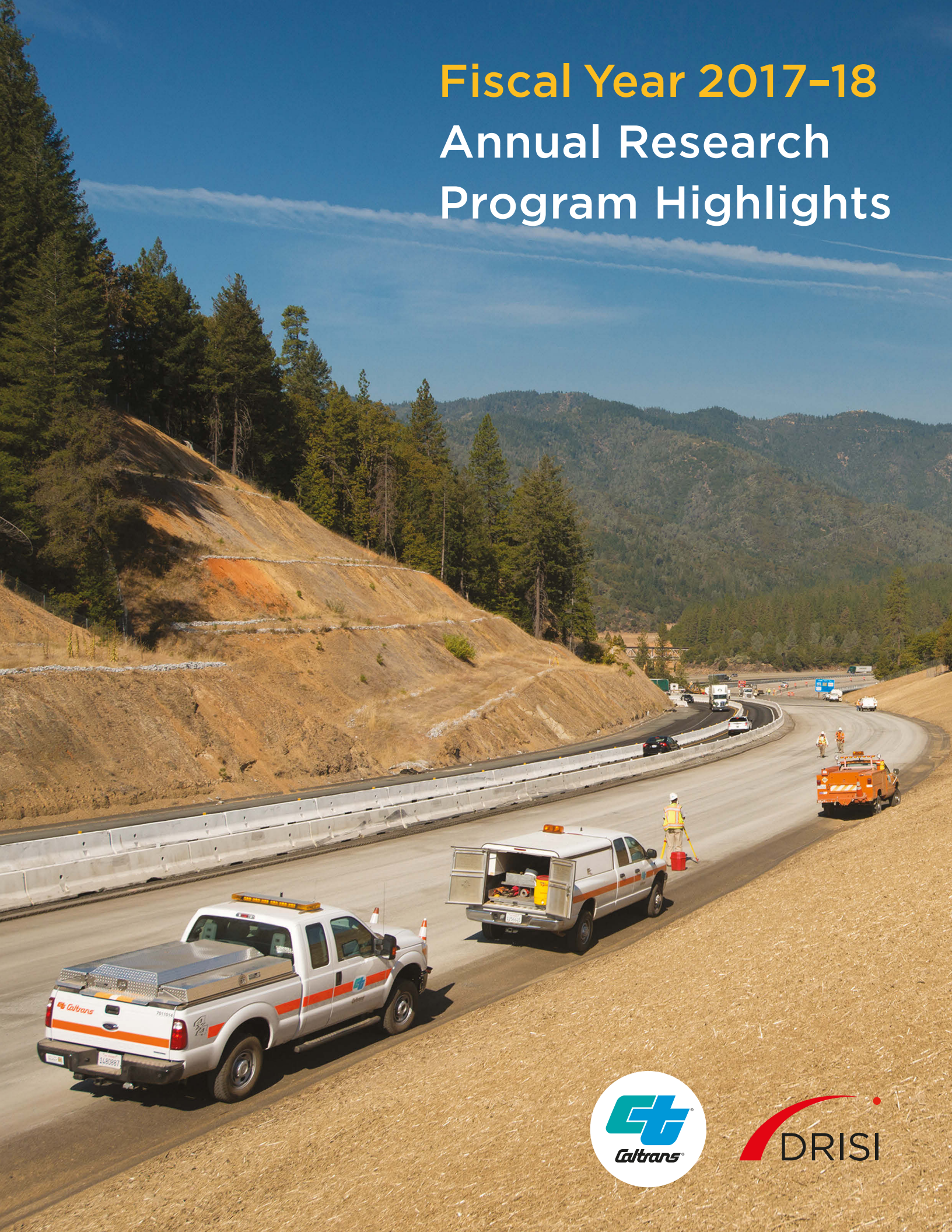
Fiscal Year 2017–18
Annual Research Program Highlights



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For individuals with sensory disabilities, this document is available in alternate formats.

To obtain a copy in an alternate format, contact:
Caltrans Division of Research, Innovation and System Information
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Caltrans Research Program

Fiscal Year 2017–18

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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DRISI

Caltrans Division of Research, Innovation and System Information

Division Chief's Message

I am pleased to present the California Department of Transportation (Caltrans), Division of Research, Innovation and System Information's (DRISI) Annual Research Program Highlights. This report covers the 12-month period ending June 30, 2018, during which DRISI continued to build its robust research program, adding staff to better support Caltrans' growing need for knowledge and solutions, using data to make informed funding decisions that align research outcomes with the Caltrans strategic goals, evaluating the performance of our research portfolio to ensure that the studies have implementable outcomes, and improving DRISI's expansive network of research partnerships.

On behalf of DRISI, and as one of my early acts as division chief, I want to thank my predecessor, Jim Appleton, for his dedicated leadership from 2015 to 2019. He was committed to developing innovative and sustainable solutions for California through research. Under his leadership, DRISI developed and institutionalized a Research Prioritization Methodology to better align Caltrans' research portfolio with the Department's overarching strategic objectives. Much of the research presented in this report was selected through that process and conducted under his guidance.

I would also like to express appreciation to our dedicated DRISI staff, Caltrans programs and districts, and the Research and Deployment Advisory Committee who made this report possible.

Like most organizations, we are always looking for ways to improve communication, transparency, and accountability. Moving forward, research continues to be a necessary part of our organizational efficiency and effectiveness. At its core, the research process is about collaborating, connecting, learning, and communicating. Over the next year, you can expect a focused effort toward a better understanding of the cross-functional benefits of individual research tasks to leverage their contribution toward Caltrans strategic goals and objectives. You can also expect to see new and innovative communication practices for sharing research results in the spirit of transparency and accountability. We welcome your comments, questions, and suggestions on how we can improve.

This document highlights a wide variety of research projects supporting Caltrans' mission to provide a safe, sustainable, integrated, and efficient transportation system to enhance California's economy and livability. Additional information about our research efforts and specific projects highlighted within these pages can be obtained by contacting any of the research staff identified in this report.

Dara Wheeler, Chief
Division of Research, Innovation and System Information

Spotlight on Active Transportation

Toward an Active California: A Strategic Pedestrian and Bicycle Research Roadmap

DRISI is committed to providing research-based solutions to help achieve the goal of improving the safety and comfort of pedestrians and bicyclists throughout the State. Its vision is that people in California of all ages, abilities, and incomes can safely, conveniently, and comfortably walk and bicycle to meet their transportation and mobility needs.

To help achieve this vision, DRISI collaborated with members from six Caltrans divisions and one district, the California Air Resources Board, the California Department of Public Health, the Strategic Growth Council, California Walks, and the California Bike Coalition. Along with expert researchers from UC Davis and UC Berkeley, the interdisciplinary team constructed a research roadmap to strategically guide the Caltrans bicycle and pedestrian research portfolio. The roadmap identifies existing research and gaps that need to be filled in past and current research done by Caltrans and other local, state, and national institutions as well as research opportunities to pursue in the area of active transportation over the next 3–5 years.

The Pedestrian and Bicycle Research Roadmap graphically depicts our research and scope and shows the planned research activities and innovations expected in the concept, research, development, and implementation phases to ensure that the research products support Caltrans goals. The roadmap optimizes resources by focusing on research that needs to be done, eliminating duplication of effort, and using or building on research already performed in the state, country, or worldwide. While formulating the roadmap, we identified 40 projects undertaken by DRISI and 395 national projects that could potentially address the research needs and fill the knowledge gaps.

The Pedestrian and Bicycle Research Roadmap establishes a framework of system integration by identifying cross-cutting interconnections in which a research project or product can serve multiple objectives. This roadmap complements the 2017 *Toward an Active California, State Bicycle and Pedestrian Plan,* California's first-ever statewide plan to promote active modes of transportation, and helps pave the way for achieving the goals of the *California Transportation Plan 2040.*

Bike boxes improve connectivity for bicyclists and pedestrians when crossing a major boulevard.

State Route 28 was converted from four lanes to three to accommodate new sidewalks, Class II bike lanes, and bus shelters. Two single-lane roundabouts were constructed to slow traffic.

For more information about *Toward an Active California, State Bicycle and Pedestrian Plan*, visit *www.dot.ca.gov/activecalifornia/index.html.*

PEDESTRIAN AND BICYCLE RESEARCH ROADMAP

MISSION

Formulate and promote research aligned with the Caltrans Strategic Management Plan that aims at enhancing the physical, social, political, and economic environment in which walking and bicycling are promoted as safe, convenient, and comfortable modes of mobility while helping preserve a clean environment and sustaining safe, healthy, and vital communities.

STRATEGIC GOALS

- Optimize pedestrian and bicycle safety, mobility, and access and improve multi-modal connectivity for all user, with appropriate emphasis on low-income, underserved communities.
- Develop a research roadmap that identifies and fills research gaps, promotes innovative solutions, and explores strategic opportunities for pedestrian and bicycles modes in a structured, systemic way.
- Pursue research that has deployable results and enhances the best practices in planning & design that result in systems and services where walking & bicycling are the primary means of transportation.
- Perform research that quantifies economic health, equity, and other co-benefits of walking and biking investments to local communities.

RESEARCH AREA	RESEARCH AREAS GOALS
Safety and Security	1. Identify safety data analysis tools that can analyze and prioritize locations for safety improvements across state, regional, and local jurisdictions. 2. Reduce the number, rate, and severity of pedestrian and bicycle involved collisions. 3. Ensure the personal safety of people walking and biking.
Mobility and System Performance	1. Increase walking and bicycling in California. 2. Improve connectivity of pedestrian and bicycle facilities, services, and improve data communications for directional, information dissemination. 3. Identify program requirements and evaluation criteria for innovative programs that support active transportation. 4. Establish active transportation performance metrics and collect performance data. 5. Improve pedestrian and bicycle access to public transportation.
Social Equity	1. Maximize the benefits of investing resources in all communities, especially those with low-income and vulnerable populations. 2. Design effective programs & projects for all users with a focus on low-income and vulnerable populations. 3. Ensure equitable distribution of resources and opportunities. 4. Utilize effective social equity tools and resources available for transportation decision making.
Healthy and Sustainable Communities	1. Identify research opportunities to improve public health, including mental health, by increasing physical activity and social cohesion and improving air quality. 2. Identify research opportunities to reduce environmental and climate change impacts of transportation and land use by shifting car trips to walking and bicycle trips. 3. Study and identify pedestrian & bicycle facility designs that are appropriate, comfortable, and attractive for different land uses and community types.

This highest level of the roadmap highlights the key research areas and goals. To view the identified research topics, opportunities, strategic objectives, and research needs, visit *www.dot.ca.gov/research/planning/docs/Ped__Bike_RR_V-H_Representation_v7-Sections.pdf.*

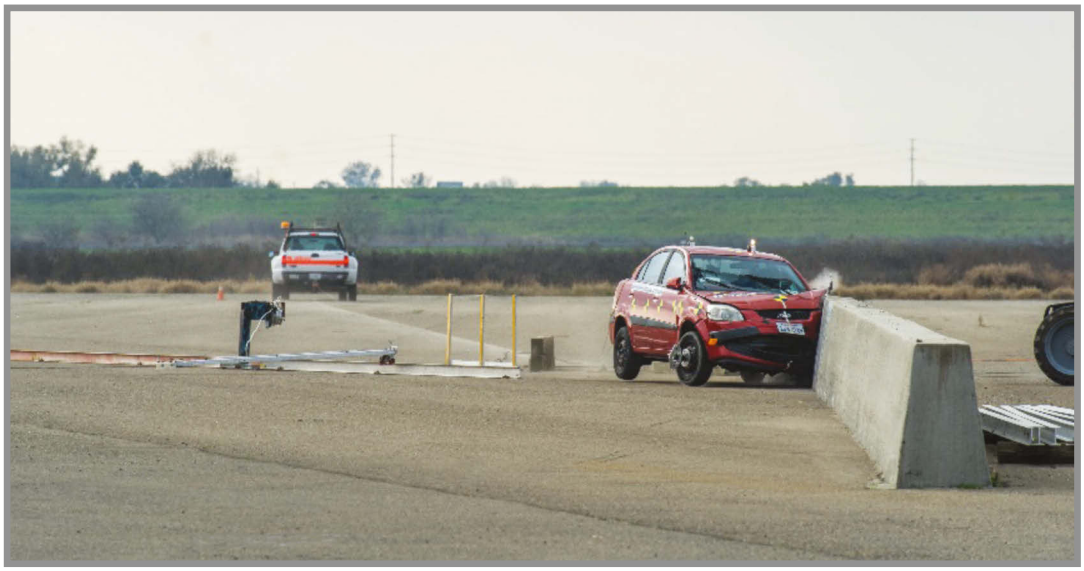
Spotlight on Roadside Safety

Ensuring That All Roadside Structures Meet the Highest Safety Standards

The goal of the DRISI Roadside Safety Research Group is to ensure the safety of the traveling public and field personnel in work zones by confirming that California's roadside structures meet the national crashworthy requirements. The researchers design, analyze, and test a variety of roadside structures, including bridge rails, guardrails, median barriers, and work zone traffic control devices, using in-service performance evaluation studies, computer simulation, and full-scale crash testing.

In 2016, Caltrans committed to implement the AASHTO Manual for Assessing Safety Hardware (MASH) criteria for determining the safety of specific proprietary and non-proprietary roadside structures and technology, such as inline w-beam terminals, w-beam and cast-in-place barriers, cable barriers, crash cushions, and bridge rails. The adopted timetable to implement a MASH-compliant system was aggressive. The Roadside Safety Research Group helped support this effort by providing technical support and reviews of new products, identifying new designs developed by other state departments of transportation (DOT) and private industry, and partnering with roadside safety pooled fund projects.

Pooling efforts and funding with other state DOTs allowed Caltrans to share knowledge, avoid duplicating research and testing, and collaborate with world leaders in roadside safety research. As a result, Caltrans was able to collect and evaluate a larger number of MASH-compliant roadside safety features than what would have been available through the usual adoption process.



The Kia Rio sedan test vehicle was towed into the Type 60 barrier using a cable attached to a one-ton pickup. The researchers documented the test using still cameras, video cameras, high-definition high-speed digital video cameras, and data acquisition systems to record accelerations and rotational rate changes.

To expedite the implementation of the MASH guidelines, DRISI verified the crashworthiness of the Caltrans Type 60 median barrier. Caltrans has used the Type 60 median barrier for decades as a single-slope concrete median barrier in Test Level 3 (TL-3) applications. Caltrans successfully tested the barrier in the mid 1990s according to the guidelines of that time. However, it had not been evaluated using the MASH criteria. The barrier passed the MASH test and is now eligible for federal funding.

To view the Road Safety Research Group projects: *www.dot.ca.gov/research/operations/roadsidesafety.*

Testing the Caltrans-designed ST-70SM side-mounted bridge rail to verify that it meets the MASH criteria as a Test Level 4 longitudinal barrier. It successfully contained and redirected all three levels of vehicles and impact conditions as required.

Research Program Administration

DRISI manages a balanced, comprehensive portfolio of projects to address 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 2017-18, DRISI managed a $25.3 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).

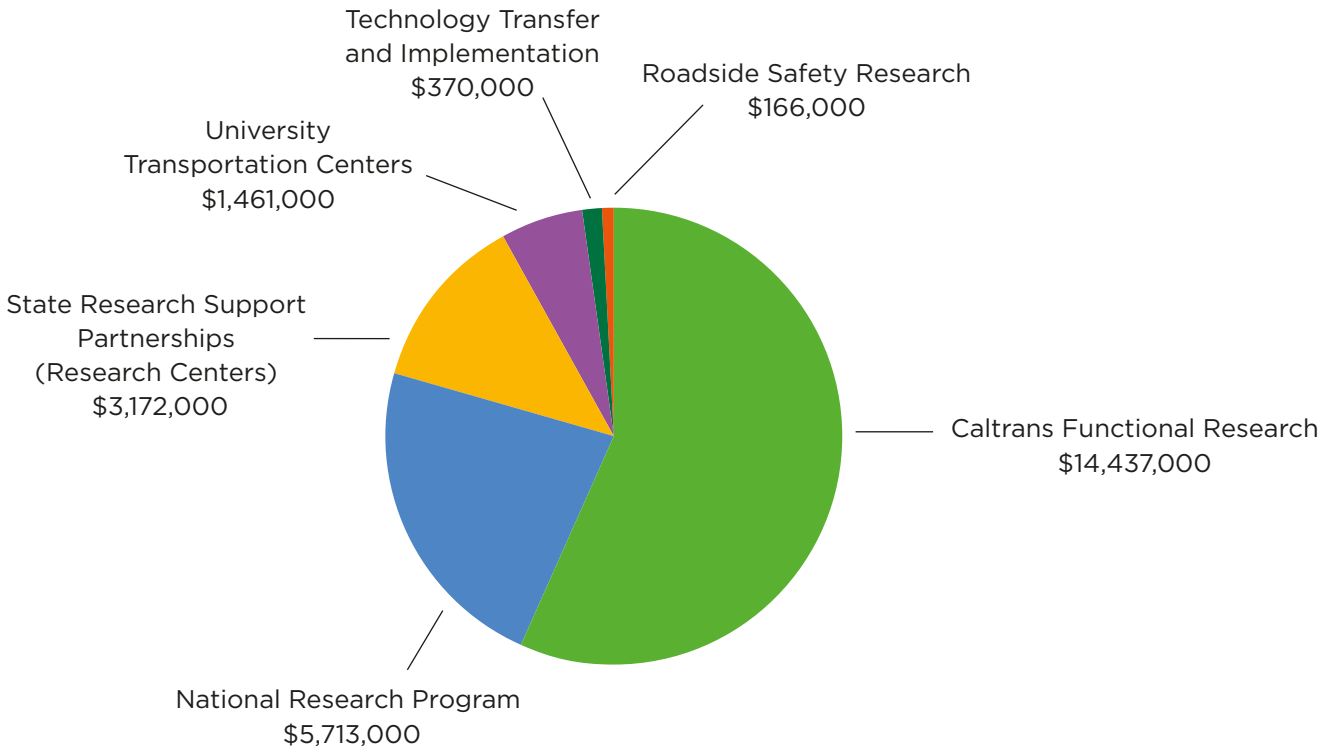
The SP&R provided $20.0 million ($17.1 million in federal funds and $2.9 million in matching state funds). This federally mandated program sets aside 2% of California's apportionments from these federal programs to fund planning and research activities:

- 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 state component of the SP&R is met through the SHA, which is funded through state gasoline and diesel fuel taxes, motor vehicle fees, and truck weight fees. 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.

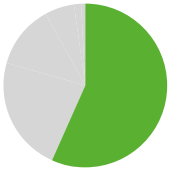
The following graph shows the breakdown of DRISI's research program into major areas of focus.

Allocation of FY 2017–18 Research Funds



Total FY 2017–18 funding
$25.3 million

FUNDING CATEGORIES

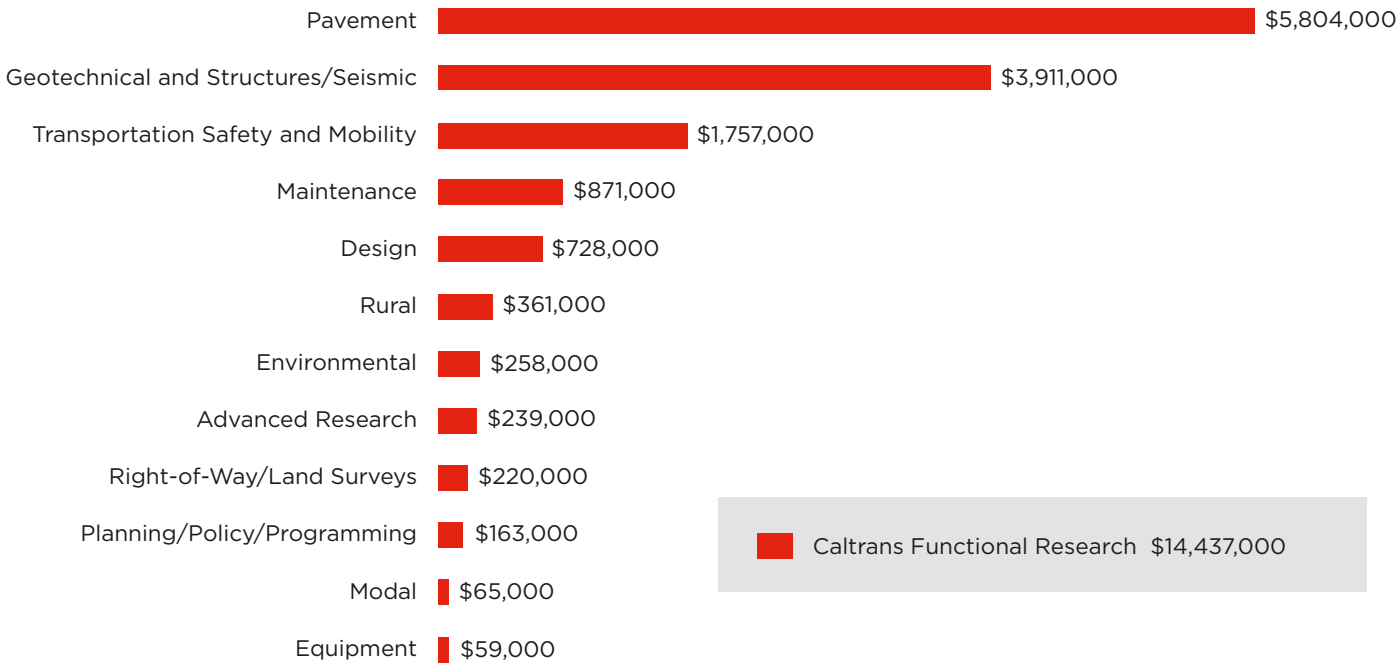


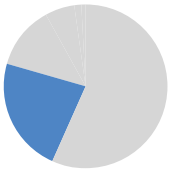
Caltrans Functional Research | $14,437,000

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 2017–18, DRISI managed 210 research tasks covering various functional areas, of which 77 reached completion. For a summary of all research tasks underway in FY 2017–18, see the "Research Task Summary."

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

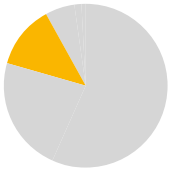
Distribution of Caltrans Functional Research by Research Area





National Research Program | $5,713,000

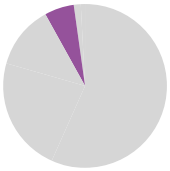
Caltrans partners with national transportation organizations, including the TRB and the National Cooperative Highway Research Program (NCHRP). Caltrans benefits from national research efforts through leveraging research conducted at the national level and by serving on committees and panels that identify critical transportation issues, recommend project selection, and guide implementation. More information about these national programs is on pages 16–17. As of January 2019, Caltrans staff actively participated on 147 highway, 2 airport, and 2 transit cooperative research project panels (see Appendices 2–4).



State Research Support Partnerships (Research Centers) | $3,172,000

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 18–20.

- 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)



University Transportation Centers | $1,461,000

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.

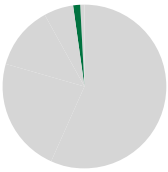
In FY 2017–18, these five MAP-21-funded UTCs continued to conduct research initiated in prior years, completing all research by the end of the fiscal year.

- 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

Caltrans began new partnerships with three UTCs in FY 2017–18 that were awarded funds under the Fixing America's Surface Transportation (FAST) Act:

- Mineta Consortium for Transportation Mobility
- National Center for Sustainable Transportation
- Pacific Southwest Region University Transportation Center

More information about these organizations is on pages 21–23.



Technology Transfer and Implementation | $370,000

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*

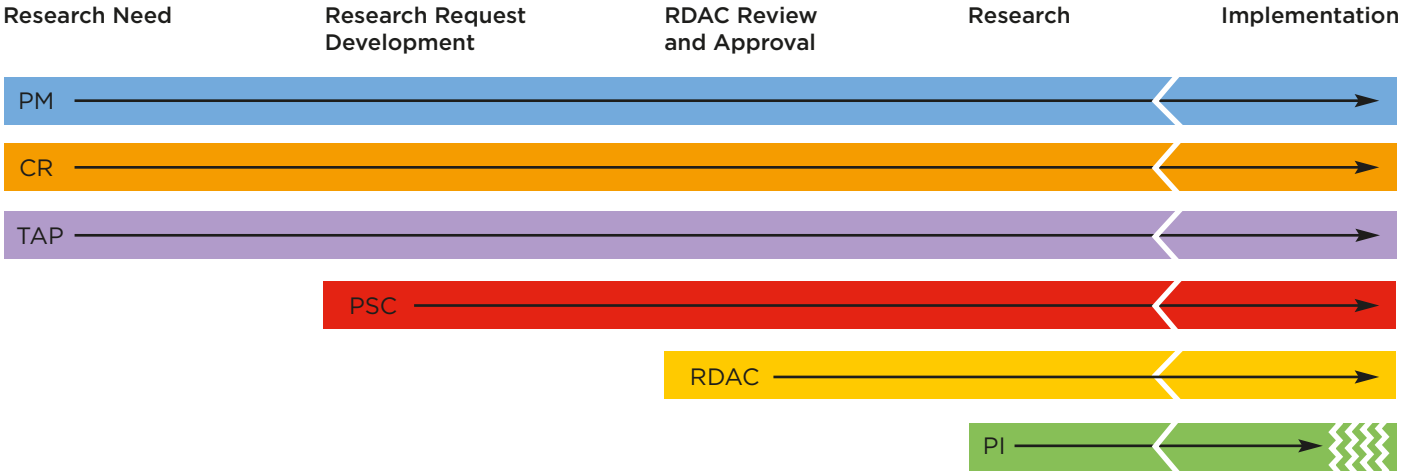
Roadside Safety Research | $166,000

DRISI's Roadside Safety Research group evaluates the crash worthiness of safety technology, including 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.

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, approves 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 annual portfolio in April.

Research Program 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.

RESEARCH AND DEPLOYMENT ADVISORY COMMITTEE (RDAC)

The RDAC reviews and recommends the program of research projects

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 $515,933 in 2018, 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

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 2018, the NCHRP selected 37 new projects for funding, of which 14 were important to Caltrans. Caltrans staff is currently serving on nine 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.

LEARN MORE

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 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.

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www.ucprc.ucdavis.edu

Photo: Paul Kirchner Studios

University Transportation Centers

In FY 2017–18, 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.

LEARN MORE

www.dot.ca.gov/newtech/utc

The following five MAP-21-funded UTCs completed research initiated in prior years by the end of FY 2017–18.

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.

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

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.

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

In FY 2017–18, Caltrans transitioned from partnering with the five UTCs funded under MAP-21 (listed above) to those funded under the FAST Act (listed below). New partnerships were formed with three UTCs.

The Mineta Consortium for Transportation Mobility

MCTM, led by the Mineta Transportation Institute at San José State University, conducts research, education, workforce development, and technology transfer activities to improve mobility of people and goods and make our nation's transportation system safe, efficient, accessible, and convenient for all. MCTM primarily supports the research needs of Caltrans' divisions of Rail and Mass Transportation, Transportation Planning, and Traffic Operations. Consortium members include:

- Howard University
- Navajo Technical University
- San José State University
- The University of North Carolina at Charlotte

The National Center for Sustainable Transportation

NCST, led by the Institute of Transportation Studies at UC Davis, provides national leadership in advancing environmentally sustainable transportation through cutting-edge research, direct policy engagement, and education of our future leaders. NCST serves as one of the U.S. DOT's five national UTCs and is addressing the FAST Act research priority area of Preserving the Environment. 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

The Pacific Southwest Region University Transportation Center

PSR UTC, led by the University of Southern California, addresses the FAST Act research priority area of Improving Mobility of People and Goods by conducting an integrated, multidisciplinary program of research, education, and technology transfer aimed at improving the mobility of people and goods throughout the region. The PSR UTC program is organized around four themes: technology to address transportation problems and improve mobility; improving mobility for vulnerable populations; improving resilience and protecting the environment; and managing mobility in high-growth areas. PSR UTC primarily supports the research needs of Caltrans' divisions of Rail and Mass Transportation, Transportation Planning, and Traffic Operations. Consortium members include:

- California State University, Long Beach
- Northern Arizona University
- Pima Community College
- University of California, Davis
- University of California, Irvine
- University of California, Los Angeles
- University of Hawaii


University of Nevada, Reno
Caltrans

Research Task Summary

The Research Task Summary lists selected research tasks completed in FY 2017–18 and scheduled to be completed in FY 2018–19 or 2019–20 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 2017–18

Research tasks scheduled to be completed in FY 2018–19 or 2019–20

Advanced Research

Task ID	Task Title	Task Manager	End Date	Page #
2623	**Cooperative Adaptive Cruise Control for Partially Automated Truck Platooning**	**Hanson, Matt**	**3/31/18**	**36**
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	-
3309	Red Light Violation Warning (RLVW) over Cellular Network: A comparative Study between DSRC and 4G/LTE Technologies for RLVW	Clark, Melissa	12/31/19	-
3128	Interactive Simulation of Cooperative Adaptive Cruise Control (CACC) Vehicle (Matching)	Siddiqui, Asfand	6/30/20	-
3287	Connected Vehicle Application Development (CVAD)	Siddiqui, Asfand	6/30/20	-

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 #
2982	Sustainable Mitigation of Stormwater Runoff Through Fully Permeable Pavement	Provost, Leanne	9/15/17	-

Design

Task ID	Task Title	Task Manager	End Date	Page #
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	-
3178	Developing a Strategic Roadmap for Caltrans Implementation of Virtual Design Construction/Civil Integrated Management	Ali, Akber	12/31/18	-
3106	Effective Utility Encasement Criteria and Methods	Ali, Akber	3/31/19	-
2895	Corrugated Steel Culvert Corrosion & Abrasion Performance	Ali, Akber	8/27/19	-
3289	Performance Measures for Roadside Features (Phase 2)	Ikram, Hamid	9/30/19	-

Design TPF

Task ID	Task Title	Task Manager	End Date	Page #
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 #
2724	Develop a Tidewater Goby Survey Method Using Environmental DNA	Bisrat, Simon	12/31/18	-
3185	Landscape Genomics Study for California Tiger Salamander	Bisrat, Simon	12/31/19	-
2666	Develop roadway crossings for sensitive amphibians (WTI)	Bisrat, Simon	6/30/20	-
2700	Develop roadway crossings for reptiles (USGS)	Bisrat, Simon	6/30/20	-
3233	Fish Passage Engineering Research	Bisrat, Simon	6/30/20	-

Environmental TPF

Task ID	Task Title	Task Manager	End Date	Page #
2538	Near Road Air Quality Research TPF-5(284)	Bisrat, Simon	6/30/19	-

Equipment

Task ID	Task Title	Task Manager	End Date	Page #
3085	Continued Evaluation of the TowPlow Trailer System	Baumeister, Larry	1/12/18	-
3300	Comparison of New and Existing Caltrans Hopper Body and Tailgate Sanders	Baumeister, Larry	12/31/19	-
3273	Evaluation of the AutoCone 130 Cone Trailer	Benouar, Azzeddine	6/30/20	-

Executive

Task ID	Task Title	Task Manager	End Date	Page #
2780	Road Charge Pilot Demonstration Program	Williams, Scott	3/31/19	-

Geotechnical/Structures

Task ID	Task Title	Task Manager	End Date	Page #
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	Lee, Peter	12/31/17	-
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	-
3017	Development of Guideline for Generation, Selection, and Adjustment of Ground Motions	Hipley, Pat	11/30/18	-
1805	Corridor-Scale Landslide Hazard Mapping: Conversion of CGS Hazard Maps	Roblee, Cliff	12/31/18	-
3163	Impact of increased limestone cement content on concrete performance	Kartoum, Allaoua	1/1/19	-
3169	Development of a replacement for breakaway supports for large roadside signs and crash testing to MASH 2016 Test Level 3	Caldwell, Christopher	1/1/19	-
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, continued

Task ID	Task Title	Task Manager	End Date	Page #
3018	Accurate Damping Model for Nonlinear Time History Analysis	Hipley, Pat	10/31/19	-
2743	Experimentation to investigate liquefaction-induced lateral load in multilayer soil strata	Le, Anhdan	12/31/19	-
3114	The Effect of End Eccentricity in Steel Truss Bridge for Load Rating Analysis	Huang, George	3/31/20	-
3168	Validation of Design for Liquefaction-Induced Downdrag on Piles	Barnes Benjamin	3/31/20	-
3155	Shear Resistance of Cast-in-Place Post-Tensioned Girders	Ibrahim, Ahmed	4/30/20	-
3022	Developing and Testing Non-Proprietary Cement-Based Materials and Ultra High Performance Concrete (UHPC) for Accelerated Bridge Construction (ABC) Bridge Column Seismic Anchorage	Lee, Peter	5/31/20	-
3156	High Performance Link Slab to Replace Bridge Expansion Joints	Lee, Peter	6/30/20	-

Geotechnical/Structures TPF

Task ID	Task Title	Task Manager	End Date	Page #
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 #
2887	Solar Lighting Evaluation for Highway Applications	Mizuno, Bradley	8/1/17	-
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 Compressive Strength of Precast Concrete Girders**	**Baumeister, Larry**	**12/31/17**	**38**
3148	Evaluation of Pavement Striping Management Services	Chung, Haniel	12/31/18	-
3043	Visibility Standards for Field Worker Apparel and Personal Protective Equipment (Nickname: Worker Visibility)	Chow, Stan	7/31/19	-
3038	Evaluation of Work Zone Intrusion Alarms	Lofton, Arvern	8/14/19	-
2730	Evaluation of Remote Control Mowers for Roadside Management	Benouar, Azzeddine	9/30/19	-
3176	Research to Support Crack Cleaning Operations in Moving Lane Closures	Lofton, Arvern	9/30/19	-
3255	Mountain Pass Road Opening (MPRO) Implementation and Training	Baumeister, Larry	12/31/19	-
3149	Managing Low Volume Access Points in Work Zones	Baumeister, Larry	6/30/20	-
3265	Evaluation of Autonomous TMA Trucks for Use in Caltrans' Operations	Baumeister, Larry	6/30/20	-

Maintenance TPF

Task ID	Task Title	Task Manager	End Date	Page #
2842	Western Maintenance Partnership, TPF-5(312)	Unck, Justin	6/30/19	-
2949	ShakeCast, Connecting the DOTs, TPF-5(357)	Newell, Nathan	12/31/19	-
3229	Avalanche Research, TPF-5(337)	Baumeister, Larry	6/30/20	-

Modal

Task ID	Task Title	Task Manager	End Date	Page #
2664	**Bus Rapid Transit (BRT) Toolbox: Assessing Person Throughput to Measure Transportation Impacts for BRT Projects**	**Mizuno, Bradley**	**12/29/17**	**40**

Modal, continued

Task ID	Task Title	Task Manager	End Date	Page #
3124	**Los Angeles Metro Bus Data Analysis Using GPS Trajectory and Schedule Data**	**Chow, Stan**	**12/31/17**	**42**
3135	Analysis of Comprehensive Multi-modal Shared Travel Systems with Transit, Rideshare, Carshare and Bikeshare Options	Lao, Kayo	2/28/18	-
3136	**Bicycle Infrastructure and Business District Change**	**Kwong, Jerry**	**2/28/18**	**44**
2521	**Development and Field Testing of an Interactive Transit Station Information System (ITSIS) Using Connected Vehicle Technologies**	**Mizuno, Bradley**	**4/24/18**	**46**
2663	**Development and Field Testing of an Integrated Dynamic Transit Operation System**	**Loebs, Nathan**	**5/31/18**	**48**
2998	Aviation Weather Information - Web Portal Implementation: Integration of Aviation AWOS with RWIS (AWOS/RWIS) - Phase 3	Clark, Melissa	6/30/19	-
3151	Results of Key Transit Investments	Mizuno, Bradley	6/30/20	-
3152	Development a Deployable Integrated Dynamic Transit Operation System (IDTO) for Revolutionizing Suburb Transit Operation in California	Loebs, Nathan	6/30/20	-

Pavement

Task ID	Task Title	Task Manager	End Date	Page #
2667	Standard Materials Library and Guidance	Holland, Joe	9/16/17	-
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**	**50**
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	-
2677	Binder Replacement in High RAP/RAS Asphalt Mixes: Phase 2 Accelerated Pavement Testing and Field Monitoring	Yang, John	11/30/17	-
2691	Validation of Greenhouse Gas Emissions from Pavement Deflection	Holland, Joe	11/30/17	-
2707	**Full-Depth Recycling Study: Test Track Construction and First-Level Analysis of Phase 1 and Phase 2 HVS Testing, Forensic Investigation, and Testing Phase 1 Laboratory**	**Holland, Joe**	**11/30/17**	**52**
2709	Microcracking for Cement Stabilized Layers: Phase 2 HVS & 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	-
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	-
3082	R3 - Rapid Road Rehab - web based platform - Software Service Training Support	Stafford, Patrice	9/1/18	-
3243	Improving Efficiency, Optimizing Risk and Cost of Materials QA Program Delivery	Stafford, Patrice	9/1/18	-
3206	Complete Early Age and Premature Cracking Evaluation	Wang, Yue	6/30/19	-
3209	Life Cycle Assessment (LCA) for Alternative Strategies to Reduce Greenhouse Gas (GHG)	Bisrat, Simon	6/30/19	-
3210	Fast Model for Energy Consumption Due to Pavement Structural Response	Holland, Joe	6/30/19	-

Pavement, continued

Task ID	Task Title	Task Manager	End Date	Page #
3186	Asphalt Rubber Binder	Yang, John	6/30/20	-
3187	Performance Related Testing in Superpave	Yang, John	6/30/20	-
3188	Implementation of PRS for AC Long Life Projects	Yang, John	6/30/20	-
3189	Binder Replacement in High RAP/RAS HMA and RHMA Mixes	Newell, Nathan	6/30/20	-
3190	Assessment of the PG+5 Initiative	Newell, Nathan	6/30/20	-
3212	Improved Profile Indicators for Roughness and Fuel Use Affecting Freight Damage and Truck Fuel Use	Wang, Yue	6/30/20	-

Pavement TPF

Task ID	Task Title	Task Manager	End Date	Page #
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	-
2917	Regional and National Implementation and Coordination of ME Design, TPF-5(305)	Holland, Joe	12/31/19	-

Planning/Policy/Programming

Task ID	Task Title	Task Manager	End Date	Page #
2965	Identifying and Analyzing the Relative Advantages and Disadvantages of Public-Private Partnerships and Traditional Delivery for Transport Projects	Williams, Scott	7/31/17	-
3007	Mapping and Improving the Delivery Process of Highway Pavement Rehabilitation Projects	Provost, Leanne	10/1/17	-
3073	White Paper: 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**	**54**
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, Leanne	10/31/17	-
3097	**Developing an Interactive Machine-Learning-based Approach for Sidewalk Digitalization**	**Tyner, Patrick**	**11/15/17**	**56**
3133	**Managing the Impacts of Freight in California**	**Monson, Tyler**	**11/30/17**	**58**
3118	**Caltrans Future of Mobility White Paper**	**Monson, Tyler**	**1/31/18**	**60**
3143	Developing Markets for Zero-Emission Vehicles in Goods Movement	Provost, Leanne	1/31/18	-
3123	**Evaluating Economic Mobility and Resilience of Multimodal Freight Operations in a Connected Vehicle Environment**	**Tyner, Patrick**	**2/28/18**	**62**
3138	Who's in the Driver's Seat? The Division of Car Use in Auto-Deficit Households	Williams, Scott	2/28/18	-
3122	**An Online Cost Allocation Model for Horizontal Supply Chains**	**Law, Frank**	**3/30/18**	**64**
3090	Development of a Freight System Conceptualization AND Impact Assessment (Fre-SCANDIA) Framework	Monson, Tyler	3/31/18	-
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	-

Planning/Policy/Programming, continued

Task ID	Task Title	Task Manager	End Date	Page #
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	-
3291	Parking Utilization and Site Level VMT Database	Tyner, Patrick	12/31/19	-
3292	M-580 Barge Service Feasibility and Benefits Study	Tyner, Patrick	12/31/19	-
3294	Development of Operations Analysis Tools	Azevedo, Christine	12/31/19	-

Planning/Policy/Programming TPF

Task ID	Task Title	Task Manager	End Date	Page #
2782	**Toolkit for the Deployment of Alternative Vehicle and Fuel Technologies, TPF-5(331)**	**Tyner, Patrick**	**3/30/18**	**66**

Research Support

Task ID	Task Title	Task Manager	End Date	Page #
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	-
2955	AHMCT Research Program Management for 65A0560	Unck, Justin	3/31/19	-
2956	AHMCT Research Technical Support for 65A0560	Unck, Justin	3/31/19	-
2957	AHMCT Research Administration and Outreach for 65A0560	Unck, Justin	3/31/19	-
3004	AHMCT Preliminary Research and Investigations	Unck, Justin	3/31/19	-
0547	AASHTO Innovation Initiative	Zaniewski, Pete	6/30/20	-

Research Support TPF

Task ID	Task Title	Task Manager	End Date	Page #
2591	Transportation Research Board Core Services 2018 - 2019, TPF-5(378)	Zaniewski, Pete	6/30/19	-
2597	National Cooperative Highway Research Program Annual Agreement 2018 - 2019	Zaniewski, Pete	9/30/19	-

Right of Way and Land Surveys

Task ID	Task Title	Task Manager	End Date	Page #
2729	**Expanding Mobile Terrestrial Laser Scanning Capability and Capacity Throughout Caltrans**	**Lofton, Arvern**	**2/14/18**	**68**
3179	Support for Caltrans Statewide Mobile Terrestrial Laser Scanning (MTLS) System Usage	Lofton, Arvern	9/30/19	-
3039	Specifications for Using Small Unmanned Aerial Systems to Generate High Accuracy Mapping	Lofton, Arvern	6/30/20	-

Rural

Task ID	Task Title	Task Manager	End Date	Page #
2916	**WeatherShare Phase IV - Inclement Weather Testing**	**Campbell, Sean**	**12/31/17**	**70**
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	-
1749	Professional Capacity Building for Communication Systems Phase V: IP Networking Fundamentals	Perez, Jose	12/31/19	-
3098	Responder Study Phase 4: Transition Phase - Research and Development in Support of the Implementation of the Responder System into Caltrans Operations	Clark, Melissa	12/31/19	-
1755	COATS Phase VIII	Campbell, Sean	6/30/20	-
3280	Development and Testing of an Unmanned Aerial System (UAS) Cellular & Wi-Fi Repeater Phase 1	Campbell, Sean	6/30/20	-

Rural TPF

Task ID	Task Title	Task Manager	End Date	Page #
1760	**Rural Traveler Information Needs Assessment and Pilot Study Phase III: Bordering States Rural Coverage, TPF 5(241)**	**Campbell, Sean**	**2/28/18**	**70**
1757	Western States Rural Transportation Consortium (WSRTC) Phase II, TPF-5(241)	Campbell, Sean	6/29/19	-
2649	Aurora Program – Aurora Road Weather Information (ARWI) Systems, TPF-5(290)	Clark, Melissa	6/30/19	-

Seismic

Task ID	Task Title	Task Manager	End Date	Page #
2544	**Seismic Performance of Precast Full-Depth Decks in Accelerated Bridge Construction**	**Lee, Peter**	**8/14/17**	**72**
2561	**Cut-and-Cover Tunnel Shake Table Test Program**	**Lee, Peter**	**10/31/17**	**74**
2861	**Prequalifying Testing Protocol for Buckling-Restrained Braces Applied to Steel Truss Bridges**	**Lee, Peter**	**11/30/17**	**76**
2539	Experimental Validation of Interaction of MSE Abutments with Superstructures under Seismic Loading	Mahan, Mark	1/31/18	-
2994	**Seismic Behavior of Grade 80 RC Bridge Columns – Phase 1 and Critical Bending Strain of Longitudinal Reinforcement**	**Noureddine, Issam**	**6/29/18**	**78**
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	6/30/19	-
2757	Bridge System Research for Accelerated Bridge Construction (ABC)	Lee, Peter	6/30/20	-

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 #
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**	**80**
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**	**82**
3041	Support for Challenge Area "Work Zone"	Mizuno, Bradley	9/30/17	-
3096	Evaluating the Environmental Impact of Traffic Congestion in Real Time Based on Sparse Mobile Crowd-sourced Data	Provost, Leanne	10/31/17	-
2652	**Development of an Adaptive Control Algorithm for Arterial Signal Control**	**Slonaker, John**	**12/31/17**	**84**
2452	**Pedestrian Safety Improvement Program Development Phase 2**	**Kwong, Jerry**	**1/31/18**	**86**
3134	**Safe Operation of Automated Vehicles in Intersections**	**Siddiqui, Asfand**	**2/28/18**	**88**
3139	Investigation of Multimodal Crashes using Full Bayesian Multivariate Spatial-Temporal Models	Kwong, Jerry	2/28/18	-
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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**	**90**
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 (VSA) for Freeway Traffic Control	AbouKhadijeh, Hassan	6/15/18	-
3137	**Travel Demand Nowcasting**	**Chow, Stan**	**6/30/18**	**92**
3112	A 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	TASAS (Traffic Accident Surveillance and Analysis System) and Injury Data Base Development	Ikram, Hamid	9/30/18	-
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	-
3180	Class IV Separated Bikeways: A Safety and Mobility Analysis	Loebs, Nathan	6/1/19	-
2304	Evaluating Alternative Design of Geometric Configuration for High-Occupancy Vehicle (HOV) Facilities in California	Perez, Jose	6/30/19	-
3103	SPF Tool Enhancements	Kwong, Jerry	6/30/19	-
3298	Transit Agency-run Bike Share Programs: State of the Practice and Best Practices	Loebs, Nathan	6/30/19	-
3307	Intelligent Transportation Society of America (ITS America)	AbouKhadijeh, Hassan	10/1/19	-
3027	Implementation of Safety Performance Function (SPF) Methods to Identify High Collision Concentration Locations (HCCLs) for California	Kwong, Jerry	11/30/19	-
2564	Assist in the Development and Support of an Enterprise-Wide Traveler Information System	Campbell, Sean	12/31/19	-
3005	Evaluation of Freeway Traffic Data Acquisition: Technology, Quality and Cost	Slonaker, John	12/31/19	-

Transportation Safety and Mobility, continued

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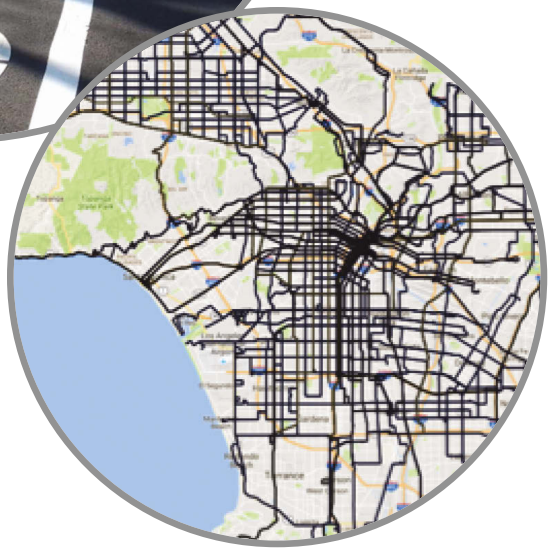
3105	Information Display Board for Corridor Management in California	Siddiqui, Asfand	12/31/19	-
3601	Intelligent Transportation Society of California (ITS-CA)	AbouKhadijeh, Hassan	12/31/19	-
3246	Graphical User Interface Development for Coordinated Ramp Metering System	AbouKhadijeh, Hassan	3/31/20	-
3245	Evaluation of Different Coordinated Ramp Metering Systems in Caltrans	Perez, Jose	6/30/20	-
3253	Alternative High Occupancy Vehicle (HOV) Lane Operational Strategies for Congestion Mitigation in California	Perez, Jose	6/30/20	-

Transportation Safety and Mobility TPF

Task ID	Task Title	Task Manager	End Date	Page #
1057	TTI Roadside Safety Research Program, TPF-5(114)	Jewell, John	6/29/18	-
2081	Urban Mobility Study, 2009 continuation - TTI Pooled Fund, TPF-5(198)	Perez, Jose	8/31/18	-
2954	Self De-Icing LED Signals, TPF-5(351)	Kwong, Jerry	9/30/18	-
2904	Traffic Control Device (TCD) Consortium, TPF-5(316)	Perez, Jose	1/14/19	-
0373	High Occupancy Vehicle (HOV) / Managed Use Lane (MUL), TPF-5(029), 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: TTI Pooled Fund Project, TPF-5(343)	Jewell, John	6/30/19	-
2905	Partnership for the Transformation of Traffic Safety Culture, TPF-5(309)	Hanson, Matt	9/30/19	-
2913	Evaluation of Low-Cost Safety Improvement, TPF-5(317)	Loebs, Nathan	12/31/19	-
3311	Exploring Non-Traditional Methods to Obtain Vehicle Volume and Class Data, TPF-5(384)	Perez, Jose	6/30/20	-



Fiscal Year 2017–18
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.

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Research Results

Improving Freight Operations with Partially Automated Truck Platooning

Cooperative adaptive cruise control provides an intermediate step toward operating trucks in closely coupled, automated platoons

Advanced Research

MARCH 2018

Project Title:
Cooperative Adaptive Cruise Control for Partially Automated Truck Platooning

Task Number: 2623

Start Date: May 1, 2014

Completion Date: March 31, 2018

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

Task Manager:
Matt Hanson
Transportation Engineer
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WHAT WAS THE NEED?

Truck platooning—when groups of trucks operate in a coordinated manner in a close-spaced formation—has the potential to improve safety, mobility, emissions, and energy efficiency. As automation technology progresses, platooning concepts are continually being explored and advanced under various conditions. With cooperative adaptive cruise control (CACC), only the truck speed is automated by using vehicle-to-vehicle (V2V) communication to coordinate breaking and acceleration. Drivers are still responsible for steering the vehicle, lane keeping, and monitoring roadway and traffic conditions. While other truck platooning systems have relied on a constant clearance distance gap control strategy, CACC uses a constant time gap in which the distance between vehicles is proportional to the speed.

The Gateway Cities Council of Governments and Los Angeles Metro are seeking ways to reduce congestion, increase truck throughput, and mitigate environmental impacts on the planned dedicated truck lanes on the I-710 corridor, which serves the busy Southern California ports. The Federal Highway Administration (FHWA) Exploratory Advanced Research Program chose this project to advance the potential of truck platooning. Although other research projects have demonstrated more-advanced levels of truck platooning, they have not yet produced the convincing body of evidence needed to encourage the broader stakeholder community in both the public and private sectors to see the benefits. This project was designed to provide more compelling evidence by partnering with the private sector, making slight modifications to available technology, and soliciting truck driver participation.

WHAT WAS OUR GOAL?

The goal was to develop and test a CACC system by integrating commercially available adaptive cruise control (ACC) systems with high-speed V2V communications on three-truck platoons and evaluate the potential benefits.

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Improving Freight Operations with Partially Automated Truck Platooning

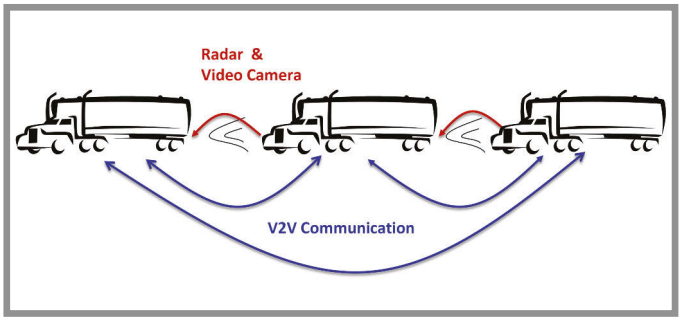
Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Partners for Advanced Transportation Technology program, developed a CACC system for a three-truck platoon built on existing ACC technology and explored the potential benefits of heavy-truck platooning: increased throughput from shorter gaps between vehicles, reduced fuel consumption as a result of improved aerodynamics, emission reductions from reduced fuel consumption, and safety improvements due to high-speed communication and coordinated maneuvering. The project team also investigated truck drivers' acceptance and comfort with the smaller than normal gaps between vehicles. The three-truck platoon was driven 5,500 miles in live traffic on the state highway system at 55 mph without incident. The trucks were driven an additional 2,500 miles on a test track to assess fuel consumption. The researchers also used traffic micro-simulations of I-710 to estimate the potential impacts on traffic congestion and energy consumption from widespread adoption of CACC for the heavy trucks driving along that corridor.

WHAT WAS THE OUTCOME?

It was possible to modify the commercially available ACC system to produce a high-performance CACC system that does not cost much more than a basic ACC system.
The CACC prototype responded to cut-in vehicles by increasing the gap to safely accommodate the vehicle.
The participating truck drivers were comfortable using the CACC system in mixed traffic and generally preferred the intermediate gap setting. The three-truck platoon pulling conventional well-loaded trailers driving at the tested gaps of 0.6 and 1.5 seconds can save about 6% and 5% of fuel consumption, respectively, when cruising at 65 mph. The first truck does not experience significant savings, while the second truck saves between 7% and 6%, and the third truck saves between 11% and 9%.



WHAT IS THE BENEFIT?

The tested CACC system can reduce fuel use and emissions, improve traffic flow, and increase highway capacity, all while maintaining a high level of safety. The V2V communication capability enables the trucks to coordinate maneuvering so that the lightest or most agile trucks can automatically moderate their maneuvers to match the more limited capabilities of the most heavily loaded trucks. These modest levels of truck platooning can be deployed relatively quickly and easily and promote future implementation of more advanced technology. Based on the results of this project, the FHWA is considering funding additional development and operational tests of truck platoons in actual freight operations.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA18-2623_FinalReport.pdf

Touch-screen tablet shows status of trucks. The driver can use the emergency disengage button to exit the platoon.

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Research Results

Determining In-Situ Precast Concrete Girder Compressive Strength

New method helps avoid unnecessary upgrades by providing more accurate estimates of the compressive strength of in-situ bridges

Maintenance

DECEMBER 2017

Project Title:
Determination of In-Situ Compressive Strength of Precast Concrete Girders

Task Number: 2748

Start Date: March 1, 2016

Completion Date: December 31, 2017

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

Task Manager:
Larry Baumeister
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WHAT WAS THE NEED?

Caltrans has over 1,200 precast I girder concrete bridges. The only information available to evaluate these structures for load-carrying capacity is the original concrete design compressive strength values listed on the project plan sheets. The state began rerating bridges using the current design permit loading, which suggested that the majority of the bridge ratings are dropping when compared to the design plans because the as-built concrete girder strength was unknown. However, based on investigations and industry practice, the minimum concrete strength specified in the design plans is typically achieved within a few days after the concrete is placed. The 28-day strengths and beyond have been found to be significantly higher than design strengths based on surveys of manufacturers' data. Evaluating representative samples of these bridges for in-situ compressive strength can help Caltrans identify the reserve in strength capacity for future expansion and compare their design with the new modified codes of practice for safety considerations. Underestimating bridge load ratings can result in unnecessary postings, rehabilitations, retrofits, replacements, and higher user costs. Reliable estimates of the actual in-situ concrete compressive strengths are needed to accurately determine whether seismic or strengthening upgrades are required.

WHAT WAS OUR GOAL?

The goal was to develop a method to assess the compressive strength and capacity of in-situ precast concrete girder bridges before implementing upgrades.

(Left) Bridge core in lab. (Right) Bridge core after testing.

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Determining In-Situ Precast Concrete Girder Compressive Strength

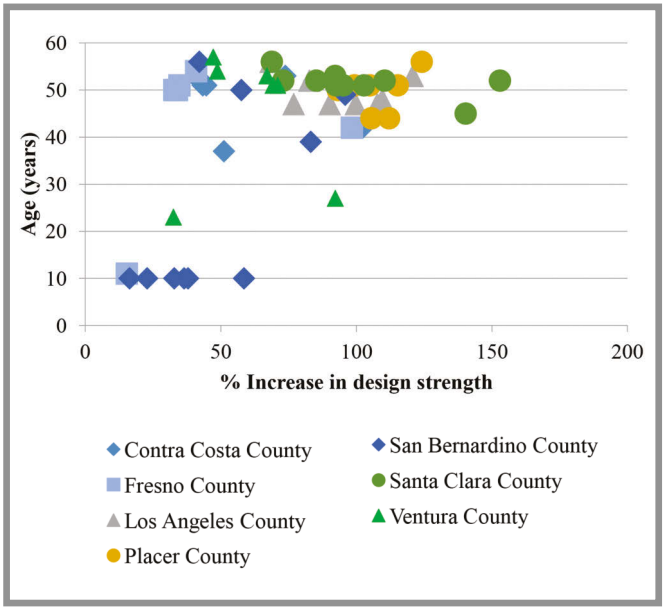
Research Results

WHAT DID WE DO?

Caltrans, in partnership with the San José State University Department of Civil Engineering, field-tested 52 precast I girder bridges in seven counties across California for in-situ compressive strength using different non-destructive test (NDT) methods. Using more than one technique ensured higher quality and reduced uncertainty in determining the in-situ concrete compressive strength. The researchers constructed concrete cylinders, slabs, and retaining walls and cured them under three different environments to calibrate the NDT equipment. The data collected from all the laboratory testing in combination with data supplied by the various manufacturers of the NDT equipment were used to develop strength prediction charts for the different bridge girders. The researchers then collected concrete cores from five bridges in Santa Clara County and San Bernardino County and performed compressive strength and NDT tests. They compared the results obtained from these cores to the lab testing data to verify the accuracy of the compressive strength predictions.

WHAT WAS THE OUTCOME?

In-situ precast concrete girders that were approximately 10 years old exhibited at least a 20% increase in their design compressive strength. In-situ precast concrete girders that were approximately 50 years old exhibited at least a 40% increase from their design compressive strength. The researchers are proposing modifications to the American Concrete Institute 209 equation used to predict bridge strength.



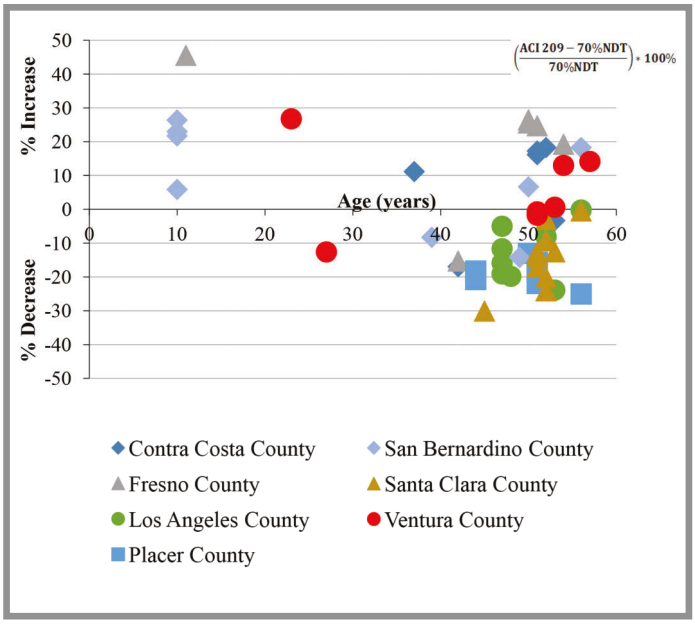
Precast concrete girder age versus percent increase from design strength to actual strength as predicted by NDT

WHAT IS THE BENEFIT?

Caltrans has a validated method to better predict the capacity for existing precast I girder bridges across the state. The process lessens the need for costly and unnecessary upgrades. Without in-situ concrete compressive strength determinations, it is anticipated that the majority of the state's precast girder bridges would be downgraded for capacity and subsequently require strengthening or replacement, resulting in millions of dollars of unnecessary upgrades.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2017/CA17-2748_FinalReport.pdf



Percent difference between the estimated strength as predicted by the ACI 2019 equation and as predicted by NDT

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Research Results

Comparing Person to Vehicle Throughput to Determine BRT Routes

New tool helps planners evaluate the tradeoffs between increasing vehicle delay versus moving more people along a corridor when reviewing BRT projects

Modal

JANUARY 2018

Project Title:
Bus Rapid Transit (BRT) Toolbox: Assessing Person Throughput to Measure Transportation Impacts for BRT Projects

Task Number: 2664

Start Date: February 1, 2015

Completion Date: December 29, 2017

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

Task Manager:
Bradley Mizuno
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WHAT WAS THE NEED?

Bus rapid transit (BRT) uses some combination of signal priority, special platforms, designated lanes, and outside fare collection to improve speed and trip quality. BRT is less expensive and more flexible than rail and faster and more reliable than conventional buses. Whether on limited-access highways or urban arterials, BRT can increase speed and reliability, and often bus mode share, by replacing one or more general purpose lanes with exclusive bus lanes. Transit agencies across California are operating or anticipating BRT corridors as a component of their service networks, and many routes align partially or completely within Caltrans rights-of-way. However, narrowing or eliminating general-purpose lanes along arterials can be politically charged. Individual car owners, sensitive to potential increases in vehicle delay, and auto-oriented businesses who are concerned about losing a parking lane, often oppose proposed infrastructure changes that prioritize modes other than private automobiles.

When planning an infrastructure project, agencies have traditionally evaluated its affect on vehicular capacity or traffic congestion. California has mandated that alternative metrics be adopted when measuring transportation effectiveness, but communities that are considering implementing BRT have expressed a shortage of resources to support the policy, tools to estimate mode shift, traffic diversion, and person throughput, and information on which approval thresholds to use. To assist Caltrans and transit agencies deploying BRT on state corridors, Caltrans needs additional metrics and tools to assess whether improved bus service can boost state highway performance.

WHAT WAS OUR GOAL?

The goal was to provide a tool for agencies to measure the effectiveness of a BRT project and whether it improves or hinders corridor performance when estimating person versus vehicle throughput.

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Comparing Person to Vehicle Throughput to Determine BRT Routes

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Partners for Advanced Transportation Technology program, developed a simple tool for characterizing and comparing transit and non-transit scenarios to assess reserving portions of a roadway for BRT. Agencies and Caltrans district planners provide demand- and design-related numeric values about the corridor, such as the type of facility, length in miles, number of lanes, and average car and bus speeds and, in return, get performance-related outputs in terms of level of service, capacity, travel time, and person throughput. To estimate people throughput for both automobile and transit trips, the researchers used evaluation criteria and metrics that better reflect an urban setting with multimodal considerations rather than focusing only on vehicle performance. The researchers also interviewed representatives from Caltrans districts that have or are considering BRT regarding how the tool could best serve planners and decision-makers and expanding the evaluation criteria to consider person throughput.

WHAT WAS THE OUTCOME?

While the tool does not specify a particular value of person throughput at which to approve a project, it includes metrics that more appropriately capture the advantages of BRT and eliminates focusing solely on automobile delay. Person throughput or capacity rather than vehicle level of service is more appropriate for corridor-level analysis when considering BRT impacts on Caltrans rights-of-way.

WHAT WAS THE BENEFIT?

Adopting planning practices that support BRT facilitates construction of an environmentally and economically progressive transportation mode that aligns with current Caltrans policy. The simple spreadsheet tool provides a non-resource-intensive way to estimate BRT impacts with metrics that more holistically address transportation models.

LEARN MORE

To view the complete report:
www.dot.ca.gov/newtech/researchreports/reports/2018/CA17-2664_FinalReport.pdf

Rendering of Van Ness Avenue in San Francisco, with dedicated BRT lanes marked in red. The innermost lanes in each direction were historically subject to frequent delays as cars waited to complete left turns. Prohibiting left turns and adding BRT is projected to increase vehicle throughput per lane.

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Research Results

Using GPS Trajectory and Schedule Data to Measure Public Transit Performance

New algorithms process massive amounts of public transportation data to analyze performance and improve efficiency

Modal

MARCH 2018

Project Title:
Los Angeles Metro Bus Data Analysis Using GPS Trajectory and Schedule Data

Task Number: 3124

Start Date: January 1, 2017

Completion Date: December 31, 2017

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

Task Manager:
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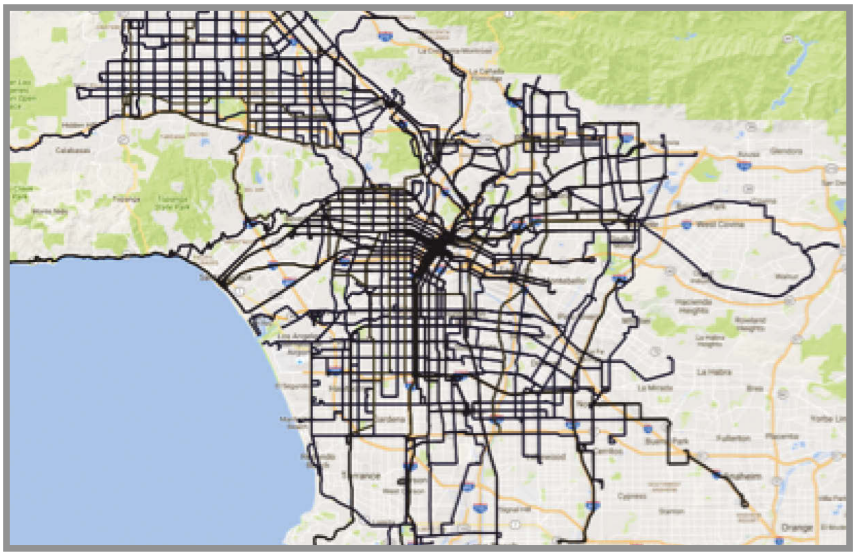
WHAT WAS THE NEED?

With the widespread installation of location-enabled sensors on public transit vehicles, a wealth of GPS trajectory data is being collected that can be used for calculating and analyzing the performance of public transportation systems and ultimately reducing operating costs and shaping public transit into a more viable and reliable option for commuters. However, harnessing this data is challenging because the GPS records are not grouped or ordered in any way and not mapped to specific transit stops and schedules. To extract meaningful and accurate information requires extensive pre-processing.

WHAT WAS OUR GOAL?

The goal was to develop a method to process transit vehicle location data and other related datasets to detect issues and improve the efficiency of public transportation systems.



Examples of route maps of all bus trajectories in Los Angeles

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Using GPS Trajectory and Schedule Data to Measure Public Transit Performance

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the METRANS Transportation Center, developed a system that can process massive amounts of GPS trajectory data collected from transit vehicle sensors and map it to related datasets. The researchers then implemented statistical algorithms to analyze a variety of public transportation system performance metrics, such as reliability, on-time performance, bus bunching, and estimated travel time. The project used real-time and historical Los Angeles Metro bus GPS trajectory datasets collected and archived in a database over the past six years. Approximately one million records are sent each day on average, and the time interval of each sensor data report is about 3 minutes. The researchers also developed a proof-of-concept web-based application to access and visualize the performance metrics.

WHAT WAS THE OUTCOME?

The data-mining algorithms effectively analyze the performance of public transportation vehicles based on their GPS trajectories. The components developed can clean and transform massive amounts of GPS data and correlate and integrate the cleaned datasets to the road network and time tables. Users can interact with the web-based application to visualize, query, and analyze performance metrics of buses in Los Angeles County based on real-time and historical GPS data. Going forward, building on the current outcomes, the researchers envision a comprehensive analytic framework that includes a web interface to test and visualize scenarios and policy hypothesis. In addition, algorithms could extract insights for possible improvements to the transportation system and actively request user feedback to advance the recommendation.

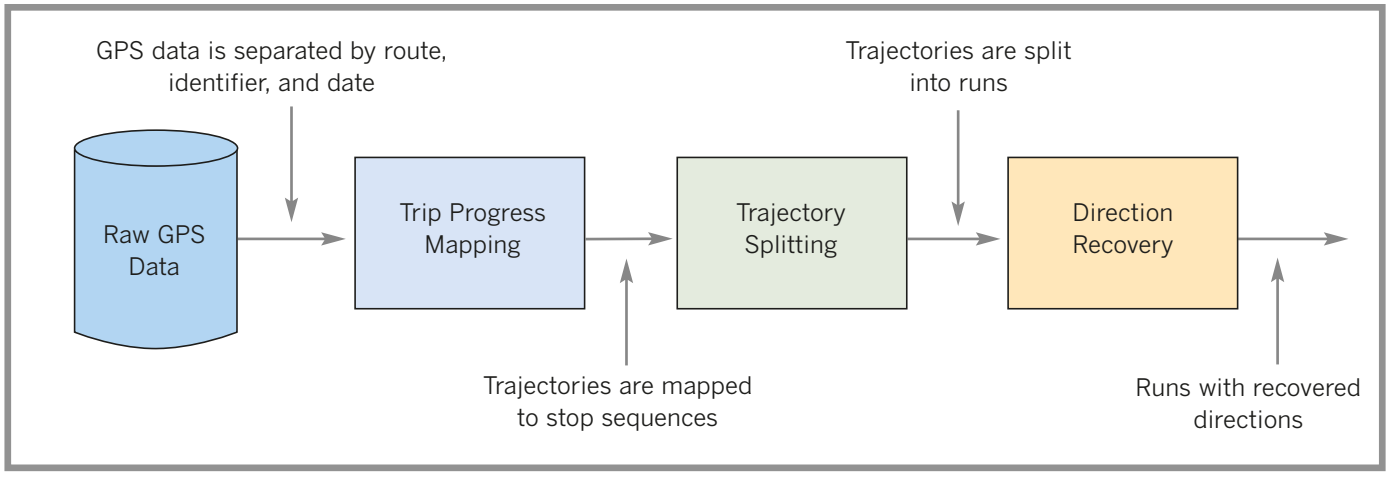
WHAT IS THE BENEFIT?

The ability to handle large amounts of data and match it with relevant information gives transit agencies a window into performance metrics. Transit operators can quickly identify problems with bus lines, such as delays possibly caused by driver behavior or technical issues, or quantify the delays in bus lines caused by construction or other route interferences. Agencies can also use the data to support drive policy decisions, such as rearranging routes or modifying timetables.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA18-3124_FinalReport.pdf

Examples of bus stops in Los Angeles



Pre-processing steps

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Research Results

Are Bikes Good for Business?

Bicycle infrastructure projects are beneficial for population health and cyclist safety and can also make business sense

Modal

MARCH 2018

Project Title:
Bicycle Infrastructure and Business District Change

Task Number: 3136

Start Date: March 1, 2017

Completion Date: February 28, 2018

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

Task Manager:
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WHAT WAS THE NEED?

As communities across California expand infrastructure to promote bicycling as a strategy to address congestion, vehicle emissions, and public health, business owners in these transitioning corridors have expressed concerns regarding the potential loss of business when replacing parking spaces with protected bike lanes. However, the quantifiable effects of adding bicycle infrastructure on business establishments has not been fully measured. The lack of data puts local governments in the difficult position of implementing bicycle infrastructure in commercial corridors with little to no supporting statistics or conversely delaying projects due to merchant-led opposition who also lack reliable evidence that bike lanes harm business. Executing projects without contextual analysis fuels controversy, while delays cost taxpayer dollars, consume government employee time, and prevent potentially beneficial projects from rolling out on schedule. Equipping planners and business owners with facts can inform policy, foster consensus, and aid in determining where best to locate bicycle infrastructure.

WHAT WAS OUR GOAL?

The goal was to use statistical analysis and modeling to better understand how installing bike infrastructure affects businesses.

Class II facility on Broadway in Oakland

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WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Center for Community Innovation, used secondary data on business performance to analyze the impact that the different classes of bicycle infrastructure have had on sales and business closures in San Francisco County and Alameda County. The primary distinction between the classes is the degree of physical separation between cyclists and vehicular traffic. The data models incorporated variables for neighborhood, built environment, and business characteristics to isolate and examine the effect of bicycle infrastructure. The researchers also surveyed shoppers along corridors to explore firsthand the relationship between bicycle infrastructure, mode choice for shopping trips, and consumer behavior.

WHAT WAS THE OUTCOME?

The relationship between the location of bicycle infrastructure and change in sales is mixed, with bike facilities appearing to have a neutral effect on sales and a neutral or positive effect on the likelihood of business turnover, with the most positive effects occurring on neighborhood roads. In both counties, the location of dedicated bike lanes (Class II) was not associated with a notable change in sales. Shared roadways (Class III) in San Francisco had little impact on businesses. In Alameda County, shared roadways generally bolstered business, although facilities on secondary roads had a negative association. In terms of business turnover, both infrastructure classes in San Francisco showed no significant relationship with the likelihood of turnover. Changes to the availability of on-street parking for the Class II model in San Francisco had minimal effect on sales volume. In Alameda County, businesses abutting Class II and Class III corridors saw a lower likelihood of turnover.

Class III facility on Milvia Street in Berkeley

Although the modeling generally disproves business owners' claims that bike infrastructure is bad for business, it does not confirm cyclist advocates' claims that bike infrastructure is good for business. Instead, the control variables indicated that a multitude of factors can affect the change in sales over time. Overall, business characteristics are the most reliable predictors of sales. For instance, across both counties, bars, services, and financial services all registered increases in sales. However, sales declined for automobile-oriented businesses and stores selling home goods. Older businesses generally saw decreases in sales, as did chains.

WHAT IS THE BENEFIT?

Gathering reliable data to understand the relationship between bicycle infrastructure and commerce is important as communities across California push for more bicycle infrastructure projects while facing concerns from business constituencies. Not all businesses are affected by bicycle infrastructure in the same way. Identifying vulnerable industries or business types during the planning process can inform the design and location of bicycle facilities and also encourage communities to work with business owners to avoid potential adverse outcomes related to bicycle infrastructure.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA18-3136_FinalReport.pdf

Class II facility on Valencia Street in San Francisco

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Research Results

Tell Me More: Developing an Interactive Transit Station Information System

An interactive transit station information system can improve the passenger experience, transit service, and ridership by making public transit more predictable, reliable, and friendly

Modal

APRIL 2018

Project Title:
Development and Field Testing of an Interactive Transit Station Information System (ITSIS) Using Connected Vehicle Technologies

Task Number: 2521

Start Date: June 30, 2014

Completion Date: April 24, 2018

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

Task Manager:
Bradley Mizuno
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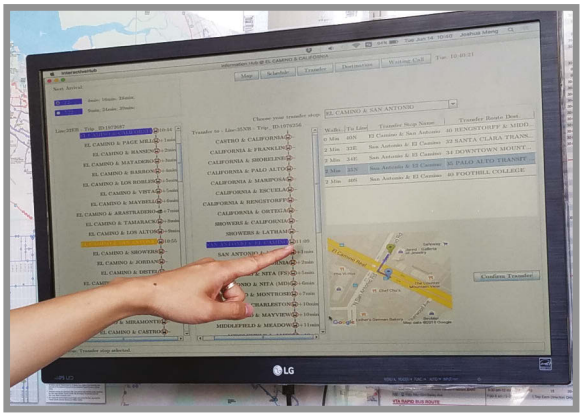
WHAT WAS THE NEED?

As a means of transportation, public transit in California is underutilized, in part because some travelers find it unreliable and inconvenient, but increasing transit use is essential for reducing congestion and emissions. To encourage ridership, transit information needs to me more accurate, helpful, and personal. An interactive transit station information system (ITSIS) provides travelers real-time information to assist in trip planning and to know that they can arrive at their destination when expected. While some of this information is provided using fixed messaging signs, websites, and mobile apps, the interactive capabilities of ITSIS can respond to real-time needs and support dynamic transit operations, enhancing the level of service to passengers. Travelers can interactively find the best itinerary to their final destination, including connectivity at transfer points, the availability of bike racks or wheelchair spaces, service disruptions along the trip route, and even send a waiting message to manage pick ups and transfers. An ITSIS system can also assist transit agencies by collecting travel demand and origin-destination data to improve operations and planning.

WHAT WAS OUR GOAL?

The goal was to develop and test an ITSIS prototype that uses connected vehicle technologies to enable real-time interaction between passengers and transit systems.



The ITSIS prototype displays real-time bus arrivals and departures, stop locations, and walking distance between stops.

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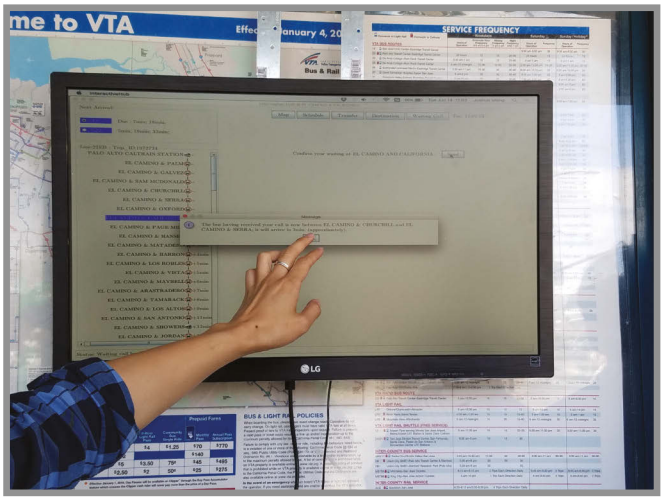
Tell Me More: Developing an Interactive Transit Station Information System

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Partners for Advanced Transportation Technology program, designed a prototype ITSIS based on connected vehicle technologies to demonstrate how it could disseminate personalized transit information to travelers and facilitate dynamic operations by providing bus operators real-time "passenger waiting" information. The ITSIS, which included a trip planner, an arrival-time prediction algorithm, and a functional user interface, was mounted at one bus shelter in Palo Alto and one in San Jose. The researchers also collected field data by inviting riders to participate in a survey at each location.

WHAT WAS THE OUTCOME?

The surveys revealed that more than 70% of the respondents found ITSIS functions valuable or very valuable. About 35% agreed or strongly agreed that a system like ITSIS would make them ride buses more frequently. ITSIS provides the next step in improving the level of service to passengers and supporting enhanced transit operations by enabling travelers to interact with transit systems regarding their current trip plans and real-time needs. The research team recommends conducting a larger scale and longer duration field test.



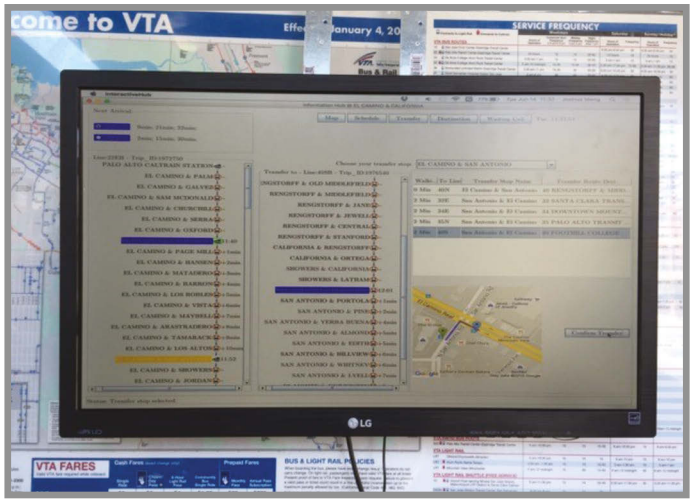
The traveler sends a waiting message to a bus along with an itinerary. The transit agency notifies the bus driver that a traveler is waiting and the transfer information.

WHAT IS THE BENEFIT?

Will I make it to work on time? How do I get from here to there? Where is my bus? Is there room for my bike? Is it time to hail a rideshare? An ITSIS could answer all these questions by providing transit riders timely personalized trip planning. Real-time transit information helps travelers make better transportation choices, fosters the impression that public transit is dependable, and encourages use while also benefitting transit agencies by helping them make operations more efficient and better serve travelers.

LEARN MORE

To view the complete report:
www.dot.ca.gov/newtech/researchreports/reports/2018/CA18-2521_FinalReport.pdf



The Information Hub shows bus line information and nearby transfer stops for a traveler who is planning a trip.

DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Hold That Bus: Developing a Dynamic Transit System to Improve Service

Transforming fixed-route transit operations into dynamic services in suburban regions can make public transit a more attractive travel alternative

Modal

AUGUST 2018

Project Title:
Demand Responsive Transit Operation Based on Dynamic Passenger Information

Task Number: 2663

Start Date: April 1, 2015

Completion Date: May 31, 2018

Product Category: New or improved tool or equipment

Task Manager:
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WHAT WAS THE NEED?

Transit agencies in Californian suburban regions grapple with maintaining cost-effective and efficient operations while trying to meet the demands for service frequency and connectivity because riders are spread across a large geographic area. To provide broad geographic coverage, transit agencies distribute a limited number of buses on various fixed routes, resulting in long intervals between buses. Long waiting times and minimal service discourages travelers from taking public transit. Now with the development of connected vehicle technologies and improvements in accessing real-time information for both transit and highway networks, the concept of dynamic transit operations is more feasible. An integrated dynamic transit operation (IDTO) system can make multimodal transit in suburban areas more convenient, faster, and cost efficient by using real-time information to hold buses at stops for connecting passengers, adjusting routes to pick up passengers not at regular stops or to avoid congestion, and facilitating first-last-mile ridesharing.

WHAT WAS OUR GOAL?

The goal was to design a prototype IDTO system to improve transit operations and reduce travel time by ensuring successful transfer connections, providing responsive dispatching, and promoting dynamic ridesharing.

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Hold That Bus: Developing a Dynamic Transit System to Improve Service

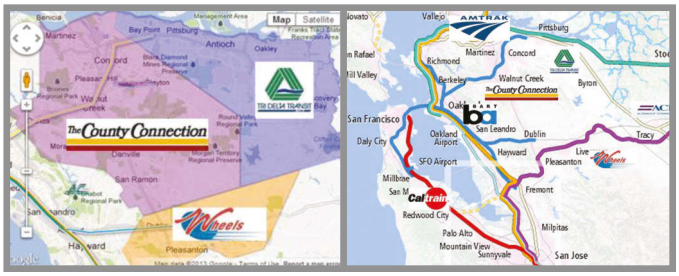
Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Partners for Advanced Transportation Technologies program, designed an IDTO system that enables transit operators to adjust routes dynamically in response to travelers' needs and traffic conditions. For this Phase I effort, the researchers developed the essential functional components, including the IDTO server, dispatch interface, and the mobile app for passengers, and field-tested the IDTO system's transit "connection protection" (T-CONNECT) functionality on selected BART and eastern Contra Costa County Tri Delta Transit bus connection points. T-CONNECT enables transit operators and travelers to communicate to facilitate the successful transfer between modes, such as from car to bus or bus to train. T-CONNECT uses real-time transit information to predict whether passengers can make their next connection and then automatically send a message to the transit operator to adjust the departure time. Passengers can also use the app on their mobile device to initiate a request for a connection to wait.

WHAT WAS THE OUTCOME?

The IDTO prototype correctly identified 85.5% of all trip delays involving connection failures, and the precision of the requests to hold a connecting bus reached 72.3%. By holding buses for transferring passengers decreased waiting time on average by 23.78 minutes for bus-to-bus connections, and 30.71 minutes for BART-to-bus scenarios. In addition, the system-submitted T-CONNECT requests to hold a bus matched the passengers' manual connection protection requests via the mobile app.



Bus and rail maps of the demonstration site

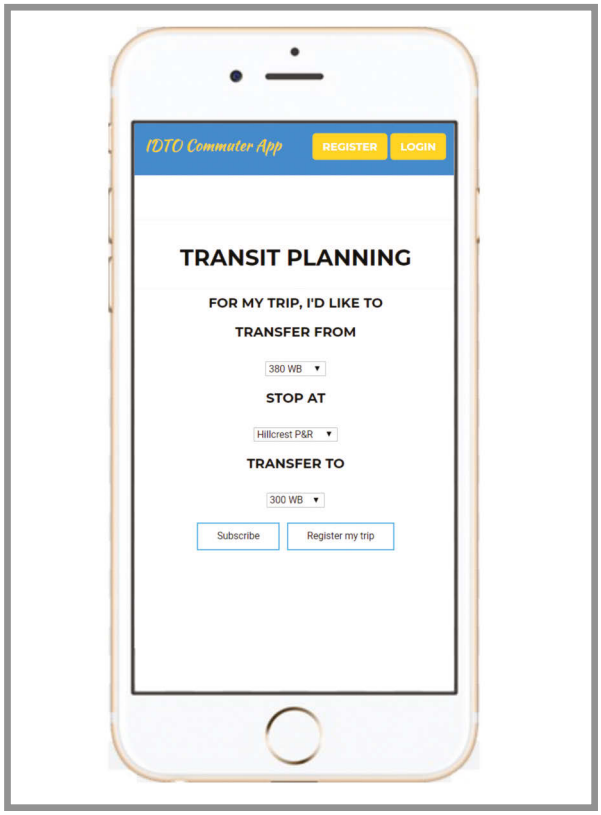
WHAT IS THE BENEFIT?

Dynamic transit services in suburban regions can improve multimodal connectivity, reduce travel time, and make transit operations more efficient. Shorter commute times and broader and more reliable service makes public transit a more attractive travel alternative. Increased transit use can relieve congestion, improve air quality, and reduce transit operation costs. Based on the success of the initial prototype, it is recommended to explore the benefits of a fully functional and deployed IDTO system.

LEARN MORE

To view a video demonstrating the interaction between a rider using the T-CONNECT application, the dispatch operation center, and the vehicle driver, visit: *https://path.berkeley.edu/research/connected-and-automated-vehicles/integrated-dynamic-transit-operation-idto-system-using*

To view the final report: *http://www.dot.ca.gov/research/researchreports/reports/2018/CA18-2663_FinalReport.pdf*



Mobile app interface

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Research Results

Testing for Alkali-Silica Reaction in Concrete Bridges and Pavements

Based on testing a broad range of samples, the Caltrans specifications adopted to prevent ASR have been effective

Pavement

SEPTEMBER 2017

Project Title:
Results from Visual Inspection and Laboratory Testing for ASR in Existing Concrete Cores from Bridges and Pavements in California

Task Number: 2702

Start Date: June 1, 2015

Completion Date: September 16, 2017

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

Task Manager:
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WHAT WAS THE NEED?

Alkali-silica reaction (ASR) is a chemical reaction between the alkalis in portland cement concrete and certain types of silica minerals present in some aggregates. The reaction produces a hygroscopic gel that absorbs moisture and swells. Under certain circumstances, the gel can cause the concrete to expand and eventually crack. Factors that affect the rate and severity of ASR include the amount and type of reactive silica minerals present, the alkalis in the concrete, the exposure conditions to moisture and temperature, and the size and reinforcement details of the concrete element. In some cases, ASR can cause severe concrete deterioration, leading to a loss in serviceability or rendering the concrete more susceptible to damage from other processes, such as freezing and thawing or chloride ingress and corrosion. After extensive research to mitigate the impact of ASR on bridges and pavements, Caltrans adopted new specifications in the 1990s. To evaluate the effectiveness of the new guidelines, Caltrans compared the results of studies on concrete materials placed before and after the specification changes to determine the presence of ASR. An examination to determine the extent of ASR on the California highway network would require extensive condition surveying and field sampling. Having existing concrete cores collected during earlier Caltrans studies provided an opportunity to initiate a less costly and more rapid ASR survey.

WHAT WAS OUR GOAL?

The goal was to evaluate the presence of ASR in California's pavement and bridges to determine the effectiveness of Caltrans' ASR-mitigation guidelines and develop procedures for evaluating ASR.

Bridge cores: Cores equal to or longer than 3 inches were used for ASR visual inspection.

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WHAT DID WE DO?

Caltrans, in partnership with the University of California, Davis Pavement Research Center, examined concrete cores collected from previous studies to perform a high-level assessment of the presence of ASR and to determine the alkali-silica reaction and deterioration rates for concrete placed before and after Caltrans changed its ASR mitigation practice in the 1990s. Most of the 311 bridge deck cores were obtained from the San Francisco Bay Area, while the 265 pavement cores were collected from across the state. The researchers examined thin sections of concrete using a petrographic microscope, the most common technique used for identifying ASR. The data and results for all the cores tested were inventoried in a database. The researchers also drafted guidelines containing step-by-step inspection procedures and selection criteria for visually inspecting concrete cores to identify signs of potential ASR-related distresses and to support decisions regarding the need for a further detailed investigation for ASR.

WHAT WAS THE OUTCOME?

None of the cores showed the likelihood of an ASR issue, as defined by a damage rating index (DRI) for concrete greater than 2,000, although a few cores showed a small number of ASR features. Most of the pavement cores inspected had DRI values of less than 1,000, with the median being approximately 200. The majority of bridge cores also had a DRI of less than 1,000, with a median of about 500 DRI. Comparison of the ages of the bridges and the ASR damage rating index for the cores showed no apparent differences between cores from bridges built before and after 1995, approximately when Caltrans changed specifications to reduce the risk of ASR.

Pavement and bridge cores after cutting for visual inspection

WHAT IS THE BENEFIT?

ASR is difficult to stop after it has begun. The best way to mitigate ASR is to prevent it from happening through the proper use of materials in a concrete mixture. The guidelines developed for visually inspecting concrete cores to identify signs of potential ASR-related distresses help reduce the impact of ASR. Caltrans staff can use the guidelines to determine the need for further detailed examinations of concrete.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2017/CA15-2702_FinalReport.pdf

Pavement core strength testing

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Research Results

Improved Guidance and Specifications for Full-Depth Reclamation

Pavements that are rehabilitated using FDR strategies can withstand traffic loads common in California

Pavement

NOVEMBER 2017

Project Title:
Full-Depth Recycling Study: Test Track Construction and First-Level Analysis of Phase 1 and Phase 2 HVS Testing, Forensic Investigation, and Phase 1 Laboratory Testing

Task Number: 2707

Start Date: October 1, 2014

Completion Date: November 30, 2017

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

Task Manager:
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WHAT WAS THE NEED?

Full-depth reclamation (FDR) is an in-place recycling alternative to road reconstruction. FDR reuses the existing pavement to rebuild a worn roadway. The old asphalt and base materials are pulverized, mixed with cement and water, and compacted to produce a new surface. Caltrans is reviewing the use of FDR as an alternative rehabilitation strategy to mill-and-replace, specifically on projects where the distress is caused by a weak base or insufficient layer support. Although FDR has been implemented in California and other states, primarily on lower-volume roads, the design approaches are based on gravel equivalency, with gravel factors for reclaimed layers based on a limited dataset, which often leads to overly conservative pavement designs. The research published offers limited guidance on how to select and design FDR projects using the different stabilization strategies. A better understanding of the behavior of FDR pavements under traffic is needed. Modeling the behavior using laboratory tests supports informed decisions on where to use FDR and how to determine the appropriate asphalt concrete thicknesses to ensure that the designs are achieved in the most cost-effective manner.

WHAT WAS OUR GOAL?

The goal was to develop guidelines for the rehabilitation and design of pavements using full-depth reclamation techniques.

Test pit after accelerated wheel-load testing on a FDR section with foamed asphalt and cement stabilization. An equivalent of 34 million equivalent single axle loads (ESAL) was applied, resulting in 6 millimeters of rut but no cracking.

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Improved Guidance and Specifications for Full-Depth Reclamation

WHAT DID WE DO?

Caltrans, in partnership with the University of California Pavement Research Center, conducted laboratory and field testing to evaluate different FDR strategies and develop mechanistic-empirical procedures for rehabilitation designs using FDR. The researchers investigated four FDR strategies—pulverization with no stabilization; stabilization with foamed asphalt and portland cement; stabilization with only portland cement; and stabilization with engineered asphalt emulsion—comparing their performance for rutting and fatigue cracking with accelerated wheel-load testing under dry and wet conditions.

WHAT WAS THE OUTCOME?

Although long-term evaluation still needs to be completed to collect sufficient data to finalize mechanistic-empirical design criteria and revised gravel factors for FDR pavements, sufficient evidence shows that pavements that are rehabilitated using FDR strategies can satisfactorily withstand design traffic loads common in California. The FDR strategies that used portland cement as a stabilizer, with or without foamed asphalt, performed better than the method without stabilization. No recommendations can be made at this time on using asphalt emulsion as a stabilizer due to problems experienced during construction of the test section, which were not representative of typical FDR procedures with this stabilizer. Results from testing under wet conditions confirmed that, as with any pavement design, good drainage is critical to ensure that the pavement performs as expected. Laboratory testing procedures have been developed to accurately simulate key mechanistic properties measured on field projects, primarily stiffness changes over time.

Testing to assess stiffness change over time

WHAT IS THE BENEFIT?

Rehabilitation using an FDR technique can speed up construction and minimize disruption to traffic. FDR reuses all materials, so there is no need to haul material away from the site. FDR that integrates stabilization approaches provides a new and stronger base. The process replaces extensively cracked asphalt layers, thereby preventing the reflective cracking that is common in more traditional overlay projects.

LEARN MORE

To view the complete report:
http://www.dot.ca.gov/research/researchreports/reports/2016/CA17-2707_FinalReport.pdf

Triaxial testing to simulate stiffness changes on FDR projects

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Research Results

How Are New Mobility Services Changing Transportation Demand and Supply?

Understanding the factors that limit and encourage the use of shared mobility services helps planners and decision-makers address the effect on other transportation modes

Planning/ Policy/ Programming

FEBRUARY 2018

Project Title:
The Adoption of Shared Mobility in California and Its Relationship with Other Components of Travel Behavior

Task Number: 3088

Start Date: November 1, 2016

Completion Date: October 31, 2017

Product Category: Processed data/ database

Task Manager:
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WHAT WAS THE NEED?

Information and communication technologies are rapidly reshaping the transportation landscape by providing on-demand access to a number of travel options, severing the costs of owning a vehicle and the restrictions of fixed public transit schedules from the mobility equation. These technology-enabled services—for example, carsharing, ridesharing, bikesharing, and ridehailing—can influence travel behavior and decisions in multiple ways by increasing the options for a trip, reducing travel uncertainty, and providing easier access to a vehicle or a car ride to those who do not own a car. The popularity of these services is expected to increase steadily, potentially transforming travel patterns in future years. In the long term, the adoption of these services could alter the level of car ownership, daily schedules, lifestyle, residential location, and choice of transportation mode. These services could also provide public benefits by making public transit more accessible and reducing congestion and parking demand. However, because the factors contributing to mode adoption can vary depending on the types of services available, the local context, user characteristics, and other circumstances, the long-term effects that the adoption of these services have on other components of travel behavior and auto ownership are unclear. A better understanding is needed of who uses these services to coordinate policy making and incentives to harvest the potential benefits of shared mobility while reducing the negative effects.

WHAT WAS OUR GOAL?

The goal was to investigate the impact of shared mobility on travel behavior, vehicle ownership, and use of public transit among young adults in California.

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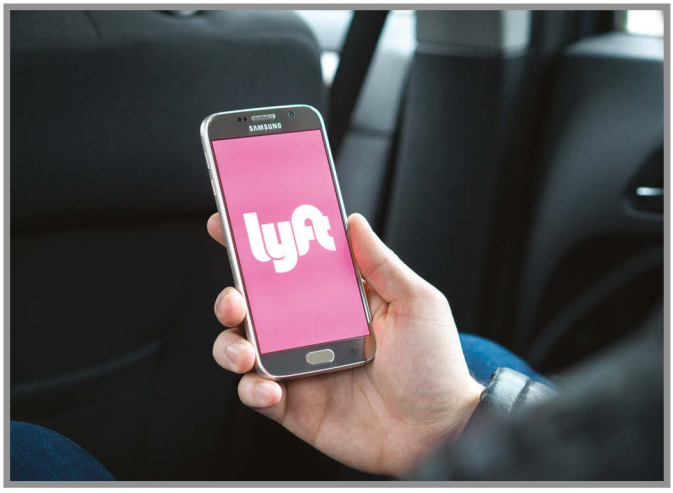
How Are New Mobility Services Changing Transportation Demand and Supply?

WHAT DID WE DO?

Caltrans, in partnership with the National Center for Sustainable Transportation, explored the use of various types of shared mobility services in California and the effect on other components of travel behavior, focusing in particular on the factors influencing the adoption of ridehailing services and frequency of use, by analyzing a unique and comprehensive dataset collected in 2015 of more than 2,000 respondents consisting of adults born between 1981 and 1997, referred to as Millennials, and adults born between 1965 and 1980, or Generation X. The researchers investigated the impact of residential location, neighborhood characteristics, sociodemographics, individual lifestyles and attitudes and the relationships between the adoption of shared mobility services and the use of other travel modes, such as driving alone and taking public transit, auto ownership, and the willingness to reduce the number of household vehicles.

WHAT WAS THE OUTCOME?

The results show that the percentage of respondents that are familiar with and use shared mobility services is higher among urban dwellers and residents of the state's large metropolitan areas. Although ridehailing is one of the newer services introduced to the market, for example, as compared to carsharing, the users of services like Uber and Lyft greatly outnumber the users of other emerging transportation services. Land-use mix and regional auto accessibility increase the likelihood of ridehailing. In addition, the adoption of on-demand ride services is higher among individuals who make more long-distance trips and those who travel more by plane.



WHAT IS THE BENEFIT?

This study provided initial insights on the awareness, familiarity, and use of various shared mobility services in California and which factors affect adoption and frequency of use. Transportation planners and decision-makers can apply this information to develop more-effective policy levers and incentives to guide future travel demand and travel modes to reduce the negative environmental impacts of transportation. For example, one application being explored by many agencies is incorporating shared mobility services with public transit to address the first-mile, last-mile issue.

LEARN MORE

To view the complete report:
http://www.dot.ca.gov/research/researchreports/reports/2018/CA17-3088_FinalReport.pdf

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Research Results

Mapping California's Sidewalks with Digitalization

Machine-learning techniques can speed up creating a statewide sidewalk inventory to support active traveling and foster sustainable transportation

Planning/ Policy/ Programming

JANUARY 2018

Project Title:
Developing an Interactive Machine-Learning-Based Approach for Sidewalk Digitalization

Task Number: 3097

Start Date: November 21, 2016

Completion Date: November 15, 2017

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

Task Manager:
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WHAT WAS THE NEED?

Active traveling, in particular walking, is a key aspect of sustainable transportation. Walking promotes physical fitness, mitigates local street congestion, and fosters community livability. To support active mobility, local and state agencies have focused efforts on planning, maintaining, and enhancing the infrastructure, such as sidewalks, which requires establishing and evaluating the sidewalk inventory on a large geographic scale, such as city- or county-wide. Conventionally, transportation engineers and planners rely on laborious and costly field surveys to assemble a sidewalk inventory. To date, a few studies have attempted to digitize walkways, for example, as part of GIS training, but they rely on the vehicle roadway network to guide pedestrians, which might not be walkable and pose safety risks. A dedicated sidewalk inventory is necessary. With the advances in computational capability, machine-learning techniques can assist in image recognition and classification. Because preparing the image set for training and analysis on a large geographic scale can be challenging, including a sidewalk digitization method would be a more reliable and cost-effective approach for creating a comprehensive sidewalk inventory.

WHAT WAS OUR GOAL?

The goal was to automate creation of a sidewalk inventory by using aerial images and advanced image-processing techniques to create the sidewalk network links and nodes and then to classify the sidewalks as paved or missing.

Outputs from initial digital processing of aerial images of the roadway network to create predictions of sidewalk locations. Yellow links are roadways, green links and blue nodes are sidewalks. Further image processing will validate the presence or absence of an actual sidewalk.

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Mapping California's Sidewalks with Digitalization

WHAT DID WE DO?

Caltrans, in partnership with the National Center for Sustainable Transportation, developed an interactive, machine-learning sidewalk digitization method that can initialize the features of sidewalks, classify walkways into two major categories—paved and missing—and construct a connected sidewalk network in a time-efficient and cost-effective manner. To digitize the sidewalk network, the researchers used available data sources of aerial and satellite images of roadway networks in Riverside, California, which covered 4,385 roadway links in the vehicle roadway network. The researchers created an image-sweeping script to extract a large number of sidewalk images along the sidewalk network and then applied a machine-learning technique to the aerial images to identify whether a paved sidewalk is present or not.

WHAT WAS THE OUTCOME?

The initial mapping created 14,806 sidewalk links, including 8,774 sidewalk segments and 6,032 crosswalks. Preprocessing took approximately 2 hours, and the initial mapping process took only a few minutes. Machine-learning-based image processing correctly categorized 62% of all sidewalks: 52.2% of the paved sidewalks and 70.2% of the missing sidewalks. The rates of correctly categorized sidewalks are expected to improve as the algorithm is trained on more images. To improve the process, the researchers recommend automating the preprocessing steps and enhancing the level of details when categorizing sidewalk features, such as separating driveways from sidewalks. Future directions could also explore more advanced machine-learning algorithms, such as a convolutional neural network for classifying images into detailed sidewalk features, and applying similar image-sweeping methods to obtain other road attributes, for example, width, bicycle lane location, and freeway condition.

WHAT IS THE BENEFIT?

The automated mapping approach can provide a basis for a comprehensive sidewalk inventory to enhance the inventory of sidewalk infrastructure, improve pedestrian navigation accuracy, model pedestrian volume, and identify sidewalk sections that need improvement. Improving the sidewalk infrastructure supports sustainable transportation, Complete Streets implementation efforts, and a seamless, interconnected transportation system that provides a variety of modal options for travelers.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA18-3097_FinalReport.pdf

Screenshots of paved sidewalk sections from an aerial image at 1:300 scale

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Caltrans Division of Research, Innovation and System Information

Research Results

Strategies to Mitigate Freight-Generated Congestion

A new freight-impact measure helps identify how and where freight causes congestion

Planning/ Policy/ Programming

NOVEMBER 2017

Project Title:
Managing the Impacts of Freight in California

Task Number: 3133

Start Date: January 1, 2017

Completion Date: November 30, 2017

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

Task Manager:
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WHAT IS THE NEED?

Tons of goods are moved into California every day through its seaports, airports, and borders, some for local consumption and some for shipment to other states and countries. Freight traffic is growing faster than automobile traffic—the U.S. Department of Energy projects that truck vehicle miles of travel will grow by 50% between 2015 and 2040, compared with 26% for light-duty vehicles. As freight and passenger vehicles compete for limited roadway access, growing freight demand is increasing recurring congestion at freight bottlenecks, where freight and passenger services conflict with one another, and on streets with not enough room for pickup and delivery. Trucks disproportionately contribute to traffic congestion, especially close to major freight generators, due to slower acceleration and deceleration rates and more limited maneuverability. In addition, diesel engine pollutants have emerged as a top health concern among vehicular-generated air pollution, especially particulate matter and fine particles. Increased freight activity will affect California's ability to achieve its objectives for reducing greenhouse gas emissions.

The federal 2016 Fixing America's Surface Transportation (FAST) Act requires states to consider the freight industry's effect on congestion and delays and identify mitigation strategies. Previous studies have focused on freight bottlenecks and the impacts of congestion on freight, but there are no studies that examine freight as the causal agent of imposing overall congestion and other delays.

WHAT WAS OUR GOAL?

The goal was to generate recommendations on the most effective strategies for reducing freight-related congestion and its impacts for inclusion in the 2019 California Freight Mobility Plan to comply with FAST Act requirements.

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WHAT DID WE DO?

Caltrans, in partnership with the National Center for Sustainable Transportation, developed a method for identifying congestion caused by freight and applied it to California's two largest metropolitan areas, Los Angeles and San Francisco, as well as the rest of the state. The method estimates the current and projected impacts by 2040 on passenger vehicles and provides descriptive information on how other modes are affected. After conducting a comprehensive international review of mitigation strategies and assessing their applicability and effectiveness for specific freight problems in California, the researchers developed a set of criteria by which to evaluate potential strategies for different types of problems and locations.

WHAT WAS THE OUTCOME?

The researchers identified the top-15 freight impact areas on the national highway system and arterials in the Los Angeles and San Francisco regions, which are concentrated on freight corridors that connect ports, intermodal terminals, and warehousing clusters in the more congested parts of the region. In the rest of the state, the top-15 areas are located in San Diego, Sacramento, and the I-5 corridor in the Central Valley.

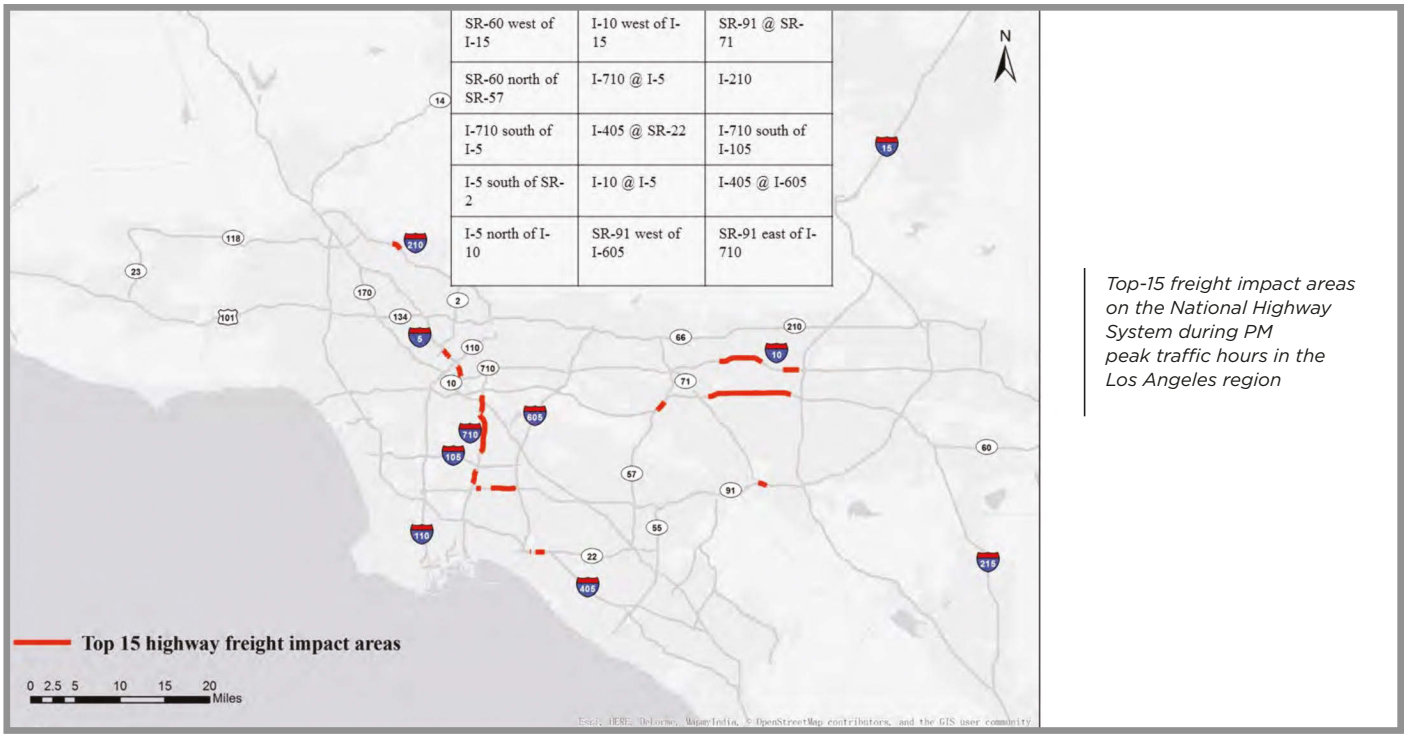
Possible mitigation strategies consistent with California Freight Mobility Plan goals were discussed in terms of infrastructure improvements, efficiency enhancements, and policy incentives. Each strategy was evaluated with respect to cost, effectiveness, co-benefits (safety and reducing pollution), technical difficulty, and implementation feasibility. Examples of higher ranking strategies include truck parking facilities, integrated freight traffic and load information services, cargo-matching services, and smart truck parking.

WHAT IS THE BENEFIT?

Identifying regional freight impact areas and relating these areas to major freight generators, such as airports, seaports, and intermodal terminals, provides a new tool for freight-impact analysis and assists California in complying with the FAST Act freight planning requirements. Transportation professionals and stakeholders can evaluate the strategies with the most potential for reducing freight-related congestion and its impacts to determine which recommendations to include in the California Freight Mobility Plan.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2017/CA17-3133_FinalReport.pdf



Top-15 freight impact areas on the National Highway System during PM peak traffic hours in the Los Angeles region

DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

What Does the Future Hold for California's Transportation Ecosystem?

Exploring the long-term impact of emerging technologies and market trends on California's transportation sector amidst social, economic, and environmental change

Planning/ Policy/ Programming

FEBRUARY 2018

Project Title:
Future of Mobility White Paper

Task Number: 3118

Start Date: February 1, 2017

Completion Date: January 31, 2018

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

Task Manager:
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WHAT WAS THE NEED?

Transportation is experiencing its most transformative revolution since the introduction of the automobile rapidly altered the mobility landscape in the early 20th century. Concerns over climate change and equity are converging with technological advances, and shifting economic, geographic, and demographic trends are affecting commerce, land use, and mode choice. When combining all these factors, making predictions about the future of transportation is complex and nuanced. Every five years, California is required to renew its long-range comprehensive California Transportation Plan (CTP). The intent of the Future of Mobility White Paper is to inform and guide policymakers and modelers developing the next iteration—CTP 2050—by presenting updated descriptions and analyses of developments impacting California's transportation system.

WHAT WAS OUR GOAL?

The goal was to provide Caltrans with an additional tool to convey what the future of transportation might look like to facilitate decision-making and planning in a rapidly evolving transportation landscape.

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What Does the Future Hold for California's Transportation Ecosystem?

WHAT DID WE DO?

Caltrans partnered with the University of California, Berkeley Transportation Sustainability Research Center (TSRC) to convene an advisory committee of 50 members representing local, regional, and state transportation agencies to identify key research areas based on current trends and timeframes for technologies in the pipeline. Through committee discussions and expert interviews, the team selected 21 topics that could impact transportation through 2050, including emerging trends that could affect the future of transportation despite a lack of research, data, and quantitative analyses, such as cybersecurity risk, blockchain, 3D printing, drones, and Hyperloop.

TSRC established a framework to capture the amount of available research covering the topic, the state of development of each technology or policy area—current, emerging, or future—and the degree to which the future impact on transportation is predictable. The framework visually presents the level of understanding and uncertainty for each topic.

WHAT WAS THE OUTCOME?

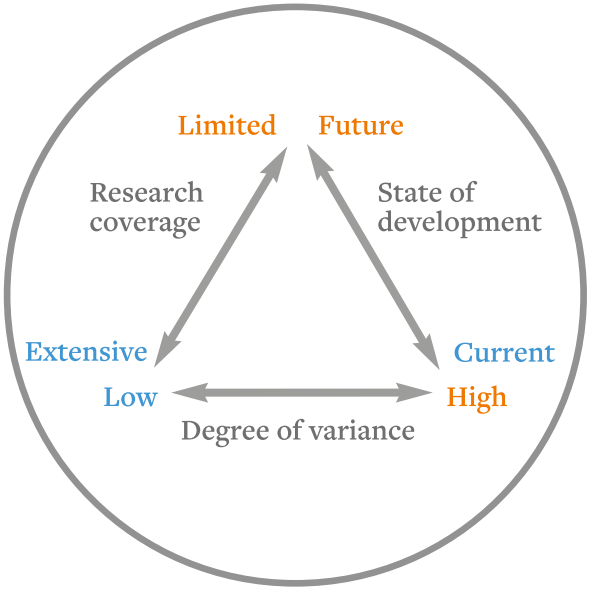
Much has transpired in the past five years. Transportation network companies (ridesourcing and ridehailing) are commonplace, and carsharing and bikesharing services have expanded. Automated vehicles could soon be on the market, and more Californians are registering electric vehicles. Drones, 3D printing, and automation could impact goods movement in California. On the policy side, transportation agencies are reconsidering existing funding mechanisms, which might become unreliable if people use public transit less. High-speed rail is under discussion and construction in the state, and recent legislation reiterates California's commitment to pedestrian- and bicycle-friendly infrastructure, evidenced by the first-ever California Statewide Bicycle and Pedestrian Plan, published in 2017. The white paper serves as a primer for people who want to explore these topics further and has been used in CTP 2050 outreach.

WHAT IS THE BENEFIT?

Trends in transportation technology, innovative business models, renewable energy, machine learning, and user behavior will continue to converge, impacting transportation systems and mobility options. This document serves as a guide for researchers and policymakers, reflecting the type of data and analysis available for each topic. It highlights current research about key trends and emerging technologies and services and documents their impacts on California's transportation ecosystem. It also helps identify gaps in knowledge and potential areas of future research.

LEARN MORE

To view the white paper:
http://www.dot.ca.gov/research/researchreports/reports/2018/CA17-3118_FinalReport.pdf



Axis graph to visually convey the level of knowledge, state of development, and degree of variance in predictions for each topic

OVERARCHING TOPICS	CURRENT AND EMERGING TRANSPORTATION-SPECIFIC TOPICS		
• Climate change and sustainability • Demographics • Economics • Transportation equity and public health	• Connected and automated vehicles • Zero-emission vehicles • Carsharing • Bikesharing	• Transportation network companies • Alternative transit services • Shared mobility • Public-private partnerships and data sharing	• Information and communications technology • Freight and goods movement • California's passenger rail system

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Research Results

Multimodal Freight in a Connected Vehicle Environment

Dynamic route guidance using connected vehicle technology can increase the mobility and resilience of freight operations

Policy/ Planning/ Programming

FEBRUARY 2018

Project Title:
Evaluating Economic Mobility and Resilience of Multimodal Freight Operations in a Connected Vehicle Environment

Task Number: 3123

Start Date: March 2, 2017

Completion Date: February 28, 2018

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

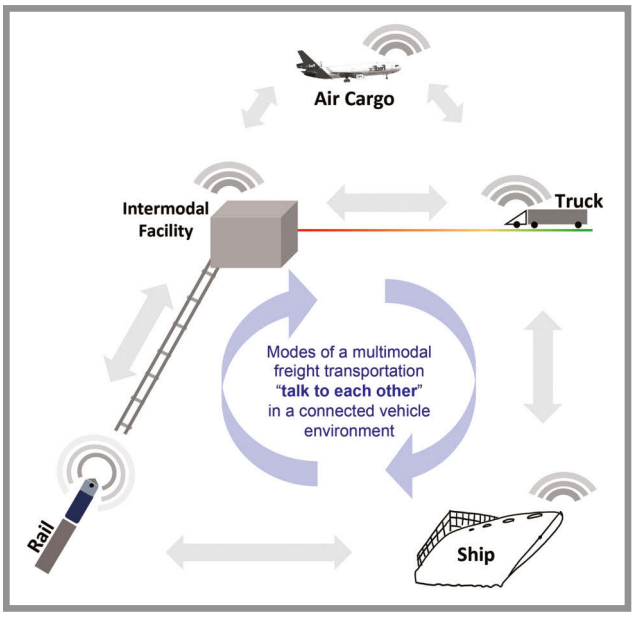
Task Manager:
Patrick Tyner
Associate Transportation Planner
patrick.tyner@dot.ca.gov

WHAT WAS THE NEED?

The U.S. Department of Transportation's Intelligent Transportation System Strategic (ITS) Plan prioritizes the design, testing, and planning for deploying connected vehicles across the nation, which has spurred freight manufacturing companies to begin integrating ITS and connected vehicle technology (CVT) features into their next generation of freight vehicles. CVT has the potential to transform the synchronization of multimodal freight operations between trucks, rail, air cargo, and ports. With the ability of the various modes to "talk to each other," they can adapt to changes in the surrounding traffic conditions, leading to more efficient transferring of goods. However, little is known about the communication reliability of the CVT network in terms of the freight industry, which is especially critical for commercial trucks, which, unlike freight rail, have some flexibility in changing course to access other links and nodes of the highway network. For freight planning purposes, a reliable network requires that all freight transport in the multimodal system communicate with each other to determine the most efficient route.

WHAT WAS OUR GOAL?

The goal was to understand the implications of CVT for multimodal freight operations in determining efficient routes for mobility and resilience and estimating the economic costs for CVT-induced route guidance.



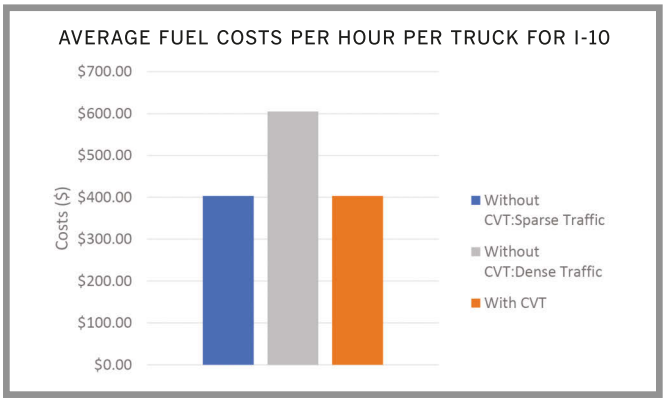
Caltrans provides a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability.

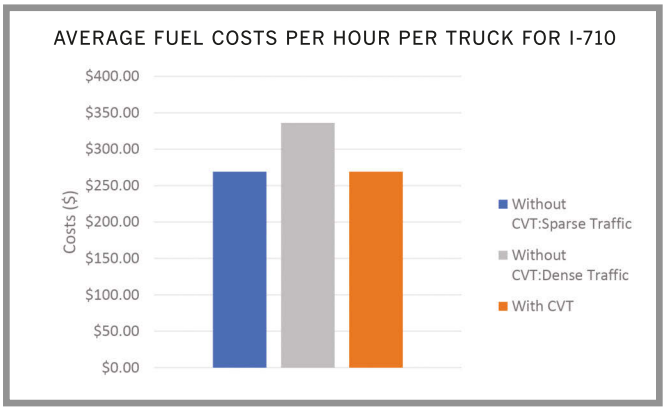
WHAT DID WE DO?

Caltrans, in partnership with the METRANS Transportation Center, developed mobility and resilience indicators, such as congestion indexes, for links and nodes of a multimodal freight network system and evaluated the influence of CVT on routing freight vehicles to design a network reliability model for route guidance. Based on the reliability model, the researchers constructed freight routes between major origin-destination pairs, using the interstate highways I-405, I-5, I-10, and I-710 in Southern California, which connect one or more intermodal terminals and ports. Links and nodes with high mobility and resilience indicator values were candidates for determining efficient routes with CVT assistance. Then the researchers estimated the economic costs of the CVT-induced route guidance for both mobility and resilience for the various freight modes: commercial trucks, freight rail, seaports, and airport.

WHAT WAS THE OUTCOME?

Based on the analysis of the four interstates of approximately 12-mile lengths when comparing them with and without CVT, the findings suggest the following.





Comparison of fuel operational costs per hour for I-10 and I-710 with and without CVT

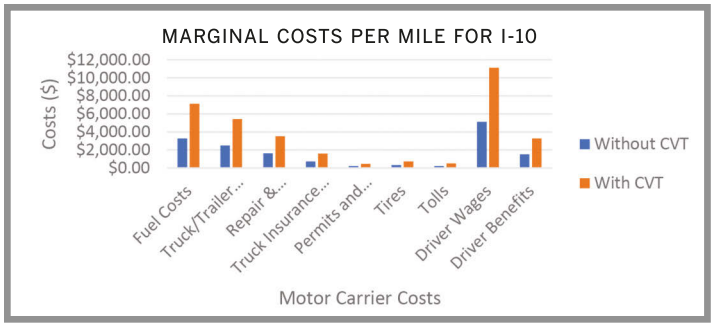
- Reliability of communication improves with the increase in the number of multimodal entities participating in CVT.
- To be fully connected, the optimum radius of sensor transmission range for vehicles with CVT is at least 1,500 feet in sparse traffic conditions, and 55 feet in congested traffic conditions.
- Motor carrier operational costs increase with CVT.
- With the implementation of CVT, I-10 is expected to experience the largest percentage increase in mobility, and I-710 would have the largest percentage increase in resilience.

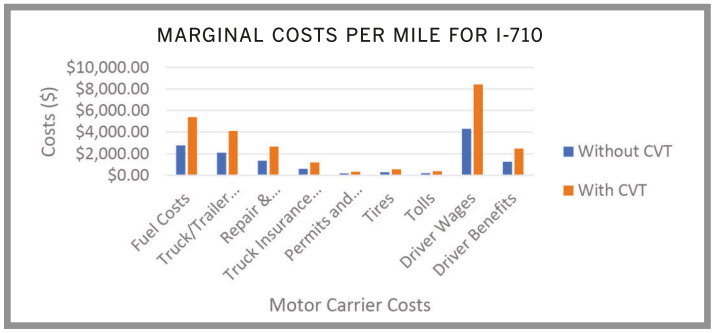
WHAT IS THE BENEFIT?

California's economy relies on the efficient movement of goods. CVT has the potential to influence large-scale, multimodal freight transportation, which relies on synchronized operation between trucks, rail, airports, and seaports. Understanding the implications of implementing CVT for multimodal freight operations can help the state maintain economic competitiveness, along with providing safety, mobility, and environmental benefits to the state's freight network.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA18-3123_FinalReport.pdf





Comparison of marginal truck operational costs for I-10 and I-710 with and without CVT

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Research Results

Designing a Real-time, Cost-sharing Freight System

Pooling transportation networks among multiple suppliers reduces the total transportation cost and vehicle miles traveled

Policy/ Planning/ Programming

APRIL 2018

Project Title:
An Online Cost Allocation Model for Horizontal Supply Chains

Task Number: 3122

Start Date: March 9, 2017

Completion Date: March 15, 2018

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

Task Manager:
Frank Law
Senior Transportation Planner
frank.law@dot.ca.gov

WHAT WAS THE NEED?

Transporting goods or delivering services in a timely, reliable, and cost-effective manner is crucial for businesses to survive in today's fast-paced economy. To compete effectively against their peers, companies have relied on internal optimization to reduce operating costs, but have overlooked opportunities for external cooperation. Consequently, the logistics sector has become highly fragmented, with each supplier developing and operating its own distribution network that is prone to low-capacity usage, high-energy consumption, and high greenhouse gas emission. The increasing amount of freight transportation also stresses the state's highway system and aggravates traffic congestion, especially in dense urban areas. One approach to make the logistics sector more economically, environmentally, and socially sustainable is for companies to pool freight transportation networks to share operating costs and alleviate the impact on traffic congestion by reducing the number of total vehicle miles. The broadened application of vehicle positioning systems and real-time information and communication networks has expanded dynamic truck fleet routing, but how to fairly allocate cost to each participant in the cooperation is challenging, especially in light of just-in time delivery constraints. Allocating costs among multiple suppliers in a real-time, cost-sharing transportation system is among the top impediments for successful horizontal cooperation.

WHAT WAS OUR GOAL?

The goal was to address cost allocation in a dynamic freight transportation network to promote fleet sharing in a horizontal supply chain and reduce the environmental, economical, and social impact of goods movement.

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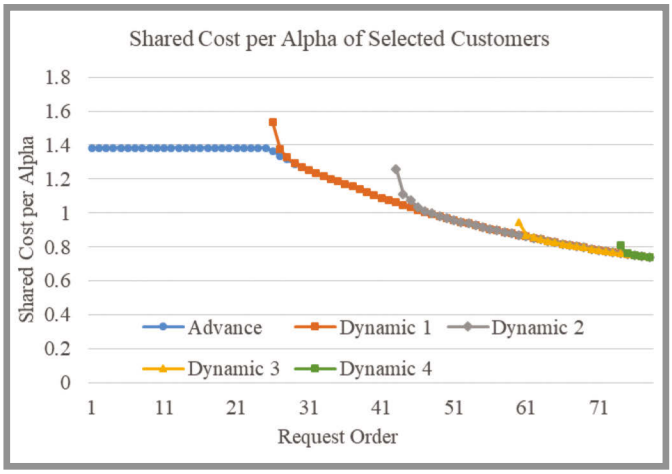
WHAT DID WE DO?

Caltrans, in partnership with the METRANS Transportation Center, designed a hybrid proportional cost-sharing (HPOCS) mechanism that incorporates dynamic vehicle routing to promote horizontal cooperation among multiple suppliers and tested its performance through simulation. For this real-time, cost-sharing transportation system, some customer requests are known in advance, and the rest are realized dynamically over time. The researchers focused on how to allocate the cost to each new customer at the time of the request without knowing the future customer requests and the total cost of the service. Dynamically routing vehicles and real-time cost allocation are interdependent and must be considered simultaneously. The vehicle route depends on whether the new customer accepts or declines the quote for service, and the quote in turn depends on how the vehicle route is designed and what is the expected total cost of the route. To incentivize customers to request service early, the researchers extended the model to incorporate discounts for advance customers and overcharges for dynamic customers.

WHAT WAS THE OUTCOME?

The model (the HPOCS mechanism and extensions) combines proportional cost sharing for calculating the initial quotes for advance customers and handling the proportional costs for dynamic customer requests. Customers can choose to form coalitions with those who request service directly after them to decrease shared costs. The HPOCS mechanism addresses online fairness, budget balance, immediate response, individual rationality, and ex-post incentive compatibility.



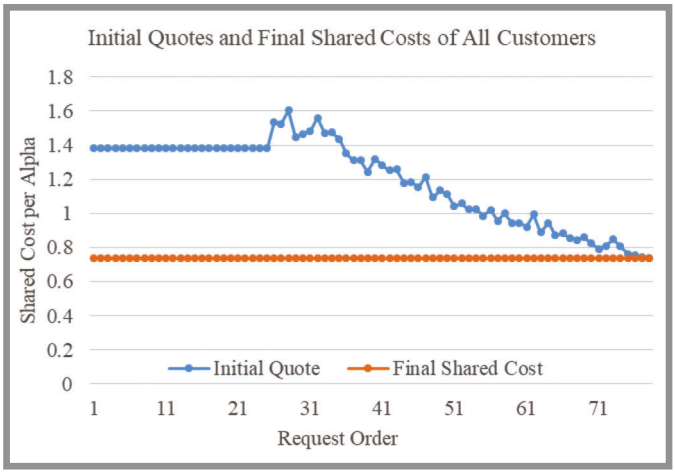
Costs lower as each dynamic customer requests service.

WHAT IS THE BENEFIT?

Businesses can reduce operating costs by using a shared transportation network and alleviate congestion by reducing the number of trucks on the road. Horizontal cooperation among companies not only generates savings for those already in business but also lowers the barrier for new businesses to enter the market.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA18-3122_FinalReport.pdf



The initial quote is reduced as more customers share the costs.

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Research Results

Adopting Alternative Fuels, Vehicles, and Infrastructure

States share best practices and emerging technologies related to alternative fuels and infrastructure

Policy/ Planning/ Programming

MARCH 2018

Project Title:
Toolkit for the Deployment of Alternative Vehicle and Fuel Technologies, TPF-5(331)

Task Number: 2782

Start Date: July 14, 2015

Completion Date: March 30, 2018

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?

The United States highway infrastructure and funding practices have been designed around a gasoline- and diesel-powered vehicle fleet. California and other states share the goal of encouraging the development and success of alternate fuel vehicles (AFV) to move toward a more sustainable transportation future, protect the environment, improve the quality of life, and remain competitive in a global market. Alternative vehicle and fuel technologies require different fueling practices and infrastructure needs and could have other implications for highway finance, safety approaches, and operations. To address this new nexus between the energy and transportation sectors, the Oregon Department of Transportation (DOT) and the Federal Highway Administration initiated a pooled fund to share information about strategies and best practices to support the commercialization of AFVs and infrastructure. In addition to Oregon, seven other state DOTs participated: California, Connecticut, North Carolina, New York, Texas, Vermont, and Washington.

WHAT WAS OUR GOAL?

The goal was to assist state and local transportation agencies interested in promoting the use of alternative vehicle and fuel technologies at a state, regional, or corridor scale with tools, information, and knowledge.

"Learning from the California Experience: Alternative Fuels, Vehicles, and Infrastructure" workshop

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WHAT DID WE DO?

The participating DOTs conducted five workshops around the country to discuss the current status of alternative vehicle and fuels technologies in their specific region. Each workshop has a corresponding toolkit with topic-specific tools and resources.

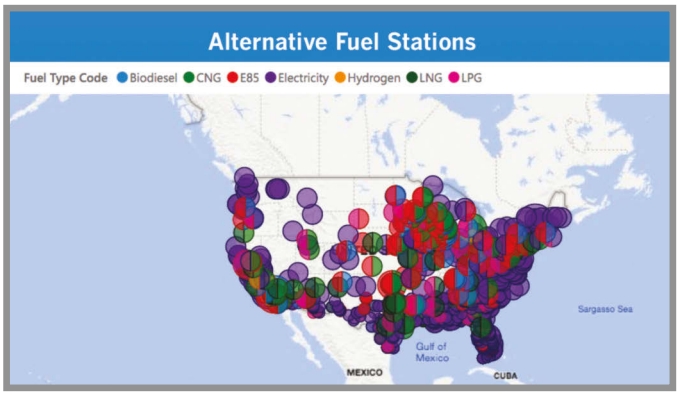
- EV Infrastructure Corridor Development Workshop: Lessons Learned from the West Coast Experience
- Accelerating Alternative Fuel Vehicle and Infrastructure Deployment with Innovative Finance Mechanisms
- State Transportation Fleet Adoption of Alternative Fuel Vehicles
- Clean Corridors Meeting: Tools for Implementing Alternative Fuel Corridors
- Learning from the California Experience: Alternative Fuels, Vehicles, and Infrastructure

In 2017, Caltrans hosted the final workshop, which focused on California's unique policy landscape, the procurement process for alternative fuels for fleets, infrastructure planning, consumer adoption of electric vehicles, and the state's Sustainable Freight Action Plan.

WHAT WAS THE OUTCOME?

The Alternate Fuel Toolkit website was developed in conjunction with the initiative. It hosts all materials related to the workshops and a wealth of tools and resources, such as:

- Overview of alternative fuels, including price and emission information
- Timeline of alternative fuels development in the United States
- Public funding sources for clean freight corridors
- Payback calculator for AFVs
- Interactive map to locate alternate fueling stations
- Interactive map of truck parking and truck stop electrification



Locate alternative fuel stations thoughout the United States

WHAT IS THE BENEFIT?

States face challenges in planning and implementing alternative fuel infrastructure on DOT facilities. The online Alternative Fuel Toolkit assists Caltrans and other state DOTs in learning about fuel technologies, negotiating planning, and strategizing funding. Through the interactions with other DOTs, Caltrans continues to gain insights into how to integrate alternative fuel infrastructure development into the planning process at the collaborative, technical, and policy development levels.

LEARN MORE

To view the various toolkits and other resources:
altfueltoolkit.org

To view the report of the California workshop:
www.dot.ca.gov/research/researchreports/reports/2017/CA19-2782_FinalReport.pdf

Find truck stop parking and electrification sites along a given route

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Research Results

Faster, Safer Surveying with Mobile Terrestrial Laser Scanning

MTLS increases employee safety, reduces costs, and expedites delivery of transportation improvement projects

Right of Way and Land Surveys

FEBRUARY 2018

Project Title:
Expanding Mobile Terrestrial Laser Scanning Capability and Capacity Throughout Caltrans

Task Number: 2729

Start Date: February 15, 2015

Completion Date: February 14, 2018

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

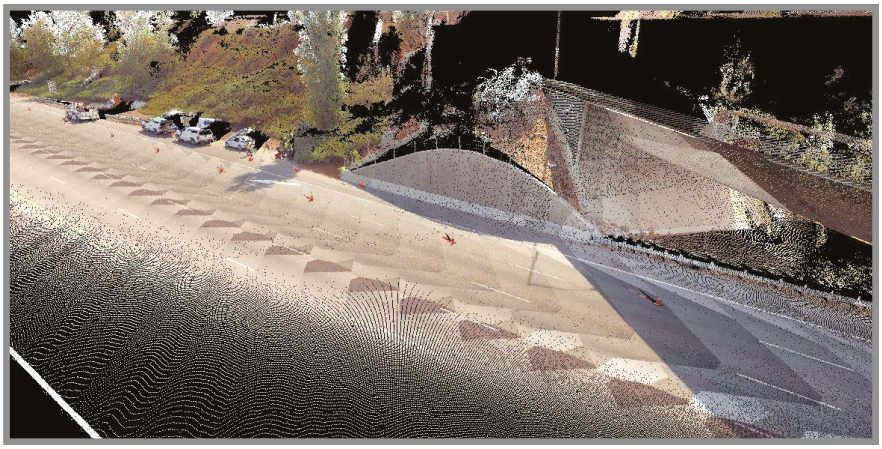
Task Manager:
Arvern Lofton
Transportation Engineer, Electrical
arvern.lofton@dot.ca.gov

WHAT WAS THE NEED?

Caltrans requires survey grade measurements for various projects, such as bridge structures, pavements, major accident investigations, and roadside assets. Typically, performing a survey exposes field personnel to high-speed traffic, often with no barrier or protection. In 2012, Caltrans began testing mobile terrestrial laser scanning (MTLS), which enables surveyors to work safely from a vehicle while also providing many efficiency and technological improvements. The system produces accurate and precise geospatial data at or near highway speeds, enabling surveyors to collect many miles of roadway in a single day, accelerating project delivery. Users can then work with the broad range of data collected while in the office, removing the need to return to the field for measurements. Caltrans surveyors used the Trimble MX8 on over 90 projects, primarily in northern California, to produce pavement digital terrain models. After the initial successful deployment, Caltrans wanted to expand the benefits of the MTLS system to central and southern California.

WHAT WAS OUR GOAL?

The goal was to use MTLS technology throughout California and develop MTLS standards, specifications, and best practices.



Colorized point cloud of a collision site

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Faster, Safer Surveying with Mobile Terrestrial Laser Scanning

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Davis Advanced Highway Maintenance & Construction Technology Research Center, compiled the lessons learned from the northern California implementation and identified the information technology (IT) resources needed to deploy an MTLS system in Caltrans' central and southern regions. Prior to deployment, the researchers developed training materials and provided live training sessions regarding on-site data collection and in-office data post-processing in preparation of conducting pilot projects with the central and southern district surveyors. The researchers also tested the Riegl VMX-1HA, the next generation of MTLS technology.

WHAT WAS THE OUTCOME?

The deployment for both the Trimble MX8 and the Riegl VMX-1HA MTLS systems was successful. The research provided guidance and policies for MTLS data management and distribution, data backup, retention for raw and post-processed MTLS data, data sharing, and visualization. Caltrans is considering adding a new 360-degree camera and integrating 3D ground-penetrating radar technology to the MX8 MTLS system. Caltrans is incorporating the IT infrastructure requirements and recommendations into its MTLS documentation.

Point cloud rendering of the Connected Vehicle Testbed

Distance measuring instrument mounted on the vehicle wheel

WHAT IS THE BENEFIT?

MTLS provides high-resolution 3D data that improves visualization, enhances project design, and facilitates decision-making. Collecting and processing data safely, efficiently, and accurately saves money while reducing work crews' exposure to direct traffic, minimizing injuries, injury-related costs, and roadway congestion for traveling motorists by reducing the lane closures required for survey work.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA18-2729_FinalReport.pdf

Riegl VMX-1HA sensor pod mounted on a custom roof rack

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Research Results

Know Before You Go with One Place for All Routes and Weather

One-Stop-Shop and WeatherShare give rural travelers and Caltrans staff real-time mobility and weather information to make informed travel decisions

Rural

MARCH 2018

Project Title:
Rural Traveler Information Needs Assessment and Pilot Study Phase III : Bordering States Rural Coverage, TPF 5(241) and
WeatherShare Phase IV – Inclement Weather Testing

Task Numbers: 1760 and 2916

Start Date: March 1, 2016

Completion Date: February 28, 2018 and December 31, 2017

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

Task Manager:
Sean Campbell
Senior Transportation Electrical Engineer, Specialist
sean.campbell@dot.ca.gov

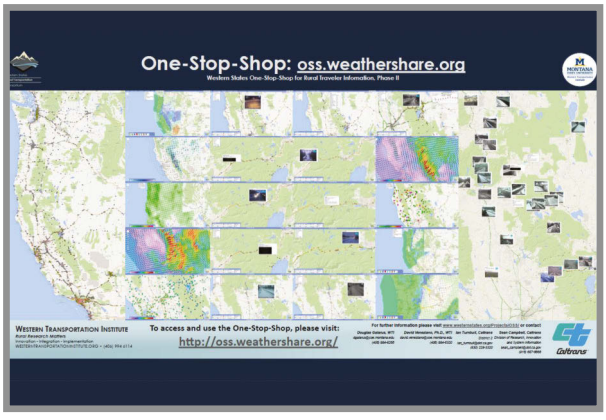
WHAT WAS THE NEED?

Travel and weather don't end at the state or district border, and with One-Stop-Shop (OSS), traveler information doesn't either. Real-time transportation information services are typically urban-focused or within jurisdictional borders, and regional systems tend not to efficiently serve the rural traveler, whose trip can span a great distance between urban areas or include multiple districts. Previously, rural travelers had to gather trip-planning information from a variety of sources, some web-based and some not, with each system managing its own content and interface. OSS consolidates the data from these disparate sources and makes the information available in one location, unified with a single interface. OSS was one of the first systems to synthesize data from multiple state transportation departments with the intent to complement each state's traveler information website, not compete with it.

OSS is an offshoot of WeatherShare, developed by the Montana State University Western Transportation Institute under Caltrans sponsorship, which integrates road and weather information from multiple sources into a single, interactive, map-based online application. Although both applications are similar in providing users a quick, visual picture of real-time conditions, WeatherShare focuses on the specific needs of Caltrans personnel, while OSS serves the traveling public.

WHAT WAS OUR GOAL?

The goals were to enhance One-Stop-Shop and provide real-time roadway and weather information across the western United States and to update WeatherShare to address the needs of Caltrans personnel.



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

Know Before You Go with One Place for All Routes and Weather

WHAT DID WE DO?

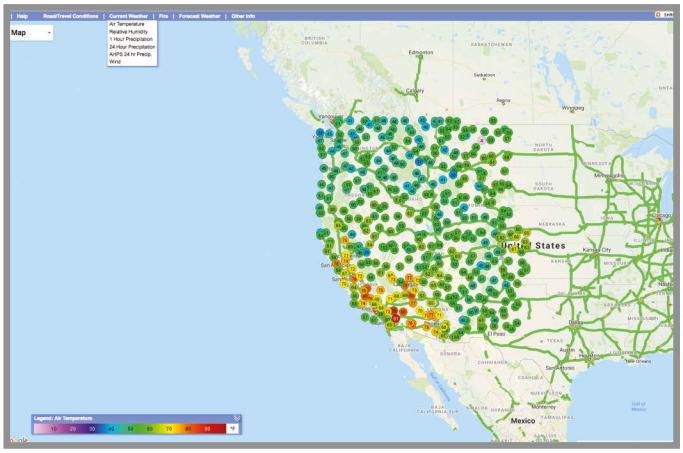
The OSS researchers expanded the application to incorporate traveler information for 11 states—Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming—and investigated adding more types of information that could be relevant to travelers. They also designed a mobile app that is usable across platforms, which was not feasible in earlier stages.

The WeatherShare team added alerting functionality: When a user-defined weather threshold for a location is exceeded, the system messages the user regarding the current conditions. They also conducted tests to ensure that information is accessible during inclement weather and added the capability for users to define how they want to view data.

WHAT WAS THE OUTCOME?

The OSS application provides real-time data, such as weather conditions, road alerts, work zone activities, rest areas, and elevation profiles, to help the general public, commercial vehicle operators, and emergency responders make informed travel decisions. The consistent, easily accessible, and intuitive interface helps travelers plan trips in the state and across state borders.

WeatherShare is now the central repository for Caltrans Road Weather Information System (RWIS) data, along with other essential information. Caltrans maintenance and operations staff have access to real-time and historical weather information to help better manage roadways, apply treatments, and handle weather-related incidents.



Current weather on oss.weathershare.org

WHAT IS THE BENEFIT?

Having all roads and all weather in one stop enhances safety and improves the traveling experience, especially in rural areas. Remote rural travelers can be informed of potential weather challenges, such as snow, ice, and high winds, and unexpected congestion and delays caused by various roadway incidents. By having access to real-time weather conditions and forecasts, Caltrans crews can make the best possible decisions regarding maintenance operations and incident response.

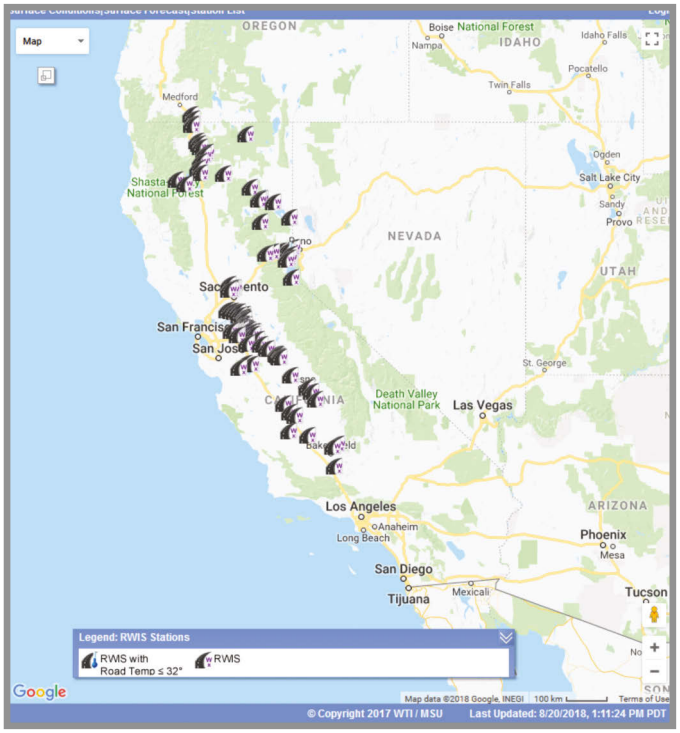
LEARN MORE

To use One-Stop-Shop trip-planning features, visit:
oss.weathershare.org

To see WeatherShare in action, visit:
www.weathershare.org

To view the complete reports:
www.dot.ca.gov/research/researchreports/reports/2018/CA17-1760_FinalReport.pdf

www.dot.ca.gov/research/researchreports/reports/2017/CA17-2916_FinalReport.pdf



Statewide view of the Caltrans RWIS

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Research Results

Seismic Performance of Precast Bridge Decks

Current seismic specifications for cast-in-place decks can be applied to precast construction

Seismic

JULY 2018

Project Title:
Seismic Performance of Precast Full-Depth Decks in Accelerated Bridge Construction

Task Number: 2544

Start Date: May 15, 2014

Completion Date: August 14, 2017

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

Task Manager:
Peter S. Lee
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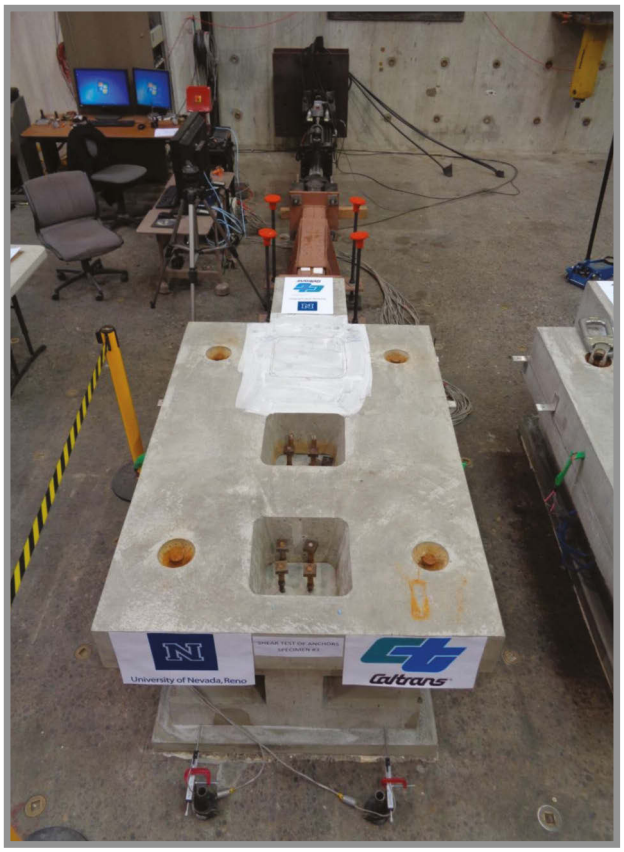
PLee@dot.ca.gov

WHAT WAS THE NEED?

Cast-in-place (CIP) concrete construction is time intensive and requires many on-site construction procedures that can negatively impact traffic flow, work zone safety, and the environment. Accelerated bridge construction (ABC) offers a viable alternative to CIP construction because it reduces on-site construction time by using prefabricated decks for new deck construction and replacement projects. Prefabricated deck panels can provide the opportunity to replace decks during the lifespan of the bridge while keeping part of the bridge in service. Prefabricated deck panels also eliminate the need for deck overlays and post-tensioning the precast deck elements. The primary challenges of using full-depth deck panels are how to connect the deck panel to the longitudinal girder and achieve full composite action and how to connect the panels transversely and longitudinally so that they act as one unit.

WHAT WAS OUR GOAL?

The goal was to design prefabricated precast bridge deck connections to precast longitudinal girders that can be used in seismic zones.



Shear test setup

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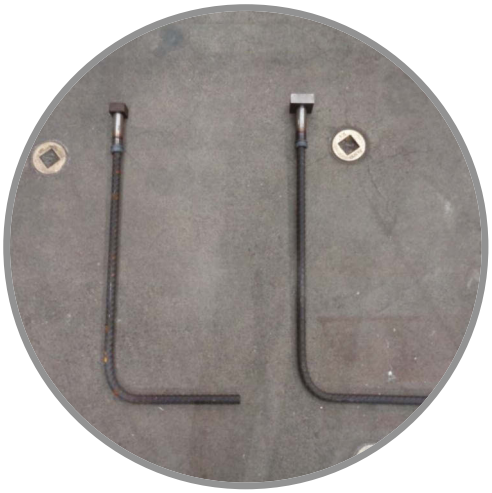
WHAT DID WE DO?

Caltrans, in partnership with the University of Nevada, Reno Department of Civil and Environmental Engineering, tested headed anchors using various head areas, grout types, and anchor group effects to determine their shear, pullout strength, and stiffness. The AASHTO LRFD seismic provisions for CIP construction were used for designing the precast reinforced concrete panels. The researchers investigated three different models: one with rigid link elements to connect the decks and girders; the other two had link elements spaced at 4 feet and 6 feet apart. The researchers used the anchor test results in computational models to perform nonlinear seismic analysis of a two-span bridge. They applied eight earthquake ground-motion records. The researchers also studied the ease and time required to remove the grout from the pockets in the shear specimens to identify the most feasible grouts for future deck replacement and rehabilitation.

WHAT WAS THE OUTCOME?

The experimental results indicated that the type of grout and head area of the anchors had an insignificant effect on the shear and pullout capacity of the anchor and that the AASHTO LRFD provisions for CIP decks can be applied to precast construction. The type of grout and anchor head area had negligible effect on the ultimate capacity and the stiffness of the anchor. Of the six types of grouts tested, latex concrete required the least amount of time to remove, with polyester concrete and ultra-high performance concrete the most difficult. The analytical investigation showed no difference in the overall seismic response of pockets spaced at 4 feet and 6 feet and that all anchors stayed within their elastic range.



Headed anchors used in the study (Left: Head Area = 4Ab; Right: Head Area = 9Ab)

WHAT IS THE BENEFIT?

The ultimate capacity and stiffness of anchors are now available to use in the seismic design and analysis of precast bridge decks. Nonlinear seismic analysis showed that the anchors of precast decks designed to the current provisions of AASHTO for CIP decks stayed within their elastic range. Prefabricated decks can be used in replacement projects while maintaining the serviceability and seismic resiliency of the bridge. Crews can quickly assemble the decks, minimizing traffic disruption, reducing environmental impact, improving worker and motorist safety, improving constructability, and increasing the quality of the final product.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA18-2544_FinalReport.pdf

Pullout test setup

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Research Results

Validating Seismic Design Procedures for Cut-and-Cover Tunnels

Large-scale tests help develop guidelines to improve the safety of subsurface, earth-covered tunnels

Seismic

DECEMBER 2017

Project Title:
Cut-and-Cover Tunnel Shake Table Test Program

Task Number: 2561

Start Date: June 1, 2015

Completion Date: October 31, 2017

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

Task Manager:
Peter S. Lee
Senior Bridge Engineer
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WHAT WAS THE NEED?

As open space to expand surface streets for transit and vehicular traffic becomes more limited, cut-and-cover tunnels are increasingly a preferred solution for transportation challenges in California, but the knowledge base and quantitative datasets concerning seismic response are scarce. The cut-and-cover method is used for tunnels with relatively shallow earth cover. For seismically active regions, the structures need to be designed to resist significant ground motions. The seismic response of the underground structure is governed by the surrounding soil's larger deformation and inertial responses. To develop insights and seismic design guidelines requires testing the capacity and potential seismically induced nonlinear deformation mechanisms of the reinforced concrete tunnel liner and the seismic demand as dictated by the input ground-shaking excitation and the tunnel-ground interaction mechanisms. The first phase of this research under Task 2420 modeled the seismic performance to develop preliminary recommendations. This phase assesses the previous results using large-scale shake table tests, which provide more accurate representations of the soil-structure interactions.

WHAT WAS OUR GOAL?

The goal was to perform large-scale shake table tests to experimentally validate and establish engineering procedures and seismic design guidelines for constructing cut-and-cover tunnels.

Large-scale shake table test model: model of tunnel structure

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WHAT DID WE DO?

Caltrans, in partnership with the University of California, Davis School of Engineering, evaluated the seismic response of a tunnel-ground system by conducting a series of large-scale shake table tests. The researchers tested three model configurations, each with different backfill conditions for the surrounding soil and thickness of overburden soil, and considered two levels of soil compaction relative density (about 99% and 85%). They documented the resulting response in terms of peak racking, wall bending moment, lateral earth pressure resultant force on both sides, and the associated location of the resultant forces in model scale and prototype dimensions. The researchers then compared the responses to those estimated by the 2009 Federal Highway Administration (FHWA) procedures.

WHAT WAS THE OUTCOME?

The shake table tests indicated that the seismic demands of the racking and the wall bending moment increased as the thickness of overburden soil increased despite the lower peak ground acceleration. This trend was associated with the relative stiffness between the tunnel and the surrounding soil. The tunnel deformation was caused by the relative difference between the resultant force and the associated point of action on both sides of the tunnel evaluated from the measured lateral earth pressure.

When comparing the FHWA guidelines to the test results in both model and prototype scale, the FHWA procedure for higher overburden soil depth, for example, approaching 20 feet, provided reasonable estimates of peak lateral moments. When there is no or little overburden soil—less than 10 feet—the FHWA estimates were overly conservative. As the earthquake intensity increased, the application of the FHWA procedure tended to be sensitive to the backfill material stiffness properties, which is associated with high levels of shear strain in the surrounding soil adjacent to the tunnel.

Shake table test model: tunnel being lowered into large soil container; tunnel inside soil container resting on compacted ground

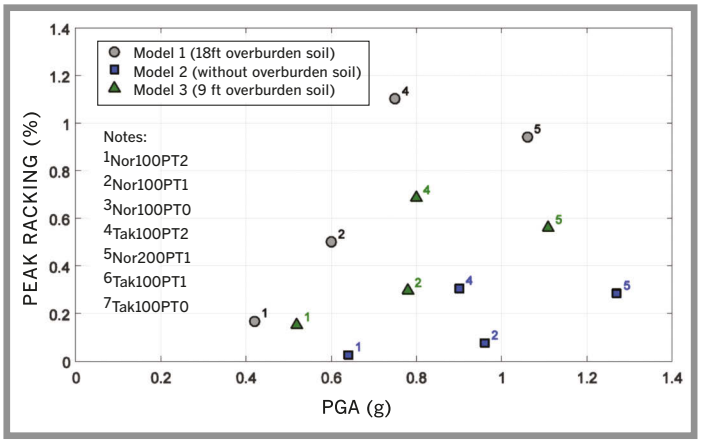
WHAT IS THE BENEFIT?

Sub-surface shallow roadway tunnels are a viable option for addressing limited surface space. The cut-and-cover tunnels can minimize the impact of roads and railway lines by reducing noise, integrating better with the surrounding landscape, and offering continuity with the ground surface. This research produced calibrated, reliable assessment tools and approaches to ensure that these structures are designed and constructed for seismically active regions.

LEARN MORE

To view the complete report for Phase I, Task 2420:
www.dot.ca.gov/newtech/researchreports/reports/2016/CA15-2420_FinalReport.pdf

To view the complete report for Phase II, Task 2561:
www.dot.ca.gov/research/researchreports/reports/2017/CA17-2561_FinalReport.pdf



Relationship of peak racking with peak ground acceleration (PGA) in the full-scale model dimensions

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Research Results

Buckling-Restrained Braces for Steel Truss Bridges

Retrofitting arched truss bridges with buckling-restrained braces can reduce earthquake damage

Seismic

JANUARY 2018

Project Title:
Prequalifying Testing Protocol for Buckling-Restrained Braces Applied to Steel Truss Bridges

Task Number: 2861

Start Date: May 1, 2016

Completion Date: November 30, 2017

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

Task Manager:
Peter S. Lee
Senior Bridge Engineer
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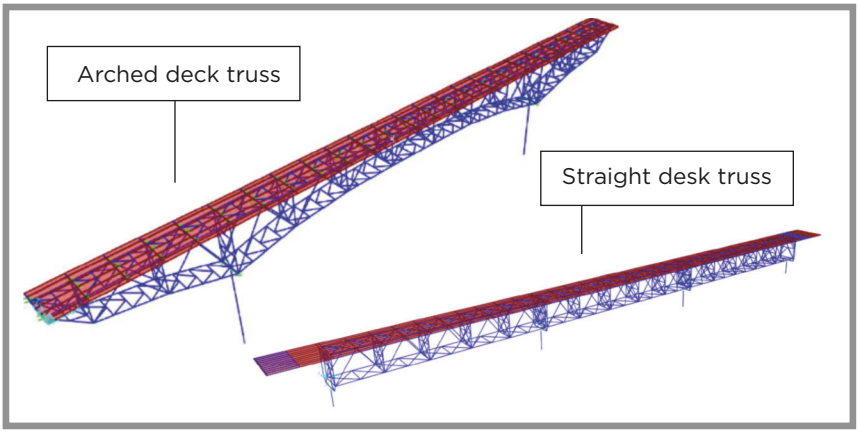
WHAT WAS THE NEED?

Buckling-restrained braces (BRB), originally developed in the 1970s in Japan as seismic devices for structural steel buildings, were introduced in practical applications in the 1990s and gained broad acceptance after the 1995 Kobe earthquake. The braces can withstand large seismic motions, during which they soften to not overload the rest of the structure. During an earthquake, they act as a type of structural fuse while still maintaining the stability of the structure. BRBs have become popular in building design in seismic areas throughout the world, however their use for bridges is almost nonexistent. Building designers have a comprehensive guide for BRB frames, and the AISC Seismic Provisions for Structural Steel Buildings provides a substantiated component testing protocol. However, these tools have not been validated for bridge design, so there is a need to investigate the application of BRB for bridges and to generate acceptable test protocols for bridges.

WHAT WAS OUR GOAL?

The goal was to identify the characteristics and configurations of BRBs on steel truss bridges that improve structural seismic performance and to develop a test protocol for prequalifying BRB components for steel truss bridges.



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Buckling-Restrained Braces for Steel Truss Bridges

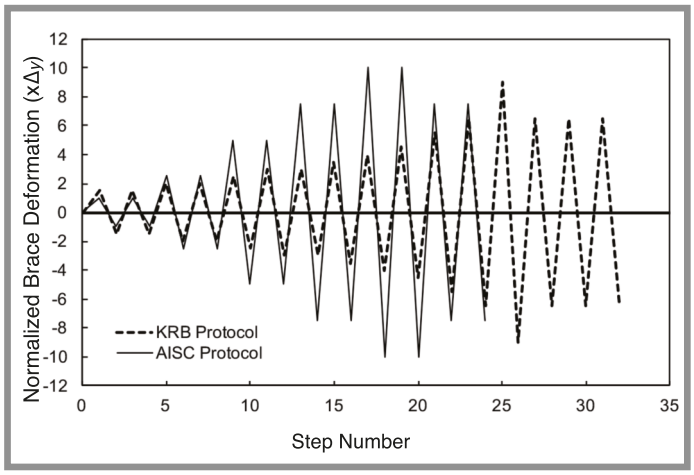
Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Irvine Department of Civil and Environmental Engineering, tested BRBs on models based on two as-built drawings of different steel truss bridges, one arched truss and one multispan straight deck truss. The researchers investigated a hypothetical seismic retrofit using BRBs as replacements for truss members that were identified as failing during a design earthquake. They used a parametric approach to determine the BRB sizes and configurations within the bridge structures. The retrofitted bridge models were then subjected to over 20 ground motions that generated BRB deformation demands used to develop a new loading protocol.

WHAT WAS THE OUTCOME?

Of the two bridges studied, only the arched truss bridge was a suitable candidate for retrofitting with BRBs. Adding BRBs significantly reduced the estimated damage during the design earthquake. Despite many different brace layouts and sizes attempted, the straight deck truss bridge did not demonstrate a reduction in damage. Therefore, the arch bridge was used to develop the prequalifying protocol and was compared to the AISC protocol for building frames. The similarities included the maximum brace deformation, number of deformation cycles (as the structure experiences shaking, the brace is compressed and stretched), and accumulated damage. Therefore, the existing AISC protocol, which has been used for over 10 years to prequalify many BRB component designs, could be used to qualify BRBs for use on steel truss bridges.



Comparison of AISC protocol with proposed bridge protocol

WHAT IS THE BENEFIT?

This research represents one of few studies addressing the use of BRBs on bridges. The developed protocol provides insight into the expected demands on these braces with a conventional bridge type, and it appears that designers can use the AISC protocol on steel truss arch bridges. With these initial steps, this work can be expanded to include other bridge types and BRB configurations.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA18-2861_FinalReport.pdf

Typical BRB frames within a building structure

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Research Results

Seismic Behavior of A706 Grade 80 Rebar in Bridge Columns

Grade 80 rebar in reinforced concrete columns provides similar performance to grade 60 rebar with reduced construction time and costs

Seismic

JUNE 2018

Project Title:
Seismic Behavior of Grade 80 RC Bridge Columns – Phase 1 and Critical Bending Strain of Longitudinal Reinforcement

Task Number: 2994

Start Date: June 30, 2016

Completion Date: June 29, 2018

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

Task Manager:
Issam Noureddine
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WHAT WAS THE NEED?

Current seismic design relies on the principles of capacity design wherein certain structural elements are chosen as plastic hinge members to dissipate energy during a seismic event and protect other members from sustaining extensive damage. When designing reinforced concrete members as plastic hinges, the tensile reinforcement must have a large inelastic strain capacity to ensure that the member can sustain displacement prior to failure. Engineers must also accurately know the material properties of the reinforcement to guarantee correct force demands to the surrounding capacity-protected members. A706 rebar is typically specified for plastic hinge members for structures in higher seismic regions because of its strict chemical composition and limits on minimum and maximum yield and tensile strengths. Until 2009, the A706 standard included only steel rebar with a maximum yield strength of 60 ksi (grade 60), but the standard now includes grade 80 rebar with a yield strength of 80 ksi. A member reinforced with A706 grade 80 rebar would require less steel to achieve the same strength as a member designed with grade 60. Using higher strength reinforcement grade 80 rebar has the potential to reduce rebar congestion and decrease the cost and time of construction. However, due to a lack of experimental evidence, engineers are hesitant to specify grade 80 rebar for use in plastic hinge members.

WHAT WAS OUR GOAL?

The goal was to evaluate the seismic performance of grade 80 reinforced concrete columns and compare design variables to the values used for grade 60 columns.

Constructing the test columns and footings

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Seismic Behavior of A706 Grade 80 Rebar in Bridge Columns

WHAT DID WE DO?

Caltrans, in partnership with the North Carolina State University Department of Civil Construction and Environmental Engineering, constructed four circular columns reinforced with A706-80 rebar with varying axial load and transverse steel ratios and subjected them to reverse cyclic loading to simulate the effects of a seismic event. The researchers compared each grade 80–column's seismic performance to the values used for columns reinforced with grade 60 rebar, including the equivalent viscous damping and the hysteretic energy dissipation at given ductility levels.

WHAT WAS THE OUTCOME?

The plastic hinge length, bond slip, strain-based limit states, and equivalent viscous damping of the columns reinforced with grade 80 rebar were not significantly different from typical grade 60 columns. Based on the results of these four column tests, grade 80 rebar could be specified in place of grade 60 rebar without major changes in design practice. However, the grade 80 columns had slightly lower displacement capacities than the grade 60 columns due to differences in the critical bending strain, which caused bar fracture after buckling. Rebar rib radius and the manufacturing process influenced the critical bending strain.

The researchers developed a method to predict the tensile strain prior to longitudinal bar fracture based on the relationship between uniaxial tension strain demand, the degree of longitudinal bar buckling, and the newly identified critical bending strain. They also created a simplified material test to quantify the critical bending strain for any rebar.

Test column

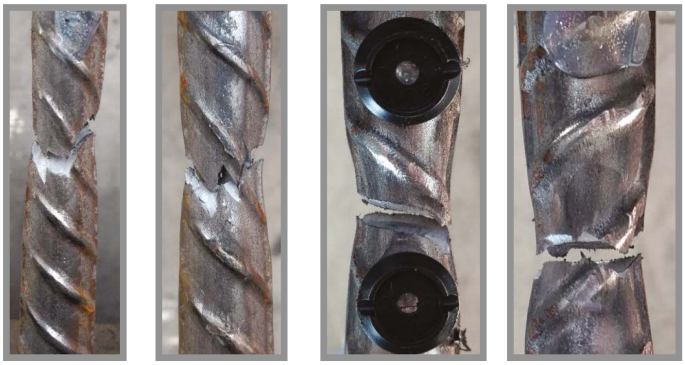
WHAT IS THE BENEFIT?

Using higher strength A706 grade 80 rebar in concrete columns instead of grade 60 reduces material costs and congestion in the footing and cap-beam joints because the columns have fewer bars of the same size. Reducing congestion could also simplify the design of cap beams and connection details.

LEARN MORE

To review the complete report:
www.dot.ca.gov/newtech/researchreports/reports/2018/CA18-2994_FInalReport.pdf

Buckled bar tension test (left); rebar with optical markers (center); buckled rebar (right)



Ductile fracture surfaces of tested rebar

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Research Results

Moving on Empty

Routing model optimizes the movement of freight containers to more efficiently reuse empty containers and reduce truck miles

Transportation Safety and Mobility

AUGUST 2017

Project Title:
Congestion Reduction Through Efficient Empty Container Movement

Task Number: 2984

Start Date: August 24, 2016

Completion Date: August 14, 2017

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

Task Manager:
Patrick Tyner
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WHAT WAS THE NEED?

The maritime transportation industry has been growing steadily during the past decades. The ports of Los Angeles and Long Beach move millions of freight containers a year of which more than 20% are empty due in part to imbalanced trade between imports and exports, container leasing agreements, and the coordination required between companies to make the exchange in a timely manner. The containerized traffic between ports and distribution sites contributes to traffic congestion and air pollution along transportation corridors and in urban areas, which could be minimized by reducing the movement of empty containers. Currently, most container movement at the ports of Los Angeles and Long Beach goes from the port to importers and then back to the port as an empty container. Subsequently, some empty containers go from the port to exporters and then return as loaded containers to the port, and both empty and full containers are shipped from the ports to Asia. To reduce truck miles, strategies are needed to efficiently move and reuse empty containers.

WHAT WAS OUR GOAL?

The goal was to develop strategies that optimally move laden and empty containers to have fewer truck trips and reduce congestion in and around ports.

Los Angeles Port

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WHAT DID WE DO?

Caltrans, in partnership with the METRANS Transportation Center, developed an empty container management model using double- and single-container trucks that transfers empty containers directly from importers to exporters rather than returning them back empty to the port. The researchers tested models using container-demand data from the ports of Los Angeles and Long Beach, focusing on intermodal stations near the port where containers can be switched, to compare the performance of the current policy of no container reuse, a container reuse policy using only single-container trucks, and a container reuse policy using both single- and double-container trucks.

WHAT WAS THE OUTCOME?

Both the single- and double-container reuse policies are improvements over the current policy of no reuse. Using only single containers reduces truck miles by 12%, and with double-container trucks, the reduction is 55%. Although due to infrastructure constraints, double-container trucks are currently not permitted in the port area and some roads in the vicinity, the research shows the impact in reducing truck miles if the infrastructure were modified to accommodate double-container trucks.

WHAT IS THE BENEFIT?

As more and more containers pass through ports every year, it becomes increasingly important to efficiently move containers. The proposed routing model provides a dynamic routing plan to deliver laden containers and reposition empty containers. By implementing empty container reuse, either with single-container or double-container trucks, the number of trucks and truck miles needed to fulfill the daily container demand can be reduced, thereby reducing traffic congestion and the environmental impact of the activities centered around port areas.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2017/CA17-2984_FinalReport.pdf

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Research Results

Improved Safety Screening for High-Collision Locations with More Robust Data

Incorporating both Caltrans and external data sources improves the accuracy of identifying sites benefiting from safety improvements

Transportation Safety and Mobility

FEBRUARY 2018

Project Title:
Identify the Data Requirements for Safety Screening to Identify High Collision Concentration Locations

Task Number: 2899

Start Date: October 1, 2015

Completion Date: September 30, 2017

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

Task Manager:
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WHAT WAS THE NEED?

Identifying sites that require safety improvements must be accurate; otherwise, scarce resources are applied to incorrectly classified high-collision areas while sites that necessitate safety improvements are overlooked. However, collisions alone are not adequate predictors of safety risk areas. Other factors, such as facility type, roadway geometry, and traffic volumes, play important roles in determining if a location has safety issues. To help identify high-collision concentration locations (HCCL) requires safety performance functions (SPF). An SPF is a statistical method that relates different types of collision frequencies to traffic volumes at a given location and can include other site characteristics. The outcome of an SPF is the expected—or average—number of collisions per year for a given location, which serves as a baseline to detect whether the site has a higher number of collisions than expected. Prior research efforts to develop California-specific SPFs using data from the Traffic Accident Surveillance and Analysis System (TASAS) to identify HCCLs revealed missing variables and inconsistent quality, motivating the need to incorporate additional data sources to develop more accurate and robust SPFs.

WHAT WAS OUR GOAL?

The goal was to evaluate the suitability of existing data sources being used for SPF development and identify additional data sources both within and outside of Caltrans to address the gaps in data.

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Improved Safety Screening for High-Collision Locations with More Robust Data

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Safe Transportation Research and Education Center, identified desirable variables and potential data sources within and outside of Caltrans to incorporate in SPFs. The researchers developed a suitability analysis framework for evaluating the quality of the data sources in terms of completeness, frequency of updates, and spatial variation to ensure that the SPF variables can be populated and maintained for the entire state highway system.

WHAT WAS THE OUTCOME?

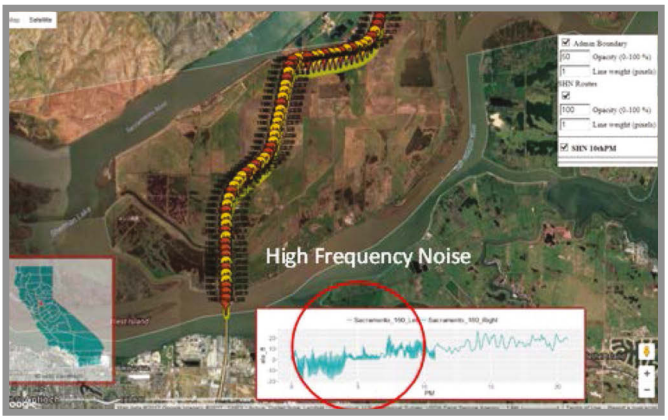
In addition to the data available within TASAS, the research identified external and internal data sources for collecting new variables to improve the quality of the SPFs. The data sources include automated pavement condition survey data for generating horizontal and vertical alignment attributes, Google Street View and Google Earth for manually collecting design and operational attributes, the HERE Maps API for automated estimation of posted speed limits, the Google Elevation API for automated estimation of vertical alignment attributes, and GIS-based tools for automated assessment of horizontal alignment attributes. The researchers proposed a roadmap for which variables are suitable for SPF modeling and data collection recommendations to ensure consistent and effective safety screening for the entire state highway system.

WHAT IS THE BENEFIT?

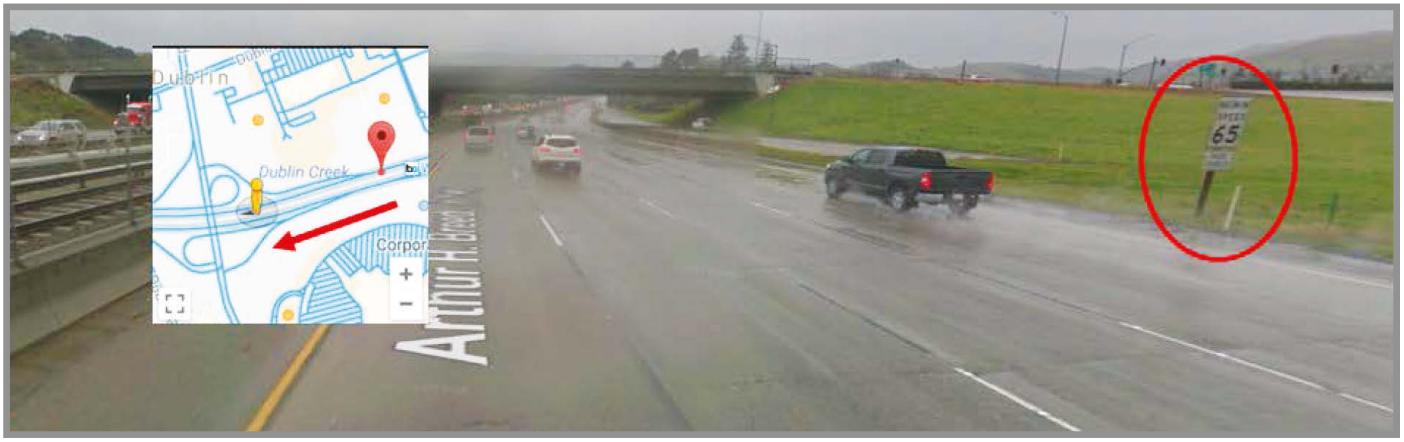
Safety performance equations are used to identify locations with a high-concentration of incidents and dictate how Caltrans allocates funding for safety improvements. By adding more variables to the SPFs and integrating more data sources improves the SPF models and helps Caltrans maximize the resources available. The development of high-quality SPFs will lead to more statistically robust methods and tools for network screening, helping to reduce traffic-related injuries and fatalities on the California state highway system.

LEARN MORE

To review the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA17-2899FinalReport.pdf



The Google Maps Elevation API provides a simple interface that can reduce time and cost in calculating highway vertical alignment.



Street View helps in manually collecting ground truth about posted speed limit signs, elevation, driveways, crosswalks, and other street items.

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Research Results

Timing Is Everything: Improving Traffic Flow Along Arterials with Adaptive Signal Control

Caltrans develops an adaptive signal coordination algorithm that operates with existing signals, loop detectors, and traffic management software

Transportation Safety and Mobility

MARCH 2018

Project Title:
Development of an Adaptive Control Algorithm for Arterial Signal Control

Task Number: 2652

Start Date: January 1, 2015

Completion Date: December 31, 2017

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

Task Manager:
John Slonaker
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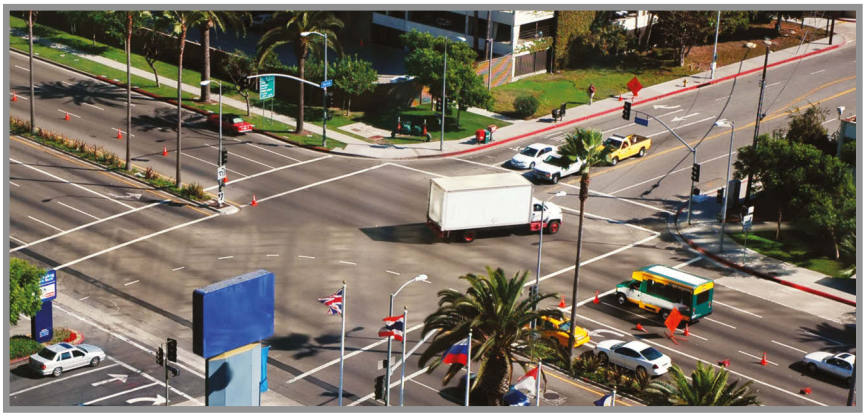
WHAT WAS THE NEED?

Optimizing signal timing along arterials can reduce unnecessary delays and stops at traffic signals, improve travel times, and cut fuel consumption and emissions. In contrast to fixed-time signal plans, which are based on historical traffic demand data, adaptive signal control techniques adjust signal settings in real time based on data from detectors located at each intersection. To improve traffic flow and reduce delay on signalized arterials on California state highways, Caltrans evaluated commercially available adaptive systems and found that implementing a vendor-supplied system statewide is too expensive because of per-site licensing fees and additional detection requirements as well as overly complicated to operate effectively and efficiently. Caltrans chose to develop its own adaptive signal capability to incorporate into its existing software and field hardware for a one-time cost.

WHAT WAS OUR GOAL?

The goal was to develop a simplified, economical signal-optimization algorithm that is compatible with Caltrans' existing detector configurations and signal control software.



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Timing Is Everything: Improving Traffic Flow Along Arterials with Adaptive Signal Control

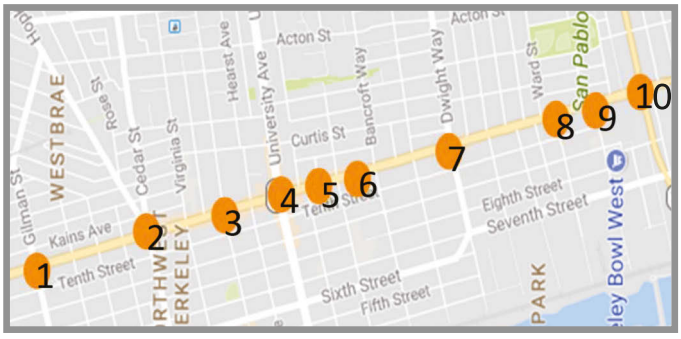
Research Results

WHAT DID WE DO?

Caltrans worked with the University of California, Berkeley Partners for Advanced Transportation Technology program to develop an adaptive signal coordination algorithm that makes real-time adjustments to the splits and offsets of baseline time-of-day (TOD) plans in response to current traffic demands by collecting volume data from loop detectors. The researchers tested the algorithm in a range of traffic and geometric scenarios using VISSIM simulations of three real-world arterials and compared its performance to TOD plans generated with Synchro, a widely used signal coordination optimization tool. The researchers also developed an algorithm to validate the data received from each detector, and they applied a clustering algorithm to the intersection detector data to determine traffic volumes and switching times for designing TOD signal plans to address changing needs.

WHAT WAS THE OUTCOME?

The algorithm-generated timing differences between signals performed better than the offsets generated by Synchro. In general, the degree of improvement was higher for networks with more complex geometries and traffic patterns. The detector diagnostics algorithm works in real time and can be part of the data collection process. Applying it to a real-world intersection with multiple detectors resulted in up to a 25% error reduction on high-volume approaches, which has significant implications in determining appropriate signal settings. The timing plans based on the volumes gathered from the clustering algorithm outperformed the conventional TOD plans created from traffic volumes obtained at predetermined time periods.



San Pablo Avenue test arterial in Berkeley, CA

WHAT IS THE BENEFIT?

Caltrans now has an adaptive algorithm with unrestricted use and modification without license fees. It can adjust signal timing as conditions change throughout the day to minimize queue lengths and delay times at intersection approaches. It also provides the ability to automatically update the underlying TOD plans as volumes change over time, reducing the costs associated with manually updating signal timing plans at the state's numerous intersections under Caltrans' jurisdiction. If implemented, it could provide the traveling public with reduced travel times and improved fuel efficiency.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA18-2652_FinalReport.pdf

TRAFFIC SCENARIO	NUMBER OF STOPS			DELAY (sec/veh)		
	SYNCHRO	ALGORITHM	% DIFF	SYNCHRO	ALGORITHM	% DIFF
1	3.1	2.8	9.7	95	95	0.0
2	3.8	3	21.1	110	105	4.5
3	3.1	2.9	6.5	65	65	0.0

Comparing Synchro to the algorithm: San Pablo Avenue in Berkeley, CA, between Ashby Avenue and Gilman Street

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Caltrans Division of Research, Innovation and System Information

Research Results

Going Feet First: Improving Safety for Pedestrians

Identifying and addressing systemic safety problems can reduce pedestrian fatalities and injuries

Transportation Safety and Mobility

JANUARY 2018

Project Title:
Pedestrian Safety Improvement Program: Phase 2

Task Number: 2452

Start Date: October 1, 2015

Completion Date: January 31, 2018

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

Task Manager:
Jerry Kwong
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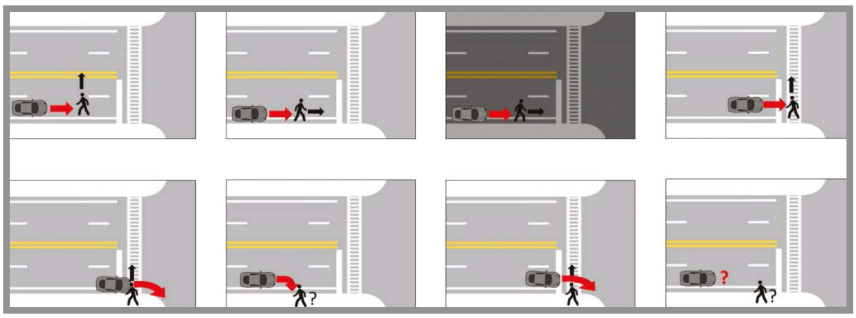
WHAT WAS THE NEED?

Compared to all other roadway users, pedestrians are the most vulnerable. Although California has seen major gains in traffic safety over the past decade, these gains were mostly realized for motorized modes, with a 19% reduction in fatalities, while pedestrian deaths increased by 34% during the same period. Pedestrians need more protection and investment, but receive less of both compared to motorized users.

Collecting pedestrian volume data is the foundation for safety analysis by providing a basic measure of exposure to risk at a specific location. For example, the risk of pedestrian crashes for people traveling along state highways can be estimated as the number of pedestrian crashes per million pedestrian crossings. Using pedestrian volume as a variable in safety performance functions also reveals which roadway design features or location characteristics to modify to reduce pedestrian crashes and injuries. Volume data also helps identify how common pedestrian activity is on the California state highway system and where and how to design roadways for safe and convenient pedestrian access. Previously, Caltrans had only short-term counts at a limited number of state highway intersections. In the absence of readily available pedestrian exposure data for the entire state highway system, it is important to develop crash frequency-based network screening methods for identifying pedestrian hotspots—high-collision concentration locations (HCCLs). Because it is impractical to count pedestrians at every intersection and segment of the 15,000-mile state highway system on a routine basis, applying statistical models to estimate volumes at specific locations can address this information gap.



Crash types based on pedestrian and auto movements

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WHAT WAS OUR GOAL?

The goal was to develop a pedestrian exposure model for intersections on the state highway system and enhance pedestrian safety monitoring to reduce fatalities and injuries.

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Safe Transportation Research and Education Center, compiled short-term pedestrian counts that are routinely collected throughout the state by districts and converted the counts of various durations to a common unit of volume. To predict exposure, the researchers developed a direct demand model to estimate the annual pedestrian volumes on the state highway system and applied it to all state highway intersection locations. The model identifies the relationship between land use and other surrounding environmental attributes. The team also developed a pedestrian crash typology to distinguish between the different pedestrian crash dynamics occurring along the state highway system and assess emerging trends among HCCLs.

Final pedestrian exposure model scope – intersections with volume predictions

WHAT WAS THE OUTCOME?

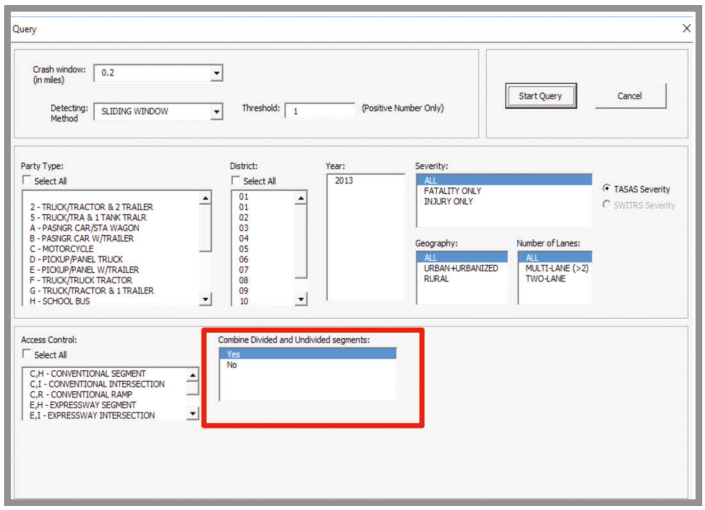
The research developed the 2016 annual pedestrian exposure estimates for more than 12,000 intersections along the state highway system. In tandem, the researchers enhanced the Pedestrian Safety Monitoring Report (PSMR) tool to improve HCCL identification and provide greater flexibility for importing text and Excel-based crash data. The new TSAR2XLS tool broadens data collection by converting text-based files from TASAS Selective Accident Retrieval (TSAR) records into Excel files, which can then be imported into the PSMR.

WHAT IS THE BENEFIT?

The goal of the Caltrans Pedestrian Safety Improvement Program is to identify and address problems that impede pedestrian safety. These first statewide estimates of pedestrian exposure provide Caltrans the data to improve the quality of pedestrian safety analyses by evaluating risk. The pedestrian crash typology allows alternative crash frequency-based HCCL identification methods to be applied to evaluate the statistical significance of the presence or absence of specific crash types.

LEARN MORE

To review the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA18-2452_FinalReport.pdf



Modified network screening query window in PSMR

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Research Results

Designing Intelligent Intersections to Improve Safety

The sensing capabilities of an intelligent intersection gives drivers, pedestrians, and cyclists information about the movement of others to more safely proceed through an intersection

Transportation Safety and Mobility

MAY 2018

Project Title:
Safe Operation of Automated Vehicles in Intersections

Task Number: 3134

Start Date: March 1, 2017

Completion Date: February 28, 2018

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

Task Manager:
Asfand Siddiqui
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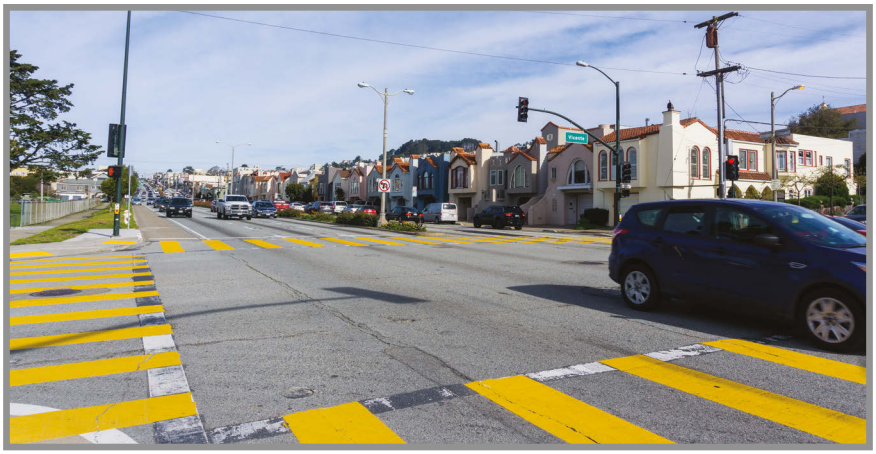
WHAT IS THE NEED?

Intersections are dangerous: 40% of all crashes, 50% of serious collisions, and 20% of fatalities occur in intersections. Intersections are challenging because drivers, pedestrians, and cyclists lack sufficient spatial and temporal information about the movement of others as they proceed through an intersection. Traffic signals do not tell us who else is exercising their right of way and entering from the other approaches or whether enough time is available to drive through before the light changes to red. Blind spots created by vehicles stopped in adjacent lanes can hide conflicting movements, and there is no indication of red light violators and other illegal actions. The on-board sensing capabilities of automated vehicles (AV) are not sufficient to maneuver the complex environment of urban intersections. To be situationally aware of the myriad of potential interactions requires augmenting their capabilities with infrastructure-based sensing to create an "intelligent intersection."

WHAT WAS OUR GOAL?

The goal was to design an intelligent intersection system and evaluate its performance in terms of improving safety and mobility.



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

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Safe Transportation Research and Education Center, explored and tested how AVs could avoid hazardous situations at intersections by using infrastructure sensors and designing a framework for AVs to detect and properly respond to situations encountered. To implement an intersection's intelligence, the researchers incorporated various algorithm families that analyze intersection geometry to identify possible maneuvers, conflicts, and blind zones; compute the likelihood of blind zones given a traffic pattern and signal timing; classify conflicts by their importance; interpret sensor readings to determine traffic presence and dynamics; implement signal phase prioritization to ensure safe and efficient passage of different travel modes; and predict signal phase duration for adaptive and actuated signals.

WHAT WAS THE OUTCOME?

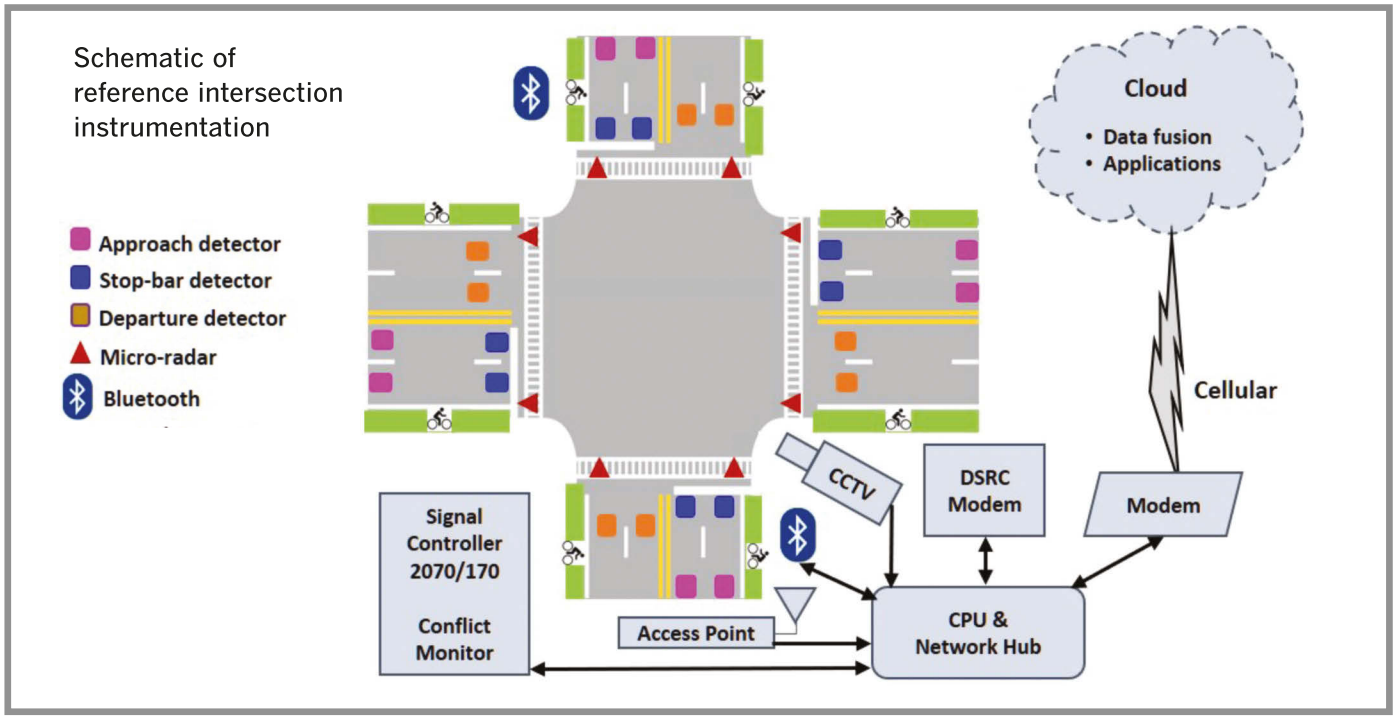
An intelligent intersection could improve safety for all travelers by processing sensor data and generating infrastructure-to-vehicle messages that give complete signal phase information and timing, accurately assess the occupancy of blind zones, and warn of traffic-signal violators. The information is broadcasted via radio and can be received by a connected vehicle or anyone in the intersection with a smartphone or Bluetooth device. An intelligent intersection can be more effective and less costly and intrusive than road diets and redesigns. Upgrading to an intelligent intersection costs between $25,000 and $100,000, depending on which sensors are already in place. Traffic data collected at an intersection can be analyzed to estimate how many crashes could occur and ranked accordingly so that funds can be directed toward the most unsafe intersections.

WHAT IS THE BENEFIT?

An absence of lane markings to guide vehicles, split phases that prevent determining who has the right of way, obstructions from stopped vehicles, and illegal movements all contribute to uncertainties that lead to wrong decisions and end in crashes. These challenges are not fully addressed by physically modifying the road infrastructure nor are they handled by AVs that rely only on on-board sensors. By instrumenting signalized intersections, AVs can perceive and plan the environment to safely and efficiently maneuver through intersections. These sensing capabilities can improve the safety and mobility of all travelers by providing the spatial and temporal information that is currently lacking.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA18-3134_FinalReport.pdf



DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Automated Vehicles: For Better or for Worse?

Forecasting the potential system-level effects of AV technologies on the transportation ecosystem

Transportation Safety and Mobility

APRIL 2018

Project Title:
Automated Vehicle Scenarios: Simulation of System-Level Travel Effects Using Agent-Based Demand and Supply Models in the San Francisco Bay Area

Task Number: 3094

Start Date: January 9, 2017

Completion Date: May 15, 2018

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

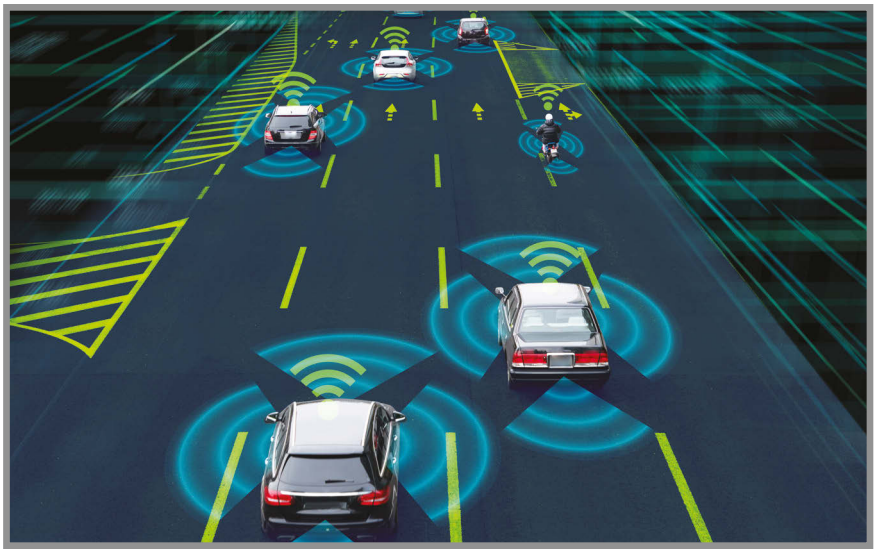
Task Manager:
Tyler Monson
Associate Transportation Planner
tyler.monson@dot.ca.gov

WHAT IS THE NEED?

A century after the motorized vehicle replaced horse-and-cart transportation, automated vehicles (AV) can radically transform the current system of transportation and the fabric of the built environment. Experts predict that vehicles could be fully automated between 2025 and 2035, yet many questions remain unanswered. Will AVs have a negative or positive effect on congestion, vehicle miles traveled (VMT), greenhouse gas emissions (GHG), energy consumption, and land development patterns? Understanding the potential impacts of AV technologies on regional transportation systems can help guide their integration in ways that improve multimodal accessibility and minimize negative environmental effects. Although observable data is not yet available on how travelers will adapt and respond to AVs, existing travel survey data and activity-based travel demand models can be used to predict future traffic behavior.

WHAT WAS OUR GOAL?

The goal was to develop methods to help the public and private sectors understand AV technologies and their system-level effects.



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WHAT DID WE DO?

Caltrans, in partnership with National Center for Sustainable Transportation, explored the medium- to long-term effects of AVs using the San Francisco Bay Area Metropolitan Transportation Commission's activity-based travel demand model (MTC-ABM) by simulating a range of AV scenarios to articulate the change on travel in terms of mode choice, VMT, congestion, and vehicle hours of delay (VHD). The researchers also evaluated the potential to reduce the demand for personal AVs by introducing an automated taxi service with low per-mile service costs. Using the MTC-ABM and the MATSim dynamic assignment model, the researchers compared different first-mile transit access services, including ride-hailing and ridesharing with and without AVs, to assess the relative benefits of each service and AV technology and the potential market for these services.

The researchers defined the following speculated scenarios for simulation.

- Highway capacity doubled—Safety improvements increase effective roadway capacity by enabling smaller vehicles and shorter headways and by reducing time delays due to fewer accidents and improved operations.
- 25% reduction in driving time—Passengers are free to use in-vehicle travel time to work and "play" in their vehicle.
- 20% reduction in operating costs—Safety improvements reduce insurance costs. Optimal vehicle flow and reduced vehicle weight reduce fuel use.
- New drivers—Full automation increases mobility for older adults, people with disabilities, young people without driver's licenses, and people living in poverty.
- Combined effects—This scenario combines all the effects described above.
- Road pricing and combined effects—The per-mile operating cost in the combined effects scenario is doubled to 36 cents per mile.

WHAT WAS THE OUTCOME?

The results indicate that AVs are likely to increase VMT and associated GHG impacts between 2% to 14%, could relieve congestion or worsen it due to induced travel, and are likely to undermine efforts to maintain or expand carpooling, public transit, walking, and biking. Road-pricing policies could counteract these negative impacts. However, incentives for carpooling would need to be adjusted to be significant in the context of the travel time benefits of AVs. An automated taxi service has a 4%–6% market potential in the inner-city areas, but expands in the outer areas as the relative cost declines. Similarly, average empty-vehicle travel time and distance can be up to 10 times in the outer areas compared to the inner city.

WHAT IS THE BENEFIT?

Understanding the potential impacts of AV technologies and services is critical to guiding their adoption in ways that improve multimodal accessibility for all citizens and minimize negative environmental effects. This study provides insights into the societal and technological trends for consideration in future state transportation plans. It demonstrates elements of AV systems that could enhance or hinder accessibility, livability, and environmental sustainability. Using available data and modeling tools to conduct early studies of AV systems helps policy-makers and planners develop the policies and incentives most likely to encourage the types of AV systems that best align with public goals.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA17-3094_FinalReport.pdf

Scenario	VMT	VHD	Drive Alone	Shared Ride	Transit	Walk and Bike
Increase Highway Capacity (100%)	4%	-78%	0%	0%	1%	-2%
Reduce Value of Drive Time (25%)	3%	7%	1%	1%	-5%	-4%
Reduce Operating Vehicle Costs (20%)	3%	5%	1%	1%	-4%	-4%
New Drivers	2%	1%	6%	-5%	-12%	-4%
Combined Effects	11%	-70%	9%	-3%	-20%	-12%
Road Pricing and Combined Effects	-7%	-84%	2%	-10%	6%	22%

Percentage change for AV scenarios relative to the baseline travel demand data

DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

24/7: Predicting Daily Activity–based Travel Demand

The spatial and temporal markers in anonymized cellular data records fill the gap in forecasting travel demand by providing information to nowcast the next few hours

Transportation Safety and Mobility

JUNE 2018

Project Title:
Travel Demand Nowcasting

Task Number: 3137

Start Date: March 1, 2017

Completion Date: June 30, 2018

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

Task Manager:
Stan Chow
Transportation Engineer
stan.chow@dot.ca.gov

WHAT WAS THE NEED?

To date, travel-demand forecasting has focused on the long term (months to years ahead) and the very short term (seconds to minutes ahead). Long-term forecasts provide the basis for infrastructure planning, such as how many people will be affected if a new subway line is introduced or how travel patterns will change if a major bridge is upgraded. These studies typically use data collected from manual travel surveys that are infrequent and expensive. For example, the commonly used National Household Travel Survey is conducted every five years and costs millions of dollars. The more immediate short-term predictions use road sensors and detectors to inform local operations, such as real-time traffic conditions and estimated travel times. A missing element in optimizing transportation systems is medium-term forecasting (hours to days ahead), which could answer questions like, based on observations of early morning or noon traffic, what will traffic be like during the evening commute? This critical piece of knowledge, which can be used in the design of demand-responsive congestion mitigation interventions, can be extracted from passively collected anonymized cellular data to model travel.

WHAT WAS OUR GOAL?

The goal was to produce activity-based travel demand models from locational cellular data records obtained from telecommunication operators.

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24/7: Predicting Daily Activity–based Travel Demand

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Department of Civil and Environmental Engineering, used cellular data that is collected passively, continuously, and in real time to predict the intended travel plans of anonymized and aggregated individual travelers within hours. The researchers used sequence-prediction machine-learning methods to create models to simulate trips at different times of the day. To assess the accuracy of the results, the researchers compared the predictions to historical traffic data and observed travel in the San Francisco Bay Area. The researchers explored a non-parametric, individualized nearest neighbor model as the practical limit of predictability of an individual's daily travel and demonstrated that parametric models trained at an aggregated group level—to address privacy concerns—can approach this limit in terms of prediction accuracy.

WHAT WAS THE OUTCOME?

The medium-term travel demand forecast system developed fills the gap between long-term travel demand forecasting and short-term traffic state prediction. The system uses abundant and ubiquitous cellular data, which is less expensive than manual surveys and more broadly available than sensor data. It provides a transparent structure revealing daily travel patterns and an interpretable set of parameters that describe activity choices and the transitions between them. In terms of accuracy, the predictions reached a mean average percentage error of less than 5% one hour ahead and 10% three hours ahead. The prediction accuracy would be improved as more data is incorporated.

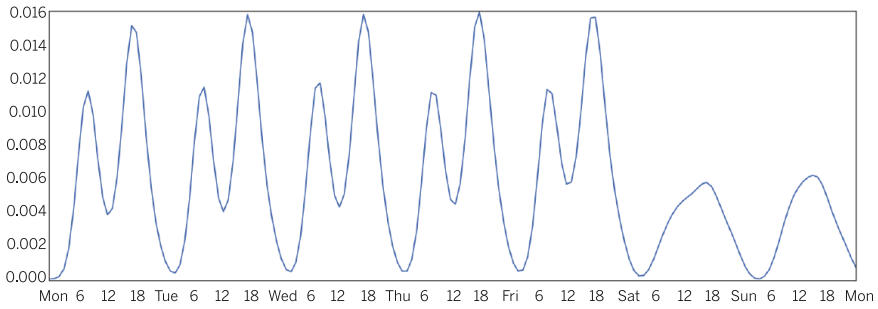
WHAT IS THE BENEFIT?

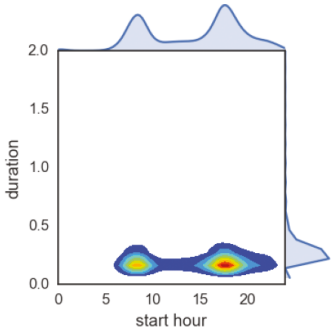
With smartphone data becoming more ubiquitous, developing a conceptual framework using cellular data records to frequently update activity-based models provides an opportunity to make travel-demand forecasting more timely, accurate, and cost efficient. Near-term travel-demand nowcasting helps planners better understand rapidly changing patterns for a specific peak period to optimize the transportation network, for example, adjusting ramp metering, changeable lanes, and traffic signal timing to meet forecasted travel demands.

LEARN MORE

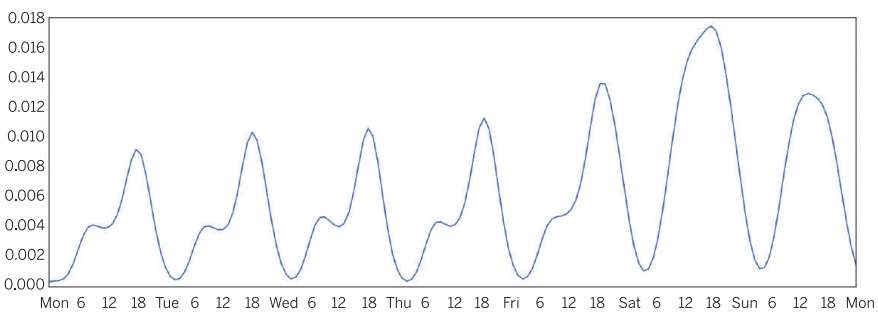
To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2018/CA18-3137_FinalReport.pdf

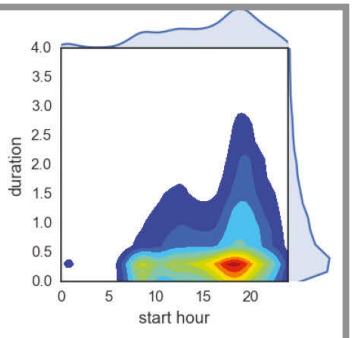
DAS in a major train station used by suburban commuters.





DAS in a fitness center station used with multiple recreational health studios.





A distributed antenna system (DAS) is a common component of a cellular network that is installed indoors in large commercial buildings, such as shopping malls, or outdoors, such as in a high-occupancy venue, to provide better signal coverage. These charts illustrate the times and durations of cellular connections, which can be used to inform mobility patterns.

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 2019, Caltrans staff served on the following TRB committees.

Committee Member	Committee Name
Coco Briseno	Technical Activities Council
Steve Takigawa	AASHTO Special Committee on Research and Innovation (formerly SCOR)
Jeanne Scherer	Legal Resources Group
Thomas Pyle	Review of Federal Highway Administration Infrastructure R&D – Expert Task Group on Pavement
Marc Birnbaum	Standing Committee on Access Management
Rachel Carpenter	Standing Committee on Bicycle Transportation
Michael B. Johnson	Standing Committee on Bridge Management
Michael B. Johnson	Standing Committee on Bridge Preservation
Dulce Feldman	Standing Committee on Concrete Pavement Construction and Rehabilitation
Joseph Rouse	Standing Committee on Congestion Pricing
Herby Lissade	Standing Committee on Critical Transportation Infrastructure Protection
Lucille Baca	Standing Committee on Eminent Domain and Land Use
Glenn Mueller	Standing Committee on Environmental Issues in Transportation Law
Peter Bond	Standing Committee on Environmental Justice in Transportation
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. Joe 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
Helen Blackmore	Standing Committee on Historic and Archeological Preservation in Transportation
Kyle Gradinger	Standing Committee on Intercity Passenger Rail
Zhongren Wang	Standing Committee on International Cooperation
Jack Broadbent	Standing Committee on Landscape and Environmental Design
Lisa Kunzman	Standing Committee on Maintenance Equipment
Joseph Rouse	Standing Committee on Managed Lanes
Cristiana Rojas	Standing Committee on Management and Productivity
Dee Lam	Standing Committee on Management and Productivity
Dulce Feldman	Standing Committee on Pavement Condition Evaluation
Zhongren Wang	Standing Committee on Pavement Management Systems

Committee Member	Committee Name
Kishore Gorle	Standing Committee on Project Delivery Methods
Erik Alm	Standing Committee on Regional Transportation Systems Management and Operations
Sharid Amiri	Standing Committee on Seismic Design and Performance of Bridges
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 Multimodal Transportation Planning
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
Dana Hendrix	Standing Committee on the Logistics of Disaster Response and Business Continuity
Jeanne Scherer	Standing Committee on Tort Liability and Risk Management
Lauren Machado	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
Ellen Greenberg	Standing Committee on Transportation and Sustainability
Michael B. Johnson	Standing Committee on Transportation Asset Management
Rahul Srivastava	Standing Committee on Transportation Education and Training
Venkata Lakshman Mandapaka	Standing Committee on Transportation Law
Neil Peacock	Standing Committee on Transportation Planning for Small and Medium-Sized Communities
Bruce Rymer	Standing Committee on Transportation-Related Noise and Vibration
Yatman Kwan	Standing Committee on Urban Freight Transportation
Greg Larson	Standing Committee on Vehicle-Highway Automation
Joseph Horton	Standing Committee on Winter Maintenance
Susan Hida	Policy Study Committee on Truck Size and Weight Limits Research Plan
Zhongren Wang	Task Force on Arterials and Public Health
Coco Briseno	Task Force on Data for Decisions and Performance Measures
Diane Jacobs	Task Force on System Simulation
Coco Briseno	Task Force on TRB Centennial
John Bulinski	TRB 11th University Transportation Center Spotlight Conference: Rebuilding and Retrofitting the Transportation Infrastructure
Michael B. Johnson	TRB 12th National Conference on Transportation Asset Management
Michael B. Johnson	TRB 13th National Conference on Transportation Asset Management
Coco Briseno	TRB Forum on Preparing for Automated Vehicles and Shared Mobility
Yatman Kwan	TRB Innovations in Freight Data Workshop

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 2019, 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 Result
Antonette Clark	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
Tony Tavares	Alternative Technologies for Mitigating the Risk of Injuries and Deaths in the Work Zone
Dale Widner	An Assessment of Geometric Design Policies and Processes
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
Rachel Carpenter	Assessing the Impacts of Turn Lanes in Different Contexts and Modal Considerations to Increase Safety Performance
Rose Agacer	Assessing the Value of Added Capacity Highway Projects
Imad Basheer	Assessment and Simplification of Pavement Environmental Effects Models on Pavement Performance
La Keda Huckabay	Attracting, Retaining, and Developing the Transportation Workforce: Transportation Planners
Susan Hida	Bridge System Reliability for Redundancy
Mandy Chu	Business Intelligence Techniques for Transportation Agency Decision Making
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 and
John Rogers	Detection and Remediation of Soluble Salt Contamination Prior to Coating Steel Highway Structure
Marc Birnbaum	Development and Application of Access Management Guidelines

Panel Member	Project Title
Randy Hiatt	Development of a Collaborative Approach for Multi-State In-Service Evaluations of Roadside Safety Hardware
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
Randy Hiatt	Development of MASH TL-3 Deflection Reduction Guidance for 31-inch Guardrail
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 TMDL Goals
Joanne McDermott	Enhanced Truck Data Collection and Analysis for Emissions Modeling
Chris Schmidt	Environmental Justice Analyses When Considering Toll Implementation or Rate Changes
Ferdinand Milanes	Essential Communications
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
Cristiana Rojas	Evaluation of Opposite Direction Crashes and Appropriate Countermeasures
Robert Peterson	Evaluation of Opposite Direction Crashes and Appropriate Countermeasures
Herby Lissade	FloodCast: A Framework for Enhanced Flood Event Decision Making for Transportation Resilience
Lian Duan	Fracture-Critical System Analysis for Steel Bridges
Mandy Chu	Framework for Designing and Managing Data and Information Workflows for Transportation Assets
Loren Turner	Guidance for Development and Management of Sustainable Information Portals
Nicholas Compin	Guidance for Planning and Implementing Multimodal, Integrated Corridor Management
Agustin Rosales	Guidance for the Management of Traffic and Safety Assets
Sharid Amiri	Guidance on Seismic Site Response Analysis with Pore Water Pressure Generation
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
Michael Mayor	Guide to Calculating Ownership and Operating Costs of Department of Transportation Vehicle and Equipment Fleet
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
Richard Foley	Guidebook for Risk-based Construction Inspection

Panel Member	Project Title
Michelle Tucker	Guidebook on Agency Risk Management Strategies, Methods, and Tools
Joseph Dongo	Guidelines for Managing Geotechnical Risks in Design-Build Projects
Kristina Assouri	Guidelines for Managing Geotechnical Risks in Design-Build Projects
Kenneth Brown	Guidelines for Risk-Based Inspection and Strength Evaluation of Suspension Bridge Main Cable Systems
Louis Betancourt	Guidelines for Selecting Ramp Design Speeds
Jeremy Matsuo	Guidelines for the Development of Highway Operations Equipment Replacement Lifecycle Criteria
Edward Hardiman	Guidelines for Vehicle and Equipment Color, Marking, and Lighting
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
Dawn Foster	Implementation of Programmatic Life Cycle Cost Analysis in a Transportation Asset Management Framework
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
Jody Brown	Integrating Tribal Knowledge into Processes to Identify, Evaluate, and Record Cultural Resources
Mandy Chu	Integration of Roadway Safety Data from State and Local
Joann Georgallis	Legal Problems Arising Out of Highway Programs
Melissa Clark	Leveraging Big Data to Improve Traffic Incident Management
Karla Sutliff	Low-Cost Improvements for Recurring Freeway Bottlenecks
Seungwook Lim	LTPP Data Analysis: Accounting for Temporal Variations in Pavement Performance Monitoring Measurement
David Lim	LTPP Data Analysis: Develop Tools to Improve Accuracy of Traffic
Wilfung Martono	Mechanistic-Empirical Model for Top-Down Cracking of Asphalt Pavement Layers
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
Kee Foo	Performance-Related Specifications for Asphaltic Binders Used in Preservation Surface Treatments
Jack Broadbent	Permanent Vegetation Control Treatments for Roadsides
Allexandra Neeb	Post-World War II Commercial Properties and Transportation Project Development: Historic Context and National Guidance on Evaluation of National Register of Historic Places Eligibility
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
Charles Suszko	Procedures and Guidelines for Validating Contractor Test Data

Panel Member	Project Title
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
Yoojoong Choi	Quantifying the Contribution of Vehicle Emissions to Local Air Quality
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
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
Amar Cid	Research for the AASHTO Standing Committee on Public Transportation
Jila Priebe	Research for the AASHTO Standing Committee on Public Transportation
Marilee Mortenson	Research Roadmap--Public Health and Transportation
Julia Biggar	Resilience in Transportation Planning, Engineering, Management, Policy, and Administration
Hamid Sadraie	Risk Assessment Techniques for Transportation Asset Management
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 Dmytrow	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
Amir Malek	Structural Testing and Design Methodology for Single Column-Single Shaft Foundation Considering the Flexural Capacity of Steel Casing
Herby Lissade	Synthesis of Airport Closings and Emergency Evacuation Problems
John Hancock	Synthesis of Emerging Technologies for Construction Delivery
Ramamohan Bommavaram	Synthesis of Impact of Asphalt Materials Lift Thickness on Pavement Quality
Coco Briseno	Synthesis of Information Related to Highway Problems
Nizar Melehani	Synthesis of Leveraging Private Capital for Infrastructure Renewal
Aaron Truong	Synthesis of Methods to Acquire Proprietary Data for Transportation Applications
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
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
Herby Lissade	Update of a Guide to Emergency Response Planning at State Transportation Agencies

Panel Member	Project Title
Herby Lissade	Update of Security 101: A Physical Security Primer for Transportation Agencies
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
Jim Ma	Use of 0.7-in. Diameter Strands in Precast Pretensioned Girders
Carin Loy	Valuing Wildlife Crossing Enhancements for Mitigation Credits
Asfand Siddiqui	Variable Message Signs
Theresa Drum	Work Zone Crash Characteristics and Countermeasure Guidance
Joseph Horton	Wrong-Way Driving Solutions, Policy and Guidance

Appendix 3: 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 2019, Caltrans staff served on the following ACRP project panels.

Panel Member	Project Title
Philip Crimmins	Guidebook of Practices for Improving Environmental Performance at Small Airports
Jeff Brown	Design and Development of a State Aviation Information Database

Appendix 4: 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 2019, Caltrans staff served on the following TCRP project panel.

Panel Member	Project Title
Rene Garcia	Command-Level Decision Making for Transit Emergency Managers
Rachel Carpenter	Tactile Walking Surface Indicators to Aid Wayfinding for Visually Impaired Travelers in Multimodal Travel

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