

2024 DRISI Accomplishments





San Francisco Bay Area Rapid Transit (BART) train approaches Daly City Station.

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This brochure highlights the top accomplishments delivered by the Division of Research, Innovation and System Information (DRISI) that are tied directly to California Department of Transportation (Caltrans) Goals: Safety, Equity, Climate Action, Prosperity, and Employee Excellence.

Safety



Next Generation Attenuation (NGA) Programs

DRISI supported the Next Generation Attenuation (NGA) programs, which successfully developed comprehensive databases and ground motion models to estimate earthquake ground shaking for the seismic design of bridges and other structural systems. Developed in collaboration with state agencies, private industry, and practicing professionals, these NGA models have been adopted into Caltrans' Seismic Design Criteria, widely implemented by other agencies and the private sector, and incorporated by the U.S. Geological Survey into the National Seismic Hazard Model. This research has also informed national standards and global seismic design practices, reinforcing Caltrans' leadership in earthquake engineering.



The latest phase NGA-West3 expanded the ground motion database fivefold by incorporating earthquake recordings from around the world. Photo credit: Tristan E. Buckreis, et al.



A pickup truck crashes into a concrete barrier during a controlled impact test, with debris flying and personnel watching from a safe distance.

Cal F-23 F-Shape Portable Concrete Barrier

Caltrans contracted with Texas Transportation Institute to develop and crash test a portable concrete barrier (PCB) that meets the current Manual for Assessing Safety Hardware (MASH) 2016 crashworthiness guidelines. The new system has lower lateral deflections than freestanding PCB and many types of anchored PCB. It also has vertical anchors for ease of installation and to minimize pavement damage when removed. The barrier can be used on asphalt pavement with vertical anchoring pins and on concrete pavement or deck using vertical epoxy anchors. Named the Cal F-23 F-Shape Portable Concrete Barrier, it can be used as a median barrier or roadside guardrail.

Safety



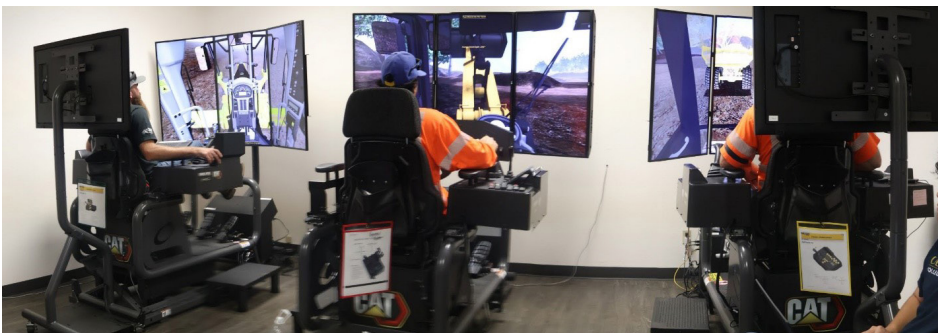
Two photos show a pickup truck equipped with a rear-mounted camera on a vertical pole, photographed at daylight and dusk.

Targeted Warning Messages to Protect Moving and Stationary Maintenance Lane Closures

Caltrans uses truck mounted attenuators (TMAs) to establish moving or stationary temporary highway lane closures. These closures require approaching vehicles to merge out of the lane into adjacent lanes before reaching the TMA. A closed lane typically disrupts traffic flow by slowing traffic in the through lanes as motorists in the merging lane merge over. Some motorists will take advantage of the thinning traffic in the merging lane to leapfrog ahead of traffic. The goal of the research was to develop a prototype intelligent TMA truck messaging system based on artificial intelligence that monitors vehicles approaching highway lane closures, recognizes unsafe driving patterns, and generates vehicle-specific warning messages. In addition, the research aimed to increase the safety of both highway maintenance workers and traveling motorists through the development of such an intelligent message board system. This research project was successful, and the next phase is currently active.

Implementation of Heavy Equipment Simulators

Implementation funding was provided to the Maintenance Equipment Training Academy (META) in Sacramento, enabling Advanced Highway Maintenance and Construction Technology (AHMCT) researchers to conduct on-site troubleshooting and support of the Heavy Equipment Simulators. Heavy equipment simulators provide a safe, cost-effective training environment that improves operator skills and proficiency while reducing equipment wear, fuel use, and safety risks. The funding also supported upgrades to the simulators used at the academy, enhancing training capabilities and improving the overall effectiveness of maintenance equipment instruction.



Three participants are seated in three separate simulators in a training room.

Safety



Stone Lagoon U.S. 101 Elk Electronic Detection System

DRISI has collaborated with university researchers, the California Department of Fish and Wildlife, and Caltrans District 1 to develop an electronic wildlife detection system aimed at reducing wildlife-vehicle collisions and improving driver safety. U.S. Highway 101 in Humboldt County has become a significant barrier to Roosevelt elk movement, fragmenting habitats and increasing collisions as elk populations have grown over the past 20 years. The highway cuts through protected lands, increasing risks for both wildlife and motorists, making this safety innovation essential.



A Roosevelt elk crosses U.S. Highway 101 in Humboldt County, California, alongside moving traffic.

Developing A Safe Systems Approach to Setting Speed Limits - Phase II

In California, the relationship between speed and crash involvement has prompted calls from local governments to change the way that speed limits are set. This research project represents the second step towards developing a Safe System Approach to setting speed limits, per California State Transportation Agency's (CalSTA) recommendation. The goal of this project is to begin developing the technical requirements for a Safe System Approach to setting speed limits in California. The objective of adopting the new speed-limit setting is to increase safety of the users of the State's roadway system, including motorists, bicyclists and pedestrians.

Bridge Rapid Assessment Center for Extreme Events (BRACE2)

This research aimed to develop a decision support tool for real-time assessment of bridge damage during major earthquakes using sensor data. Caltrans and UC Berkeley collaborated to create the BRACE2, which continuously monitors the Hayward 580/238 Separation Bridge. The project established real-time communication infrastructure and developed advanced structural models to support simplified fragility algorithms for damage estimation. These estimates are delivered to Caltrans through a secure website, and the project has successfully demonstrated the feasibility of the Rapid Assessment Center concept.



Structure model of Hayward 580/238 Separation Bridge. (Courtesy of UC Berkeley)

Equity



An Assessment of Paved Road Dust Emissions Modeling Methods

DRISI completed a three-year study in collaboration with university researchers, the California Air Resources Board (CARB) and the U.S. Environmental Protection Agency (US-EPA) to develop a more accurate road dust emissions factor for highways with higher traffic volume. As tailpipe emissions decline, road dust has emerged as a significant source of particulate matter (PM) in project-level air quality analyses. The current US-EPA AP-42 model has several limitations and has not been validated for the heavy traffic conditions common in California, leading to potentially biased PM estimates. This study underscores the need for a California-specific model to improve the reliability of PM emissions estimates in transportation projects.



Vehicle driving on a scenic California road next to a dirt pathway.

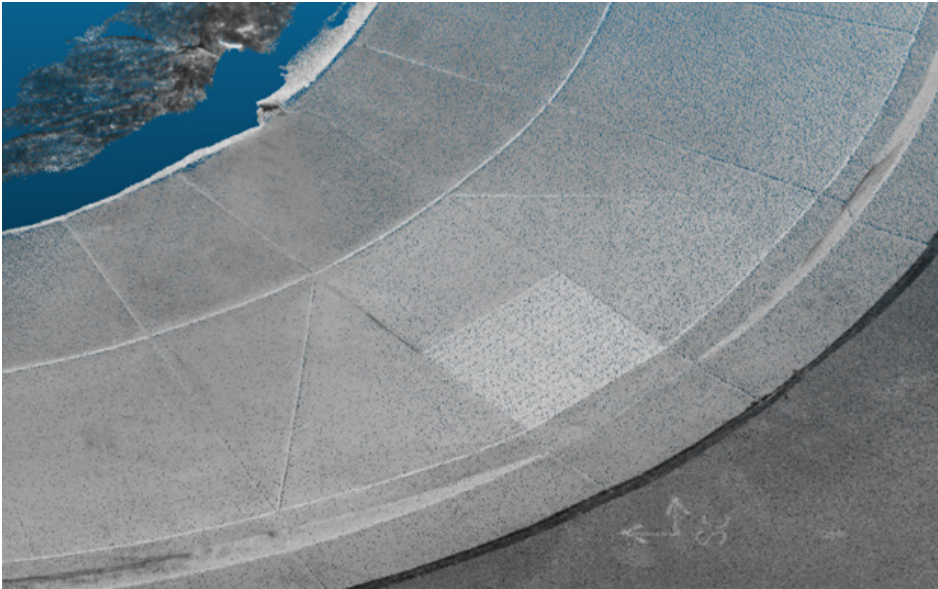
Reconnecting Communities Research

Governor Newsom's California Assembly Bill (AB) 3121 recently established the Task Force to Study and Develop Reparation Proposals for African Americans, with a special consideration for African Americans who are descendants of persons enslaved in the United States. Additionally, legislation passed in July 2021 allows Tribal communities a right to procure excess land like that of local governments. By conducting research on reparations, this research will better position Caltrans as a leader in California's pursuit of racial justice and transportation equity. The overall objective of this research will be to inform procedures and policies that will support and prioritize the sale or release of surplus land to Tribal Governments and communities and/or individuals that have been impacted by the state for transportation development.

Improving Access and Efficiency to Transportation Affordable Programs in California

Despite transportation being the second largest expenditure category for low and moderate-income households, frameworks and actions supporting comprehensive transportation affordability policies lag far behind other basic service programs (utilities, housing, food) offered at local, state, or federal levels. The goal of this research is to assess the landscape of income-related multi-modal service discounts, comparing this landscape of non-travel entitlement programs, and developing lessons learned from Universal Basic Mobility (UBM) pilots/programs. Researchers will be able to identify near and longer-term opportunities to provide more effective UBM programs.

Equity



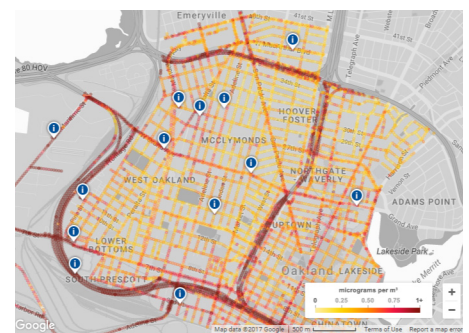
Example ramp point cloud collected by Caltrans using Mobile and Static Terrestrial Laser Scanning (MTLS) systems, as utilized in this research. Photo credit: Iman Soltani.

Point Cloud Feature Extraction for Americans with Disabilities Act (ADA) Ramp Compliance Assessment

This project introduced an automated solution for evaluating ADA ramp compliance using Light Detection and Ranging (LiDAR) point cloud data. This innovation significantly reduces labor costs and processing time while improving consistency and reliability in compliance assessments. This approach provides a scalable solution for statewide infrastructure evaluations and establishes data quality standards for future point cloud collection efforts.

Developing Methods and Guidance for Vehicle-Miles-Traveled (VMT) Mitigation Actions

In 2020, Caltrans implemented Senate Bill (SB) 743 and works with the California Environmental Quality Act (CEQA) to prioritize development and transportation projects that get people out of cars and into carpools, transit, biking and walking. By doing so, SB 743 helps reduce transportation's impacts on the environment. Under SB 743, these impacts are now measured according to the miles that people drive VMT, because of their surroundings. This project will assist in determining who benefits and who is negatively impacted by highway expansions and VMT mitigation efforts. In addition, the project seeks to provide Caltrans and partners alternative designs for projects and VMT mitigation actions that reduce disparities in communities of concern.



Hyperlocal Air Quality Map of West Oakland.

Climate Action



Plastic Greenhouse Gas (GHG) Emissions Field Measurement Along Caltrans Right of Way

DRISI has partnered with university researchers to advance baseline studies measuring and quantifying GHG emissions from Caltrans' plastic use. A Caltrans study found that plastics account for 33% of highway litter by mass and that materials such as thermoplastic paint and rubberized asphalt also contain significant plastic content. Preliminary results indicate that photochemical degradation of these plastics along roadways can release GHGs, including carbon dioxide and methane. Understanding these emissions is critical to managing plastic use and ensuring that transportation projects' GHG-reduction efforts remain effective.

Laboratory Testing of Asphalt Mixes with Increased Recycled Material Contents

DRISI collaborated with the University of California Pavement Research Center (UCPRC) and industry partners to test asphalt mixes with higher recycled material contents from three pilot projects on state highways and to sample a fourth. The pilots included control mixes and mixes with up to 40% or 100% recycled asphalt pavement, combined with a recycling agent. Results from these pilots will inform updates to the current non-standard special provisions for recycled asphalt mixes.



View of the large-scale gas chamber being used for this project.
Photo credit: Akula Venkatram.



Crews sampling asphalt mixes from a pilot project for laboratory testing.

Assessment of VMT Mitigation Actions

Under the Transportation Analysis Framework (TAF) developed in response to SB 743, Caltrans must analyze the impacts of projects on the State Highway System (SHS) on VMT as a part of the environmental review process under the California Environmental Quality Act (CEQA). The goal of this project was to develop guidance and methods for assessing VMT reduction for various potential mitigation measures for SHS projects.

Climate Action



Solar Bike Path in the Netherlands. Photo credit: Sander Koning ANP.

Review and Analysis of Current and Future Battery Technologies for Transit Electric Vehicles

CARB mandated the Innovative Clean Transit (ICT) regulation, that requires transit agencies to purchase 100% zero-emission vehicles (ZEV) by 2029. California transit agencies are therefore spending hundreds of millions of dollars on purchasing such ZEVs, which today cost approximately twice as much as their Compressed Natural Gas (CNG) counterparts. This project aimed to provide a summary of the role of current and advanced batteries in the design, operation and charging, and cost of heavy-duty trucks from 2025 through 2040. The research will also address how the new advanced battery technologies impact the versatility and costs of each vehicle type, and which types of heavy-duty vehicles will benefit most from and be more suitable for use of the advanced batteries.

Shifting Gears to Sustainability: A Deep-Dive into Solar-Powered Bike Pathways

Transportation infrastructure contributes significantly to carbon emissions, making it a prime target for sustainable interventions. However, most existing solutions focus solely on either transportation or power generation, rarely integrating the two in a seamless manner. This project addressed the need for a holistic approach to sustainable infrastructure. By incorporating solar panels into bike paths, the project harnessed the dual potential of reducing transportation emissions while also generating clean energy. The ultimate objective of this research project was to generate a robust, evidence-based white paper that serves as a starting point towards a roadmap for the successful implementation and scalability of solar-integrated bike paths as part of California's sustainable transportation infrastructure.

Assessment of State Assets for Advanced Air Mobility (AAM) Integration and Development of State Workplan

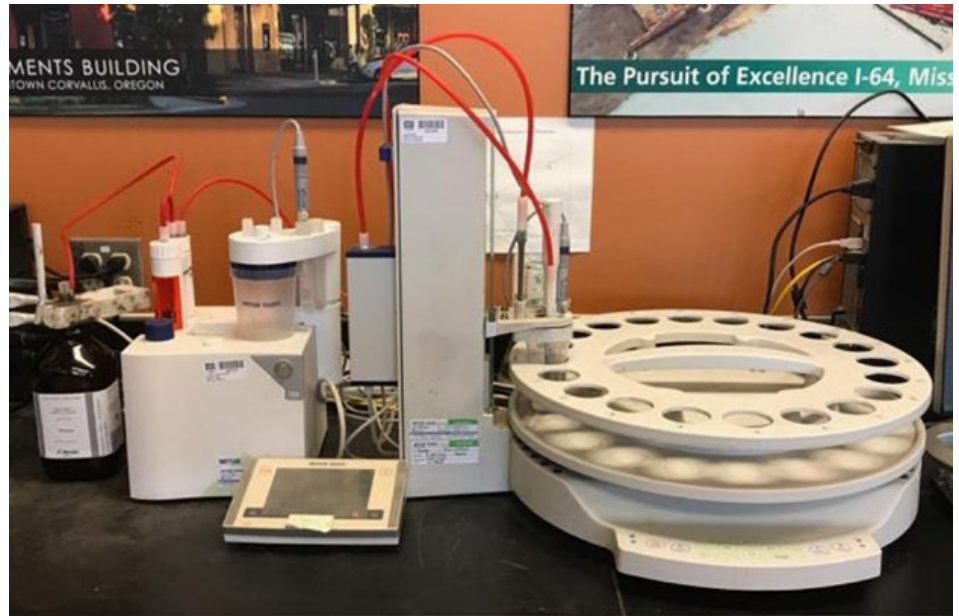
The aviation sector has been undergoing a dramatic transformation in electrification and autonomous flight. A new generation of vertical/short take-off and landing (e-VTOL/eSTOL) aircraft will alter urban and regional aviation, providing new opportunities for passenger mobility, cargo and logistics, and emergency response. The goal of this project is for Caltrans to incorporate AAM into its vision for a safe, accessible, low carbon, 21st century multimodal transportation network.

Climate Action



Advanced Technology and Materials Recycling Techniques for Use of Alternative Materials in Concrete as Plain or Reinforced Materials

This project evaluated the use of Alternative Supplementary Cementitious Materials (ASCs) to replace cement clinker in concrete, supporting the California Green Building Standards Code (CALGreen) goal of reducing embodied carbon in building materials. This research demonstrated that ASCs can contribute to strong, durable concrete when their reactivity, specific gravity, and water absorption are properly accounted for in mixture design. The findings from this study will inform future specifications and guide mix proportioning practices.



Automatic titration device used for determination of bound chlorides.
Photo credit: Jason Weiss.

Prosperity



Cyclists riding in a designated bike lane.

New Design Formulae for Wood Lagging in Nongravity Cantilevered and Anchored Walls

DRISI led Caltrans' efforts, in collaboration with the Division of Engineering Services, to successfully develop design formulae for the Format Conversion Factor for wood lagging used in nongravity walls. These formulae are analogous to those used for wood bridge members but are adapted to the significantly different live-to-dead-load ratios found in earth-retaining structures. The findings were implemented in Sections 8.4.4.2 and C8.4.4.2 of the California Amendments to the 2017 American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications (8th Edition), enabling more realistic and economical design practices.

Technologies and Approaches for Assessing Condition of Complete Streets Pavement Assets

DRISI collaborated with the University of California Pavement Research Center (UCPRC) and Georgia Tech to advance technologies and methodologies for evaluating complete streets pavement assets. An interim report—Complete Streets Core Assets, Condition Evaluation, and Treatments: A Review of Current Possibilities—was delivered to the Caltrans oversight committee. The report highlights emerging tools for assessing active-transportation pavement features and provides recommendations to inform Caltrans' asset-management strategies.

Advancing Adoption of General Transit Feed Specification (GTFS) Programs in California

The GTFS and its more recent extension to real-time data allow transit agencies to make their route and schedule information (as well as real-time updates) available to external trip planners. Research has found that the availability of this information, particularly via smartphone applications increases the legibility, predictability, and, consequently, use of transit services. The goal of this project is to facilitate the adoption of GTFS static and GTFS real-time into the practices of transit agencies across the state as well as create a statewide clearinghouse and historical archive of GTFS information. Additionally, it will develop and test a method for assessing GTFS accuracy in relation to vehicle location information.



Timber lagging in a completed nongravity anchored wall.

Employee Excellence



Transportation Research Board (TRB) and National Cooperative Highway Research Program (NCHRP)

DRISI's participation in TRB and NCHRP helps influence the direction of national research policy, programs, and projects. The TRB Core Program's annual budget was approximately \$19.1 million. Caltrans contribution to the Core Program was \$634,712, which means the Department leveraged approximately \$30 for every \$1 invested. TRB's Annual Meeting is the most important yearly transportation forum where state and federal representatives meet to address issues of common interest and form partnerships to leverage limited state funds. Historically, Caltrans has sent 15 to 20 representatives to the annual meeting. In 2024, Caltrans was able to send 29 delegates representing 15 different Districts and Programs to the meeting. The 2024 TRB Annual Meeting Key Takeaways & Lessons Learned report memorialized the success with Caltrans' involvement. On the NCHRP front, state contributions to the program in 2023 totaled \$55.2 million. Caltrans contribution to that total was \$5,107,758 which means the Department leveraged approximately \$11 in research-related activities for every \$1 invested in TRB's NCHRP activities.

Research Implementation

DRISI successfully completed its fourth year of the Research Implementation Program, an initiative designed to provide seed funding to advance the implementation of research outcomes. During this period, multiple workshops were conducted to introduce and explain the Research Implementation Program, outline application and participation requirements, and address questions from potential participants to ensure a clear understanding of the program's goals and processes.

Caltrans Structure Construction Annual Winter Training

DRISI supported Caltrans Structure Construction's Annual Winter Training by delivering 14 foundation design sessions across California. This collaboration bolstered technical expertise and ensured consistent foundation practices statewide, reinforcing Caltrans' commitment to cultivating excellence in infrastructure design and construction.



Caltrans foundation design team at the 2024 Structure Construction Annual Winter Training.

Employee Excellence



European Tunnel Study

DRISI supported District 1 and the Division of Engineering Services (DES) on the Last Chance Grade Project, a 1.1-mile tunnel in Del Norte County, by researching advanced tunneling and safety technologies from Europe and Japan. The findings were presented to the Caltrans District 1 Director and DES Division Chief, informing strategic leadership decisions. In October 2024, the project team conducted site visits in Europe and documented their observations and recommendations in a comprehensive reconnaissance mission report to further enhance Caltrans' knowledge on tunnel design.

European Tunnel Reconnaissance Trip Mission Report



By Matt Brady, Jaime Matteoli, Bryan Bet, and Sebastian Cohen

Last-Chance-Grade Project Study of Tunnels in Japan

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Division of Research, Innovation and
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Date: February 6, 2025



(Left) The European Tunnel Reconnaissance Trip Mission Report prepared by District 1 leadership. (Right) Presentation on Japanese tunneling innovations and technologies.

Mobile Terrestrial Laser Scanning (MTLS) System Implementation Support

During this implementation task with DRISI and University of California (UC) Davis research teams, UC Davis conducted a one-week-long MTLS Trimble MX system upgrade/repair and training workshop sessions with Caltrans Office of Land Surveys (OLS), North Region surveyors, Trimble MX representatives, and the local California Surveying & Drafting Supply (CSDS) vendor for four northern California MX systems. The successful workshop operation resulted in the establishment of a dedicated, certified CSDS technician to troubleshoot the MX systems and provide local support to OLS and district surveyors for future MX system maintenance, thus minimizing and mitigating MTLS MX system downtime on Caltrans projects.



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