2445

Start Date: June 30, 2014

Completion Date: March 15, 2017

Product Category:
Decision support tool, simulation, model, or algorithm (software)

Task Manager:
Hassan Aboukhadijeh
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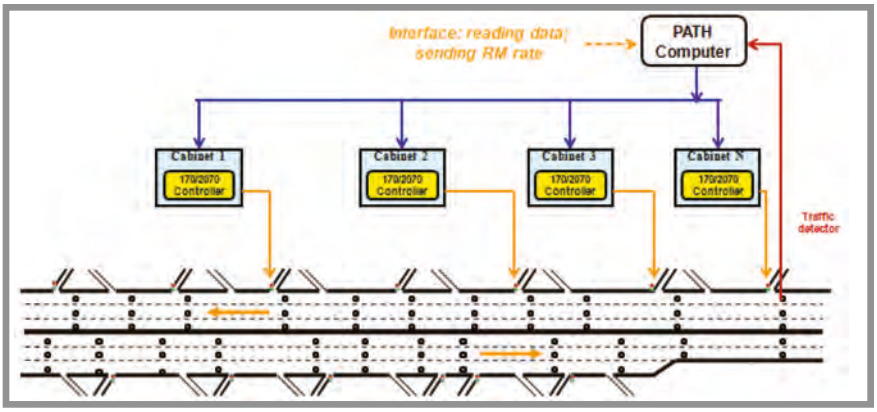
WHAT WAS THE NEED?

Ramp metering is widely implemented to regulate inflow from on-ramps to the mainline network. Most ramp-metering operations on California freeways are fixed by time of day or locally responsive to occupancy measurements immediately upstream of the entrance ramp merge. The responsive metering strategy adjusts the ramp rate to improve traffic flow at the entrance ramp merge area. However, traffic on each section of a freeway affects each other dynamically. The downstream section flow depends on the demand flow from its upstream, and downstream congestion could back-propagate to the upstream. Corridor coordinated ramp metering (CRM) can improve throughput and accommodate more traffic by controlling all metered ramps along the corridor in conjunction. As part of a multiphased project, a CRM strategy was developed, and simulation indicated that the algorithm could potentially reduce freeway congestion at recurrent bottleneck locations. The strategy needed to be tested in the field to determine whether the projected benefits could be achieved.

WHAT WAS OUR GOAL?

The goal was to field-test the recently developed CRM algorithm to determine the feasibility of implementing CRM based on real-time data and its effectiveness in improving corridor traffic flow.



The system directly interfaces with the traffic management center's ramp-metering computer to retrieve traffic data. A computer is used for data processing and calculating the metering rate. Real-time data is obtained from the controllers every 30 seconds, and the CRM rate is sent back for activation every 30 seconds.

Caltrans

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WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley PATH research center, tested the CRM algorithm on 11 on-ramps along a 13-mile stretch of the State Route (SR) 99 northbound corridor in Sacramento between Calvine Road and the SR 50 interchange after 12th Avenue over a five-week period. The algorithm uses a simplified optimal control strategy to process real-time data collected from field detectors to calculate the ramp metering rate by looking at mainline occupancy and flow of the whole corridor, demand at all on-ramps, and outflow at all off-ramps to maximize vehicle miles traveled (VMT) and minimize vehicle hours traveled (VHT). The system links with the existing traffic controllers and does not require extra sensors or any other equipment beyond a computer running the Linux operating system. The researchers evaluated the VMT/VHT ratio and compared it with data collected using the local ramp metering strategy.

Map of SR 99 between 12th Avenue and the SR 50 interchange. The red arrows indicate the potential candidate bottleneck and the downstream bottleneck.

WHAT WAS THE OUTCOME?

During the morning peak traffic hours, between 6:00 a.m. and 9:00 a.m., the VMT/VHT ratio was increased by 7.25% on average, demonstrating improved traffic flow. In contrast, the 3:00–6:00 p.m. hours had no improvement, with VMT/VHT decreasing by 0.44% on average. The reason for the lack of improvement was that traffic was not congested during most of the afternoon hours, suggesting that the CRM algorithm is more effective for congested conditions. Caltrans traffic engineers closely monitored the field tests, and based on their observation of traffic condition improvements, requested to continue using the CRM control for the SR 99 northbound corridor and to develop a computer interface for the algorithm so that traffic engineers could more conveniently apply it to similar freeway corridors.

WHAT IS THE BENEFIT?

The intention of CRM is to balance the ramp metering rate from on-ramps into the freeway mainline by considering the differences of demand and length of all on-ramps along the corridor to maximize flow. Optimizing a corridor's storage capacity and reducing the stop-and-go traffic caused by bottlenecks improves mobility and safety and reduces the energy and emission impacts of freeway congestion. Successful development and implementation of the algorithm is expected to reduce total travel time along the corridor.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2017/CA16-2445_FinalReport.pdf

DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Increasing Throughput on Arterial Networks

Integrating signal and vehicle controls can ease congestion on city streets and make traffic more predictable

Transportation Safety and Mobility

FEBRUARY 2018

Project Title:
Sustainable Operation of Arterial Networks

Task Number: 3001

Start Date: May 1, 2016

Completion Date: April 30, 2017

Product Category: New or improved decision support tool, simulation, model, or algorithm

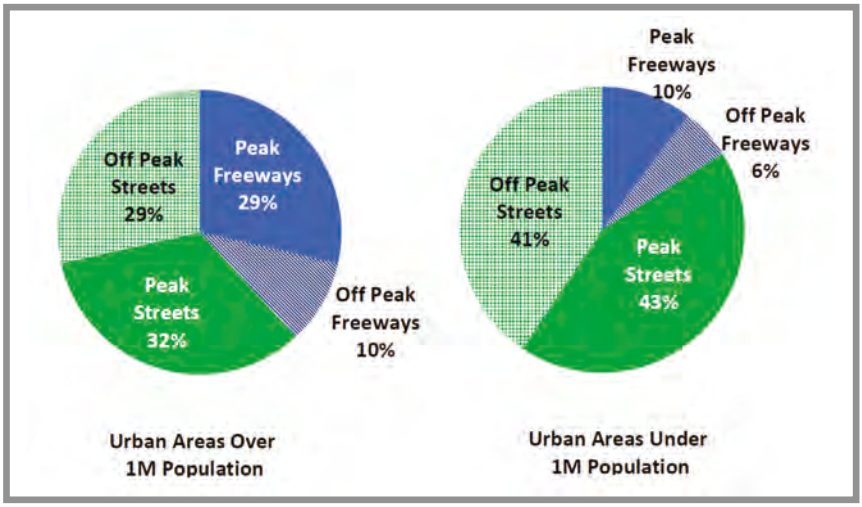
Task Manager:
Jose Perez
Transportation Engineer
jose.perez @dot.ca.gov

WHAT WAS THE NEED?

The 2015 Urban Mobility Scorecard estimated that the average U.S. commuter wastes 42 hours and 19 gallons of fuel per year because of congestion, amounting to a $960 annual congestion cost per commuter. Almost two-thirds of congestion in large cities, and more than 80% in smaller urban areas, occur on city streets, and half of it happens during off-peak hours. Off-peak congestion, which affects not just motorists but the shipping industry and manufacturers that depend on timely delivery of goods, is evidence of poor arterial management. The effectiveness of arterial congestion management depends on the efficiency of signalized intersections. But tuning signal timing alone does not always resolve intersection bottlenecks. Integrating vehicle-level adaptive cruise control (ACC) and cooperative adaptive cruise control (CACC) could increase the saturation flow rate by creating platoons to maximize a green signal phase and reducing headway—the gap between vehicles.

WHAT WAS OUR GOAL?

The goal was to develop techniques that make traffic on urban streets more reliable, predictable, and efficient with actuated signaling and vehicle-level controls and communication.



Percent delay by road type and time of day

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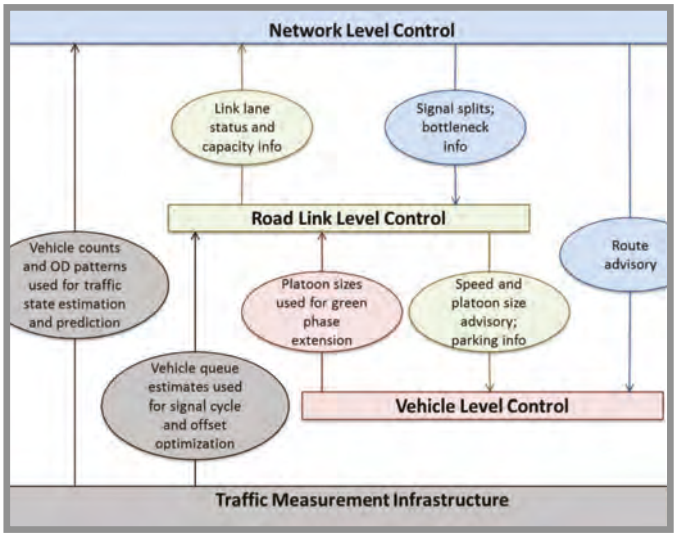
WHAT DID WE DO?

Caltrans, in partnership with the University of California Center on Economic Competitiveness in Transportation (UCCONNECT), analyzed actuated signal phase and timing (SPaT) data and modeled vehicle-level controls to develop techniques and algorithms to increase the flow rate through arterial intersections. The new SPaT algorithms estimate the residual duration of a signal phase for a semi-actuated intersection and predict the times for future phase transitions based on previous phase measurements and real-time information. The researchers tested the ability to use ACC and CACC to move vehicles in a platoon and maintain a tight headway along a signalized arterial network using the free, open-source Simulation of Urban MObility application. The simulation scenarios were based on an arterial in Rollins Park, Maryland that is instrumented with seven actuated signals (as opposed to pre-timed), with the green signal phase varying between minimum and maximum thresholds depending on traffic flow.

WHAT WAS THE OUTCOME?

This research is an important stepping stone for building a three-level traffic management and information system for urban networks with high-density traffic.

- At the vehicle level, the control system moves a group of connected vehicles in a fuel-efficient manner by reducing the number of stops at intersections. The flow through intersections is increased by forming platoons with minimal inter-vehicle spacing. Car speed and the distance between vehicles are adjusted to increase throughput and safety.



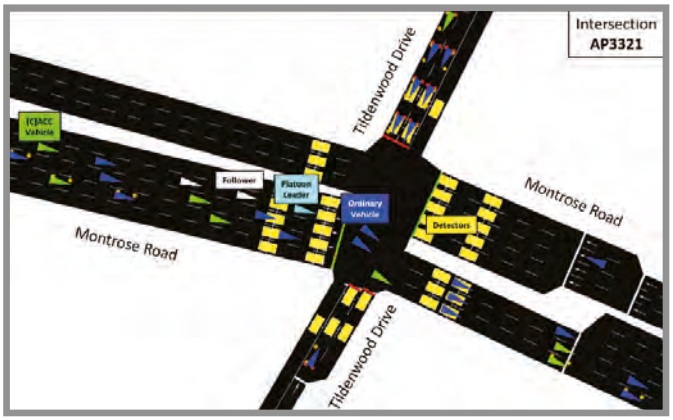
- At the road-link level, signal timings are tuned to increase traffic throughput and not waste the green phase. Link capacity is expanded at certain times of day by opening designated lanes, such as a bus or parking lane, to all traffic.
- At the network level, intersection signal split timings are used to minimize congestion and delay. Traffic demand is managed via route advisories, and signals are adjusted to favor traffic on particular routes at a given time of day.

WHAT IS THE BENEFIT?

The results of this project provide a foundation to investigate how to reduce travel times and delay through intelligent transportation systems, operational strategies, and integrated corridor management. The proposed techniques can increase the throughput of urban corridors, reduce emissions caused by idling and stop-and-go traffic, and improve transportation predictability, reliability, and efficiency for motorists and freight movement.

LEARN MORE

To view the complete report:
www.dot.ca.gov/newtech/researchreports/reports/2017/CA17-3001_FinalReport.pdf



Simulation of ordinary vehicles (dark blue), standalone CACC and ACC vehicles (green), platoon followers (white), and platoon leader (light blue) crossing the intersection

DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

On-ramp Metering to Control and Minimize Merging Bottlenecks

Traffic control strategies that focus on individual active bottlenecks can backfire and create new bottlenecks

Transportation Safety and Mobility

FEBRUARY 2018

Project Title:
Performance Analysis and Control Design for On-ramp Metering of Active Merging Bottlenecks

Task Number: 2808

Start Date: September 23, 2014

Completion Date: June 30, 2016

Product Category: New or improved decision support tool, simulation, model, or algorithm (software)

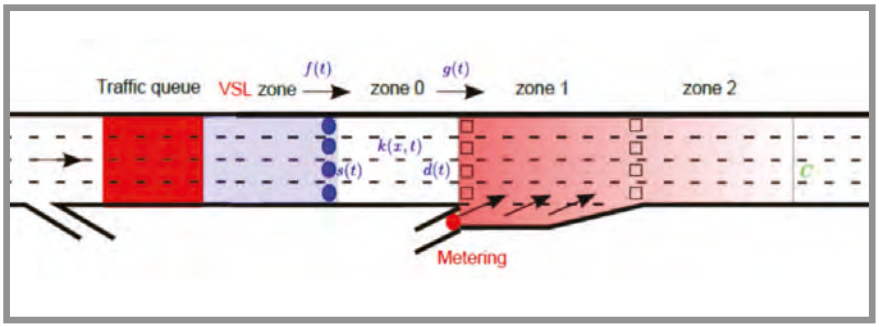
Task Manager:
John Slonaker
Senior Transportation Engineer, Electrical
john.slonaker@dot.ca.gov

WHAT WAS THE NEED?

The complex interaction between merging, lane changing, and accelerating behaviors plays an important role in determining the performance of a congested merging area. When a merging bottleneck occurs, the flow of exiting vehicles can drop by 10%—about 800 vehicles per hour on a four-lane freeway. This capacity drop can cause traffic queues and stop-and-go traffic patterns that increase fuel consumption and greenhouse gas (GHG) emissions. Ramp metering is an effective strategy for relieving congestion in corridors prone to bottlenecks. However, successfully controlling some active bottlenecks can trigger other bottlenecks and actually deteriorate the overall road network's performance. To make the correct investment decisions and not worsen traffic congestion, criteria for selecting which on-ramps to meter and which metering techniques to implement to minimize congestion on the main line caused by entering is needed.

WHAT WAS OUR GOAL?

The goal was to develop guidelines to determine the necessity, priority, and technique of ramp metering systems to increase the throughput of merging areas.



An active merging bottleneck

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On-ramp Metering to Control and Minimize Merging Bottlenecks

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Irvine Institute of Transportation Studies, quantified the congestion mitigation effects of different ramp-metering algorithms at an active merging bottleneck, designed control parameters for efficient and robust traffic-responsive algorithms, identified demand patterns when ramp-metering algorithms are effective, and developed simple decision-support tools.

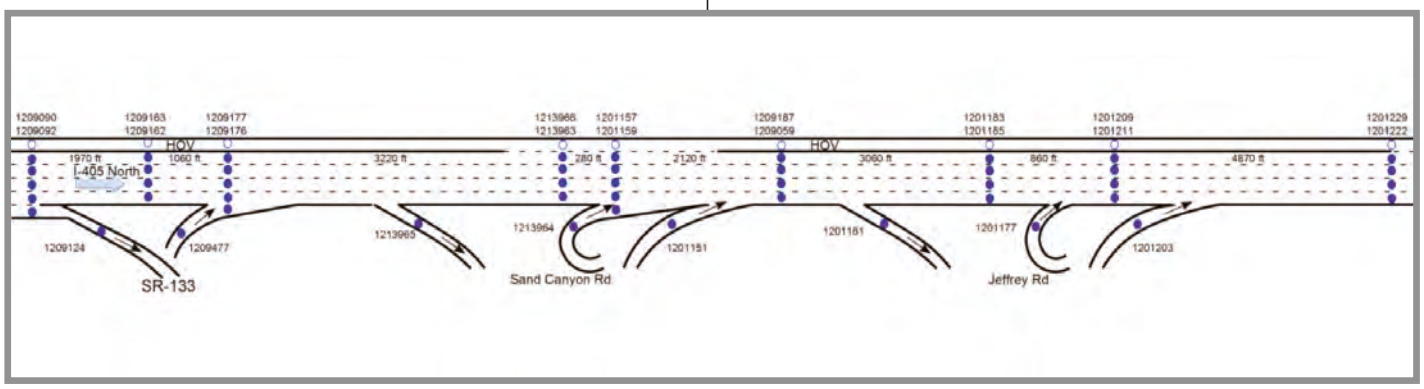
WHAT WAS THE OUTCOME?

The maximum metering rate for avoiding a capacity drop is greater than the metering rate necessary to recover from the capacity drop. A small disturbance can have an asymmetrical effect: A small decrease on the upstream demand leads to a small decrease in the flux of exiting vehicles; however, a small increase can trigger a capacity drop and severely decrease the flux of exiting vehicles. Regardless of the control strategy, if a disturbance to the system leads to a capacity drop, it might not be possible to recover from it unless the upstream demand decreases.

Coordinated traffic control is not only beneficial, but necessary, to optimize capacity. But myopic traffic control strategies—focusing on individual active bottlenecks—can be detrimental to the entire corridor because successful local control activates a downstream, otherwise dormant, bottleneck, and the resulting queue further blocks the upstream bottleneck. To avoid the "price of myopia," all bottlenecks that can be potentially activated by the control strategy need to be included. Paradoxically, creating artificial bottlenecks at certain locations to slow demand could improve traffic flow.

WHAT IS THE BENEFIT?

Implementing optimized ramp-metering operations can significantly reduce congestion of merging areas near on-ramps and upstream. For a complex road network, it is necessary to understand the consequences of addressing active bottlenecks to avoid creating new ones. The decision support tool developed helps practitioners determine whether a ramp meter is warranted at a specific location, which merge areas are higher priorities, whether to implement pre-timed or traffic responsive metering algorithms, and which control parameters are the best.



Northbound I-405 from SR-133 to Jeffrey Road

Appendix 1: Caltrans Membership on TRB Committees

The Transportation Research Board (TRB) promotes innovation and progress in transportation through research. TRB is one of seven program units of the National Academies of Sciences, Engineering, and Medicine, which provides independent, objective analysis and advice to the nation and conducts other activities to solve complex problems and inform public-policy decisions. The program is supported by state transportation departments, federal agencies, including the component administrations of the U.S. DOT, and other organizations and individuals interested in the development of transportation. As of January 2017, Caltrans staff served on the following TRB committees.

Committee Member	Committee Name
Malcolm Dougherty	Executive Committee
Marc Birnbaum	Standing Committee on Access Management
Rachel Carpenter	Standing Committee on Bicycle Transportation
Michael Johnson	Standing Committee on Bridge Management
Michael Johnson	Standing Committee on Bridge Preservation
Dulce Feldman	Standing Committee on Concrete Pavement Construction and Rehabilitation
James Appleton	Standing Committee on Conduct of Research
Joseph Rouse	Standing Committee on Congestion Pricing
Herby Lissade	Standing Committee on Critical Transportation Infrastructure Protection
Sharid Amiri	Standing Committee on Foundations of Bridges and Other Structures
Ali Zaghari	Standing Committee on Freeway Operations
Diane Jacobs	Standing Committee on Freight Transportation Planning and Logistics
T. Holland	Standing Committee on Full-Scale Accelerated Pavement Testing
Dulce Feldman	Standing Committee on General and Emerging Pavement Design
Susan Hida	Standing Committee on General Structures
Chad Baker	Standing Committee on Geographic Information Science and Applications
Zhongren Wang	Standing Committee on Geometric Design
John Erickson	Standing Committee on Geospatial Data Acquisition Technologies
Anoosh Shamsabadi	Standing Committee on Geotechnical Instrumentation and Modeling
Helen Blackmore	Standing Committee on Historic and Archeological Preservation in Transportation
Kyle Gradinger	Standing Committee on Intercity Passenger Rail
Kome Ajise	Standing Committee on Intermodal Freight Transport
Zhongren Wang	Standing Committee on International Cooperation
Jack Broadbent	Standing Committee on Landscape and Environmental Design
Keith Robinson	Standing Committee on Landscape and Environmental Design
Lisa Kunzman	Standing Committee on Maintenance Equipment
Joseph Rouse	Standing Committee on Managed Lanes
Dee Lam	Standing Committee on Management and Productivity
Cristiana Rojas	Standing Committee on Management and Productivity
Dulce Feldman	Standing Committee on Pavement Condition Evaluation
Zhongren Wang	Standing Committee on Pavement Management Systems
Hamid Sadraie	Standing Committee on Pavement Structural Modeling and Evaluation
Kishore Gorle	Standing Committee on Project Delivery Methods

Committee Member	Committee Name
Erik Alm	Standing Committee on Regional Transportation Systems Management and Operations
Darold Heikens	Standing Committee on Roadside Maintenance Operations
Jerome Champa	Standing Committee on Roundabouts
Thomas Ostrom	Standing Committee on Seismic Design and Performance of Bridges
Chris Risden	Standing Committee on Soil and Rock Properties
Coco Briseno	Standing Committee on Statewide Transportation Data and Information Systems
Constantine Kontaxis	Standing Committee on Stormwater
Ramamohan Bommavaram	Standing Committee on Strategic Management
Stephen Guenther	Standing Committee on Strategic Management
Hamid Sadraie	Standing Committee on Structural Requirements of Asphalt Mixtures
Hamid Sadraie	Standing Committee on Subsurface Soil-Structure Interaction
Ramamohan Bommavaram	Standing Committee on Surface Requirements of Asphalt Mixtures
Herby Lissade	Standing Committee on Surface Transportation Weather
Joseph Horton	Standing Committee on Technology Transfer
Herby Lissade	Standing Committee on the Logistics of Disaster Response and Business Continuity
Jeanne Scherer	Standing Committee on Tort Liability and Risk Management
Zhongren Wang	Standing Committee on Traffic Flow Theory and Characteristics
Marilee Mortenson	Standing Committee on Transportation and Air Quality
Michael Johnson	Standing Committee on Transportation Asset Management
Rahul Srivastava	Standing Committee on Transportation Education and Training
Neil Peacock	Standing Committee on Transportation Planning for Small and Medium-Sized Communities
Soheila Khoii	Standing Committee on Travel Survey Methods
Greg Larson	Standing Committee on Vehicle-Highway Automation
Joseph Horton	Standing Committee on Winter Maintenance
Malcolm Dougherty	Subcommittee on Planning and Policy Review
Michael Johnson	Subcommittee on Bridge Preservation
Michael Johnson	Subcommittee on Safety and Security of Bridges and Structures
John Bulinski	11th University Transportation Center Spotlight Conference: Rebuilding and Retrofitting the Transportation Infrastructure
Michael Johnson	Committee for the 12th National Conference on Transportation Asset Management
Rahul Srivastava	Innovations in Freight Data Workshop
Jeanne Scherer	Legal Resources Group
Zhongren Wang	Task Force on Arterials and Public Health
Coco Briseno	Task Force on Data for Decisions and Performance Measures
Michelle Tucker	Task Force on Knowledge Management
Diane Jacobs	Task Force on System Simulation
Coco Briseno	Task Force on TRB Centennial
Soheila Khoii	Task Force on Understanding New Directions for the National Household Travel Survey

Appendix 2: Caltrans Membership on NCHRP Project Panels

Administered by TRB, the National Cooperative Highway Research Program (NCHRP) is a forum for coordinated and collaborative research that addresses issues integral to the state departments of transportation and transportation professionals at all levels of government and the private sector. The NCHRP provides practical, ready-to-implement solutions to pressing problems facing the industry. As of January 2017, Caltrans staff served on the following NCHRP project panels.

Panel Member	Project Title
William Owen	AASHTO Manual on Subsurface Investigations - Manual Update
Ken Solak	AASHTO Partnering Handbook, Second Edition
Joseph Horton	Accelerating the Application of NCHRP Research Results
Justin Unck	Access Management and Design Guidelines for Truck Routes
Hamid Sadraie	Addressing Impacts of Changes in Asphalt Binder Formulation and Manufacture on Pavement Performance through Changes in Asphalt Binder Specifications
Brian Syftestad	Alternate Bidding of Pipe Materials
Marco Ruano	Analysis of Oversaturated Traffic Flow Conditions and Managed Lanes on Freeway Facilities
Janessa Myers	Analyzing Data for Measuring Transportation Performance
Vue Her	Application of MASH Test Criteria to Breakaway Sign and Luminaire Supports and Crashworthy Work Zone Traffic Control Devices
Troy Tusup	Applying Risk Analysis, Value Engineering, and other Innovative Solutions for Project Delivery
Rose Agacer	Assessing the Value of Added Capacity Highway Projects
Dale Widner	Assessment of Geometric Design Policies and Processes
Susan Hida	Bridge System Reliability for Redundancy
Herby Lissade	Catastrophic Transportation Emergency Management Guidebook
Kevin Flora	Combining Individual Scour Components to Determine Total Scour
Leo Mahserelli	Construction and Rehabilitation of Concrete Pavements
Steve Takigawa	Convincing the Stakeholders: Developing a Guide for Communicating Maintenance and Preservation Needs
John Rogers	Corrosion Protection for Extending Steel Bridge Service Life
Dana Hendrix	Costing Asset Protection: An All-Hazards Guide for Transportation Agencies (CAPTA) - Update and Implementation
Greg Larson	Costs and Benefits of Public-Sector IntellDrive Deployment
Rachel Falsetti	Costs of Alternative Finance Systems
Parviz Lashai	Culvert and Storm Drain Inspection Manual
Herasmo Iniguez	Cybersecurity of Traffic Signals and Related ITS Equipment
Asfand Siddiqui	Dedicating Lanes for Priority or Exclusive Use by CVs and AVs
Brian Frazer	Design Options to Reduce Turning Motor Vehicle Conflicts with Bicyclists
John Rogers	Detection and Remediation of Soluble Salt Contamination Prior to Coating Steel Highway Structure
Jesus Mora	Developing Guidelines for GPS (Geographical Positioning System) Controlled Construction Machine Guidance and Required CADD Software
James Appleton	Developing National Performance Management Data Strategies to Address Data Gaps, Standards, and Quality
Marc Birnbaum	Development and Application of Access Management Guidelines
Randy Hiatt	Development of a Collaborative Approach for Multi-State In-Service Evaluations of Roadside Safety Hardware

Panel Member	Project Title
Jeanne Scherer	Development of a Strategic National Highway Infrastructure Safety Research Agenda
Amir Malek	Development of Bridge Foundation Movement Criteria
Karen Jewel	Development of Cost-Effective Treatments of Roadside Ditches to Reduce the Number and Severity of Roadside Crashes
Brian Alconcel	Development of Crash Reduction Factors for Uncontrolled Pedestrian Crossing Treatments
Thomas Ostrom	Development of Guidelines for Performance-Based Seismic Design
Troy Arseneau	Development of Guidelines for the Use of Simulation and Other Models in Highway Capacity Analyses
Kammy Bhala	Development of Live Load Distribution and Impact Factors for the Analysis of Implements of Husbandry Vehicles on Bridges
Joseph Horton	Development of Strategic Plan for Transforming Traffic Safety Culture
Coco Briseno	Effective Practices for Creating and Maintaining an Innovation-Delivery Culture
Constantine Kontaxis	Efficacy of Treating Highway Runoff to Meet Watershed TMDLGoals
Joanne McDermott	Enhanced Truck Data Collection and Analysis for Emissions Modeling
Chris Schmidt	Environmental Justice Analyses When Considering Toll Implementation or Rate Changes
Chris Schmidt	Estimating Bicycling and Walking for Planning and Project Development
Stephen Guenther	Estimating the Return on Investment in Transportation Asset Management Systems and Practices
Larry Bonner	Evaluating the Use of Highway Corridors by Monarch Butterflies
Robert Peterson	Evaluation of Opposite Direction Crashes and Appropriate Countermeasures
Cristiana Rojas	Evaluation of Opposite Direction Crashes and Appropriate Countermeasures
Keith Robinson	Evaluation of the Methodologies for Visual Impact Assessments
Herby Lissade	FloodCast: A Framework for Enhanced Flood Event Decision Making for Transportaiton Resilience
Lian Duan	Fracture-Critical Sysem Analysis for Steel Bridges
Loren Turner	Guidance for Development and Management of Sustainable Information Portals
Agustin Rosales	Guidance for the Management of Traffic and Safety Assets
Rachel Carpenter	Guide for Pedestrian and Bicycle Safety at Alternative Intersections and Interchanges (AII)
Michael Keever	Guide for Proposed AASHTO Seismic Specifications for ABC Column Connections
Lisa Kunzman	Guide for Utilization Measurement and Management of Fleet Equipment
Jim Gutierrez	Guide Specification for the Design of Concrete Bridge Beams Prestressed with CFRP Systems
Hamid Sadraie	Guide Specifications for the Construction of Chip Seals and Microsurfacing
Karen Kasuba	Guide to Ensure Access to the Publications and Data of Federally
Charles Fielder	Guidebook for Emergency Contracting Procedures for Administration of a
Joseph Dongo	Guidebook for Implementing Alternative Technical Concepts into All Types of Highway Project Delivery Methods
Joseph Dongo	Guidebook for Post-Award Contract Administration for Highway Projects Delivered using Alternate Contracting Methods
Michelle Tucker	Guidebook on Agency Risk Management Strategies, Methods, and Tools
Kristina Assouri	Guidelines for Managing Geotechnical Risks in Design-Build Projects
Joseph Dongo	Guidelines for Managing Geotechnical Risks in Design-Build Projects
Louis Betancourt	Guidelines for Selecting Ramp Design Speeds
Jeremy Matsuo	Guidelines for the Development of Highway Operations Equipment Replacement Lifecycle Criteria

Panel Member	Project Title
Charles Fielder	Guidelines to Incorporate the Costs and Benefits of Adaptation Measures in Preparation for Extreme Weather Events and Climate Change
Kenneth Brown	Highway Bridge Fire Hazard Assessment
Zhongren Wang	Horizontal Sightline Offset Design Criteria, Exceptions, and Mitigation Strategies
Joseph Horton	IDEA (Innovations Deserving Exploratory Analysis)
Greg Larson	Impacts of Connected and Automated Vehicles on State and Local Transportation Agencies
Prakash Sah	Impacts of Transit System Regulations and Policies on CV/AV Technology Introduction
Kathryn Griswell	Improved Test Methods and Practices for Characterizing Steel Corrosion Potential of Earthen Materials
Coco Briseno	Improving Access to Transportation Information
Chad Baker	Improving Findability and Relevance in Transportation Information
Joanne McDermott	Integrating Goods and Services Movement Commercial Vehicles in Smart Growth Environments
Mandy Chu	Integration of Roadway Safety Data from State and Local
Melissa Clark	Leveraging Big Data to Improve Traffic Incident Management
Karla Sutliff	Low-Cost Improvements for Recurring Freeway Bottlenecks
Keith Robinson	Managing Rights-of-Way for Biomass Generation and/or Carbon Sequestration
Wilfung Martono	Mechanistic-Empirical Model for Top-Down Cracking of Asphalt Pavement Layers
Bruce Rymer	Meteorological Effects on Roadway Noise
Barry Padilla	Methodology for Estimating the Value of Travel Time Reliability for Truck Freight System Users
Barry Padilla	Methodology for Estimating the Value of Travel-Time Reliability for Truck Freight System Users--Phase 2
Matthew Brady	Methods for Identifying and Evaluating Transportation Investment Right-Sizing Scenarios
Don Nguyen-Tan	Minimum Flexural Reinforcement Laboratory Testing
Roberto Buendia	Next Generation of the FHWA Transportation Pooled Fund (TPF) Website
William Farnbach	Performance Measures that Consider the Contributions of Preservation to Pavement Performance and Service Life
Nicholas Burmas	Performance Related Specifications (PRS) for Pavement Preservation Treatments
Kee Foo	Performance-Related Specifications for Asphaltic Binders Used in Preservation Surface Treatments
Paul Cooley	Practical Bridge Preservation Actions and Investment Strategies
Ed Yarbrough	Practices in One Lane Traffic Control on a Two-Lane Rural Highway
Joanne McDermott	Prioritization Procedure for Proposed Road-Rail Grade Separation Projects along Specific Rail Corridor
Kevin Flora	Procedure for Determination of the Joint Probability of Design Peak Flows at Confluences
Charles Suszko	Procedures and Guidelines for Validating Contractor Test Data
Medhi Parvini	Proposed Enhancements to Pavement ME Design: Improved Consideration of the Influence of Subgrade and Unbound Layers on Pavement Performance
Alan Torres	Proposed Revisions to the AASHTO Movable Bridge Inspection, Evaluation and Maintenance Manual. 1st Edition, 1998
Rene Garcia	Protection of Transportation Infrastructure from Cyber Attacks
Erik Alm	Providing Support to the Introduction of CV/AV Impacts into Regional Transportation Planning and modeling Tools
Jose Marquez-Chavez	Quantifying the Impact of Freight-Efficient Land Use Patterns to Support Effect Decision Making
Patrick Tyner	Quantifying the Impact of Freight-Efficient Land Use Patterns to Support Effect Decision Making

Panel Member	Project Title
Dorie Mellon	Recommended Guidelines for Prefabricated Bridge Elements and Systems Tolerances and Dynamic Effects of Bridge Moves
Hamid Sadraie	Relating Asphalt Binder Fatigue Properties to Asphalt Mixture Fatigue Performance
Malcolm Dougherty	Research for AASHTO Standing Committee on Highways
Jila Priebe	Research for the AASHTO Standing Committee on Public Transportation
Julia Biggar	Resilience in Transportation Planning, Engineering, Management, Policy, and Administration
Gurprit Hansra	Road Markings for Machine Vision
Charles Ineichen	Scour at the Base of Retaining Walls and Other Longitudinal Structures
Hernan Perez	Seismic Design of Geosynthetic-Reinforced Soil (GRS) Bridge Abutments with Flexible Facing
Cathrina Barros	Short-Term Laboratory Conditioning of Asphalt Mixtures
Raymond Tritt	Staffing for Alternative Contracting Methods
Marc Birnbaum	Strategies to Reduce Agency Costs and Improve Benefits Related to Highway Access Management
James Elder	Streamlining Project Level Air Quality Analysis through Development of New Tools/Interfaces
Amir Malek	Structural Testing and Design Methodology for Single Column-Single Shaft Foundation Considering the Flexural Capacity of Steel Casing
Jennifer Taira	Transforming Roadside Management Technology and Practices for the Benefit of Safety, Ecology, and Economy
Gary Arnold	Transit, Freight, and Emergency Services Integration in Integrated Corridor Management Using SHRP2 Business Process Tools
Bljan Sartipi	Travel Demand Forecasting: Parameters and Techniques
Jim Ma	Use of 0.7-in. Diameter Strands in Precast Pretensioned Girders
Theresa Drum	Work Zone Crash Characteristics and Countermeasure Guidance
Kome Ajise	Research Roadmap -- Freight Transportation
Marilee Mortenson	Research Roadmap--Public Health and Transportation
Herby Lissade	Synthesis of Airport Closings and Emergency Evacuation Problems
John Hancock	Synthesis of Emerging Technologies for Construction Delivery
Rachel Carpenter	Synthesis of Pedestrian Injuries and Fatalities Relative to Traffic Speed
Jose Marquez-Chavez	Synthesis of Prioritization of Freight Investment Projects
Thomas Ostrom	Synthesis of Seismic Design of Non-conventional Bridges
Dulce Feldman	Synthesis of Summary of Practice for Automated Pavement Condition Surveys
Michelle Tucker	Synthesis of Transportation Workforce Development Strategies for Young Adults, Second Career Professionals, Veterans, and Encore Careerists
Tony Tavares	Synthesis of Very Short Duration Work Zone Safety for Maintenance and Other Activities
Herby Lissade	Update of a Guide to Emergency Response Planning at State Transportation Agencies
Herby Lissade	Update of Security 101: A Physical Security Primer for Transportation Agencies
Marc Birnbaum	Update of the TRB Access Management Manual
Roberta McLaughlin	Update Section 2B.07 of MUTCD-Multi-way Stop Control (Unsignalized Intersection Control Warrants/Criteria)
Dale Widner	Update to TRB Special Report 214: Designing Safer Roads--Practices for Resurfacing, Restoration and Rehabilitation

Appendix 3: Caltrans Membership on NCFRP Project Panels

Administered by TRB, the National Cooperative Freight Research Program (NCFRP) conducts research and disseminates timely findings that inform investment and operations decisions affecting the performance of the freight transportation system. As of January 2017, Caltrans staff served on the following NCFRP project panels.

Panel Member	Project Title
Diane Jacobs	Evaluating Alternatives for Landside Transport of Ocean Containers
Diane Jacobs	Guidebook for Developing Sub-national Commodity Flow Data
Chad Baker	Web-Based Simulation Tool for Shared-Use Rail Corridors

Appendix 4: Caltrans Membership on ACRP Project Panels

Administered by TRB, the Airport Cooperative Research Program (ACRP) is an industry-driven, applied research program that develops near-term, practical solutions to problems faced by airport operators. As of January 2017, Caltrans staff served on the following ACRP project panels.

Panel Member	Project Title
Philip Crimmins	Assessing Aircraft Noise Conditions Affecting Student Learning-Case Studies
Philip Crimmins	Guidebook of Practices for Improving Environmental Performance at Small Airports
Jeff Brown	Design and Development of a State Aviation Information Database

Appendix 5: Caltrans Membership on TCRP Project Panels

Administered by TRB, the Transit Cooperative Research Program (TCRP) is an applied, contract research program that develops near-term, practical solutions to problems facing transit agencies. As of January 2017, Caltrans staff served on the following TCRP project panel.

Panel Member	Project Title
Rene Garcia	Command-Level Decision Making for Transit Emergency Managers


STOP
CHAINS REQUIRED
4 WHEEL DRIVE WITH
SNOW TIRES OK
STOP
STOP
SPEED
LIMIT
30

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