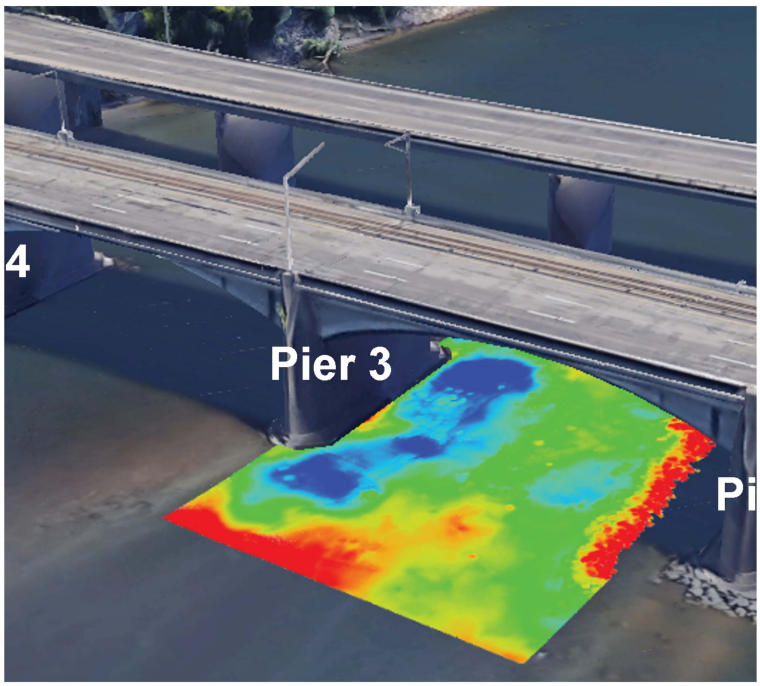

AHMCT

FISCAL YEAR 2020-21

ANNUAL REPORT

For individuals with sensory disabilities, this document is available in alternate formats. To obtain a copy in an alternate format, contact:

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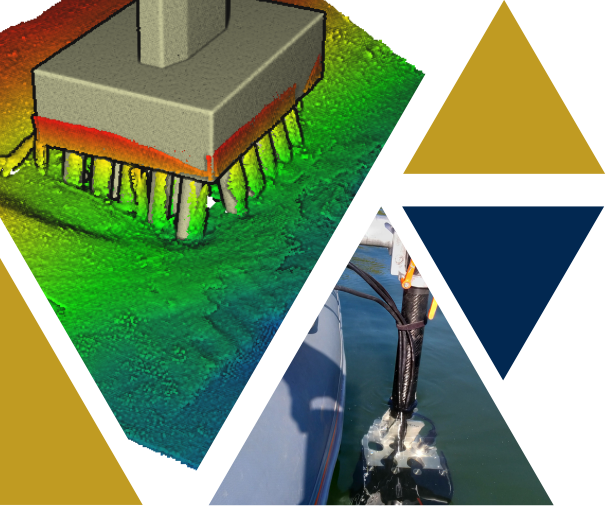
Advanced Highway Maintenance and Construction Technology Research Center

Fiscal Year 2020-21
Annual Research
Program Highlights



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Directors' Message

Bahram Ravani

Ty Lasky

We are pleased to present the Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center's Annual Report for the 12-month period from July 1, 2020 to June 30, 2021. In this period, the AHMCT Research Center continued its deployment-focused research, while also continuing to address the operational challenges of COVID-19.

The AHMCT Research Center, established in 1991, investigates methods and technologies that will improve safety, mobility and efficiency of highway construction, maintenance and operational tasks while addressing reliability of infrastructure and impact on the environment. The emphasis of recent research has been on the development and evaluation of human-centric systems and software, where humans play a key role in their control or use. This can lead to digital transformation of operations in project delivery and asset management together with workflows resulting in improved safety of operations.

The AHMCT Research Center annually deploys prototype machines, devices, systems, software applications, workflows, or methods that can lead to new policy decisions in California Department of Transportation (Caltrans) operations. In this process, the AHMCT Research Center has developed extensive experience in lining up its research and development work towards achieving Caltrans' mission.

The work completed over the past year has addressed improving work zone safety, operational efficiency in pavement management and maintenance of structures, new technologies to improve lane closure operations, better understanding of the impact of work zone collisions on safety and worker injuries, and decision support data for maintenance of roadside features. The work included new technology integration for work zone management in low traffic volume situations, and work on Global Positioning System/Inertial Navigation System (GPS/INS) integration and other sensing. The research has also included on-site evaluations with successful projects providing significant cost/benefit in areas including applications of Mobile Terrestrial Laser Scanning and maintenance of bridge structures. Some of the work has also used applications of advanced data science and database systems for understating of work zone collision and injury trends and classification of roadside maintenance activities to provide for a data-driven approach for proper decision making in maintenance and construction operations.

In addition, some of the work completed under the on-going research involved application of semi-autonomous vehicle technology to implement a driver assistance system for road opening in several mountain passes in California. Furthermore, the results of a research project completed for Caltrans in the previous year provided, in part, the data and basis for a proposed Assembly Bill (AB 1037) in California Assembly committee on Jobs, Economic Development & Economy.

Bahram Ravani and Ty Lasky
Co-Directors, AHMCT Research Center

Message from Caltrans – Dara Wheeler

I am pleased to provide a message from Caltrans, to reflect upon the joint activities of the UC Davis Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center and Caltrans over the last year. I also want to talk briefly about Caltrans' vision of the future of transportation maintenance, construction, and operations in California.

As the Chief of the Division of Research, Innovation and System Information (DRISI), my colleagues and I take great pride in promoting and implementing innovation in order to provide a safe and reliable transportation network that serves all people and respects the environment. DRISI works with Caltrans divisions and partners like AHMCT to discover, develop, evaluate, and deliver technological solutions that improve the safety and efficiency of the transportation system for both the traveling public and for Caltrans' workers.

AHMCT, through its many years of cooperative research with Caltrans, has developed the capabilities to assist Caltrans with finding innovative solutions in the area of transportation infrastructure research and development. This is the result of 30 years of careful and ongoing cooperation and refinement by DRISI and AHMCT in developing a highly effective research and development process, and in creating a team of dedicated subject area experts. I deeply appreciate the level of partnership interactions between our organizations and the responsiveness of AHMCT.

This year we were confronted with unprecedented challenges. COVID-19 disrupted our social and economic order. Despite these and other challenges, DRISI and AHMCT showed an unwavering commitment to keep the joint research and development activities moving forward with few disruptions.

An example of this commitment has been the deployment of the Mountain Pass Road Opening (MPRO) system. The MPRO system allows Caltrans Maintenance workers to safely open mountain passes in the spring after a winter-long closure. In heavier winters, snow can build up to over 50 feet deep, and Caltrans workers clear the accumulated snow by cutting down from the top. The MPRO system provides driver assistance to allow the equipment operator to accurately position and align the snow clearing equipment over the roadway, thus significantly improving the safety and efficiency of the operation, and allowing earlier access for the public. Following prototype development and subsequent Caltrans field testing, AHMCT deployed eight MPRO systems for continuing use in four Caltrans Maintenance yards in the Sierras. This deployment effort was successful only because of significant and effective cooperation between Caltrans DRISI, Equipment, Maintenance, and AHMCT.

There are many other examples of successful collaborative research, but let me sum up by saying that partnering and collaboration between AHMCT and DRISI provides for an excellent example of how public agencies and universities can work together to carefully assess and select research that will improve the safety and efficiency of California's transportation system for Caltrans workers and the public.

Summary of Activities in Addition to the Completed Projects

- Deployed eight Mountain Pass Road Opening (MPRO) driver assistance systems to four Caltrans winter maintenance yards. These systems are now available for Caltrans' future pass opening efforts.
- Teleconference regarding zipper truck guidance, provided technical guidance on vehicle location sensing and automation. Zipper trucks are able to relocate heavy linked-segment traffic barriers between lanes, e.g. on bridges, to accommodate peak traffic.
- Improved the research testing facility at the Maintenance Equipment Training Academy (META). This was needed immediately for the sander testing project. The enhancements have led to a significantly improved test area which will be useful for META and for future AHMCT testing and research.
- Presented the Caltrans/AHMCT Responder System at Caltrans Innovation Expo 2020.
- Provided technical guidance and support to District 4, for deployment and use of LidarCrawl software, which establishes a geospatial-enabled web-based portal to view Mobile Terrestrial Laser Scanning (MTLS) data availability, and improves data discovery and usage for all MTLS user levels.
- Participated in national Autonomous Maintenance Technology Pool Fund.
- Developed an improved workflow for reporting ADA compliance and remediation.
- Provided an interview to UC Berkeley California Partners for Advanced Transportation Technology in support of their Preliminary Investigation (PI) on automation in construction and maintenance.
- Conducted outreach meetings with companies Phantom and DesignatedDriver.ai to develop technologies for non-line-of-sight teleoperation of maintenance vehicles so that such equipment can become useful to certain Caltrans operations.
- Conducted several other outreach efforts related to the Autonomous Truck-Mounted Attenuator (ATMA) and other work zone safety research. This included outreach efforts with the University of Alabama, the University of Pittsburgh, and the University of California, Los Angeles.
- Addressed a bandwidth issue with Caltrans' 3D Ground-Penetrating Radar (3D-GPR) van and added a gigabit network interface to the onboard computer for the Global Navigation Satellite System – Inertial Measurement Unit (GNSS-IMU) system.
- The results of the work performed for Caltrans on "Developing a Strategic Roadmap for Caltrans Implementation of Virtual Design Construction/Civil Integrated Management" provided some of the data and basis of a proposed AB 1037 in California Assembly committee on Jobs, Economic Development & Economy.

Spotlight on Maintenance Research

Task 3149: Managing Low Volume Access Points in Work Zones

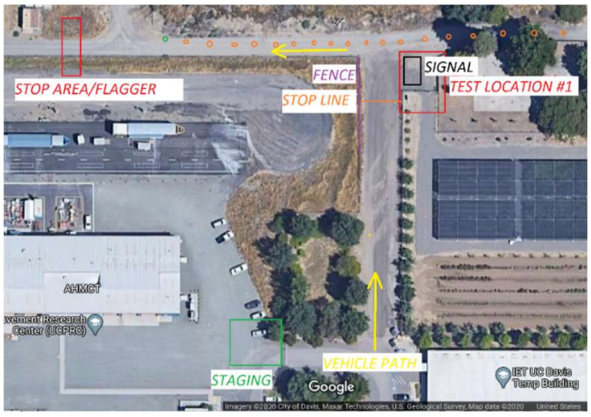
Customer: Division of Maintenance

Problem: Reversible control occurs when two opposing directions of traffic are required to share one lane. Lane sharing is generally accomplished by stationing controllers at each end of the work zone to direct traffic about when it is their turn to go. Traffic flows in one direction for a time while vehicles wanting to go the other direction are asked to wait. After some time, the lane is cleared of vehicles and the direction of traffic flow is reversed. A difficulty occurs when there is a low volume access point, such as side roads and driveways, in the work zone. If a vehicle enters the traffic lane from a low volume access point while going against the current traffic flow, significant disruptions to operations can occur and safety becomes a significant concern. There is a desire to reduce the possibility of vehicles going against traffic flow by using state of the art technology.

Goal: The main purpose of this work was to consider methods of controlling vehicle traffic entering from low volume access points and to test one commercial product suited to the task.

Methodology: This research study consisted of two phases. The first phase of the study included conducting a literature review, collecting information about systems and techniques used by others, presenting the information, assisting in the selection of the equipment to study further, developing a test plan, and proposing new concepts. The second phase included procuring commercial equipment, developing the testing protocol, performing testing, analyzing results, considering costs, and making recommendations.

As part of phase one, a thorough literature review of Traffic Control Systems (TCS) was conducted and a presentation based on the literature review was given along with possible concepts for new equipment. Commercial equipment designed specifically for reversing control lane closures with low volume access points were identified. The commercial equipment included variations of a Driveway Assistance Device (DAD) from several manufacturers. Based on a comparison of the available commercial equipment, a device made by Superior Traffic Services (STS) was selected for further testing in phase 2, and a draft test plan was generated. A proposal for new modifications to the commercial equipment was also generated.



Test site setup

As part of phase two, the equipment from STS identified in phase one was rented. The testing protocol was generated, and Institutional Review Board (IRB) approval was received to recruit volunteer test drivers. Testing was conducted on the efficacy of the signal as well as various operation considerations. Costs were also considered to compare using the equipment with a human flagger.

Conclusions: In this research, DAD equipment from STS that was capable of being controlled via remote control was tested. DAD's are often controlled by a Portable Traffic Signal (PTS), but for this testing, a human controlled the equipment via remote control (no PTS was used). Out of 11 test drivers (split into two separate tests), only two improperly entered the intersection and made a turn when the DAD had a red arrow in the direction they turned. It was noted that many drivers seemed to be anxious about the unknown wait time and/or whether the DAD had detected them. Some drivers would slowly roll forward after initially stopping but did not enter the intersection. Based on these results, a new IRB approval was generated to use the DAD with its built-in, small Changeable Message Sign (CMS) sign to inform drivers of expected wait time. The CMS sign may also be actuated by approaching vehicles. Work was completed to make the DAD capable of this feature, but testing is needed to see how drivers will react. Testing was not conducted due to shelter in place requirements of the COVID-19 pandemic. However, such testing can be part of a future study.

Benefit: The results of this work provided additional equipment options to consider when designing a work zone within which a low volume access point is contained. The modified equipment developed in this work should help facilitate controlled entry of vehicles entering work zones from low volume access points.

Task 3179: Support for Caltrans Statewide Mobile Terrestrial Laser Scanning System

Customer: Division of Right of Way and Land Surveys

Problem: Caltrans owns and operates two Mobile Terrestrial Laser Scanning (MTLS) systems, the Trimble MX8 and Riegl VMX-1HA. Maintaining a pool of trained Caltrans professionals to manage two different MTLS systems and process the data for either system is an on-going challenge. MTLS operation and data processing are perishable skills, and keeping personnel proficient is essential for successful MTLS outcomes. In addition, Caltrans did not have a Geospatial Technology Proving Ground (GTPG) or any baseline data to help verify mobile mapping data from vendors or other geospatial technology platforms elsewhere in the Department. Without a GTPG, Caltrans cannot validate system performance before system acceptance or after system component changes. Having a Caltrans-specific GTPG will aid with further research and development in using current MTLS standards and specifications and help manage capabilities and capacities.

Goal: The goal of this research was to support the Caltrans Geospatial Strategic Direction and the Caltrans Office of Land Surveys' (OLS) leading role in the creation, management, and visualization of geospatial data.

Caltrans MX8 MTLS system

Methodology: AHMCT worked with Caltrans to form a Technical Advisory Group (TAG) composed of representatives from Caltrans District Surveys, OLS, the AHMCT researchers, and Caltrans Division of Research, Innovation, and System Information (DRISI). Regular meetings were held with the Project Manager and/or the TAG. AHMCT and the TAG worked collaboratively during the research to best guide the effort. The TAG was consulted regularly throughout the project. To achieve the proposed objectives, we divided the research into the following tasks:

- Perform an MTLS literature review and attend Caltrans MTLS users peer-to-peer meetings
- Support deployment for MTLS use in California
- Update Caltrans documents and assist Caltrans in training staff on MTLS operations
- Support of MTLS data management and related IT deployment
- Integrate external sensors on the MX8
- Establish a GTPG and perform target spacing research
- Document and manage the project

Conclusions: The key deliverables of this project included:

- Updated Chapter 15 of the *Caltrans Surveys Manual*
- Created presentation files for Surveys Management Board (SMB) meetings and Transportation Research Board (TRB) AFB80 committee presentations
- Reviewed and added training and related information to the *Caltrans MTLS Guidelines*
- Documented MTLS data management plan (included in *Caltrans MTLS Guidelines*)
- Documented the process and results of 360-degree camera integration with MX8
- Implemented and documented the GTPG
- Designed, executed, and documented MTLS target spacing experiment, including results and recommendations
- Acquired and processed GTPG reference point cloud

Benefit: Due to the current research, Caltrans now has a GTPG that will enable Caltrans to improve its capabilities and capacities of geospatial data. In particular, the GTPG may allow Caltrans to increase the spacing of MTLS control points, which would enhance personnel and traveling public safety.

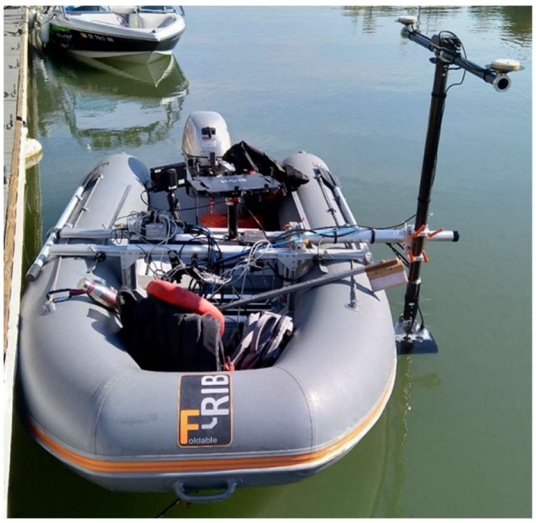
Task 3183: Development of Data Collection Systems for Large Scale Particle Image Velocimetry (LSPIV)

Customer: Division of Maintenance: Structure Maintenance and Investigations Hydraulics Branch

Problem: The Caltrans Office of Structure Maintenance and Investigations (SM&I) uses hydraulic models for bridge scour analysis and design. To calibrate hydraulic models, it is necessary to collect information about the flow characteristics in a river during flood events. However, using a manned boat can be difficult to deploy and hazardous to operate during flood conditions. Deploying instruments from a bridge deck is also challenging and limited in spatial extent.

Goal: The goal of this research was to identify a new method to measure river discharge, collect flow velocity (magnitude and direction) information, and estimate channel profiles.

Methodology: This research examined hardware, software, and deployment options to best implement current LSPIV technology for estimating flood flows to meet Caltrans' hydraulic needs. Specifically, the research investigated the most appropriate camera, the required camera accessories, LSPIV post-processing software, and hardware needed for deploying the system using an Unmanned Aerial System (UAS). The research also included procurement and testing of a Multi-Beam Echo Sounder (MBES) for bathymetric surveys. Working with SM&I personnel, AHMCT provided technical support for deploying the MBES system in several bathymetric survey pilot projects.



SM&I foldable boat with PicoMBES 120 sensor in water

UAS-based LSPIV can collect flow velocity (magnitude and direction) information at the water surface, and estimate channel discharge. This method provides valid information over a large spatial extent and can be quick to use, safe for Caltrans personnel, and easily deployed.

Conclusions: This research project has successfully designed, integrated, and deployed a manned boat-based bathymetric survey system composed of Global Navigation Satellite System/Inertial Measurement Unit (GNSS/IMU) positioning system, MBES, Acoustic Doppler Current Profiler (ADCP), and single-beam echo sounder sensors. SM&I has deployed the newly integrated bathymetric survey system in several pilot projects to monitor scour, Rock Slope Protection (RSP), and underwater riprap installations. Furthermore, Caltrans divers have used the 3D images of piers and surrounding bathymetry to plan their dives and supplement their inspections at locations too deep for diving. SM&I has also inspected underwater excavation before RSP installation by Caltrans Construction. The pilot project results were presented at Caltrans Area Bridge Maintenance Engineers meetings.

Benefit: Some of the notable benefits of this research are:

- The manned boat-based bathymetric survey system enables early detection and identification of bridge scour, improving the safety of the traveling public and reducing hazards and exposure for divers.
- The LSPIV system allows Caltrans personnel to rapidly and safely collect important water surface flow information during high flow events for hydraulic modeling.
- The final mapping system enhanced Caltrans SM&I's topographic and bathymetric survey capabilities and operational efficiency.
- With improved evaluations, the design of new construction could be more cost effective and the assessment maintenance needs for existing structures more focused, thereby improving the overall safety for the motoring public.

Spotlight on Equipment Research

Task 3273: Evaluation of the AutoCone 130 Cone Trailer

Customer: Division of Equipment and Division of Maintenance

Problem: Caltrans sets up highway lane closures daily throughout California to create work zones for workers to conduct highway maintenance activities. In high-traffic areas, lane closures are a high-risk operation. Presently, a standard cone truck requires a minimum crew of two, one to drive the truck and the other to drop off or pick up the cones. The crew operating the cones must manipulate the cones by hand, which can be physically demanding and may expose the crew to traffic. The safety of Caltrans workers and the users of California's transportation system is our number one priority. We are constantly working to improve the safety for all Caltrans workers and the public. The AutoCone 130 showed the potential to lower the risk of traffic exposure, by reducing the number of operators to one and by putting the operator into the safety of the cab. A research task was needed to evaluate the accuracy of manufacturer claims and determine the machine's overall value to Caltrans operations.

Goal: The goal was to obtain an AutoCone 130 cone trailer and evaluate its operation to determine if it works as advertised, document the decrease (if any) in worker exposure to traffic, compile other benefits and drawbacks, and obtain feedback from staff after using the machine. The overall goal was improvement of worker and traveler safety.

Methodology: AHMCT, in coordination with Caltrans, obtained two AutoCone 130 trailers. The AutoCone 130 cone trailer was tested and evaluated to determine if it works as advertised, document the decrease in worker exposure to traffic, compile other benefits and drawbacks, and obtain feedback from Caltrans staff after they used the machine. This research evaluated the performance of and provided recommendations for the AutoCone 130, including the possibility of Caltrans Division of Equipment (DOE) mounting it onto a truck.

Retrieving cones with the AutoCone 130

Conclusions: The major results and recommendations are as follows:

- The AutoCone 130 trailer cannot be used in Caltrans operations since it cannot retrieve cones while backing up. A truck-mounted system is required. It also must be redesigned to use the Caltrans 28-inch cone.
- An AutoCone 130 carries 130 cones. It is not likely to be a substitute for the typical Caltrans cone body truck due to the large size and cost. The typical maintenance lane closure requires 80 cones.
- A truck-mounted redesigned AutoCone 130 would be useful in locations such as the Bay Bridge where Caltrans places a 5-mile closure on a regular basis. Increasing the capacity to at least 260 cones is recommended.

Benefit: While the AutoCone 130 currently has a few drawbacks which prevent its use for Caltrans, the system and related commercial systems show great promise. The AutoCone could be modified as a truck-mount system, perhaps with higher capacity. In such a configuration, the system would provide Caltrans with the envisioned operational and safety benefits. Current commercial systems such as the X-CONE show significant promise to achieve the desired benefits. The research to evaluate the AutoCone 130 clarified the potential to significantly improve Caltrans lane closure operations.

Spotlight on Operations Research

Task 3236: Work Zone Safety Improvements Using Automated Injury Data Collection

Customers: Division of Design and Division of Construction

Problem: Traffic collision reporting databases available today such as the Statewide Integrated Traffic Records System (SWITRS) and the Traffic Accident Surveillance and Analysis System (TASAS) contain "check-box form" data. These databases do not provide the information that can be used to justify particular mitigation measures. They report outcomes and locations, but not information such as driver behavior, intrusion, work zone configuration, and comments by drivers, witnesses, and officers. To obtain this level of information, data from the entire collision report is needed including the diagrams and narratives provided in the write-up.

Goal: The purpose of this research was to collect and analyze work zone traffic collision reports data and develop an understanding of collision trends and attributes related work zone accidents.

Methodology: This research study used a methodology combining data collection, data integrity management, and analysis. It consisted of eight tasks as follows:

- Form the Project Panel
- Develop an Updated Data Collection Protocol
- Identify Liaison Persons at Caltrans Districts
- Collect Data
- Analyze Data Integrity
- Perform Data Coding
- Analyzes Work Zone Safety Improvement Based on the Data Collected
- Document and Present Research Results to Caltrans

Conclusions: This research resulted in collection of data for work zone accidents from all 12 Caltrans districts for the years 2011-2017. Data from over 39,000 accidents that occurred in California work zones during this period were collected, codified, and stored in a searchable database for future analysis. A generalized analysis of the data collected and codified in this research study indicates:

- The rates of injury causing collisions between those at a work zone and all collisions are approximately the same for years 2016 and 2017. The rate of injury causing collisions for years 2011 through 2015 are higher for work zone collisions than all collisions. Comparing the results for these two periods indicate that there was an overall safety improvement in 2016 and 2017.
- There are about 50% more rear-end plus sideswipe collisions in work zones than with all highway collisions of the same outcome grouping.
- The predominant primary collision factor for rear-end collisions is "Traveling too fast."
- The cost of work zone collisions averages at $820 million per year over the 2011-2017 period. The average cost per collision based on injury severity has decreased from $167,214 (2011) to $136,650 (2017) which is an 18% decrease for this 7-year period.

Benefit: AHMCT was able to provide an updated database of injury and collision data that can be used for safety and other assessments. This web-based tool can serve as a decision support system for mitigation and improvement of highway safety.

Work Zone Accident Injury Database

Task 3289: Research to Develop Performance Measures for Maintenance of Roadside Features

Customers: Division of Design and Division of Maintenance

Problem: Maintenance of roadside features can expose Caltrans workers to live traffic, increasing their safety risks. Furthermore, maintenance of certain features can be more difficult, requiring more time and increasing the potential time exposure of workers to traffic and roadway hazards. At present, there is no quantitative method of assessing the difficulty of maintaining such features and the safety risks of such operations.

Goal: The overall goal was to be able to prioritize certain classes of maintenance operations based on their difficulty as well as on the injury or hazard risks from live traffic to the workers performing such operations.

Methodology: The research approach integrated Caltrans customers using a project panel consisting of key Caltrans stakeholders for guiding the research combined with a data-driven methodology. The data-driven methodology utilized data from highway collisions and worker exposure through existing Caltrans and AHMCT injury and accident databases. The project panel met periodically to guide the research and redirect it to meet the goals of the Caltrans customers.

Conclusions: The significant results of this research study include:

- Classification of maintenance activities associated with roadside safety features.
- Determination of factors that are most significant in the difficulty of performing these maintenance activities.
- Determination of factors that are most significant in causing collisions in work zones.
- Recommendations in the form of metrics or indices for assessing the level of difficulty and risk of hazards in performing maintenance or installation operations.

Top 10 activities with the highest proportion of lane closure

Activity	Description
C95040	Test/sample manhole
F20050	Maintenance site corrective measure
F50003	Eval/develop de-icing criteria
F80201	Oversight drain clean contract
F80003	Sampling and testing contract
F80002	Drainage contract
B30010	Sub seal/jack slab rigid pavement
YD0000	Work for others d family
F30220	Construction compliance inspection
YA0000	Work for others a family

Top 10 activities with the largest crew size per work order

Activity	Description
M94020	Pre-op emergency equipment
G10010	Facility repair roadside rest
J20040	Maintenance tunnels & tubes
G21040	Grounds maintenance vista point
G41040	Grounds maintenance park & ride
G11040	Grounds maintenance roadside rest
G15040	Winter Treatment. Maint. roadside rest
M93010	Repair/replace escape ramp
G40010	Facility repair park & ride
G16000	Spec program admin. roadside rest

Top 10 activities with the highest access difficulty score

Activity	Description
C20010	Mechanical control
U80010	Fixed satcom - repair/replace
F80001	Oversight of construct contract
C93050	Clean cattleguard
F40150	Slide material hauling
F90103	Closure of existing site
S31010	Repair/replace rock fall protection
R91000	Avalanche control
R30110	Repair/replace fixed hardware
R10000	Snow removal

Top 10 activities with the longest average duration

Activity	Description
S31040	Rock scaling
F40050	Snow hauling (stormwater)
A30010	Dig out flex pavement
J70040	Maintenance toll plaza
F40210	Snow hauling (stormwater)
A21010	Profile grinding flex pavement
W52056	Legal tort cases – dscvry. rprt.
A20010	Overlay/leveling flex pavement
M30010	Repair/replace pavement markers
B31010	Slab replacement rigid pavement

Top 10 activities with the longest average mile-length

Activity	Description
F60030	Remove Acid/removal oversight
C20010	Mechanical control
F80002	Drainage contract
K20120	Night inspection sign lighting
F50005	Veg mgmt. & chem usage plans
C30020	Tree inspection
F10007	Employee specialized/training
M10120	Night inspection striping
K10120	Night inspection HWY lighting
M20120	Night inspection markings

A classification of maintenance activities

Benefit: The result of this work enables Caltrans personnel to use objective data and measures for decision-making in planning and scheduling a maintenance operation. The results can also be used in allocating resources in terms of personnel and equipment, considering additional safety measures, and deciding what type of lane closure (if any) is necessary in order to reduce the risk of injury to its personnel and roadside workers.

Summary of Current Active Research Tasks

Task ID	Task Name	End Date
3255	Mountain Pass Road Opening Implementation and Training	11/30/2021
3265	Evaluation of Autonomous TMA Trucks for Use in Caltrans' Operations	12/31/2021
3280	Development and Testing of an Unmanned Aerial System (UAS) Cellular & Wi-Fi Repeater: Phase 1	11/30/2022
3300	Comparison of New and Existing Caltrans Hopper Body and Tailgate Sanders Phase 1	3/31/2022
3685	Review of Equipment and Accessories for Truck-Mounted Attenuator Trucks	4/30/2022
3704	Improved Maintenance Methods for Bridge Drains and Expansion Joints	12/21/2021
3739	AHMCT Research Center Support for 65A0749	4/30/2022
3740	AHMCT Deployment Support for 65A0749	4/30/2022
3742	AHMCT Preliminary Research and Investigations	4/30/2022
3756	Responder Study - Interim Phase - Continued Support for Responder Transition	12/31/2021
3833	Evaluation of Heavy Equipment Simulator Systems	9/30/2022
3836	Orange Contrasted Temporary Pavement Delineation in Construction Zones	2/28/2023
3873	Evaluation of Next-Generation CCTV Encoder for ITS Field Elements	12/31/2022
4010	Research Implementation Accelerator: Workshops and Seed Funding Program	6/30/2022