2023
Caltrans / Industry
Construction Safety Summit

SUMMARY REPORT

January 31, 2023

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Executive Summary

The Caltrans / Industry Safety Summit (Safety Summit) is an annual forum where participants from Caltrans and construction industry partners come together to network, share information and brainstorm possible safety improvement initiatives in relation to a specific focus. The focus of the 2023 Safety Summit was “Automation & Innovation: The Future of the Work Zone.” The summit primarily focused on discussing ways in which Caltrans and the construction industry should consider implementing innovative technologies in the work zone to support the Department’s overarching goal of eliminating serious injuries and fatalities. The 2023 Safety Summit agenda also included two inaugural events: the Caltrans Construction Safety Awards Program Video and the Safety Summit Virtual Equipment Exhibition.

This is the fifth Safety Summit after the first in 2018. Participation has increased, and this year there were more than 350 participants from Caltrans, the construction industry, Western state departments of transportation (DOT), United Contractors, Associated General Contractors of California, Southern California Contractors Association, American Traffic Safety Services Association (ATSSA), California Highway Patrol (CHP), Federal Highway Administration (FHWA), local agencies, resident engineers, product vendors, and labor unions.

The primary purpose of this Summary Report is to show the progression of activities that took place before, during, and after the Safety Summit, leading to the final list of innovative safety recommendations presented in the “Summit Outcomes" section of this report.

Next steps include submission of this Summary Report to the Caltrans Construction Partnering Steering Committee (CCPSC) and other Caltrans divisions for review and evaluation of suggestions for potential implementation.

Process and Methodology

To kick off the Safety Summit, participants heard presentations from Caltrans leaders and Construction industry partners addressing the 2023 Safety Summit focus: Automation & Innovation: The Future of the Work Zone. All presenters emphasized the importance of safety in the work zone and discussed how different innovative technologies can and should be considered for implementation. Summaries of each presentation are included in the “Presentation Summaries” section of this report. All presentation slides are included in Appendix C, “Summit Presentations.”

The inaugural Safety Summit Virtual Equipment Exhibition took place over lunch and the participants had the opportunity to meet with 10 equipment exhibitors to learn about the new and innovative products. Each vendor had a short promotional video and a representative available for live questions and answers. The equipment exhibitors include: Artec, Pacific Highway Rentals, Solar Advanced Warning Systems, Blue Vigil, RoadVista, Horizon Signal, RoadPrintz, Inc., Ver-Mac, Inc., Plasticade, and Crashworthy Traffic Control. A link to the full

product descriptions and videos produced by each equipment exhibitor can be found in the "Equipment Exhibition" section of this report.

Content from all presentations and the Virtual Equipment Exhibitions was utilized as a primer for all subsequent breakout discussions. Utilizing a virtual meeting platform and virtual, collaborative whiteboard space, participations were divided into pre-assigned breakout rooms for three rounds of dialogue.

The final list of innovative safety recommendations is in the "Summit Outcomes" section of this report.

Summit Outcomes

All Safety Summit participants were given the opportunity to participate in three rounds of dialogue to address the following questions:

1. "Imagine it is 2050, how would you describe the perfect or ideal work zone?"
2. "What is getting in the way of innovation in the work zone?"
3. "What are ways we can remove those obstacles to achieve the future we envision?"

Each round of dialogue resulted in hundreds of ideas which have been summarized below.

In the first breakout, participants described the perfect or ideal work zone that aligned with the following themes: zero deaths and serious accidents; being fully automated; having universal buy-in to safety culture from all of Industry and the public; adhering to 100 percent exact closure plans; and having strong coordination between current work zone data and various navigation systems used by the traveling public.

In the second breakout, participants described the obstacles to innovation in the work zone to be in alignment with the following themes: legislation and politics; a lack of training or education; a lack of public awareness; the need to streamline product and process implementation; and resistance to change by all.

In the third and final breakout, participants generated ideas for removing some of the obstacles they noted, including, but not limited to: autonomous driving; inclusion of safety innovations in plans and specifications; increasing resources in the field; streamlining the implementation process; incorporating work zone awareness into driver education programs; increasing innovative pilot programs; providing the public with tours of the work zones; supporting curriculum starting in grade school; and developing safety incentives during the bidding process.

Future Action Plan

Each breakout session generated more than 300 safety ideas, which are included as raw data in Appendix D, "Breakout Sessions Raw Data" of this report. The Caltrans team analyzed all ideas and prioritized them by removing duplicates, merging similar ideas, and paraphrasing some ideas for better reader understanding. The team removed commentary style ideas that did not have a specific outcome. Consolidated Safety Ideas are listed in Table A, "Consolidated Safety Ideas for Review."

The Caltrans team will present these Consolidated Safety Ideas to CCPSC and Caltrans divisions for evaluation and further prioritization. Once prioritized, working groups will be formed collaboratively with participants from industry and Caltrans. The progress will be tracked and communicated to the stakeholders.

Table A: Consolidated Safety Ideas for Review

#	Safety Idea	Category	Notes
1	Create a platform to communicate with vehicles about upcoming work zones.	Automation	Connected Automated Vehicles
2	Acquire the use of automated cone truck for lane closures.	Automation	
3	Pilot robotic painting tool in order to see feasibility.	Automation	
4	Determine mass implementation of automated inspections.	Automation	
5	Pilot robotic crack sealing tools in order to determine feasibility.	Automation	
6	Develop safety prequalification program.	Bidders Safety Prequalification	In progress
7	Tax credit for big tech safety development.	Cost/ Legislation	
8	Provide funding to implement new technology	Cost	
9	Partnership with universities with big tech sponsorship to develop student competition to solve work zone safety issues. (Think concrete canoe or bridge building competitions.)	Cost	
10	Additional bid items for safety devices so that they are included in the project.	Cost	Move away from lump sum items
11	Engineers to put new technology into their designs.	Design	
12	Make full closures, detours, and extended closures a carefully considered option.	Detours, Full, and Extended Closures	In Progress but needs continuous improvement
13	Modify California Drivers License testing to include work zone safety.	Department of Motor Vehicles	Already identified at the 2022 Safety Summit

Table A: Consolidated Safety Ideas for Review (Continued)

#	Safety Idea	Category	Notes
14	Educational outreach program for work zone safety, describing how to transit through work zones, such as lane configuration changes and outreach to educate the public.	Education	
15	Implement through legislation the use of Speed Safety Camera, automated speed enforcement, in work zones.	Enforcement	
16	Enforcement in the work zone or use of other law enforcement agencies.	Enforcement/CHP	
17	Create a dedicated office to implement new ideas and technology.	Innovation	
18	Need to find a state and federal elected officials to champion legislation changes that will improve safety in our work zones.	Legislation	
19	Streamline and expedite Caltrans acceptance and approval process for new technology.	Process Improvement	
20	Make sole source approvals easier.	Process Improvement	
21	Work to get a separate safety contingency line item in the beginning of the project lifecycle.	Project Management	
22	Use more pilot projects to try out new technology.	Safety Pilot	
23	Identify what policy changes could be changed to promote innovation.	Specifications	Policy Review
24	Allow Lane Closure System Application to push notifications for closures to public.	Traffic System Operations	

Presentation Summaries

Stacy Tetschner, American Traffic Safety Services Association (ATSSA)

Stacy Tetschner, ATSSA President and CEO, opened the Safety Summit with a presentation on work zone safety opportunities, noting various sources of work zone safety data and work zone safety issues. Mr. Tetschner reviewed three ways in which the industry may advance roadway safety: (1) take ownership of your own business, (2) develop a safety culture, and (3) embrace new technologies. He also reviewed two specific ways that ATSSA is helping to advance roadway safety: (1) roadway worker protection through training and education and (2) being actively involved in industry innovation and technical services. Mr. Tetschner concluded his presentation with a sampling of new and innovative work zone products rolling out in 2023.

Troy Lukkes, California Highway Patrol (CHP)

Troy Lukkes, CHP Assistant Commissioner, opened his presentation by noting the importance of mutual respect and trust serving as the foundation between CHP and Caltrans. Assistant Commissioner Lukkes discussed how work zone safety is a top priority for CHP and reviewed various sources of work zone safety data. He emphasized how important it is to keep efforts collaborative amongst CHP and their partners so their COZEEP, MAZEEP, and PDZEEP are most visible. He also noted CHP and Caltrans work together to address highway work crew and motorist safety concerns. CHP is committed to enhance safety throughout work zones by increasing enforcement actions using supplemental grants received from the Office of Traffic Safety. CHP is committed to taking bold steps toward reducing fatalities and serious injuries on California roadways.

Tony Tavares, California Department of Transportation (Caltrans)

Tony Tavares, Caltrans Director, delivered a genuine and heartfelt presentation, recalling his first experience feeling unsafe while working in the work zone. He touched upon his experience in attending services for many who lost their life in the line of duty and reiterated Caltrans and Industry's ultimate responsibility is to "get our folks home safely."

Vincent Mammano, Federal Highway Administration (FHWA)

Vince Mammano, FHWA Division Administrator, reflected on the importance of the partnership between Industry and Caltrans, and specifically emphasized the importance of the Safety Summit by calling all participants present to action. Mr. Mammano encouraged active listening and engagement throughout the summit to fortify a culture of safety and thanked the Industry and Caltrans for their efforts.

David Edwards, PhD, Caterpillar (CAT)

David Edwards, Caterpillar Worldwide Market Manager for Safety Technology, delivered a presentation on ways in which technology can enable safer work zones. Mr. Edwards emphasized the importance of implementation and noted thoughtful and intentional implementation of technology increases acceptance, adoption, and safety. Mr. Edwards also reviewed various technologies offered by and implemented by Caterpillar including a seat belt reminder, the CAT® Detect Driver Safety System, the CAT® Detect with Smart Camera, and CAT® Command.

Ram Boyapati, Battelle

Ram Boyapati, Battelle Transportation Research Scientist, discussed the testing of automated vehicles in work zone conditions and how adverse weather and road conditions in different driving environments affected automatic vehicles dynamics, operations, driver behavior, communications and automated vehicles sensor capabilities. Mr. Boyapati reviewed a specific summer to spring field test that included two test vehicles, Vehicle A and Vehicle B. Both vehicles were subject to varying weather and road weather conditions, work zone lane changes marked by barrels, and work zone lane closure with lane markings. Key takeaways from the field test included test vehicle performance inconsistencies, although no specific environmental condition was more challenging than another for the vehicles tested. Mr. Boyapati also noted various other opportunities for additional research.

Equipment Exhibition

An inaugural Equipment Exhibition was held during the 2023 Safety Summit where ten safety device vendors were given the opportunity to showcase their innovative safety products and communicate with Safety Summit participants in real time. More information regarding each participating equipment exhibitionist can be found at the end of the agenda within Appendix B, "Participant Agenda," or via the online, virtual whiteboard here:
https://miro.com/app/board/uXjVP1OcRTY=/?share_link_id=589356655323

Caltrans Construction Safety Awards Program

The Caltrans Construction Safety Awards Program (CCSAP) was created to recognize teams that have excelled at safety on construction projects and was launched at the 2020 Safety Summit from an idea from a breakout session. Monica Kress-Wooster, Caltrans Deputy Division Chief of Safety Programs, delivered opening remarks reiterating the contribution the CCSAP has toward safety culture and the Department's "Vision Zero" by the year 2050. The CCSAP is intended to create healthy competition among all projects to excel in safety compliance, innovation, and extreme ownership. The CCSAP is made up of two categories: Safety Excellence and Safety Innovation. CCSAP awards will continue to be awarded at subsequent Safety Summits while Caltrans Districts will facilitate the awards for ongoing projects. The 2023 CCSAP winners are:

Safety Excellence Platinum Hard Hat Awards

- Colusa Route 20 Rehab Project (District-EA: 03-2F9804)
- US 101 Deck replacement at Alemany Circle Project (District-EA: 04-3G6204)
- Hwy 101 HOV Carpinteria – Segment 4A Project (District-EA: 05-0N7AU4)
- SR-99 & Avenue 152 Overcrossing Project (District-EA: 06-0Q9104)
- Kingsburg to Selma Rehab on SR-99 Project (District-EA: 06-0S4604)
- Interstate 710 Pavement Rehab & Bridge Widening Project (District-EA: 07-202124)

Safety Innovation Platinum Hard Hat Awards

- Posey-Webster Tubes Project (District-EA: 04-3K2004)
- SR-99 & Avenue 152 Overcrossing Project (District-EA: 06-0Q9104)
- State Route 60 Truck Lanes Project (District-EA: 08-0N69U4)
- Stockton Channel Viaduct Deck Rehabilitation Project (District-EA: 10-1C9404)

Safety Excellence Gold Hard Hat Awards

- Pasatiempo Soil Nail Wall #2 Project (District-EA: 05-1H0604)
- Route 40 Median Slope Recovery Zone Project (District-EA: 08-OR1424)
- Rt. 2 Cold In-Place Recycling in Wrightwood Project (District-EA: 08-1L6604)
- Roundabout at SR 88 and Liberty Road Project (District-EA: 10-1E5314)

Safety Excellence Silver Hard Hat Awards

- 29th and 23rd Pavement Rehabilitation Project (District-EA: 04-1A6834)
- Sidewalk Accessibility Improvements along SR-79 in Hemet Project (District-EA: 08-1F6004)
- Route 247 Rubberized HMA Project (District-EA: 08-1K8404)

Appendixes

Appendix A: Summit Attendees

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Appendix A: Summit Attendees (Continued)

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Appendix A: Summit Attendees (Continued)

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Appendix A: Summit Attendees (Continued)

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Appendix A: Summit Attendees (Continued)

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Appendix A: Summit Attendees (Continued)

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Appendix A: Summit Attendees (Continued)

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Appendix A: Summit Attendees (Continued)

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Appendix A: Summit Attendees (Continued)

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Appendix A: Summit Attendees (Continued)

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Appendix A: Summit Attendees (Continued)

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Appendix B: Participant Agenda

TIME	TOPIC
8:00	**Welcome Remarks**
	Introductions & Check In
	Industry's Focus on the Future
	CHP in the Work Zone
9:25	**Break**
	Caltrans Director's Safety Vision
	FHWA Update
10:30	**Break**
	Industry Insights: *Autonomous Technology in the Work Zones*
	Industry Insights: *Autonomous Public Vehicles through the Work Zones*
	Breakout Discussion A: *The Future of the Work Zone*
	Breakout Discussion B: *Obstacles in the Work Zone*
12:10	**Lunch**
12:15	**Equipment Exhibition (open during lunch)**
1:35	**Breakout Discussion C:** *Solutions for the Future*
	Caltrans Construction Safety Awards Program
	Closing Remarks
3:00	**Adjourn**

EQUIPMENT EXHIBITION VENDOR DESCRIPTIONS

ARTEC
Revolutionizing traffic control, the SideWinder is a channelizing device displacer designed to ensure maximum security for workers while optimizing operations. Ideal for lane closures and openings, the front-mounted truck attachment allows traffic control teams to operate 100 percent from the security of their truck's cabin all while displacing traffic drums from one side of a lane to the other quickly. Not only does the SideWinder improve efficiency as time spent setting up the worksite is reduced but it also minimizes risks for workers. The SideWinder is undoubtedly paving the way for safer traffic conditions during TTC zone setups and takedowns.

Blue Vigil
Blue Vigil is making nighttime roadway construction sites safer and more productive with its ALED Portable Light. The ALED uses an autonomously operated tethered drone to place a high-intensity LED array 80-100 feet directly above the work area, eliminating dangerous glare and shadows. The ALED generates an 8,000 sq. ft. useable light field that is double what is produced from a towed light tower. Visit Blue Vigil's breakout room to see how the ALED is dramatically transforming nighttime construction.

Crashworthy Traffic Control
Crashworthy Traffic Control is a Pasadena, California-based manufacturer of Manual for Assessing Safety Hardware (MASH) tested and certified Type 1, 2, and 3 barricades and sign supports. Its products are the only MASH- and NCHRP 350-certified barricades in production capable of legally accommodating sign supports from 1 to 7 feet high enabling multiple sign configurations with limited field inventory. The rigorous testing process confirms the company's patented design can accelerate Caltrans Safe System approach to eliminate deaths and injuries on state highways. In addition, the use of Crashworthy Traffic Control compliant devices reduces legal liability and prospects of federal funding clawbacks from the otherwise common use of field constructed and foreign manufactured, non-compliant barricades.

Horizon Signal
Horizon Signal is dedicated to enhancing work zone safety through temporary traffic control solutions. Our connected and adaptive Portable Traffic Signals use the latest proven technologies to improve safety for both workers and motorists.

Pacific Highway Rentals
Pacific Highway Rentals is a State Certified Small Business started in 2002 by Paul Indelicato and still owned and operated by him today. We have the largest rental fleet of high-quality Traffic and Highway Safety Devices, Trucks and Equipment in California and are available to meet all your roadway safety needs. We deliver throughout California and service most brands of traffic safety equipment for all of your construction projects. In addition to all the standard traffic safety stuff, we specialize in Automated Flagger Assistance Devices, AWIS and End of Queue Systems, Portable Traffic Lights, Cone and Crash Trucks and Solar as well as Diesel Powered Light Plants.

Plasticade
Plasticade's Modular Glare Screen System attaches to barrier wall to reduce headlight glare from opposing traffic. It can also be used to curtail gawking in work zones or to prevent pedestrians from crossing the barrier. Our patented system reduces installation time, transportation costs, storage space, and labor costs in comparison to other glare screen products.

RoadPrintz
Keep the boots off the pavement! RoadPrintz offers a safer alternative to stenciling transverse pavement markings. RoadPrintz' operator-driven, truck-mounted, robotic painting system keeps workers safely off the road and in the truck while also increasing efficiency and precision. Stop by to learn more!

RoadVista
Are you ready for the new MUTCD requirements for pavement marking retro-reflectivity? Learn how these standards affect you, along with solutions personalized for your region and needs.

Solar Advanced Warning Systems
Solar Advanced Warning Systems Inc. is a manufacturer of the latest work zone ITS system for work zone egress and ingress. SAWS provides advanced warning to motorists of vehicles that are emerging onto any high-speed roadway from behind the barrier. Come learn how SAWS can be a solution to a problem facing every roadway builder and help us make work zones safer for both the worker and the motorist.

Ver-Mac, Inc.
Ver-Mac is a leading manufacturer of portable traffic safety, lighting, and security equipment. We also develop innovative software solutions for remote fleet management and smart work zones. Our products help make work zones safer for workers and drivers throughout North America and worldwide. Founded over 60 years ago, Ver-Mac is a third-generation family-operated business. Today, over 350 employees contribute to our success every day in our Quebec, Canada, and Conroe, Texas, plants. Production is vertically integrated, which allows us to ensure outstanding quality, and enables better control over our delivery schedule. Our focus on Customer Experience helps make sure that you have the support you need from the first time you reach out to select equipment until you look to replace that equipment, years down the road.

Appendix C: Presentation Slides

1

Introductions

Prompt:

- What is your name?
- What is your organization?
- What ground rules do we want to set for how we work together?

Time: 15 minutes

2

Caltrans
presents

AMERICAN TRAFFIC SAFETY SERVICES ASSOCIATION (ATSSA) President & CEO

Stacy Tetschner, CAE

ATSSA
SAFER ROADS SAVE LIVES

3

4

Keeping Our Workers Safe While Making Our Roads Safer…

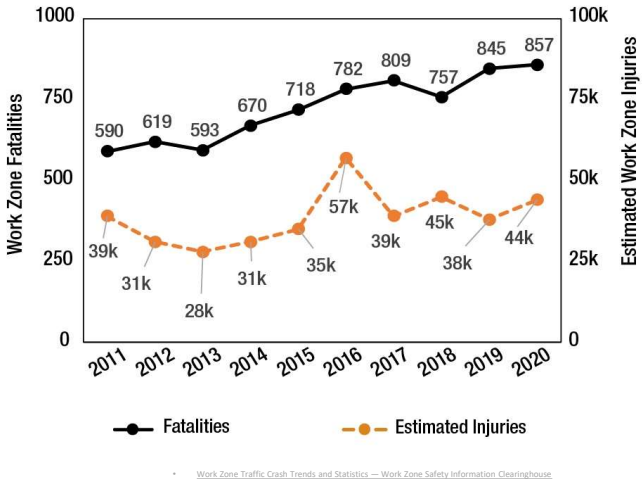
ATSSA
SAFER ROADS SAVE LIVES

Caltrans

5

Work Zone Safety Data

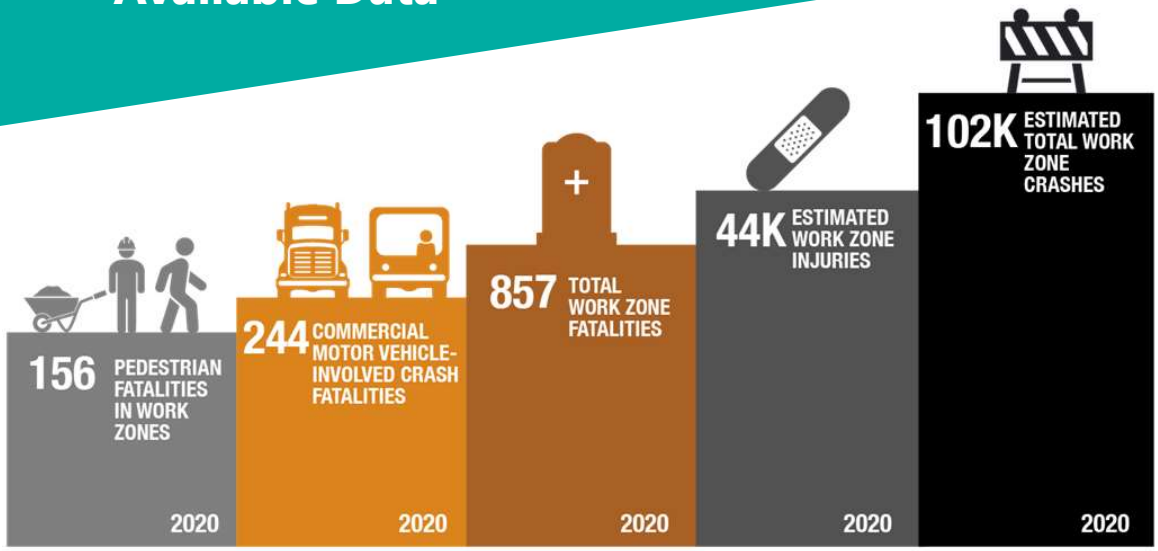
Fatalities and Estimated Injuries Occurring in Work Zones 2011-2020



Work Zone Traffic Crash Trends and Statistics — Work Zone Safety Information Clearinghouse

6

Summary of Most Recent Available Data



7

Work Zone Safety Challenges

- Increased speed
- Workforce shortages
- Materials shortages
- Drivers' education
- Connected and automated vehicles
- Distracted driving

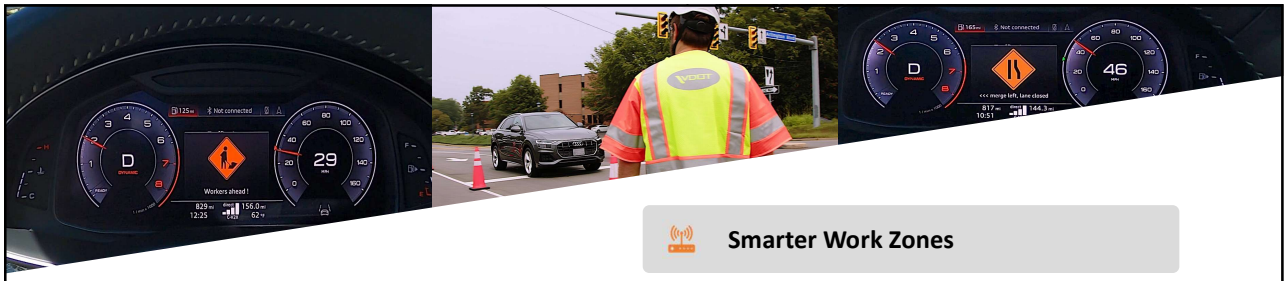
8

LED Flicker Rate

Safety Issue: A light source (the LED) has a constant flicker even though the human eye sees it as a constant light. The automated vehicles can't fully detect the light source as they are not on the same cycle/wave length and cannot detect one another. The result:

- The vehicle only sees a light source that blinks on and off
- The vehicle only sees a variation of brightness and colors from a light source
- The vehicle sees a banding effect that does not allow it to recognize signs/messages

9



Work Zone Safety Opportunities

- Smarter Work Zones
- Roadway Safety Investments
- Safety Contingency Fund
- Slow Down/Move Over Changes
- Automated Enforcement in Work Zones
- VTTI/Audi Work Zone Project

10

1. Take ownership your own business
2. Developing a safety culture
3. Embracing new technologies

Two of the Ways ATSSA Advances Roadway Safety

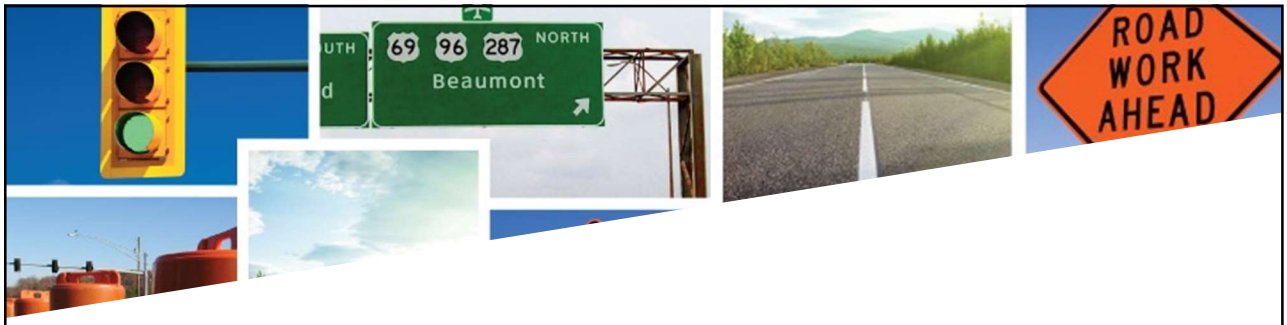
1. Roadway worker protection thru training & education
2. Being actively involved in industry innovation & technical services

11

TRAINING & EDUCATION

1. Roadway Safety Training & Certification
2. Meetings & Traffic Expo
3. Safety Summits & Forums

12



- Debuting new Signs Course at Expo in Phoenix
- Developing a course for Pavement Marking Inspections
- Offering Temporary Traffic Control for New Hires (orientation to TTC)
- Enhancing our overall training experience

13

Protecting Roadway Workers

Download the youth activity book

1. Roadway Worker Protection Council
   a. Providing Education & Resources to Protect Workers
2. ATSSA Foundation (www.foundation.atssa.com)
   a. Roadway Worker Memorial
   b. Driver's Education for Work Zones
   c. Youth Activity Book

14

New Products Roll Out at ATSSA

From 2020-2022 over 30 new products were rolled out at ATSSA Expo covering:

- Work zone safety
- Pedestrian safety
- Innovations in training
- Product management (temporary and permanent)

QR Code for NPRO Videos

To see the 2022 videos go to: https://expo.atssa.com/new-products-rollout.html

*** Top entries recognized with an innovation award at Circle of Innovation event.*

15

A Sample of New & Innovative Work Zone Products Rolling Out in 2023

- **Portable HAWK System** - The portable HAWK (High Intensity Activated Crosswalk) System is a modified version of the HAWK system except for temporary applications like work zones.
- **Road Safety Audit 3D (RSA-3D) -** Uses LiDAR to show actual deficiencies in a 3D roadway environment.
- **VORTEQ® M** - A trailer-mounted attenuator for use on stationary or moving shadow support vehicles.
- **SiteGuide™** - A water filled plastic barricade used for traffic and pedestrian channelization, road and street closures, and perimeter security for vertical construction

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Other New & Innovative Products Rolling Out in 2023

- **First Guard** - A foldable traffic cone that can be deployed nearly instantly.
- **RapidRamp** – A portable and lightweight ADA-compliant ramp.
- **GuardianSign** - Site management tool which tracks liability, compliance, and inventory.
- **ALED Portable Light** - A person-portable area lighting system to help protect workers at nighttime.
- **Flagger-Mac Lite** – Uses the same technology as a regular AFAD trailer, but in a more compact version.
- **SensorZone Proximity Warning System** – A system to help eliminate work zone incursions.
- **ZoneBloc** - A temporary concrete barrier system.
- Partnerships with AI Companies to begin to monitor assets and accident sites before deploying workers.

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Questions

Connect with us…

1. Roadway Safety Magazine
2. National Work Zone Awareness Week (April 17-21, 2023)
3. Attend the ATSSA Traffic Expo (Feb. 17-21, 2023 – Phoenix, AZ)
4. East Coast Roadway Safety Summit (May 16-18, 2023 – Richmond, VA)
5. www.atssa.com
6. newguy@atssa.com

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Technologies Enabling Safer Work
David Edwards PhD
Worldwide Safety Technology Market Manager
YOU'RE ON A JOURNEY
TO ZERO
WE'RE HERE TO HELP
CAT
Caterpillar: Non-Confidential

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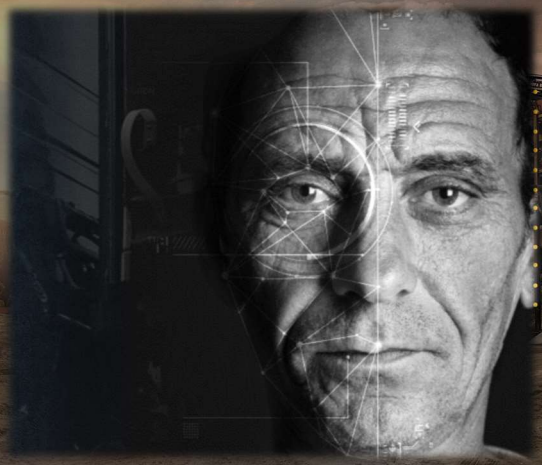
TECHNOLOGIES ENABLING SAFER WORK
Technology can enhance safety and increase productivity in hazardous work environments.
CAT
Caterpillar: Non-Confidential

20

TECHNOLOGIES ENABLING SAFER WORK

- Accountability
- Attention
- Situational Awareness
- Automation



21

TRANSFORM WITH TECHNOLOGY

How you implement is important

- Do you have a positive safety culture?
- Engage workers through technology pilots
- Make jobsite safety personal, ask for feedback

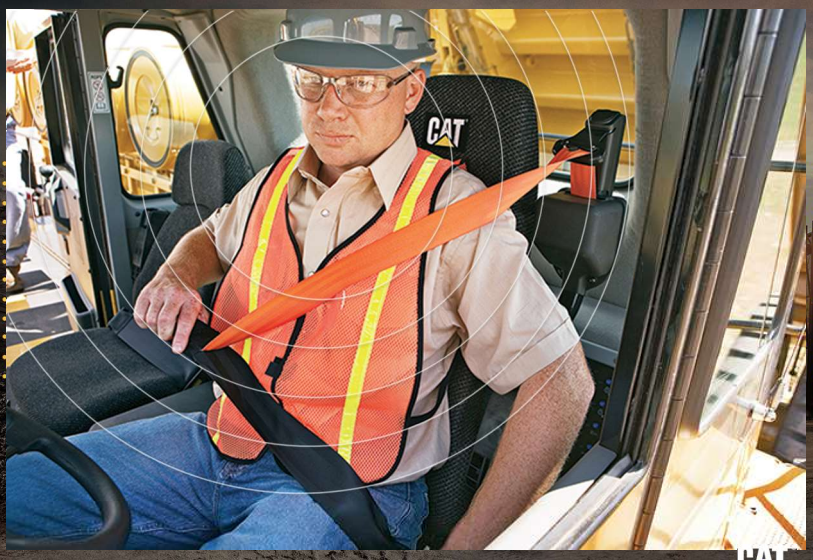
Increases acceptance, adoption and safety

22

CATERPILLAR SAFETY SERVICES

VISIBLE COMMITMENT
EMPLOYEE ENGAGEMENT
ACCOUNTABILITY
RECOGNITION

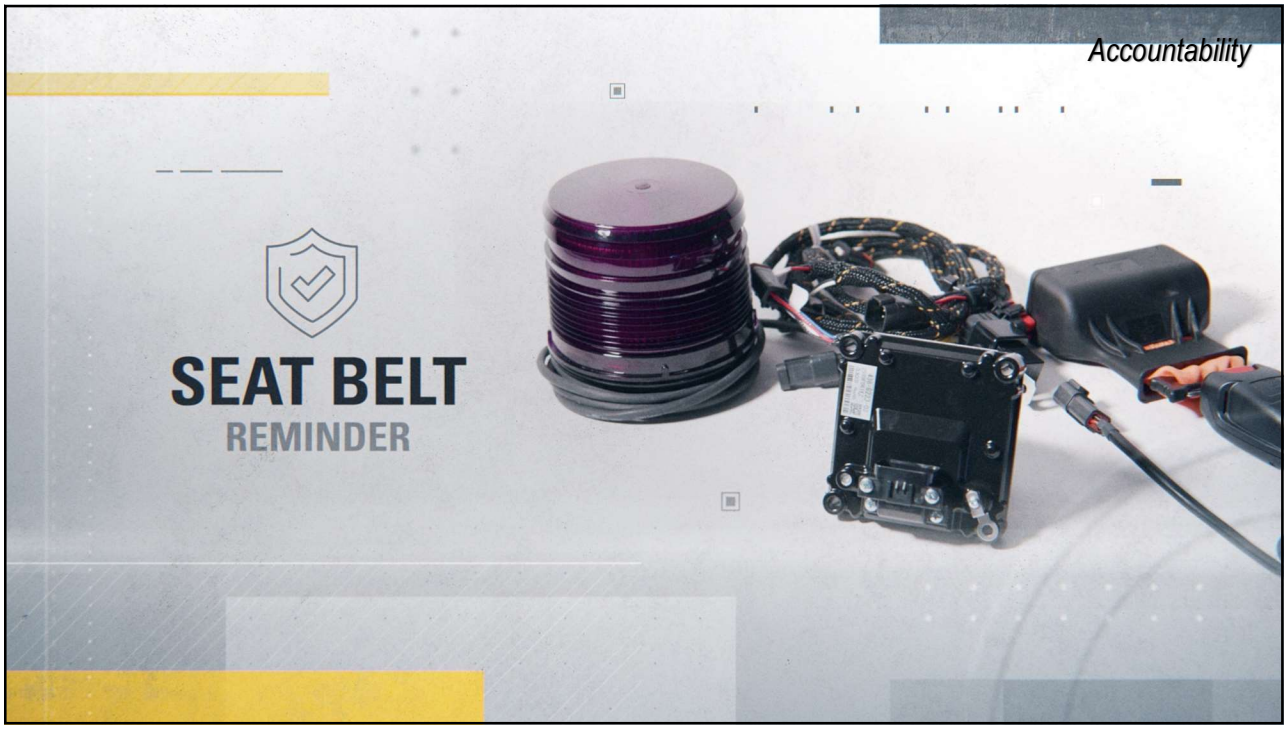
23



CAT

CAT

24



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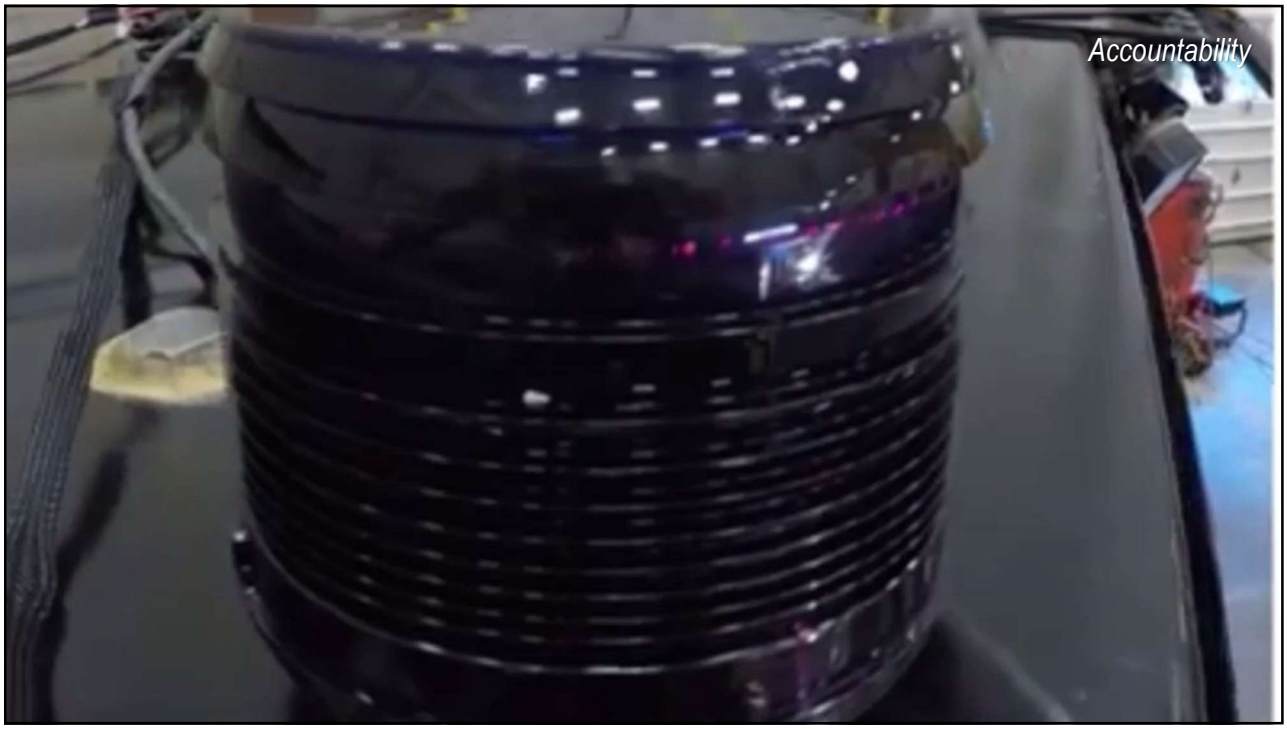
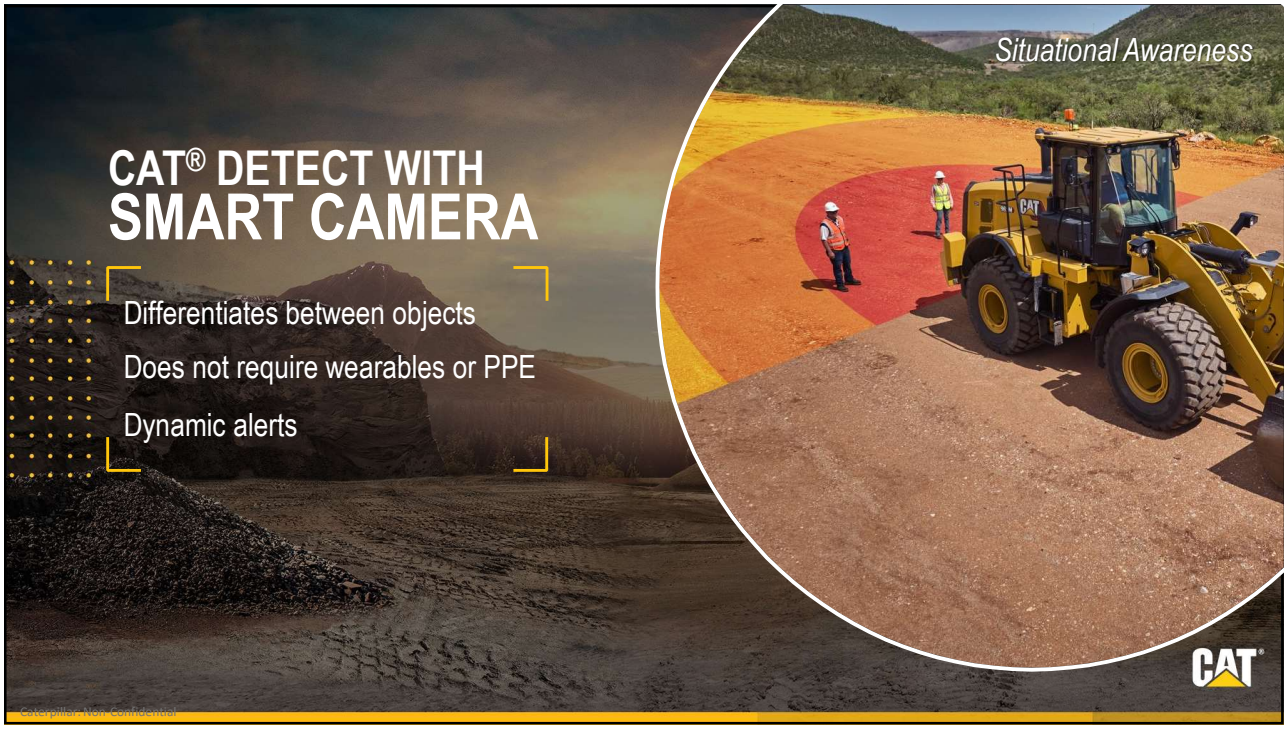


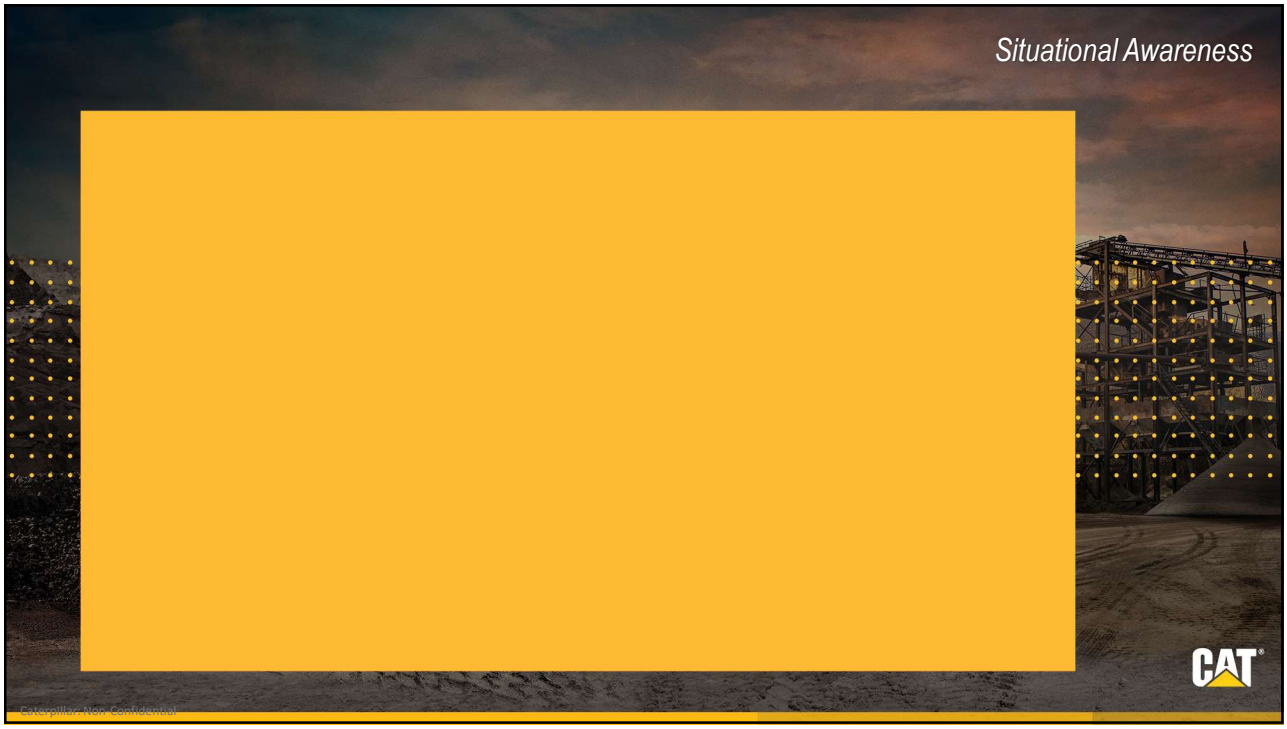
27

CAT® DETECT
DRIVER SAFETY SYSTEM

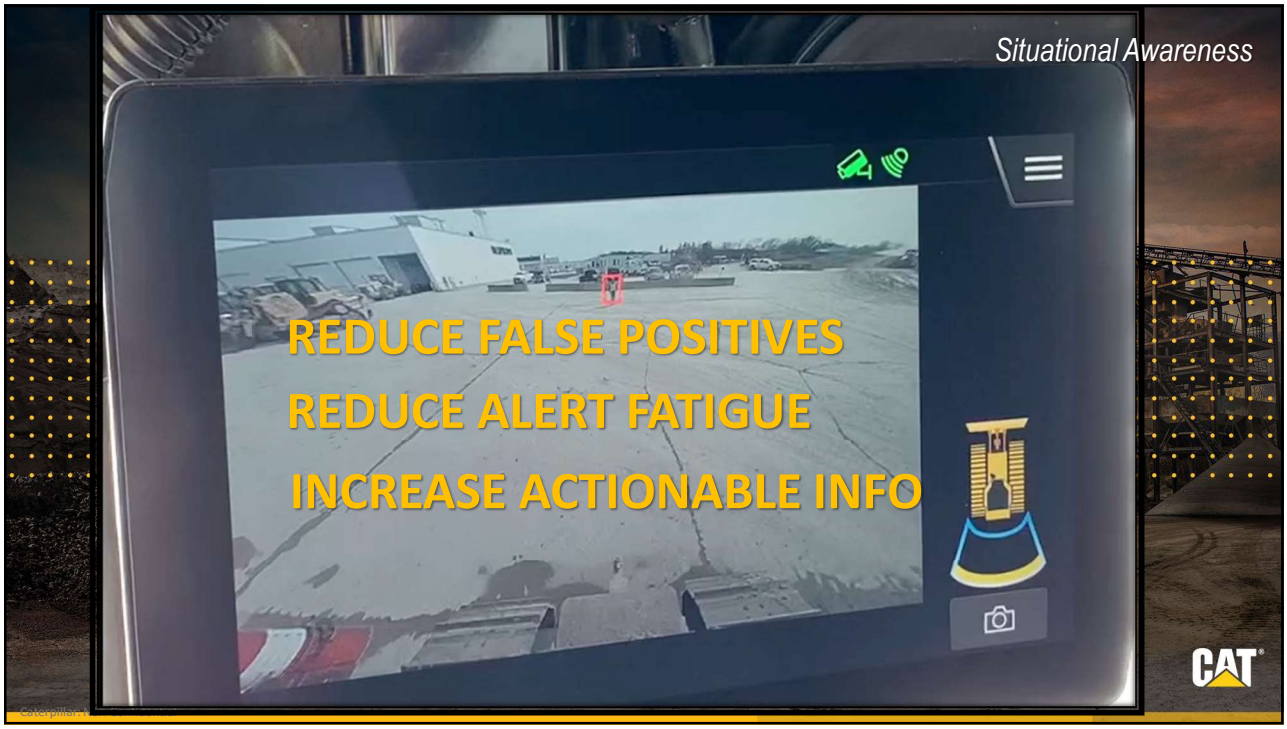
28


Situational Awareness
CAT® DETECT WITH
SMART CAMERA
Differentiates between objects
Does not require wearables or PPE
Dynamic alerts
CAT
Caterpillar: Non-Confidential

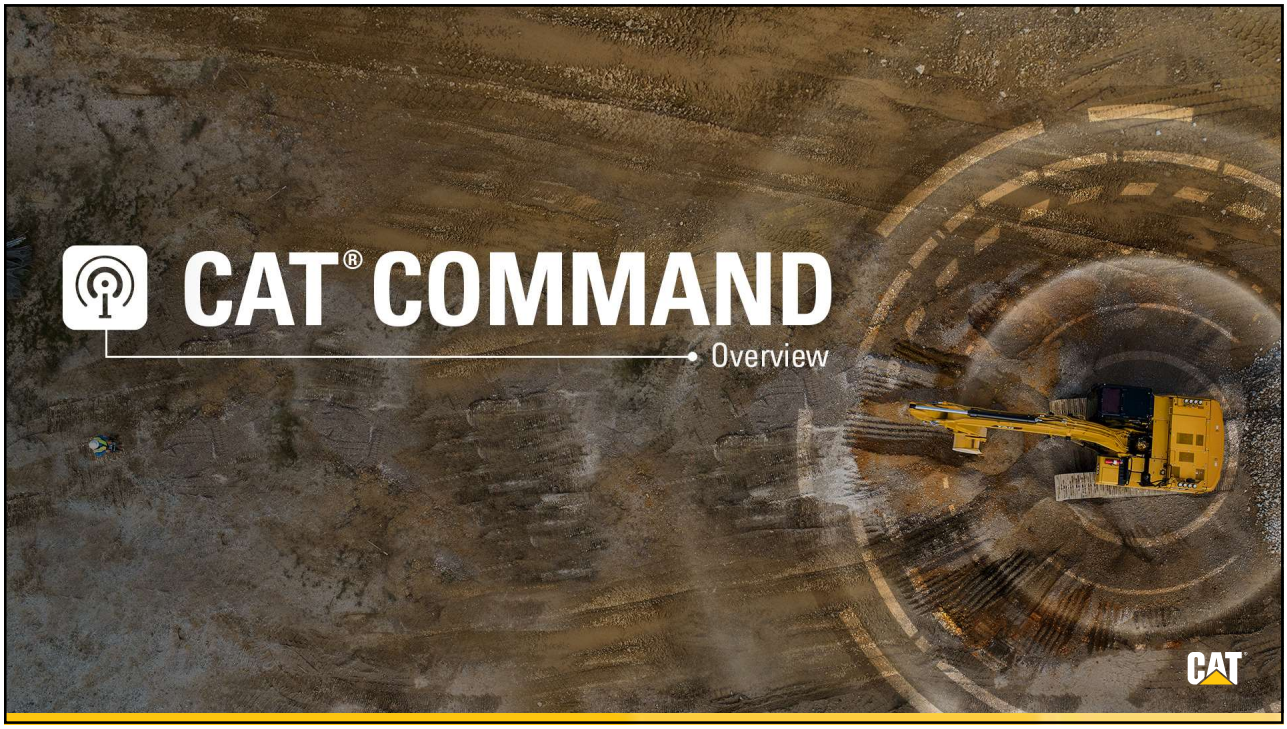
29


Situational Awareness
CAT
Caterpillar: Non-Confidential

30


Situational Awareness
REDUCE FALSE POSITIVES
REDUCE ALERT FATIGUE
INCREASE ACTIONABLE INFO
CAT

31


CAT® COMMAND
Overview
CAT

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What Is Cat Command?

Automation

REMOTE CONTROL and **SEMI-AUTONOMOUS** systems, featuring:

- onboard electronics
- vision systems
- off-board controls

Jobs become safer, more comfortable and more precise – without sacrificing control, feel or accuracy.

What we can help you do:

Boost
Safety, Efficiency, Quality

Reduce
Overall Costs

Improve
Machine Utilization, Jobsite Consistency, Project Accuracy, Profitability

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Types of Solutions and their Capabilities

Automation

Solutions are scalable and flexible, based on job site needs.

REMOTE CONTROL

Line of Sight (LOS): The Cat Command Console allows an operator to work securely and comfortably outside the machine, while remaining onsite and in direct visual contact by line of sight.

- Ideal for short-term / emergency use
- Requires no onsite communications infrastructure

Non-Line of Sight (NLOS): The Cat Command Station enables an operator to work remotely in a comfortable, seated "virtual cab" with familiar machine displays and universal controls.

- Located in a command center onsite or many miles away.
- Reduces operator fatigue from environment. having an improved working

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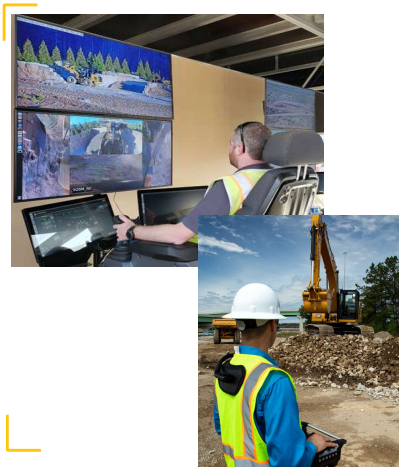
Health and Safety Benefits from Remote Control w/ Automation



Control the machine from a safe distance

Minimize operator exposure in dangerous areas
- stockpiles, steep slopes, unstable surfaces, areas with hazardous materials, risk of falling debris

Lower potential for injury while climbing on/off the machine

Reduce operator risk from machine rollover or sliding

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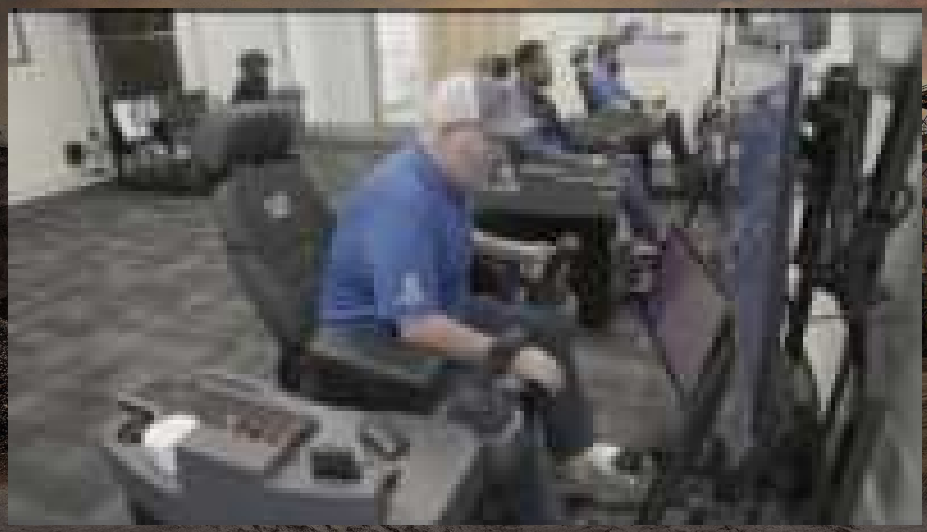
AUTOMATION IN APPLICATION



36


THANK YOU
Caterpillar: Non-Confidential

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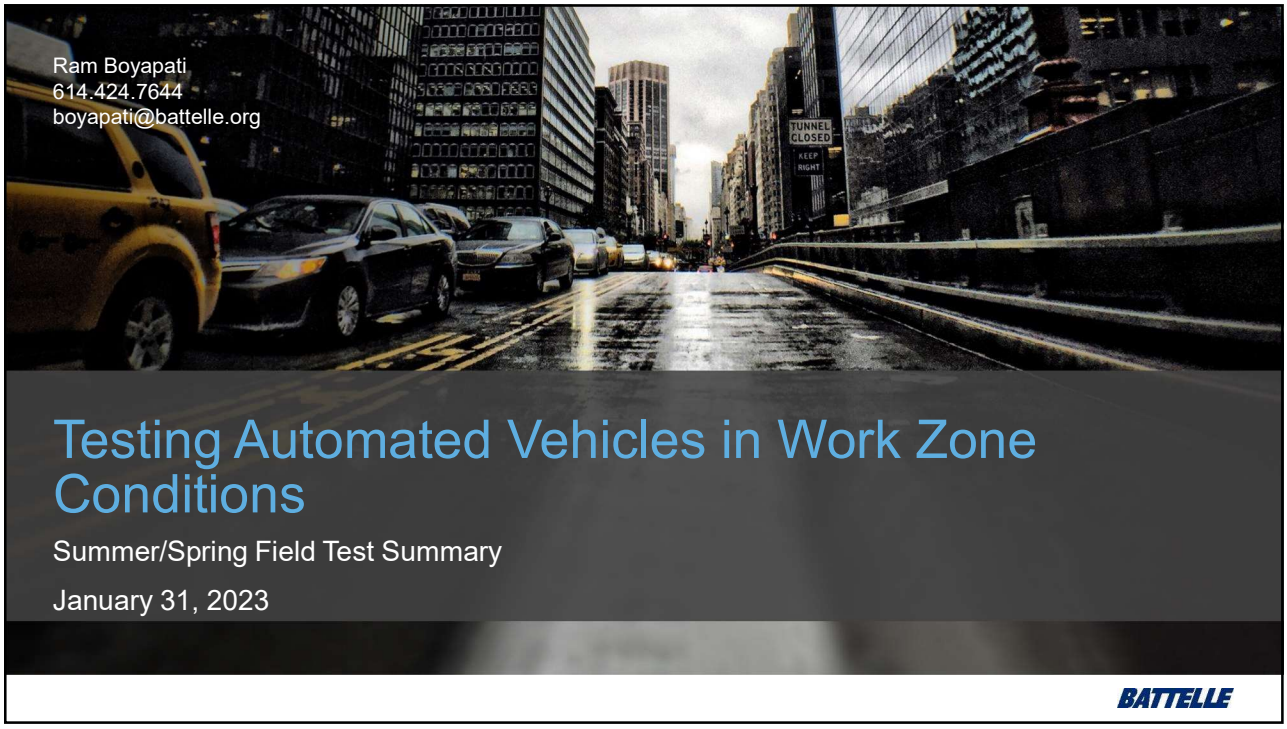
Ram Boyapati
614.424.7644
boyapati@battelle.org
TUNNEL CLOSED
KEEP RIGHT
Testing Automated Vehicles in Work Zone Conditions
Summer/Spring Field Test Summary
January 31, 2023
BATTELLE

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Outline

- Purpose
- Vehicles and ADSs
- Test Matrix
- Location
- Weather and Road Weather Conditions
- Scenarios Tested
- Test Results
- Takeaways

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AVAW Phase 3 Project Objective

- Explore how adverse weather and road weather conditions in different driving environments affect automated vehicle dynamics & operations, driver behavior, communications, and AV sensor capabilities
  - Research the needs, opportunities, and potential shortcomings of automated vehicles (AVs) during adverse weather conditions
  - Conduct research and testing to understand the impacts and effects of adverse weather and road weather conditions on currently available vehicle perception and control systems and on driver behavior

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Summer/Spring Field Test Purpose

The AVAW field test purpose is to challenge AV perception systems with artificial and controlled adverse weather (e.g., wet roadway and crosswind) and difficult roadway configurations (e.g., work zones) at a controlled outdoor laboratory setting

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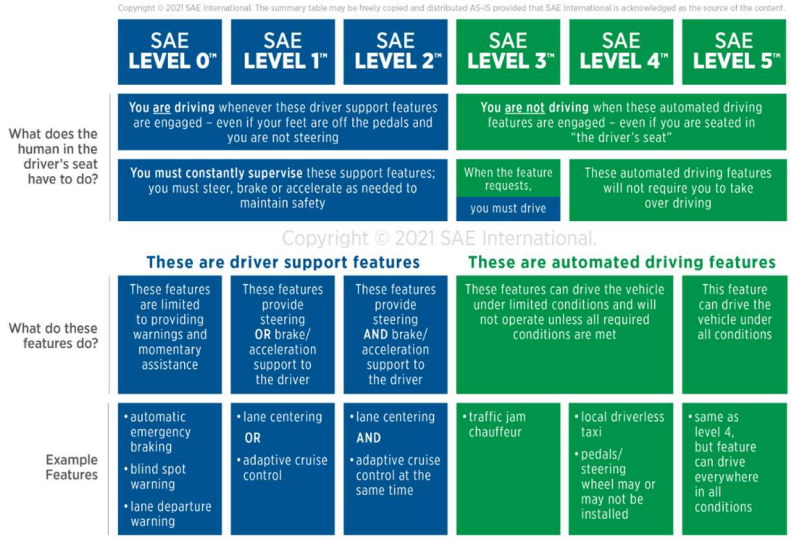
Levels of Driving Automation



Source: SAE International

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Test Vehicles' Capabilities

Vehicle	Sensors	Driver Assistance Systems	Driving Automation
Vehicle A	• Forward facing camera • Forward radar antenna	• Adaptive Cruise Control • Lane Centering Assist • Lane Departure Warning	SAE International Level 2
Vehicle B	• Eight video cameras including rear, side, and forward • Forward radar antenna • 12 ultrasonic sensors	• Adaptive Cruise Control • Lane Centering Assist • Lane Departure Warning	SAE International Level 2

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Test Matrix

	Weather Conditions				Description
Work Zone Lane Change with Barrels	Baseline	Daytime Wet	Nighttime Wet	Crosswind	Lane centering assist (LCA) will be tested with a guided lane change using barrels.
Number of runs	7	7	7	7	
Work Zone Lane Closure with Lane Marking	Baseline	Daytime Wet	Nighttime Wet	N/A	LCA will be tested with a guided lane change using lane markings.
Number of runs	7	7	7		

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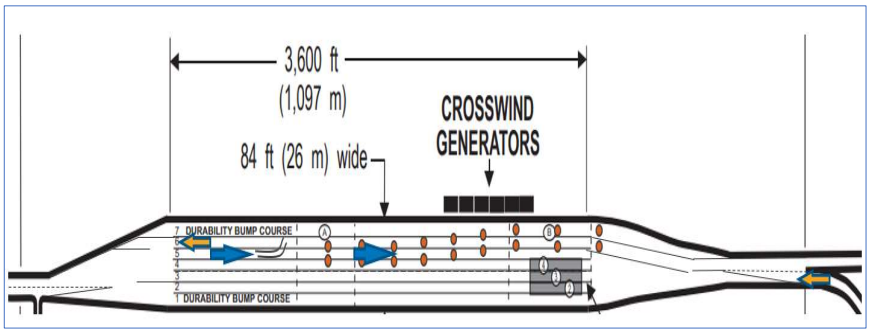
Location



Source: FHWA

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Weather and Road Weather Conditions Tested

- Baseline
  - All scenarios were tested under baseline weather conditions
  - Baseline weather conditions were:
    - Ambient air temperatures between 20°F and 100°F
    - Peak wind speeds below 22.4 mph
    - Sun position greater than 15° above the horizon
    - Ambient illumination greater than 2,000 lux
    - Dry and clear pavement

Source: FHWA

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Weather and Road Weather Conditions Tested

- Daytime Wet Roadway Conditions
  - Selected weather conditions include
    - Wet pavement with standing water
    - Clear daylight conditions
    - Glare of the roadway
    - Sun angle of 15 degrees or more above the horizon
- Nighttime Wet Roadway Conditions
  - Selected weather conditions include
    - Wet pavement with standing water
    - Natural lighting levels at or below 2 lux
    - Overhead lighting
    - Glare of the roadway

Source: FHWA

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Weather and Road Weather Conditions Tested

- Crosswind Conditions
  - Only Work Zone Barrel scenario was tested under crosswind conditions
  - Selected weather conditions include
    - Crosswinds up to 40 mph
    - Clear and dry pavement

Source: FHWA

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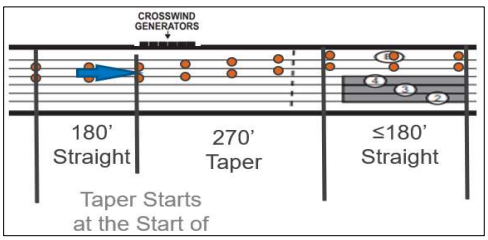
Scenario Tested – Work Zone Lane Change with Barrels



Source: FHWA

- Barrels were placed on either side of the lane, emulating a work zone and shifting the vehicle a full lane width across a solid pavement marking
- The desired performance was for the vehicles to maneuver through the work zone barrels by crossing the solid pavement marking without the test drivers having to take control of the test vehicle to avoid hitting the barrels, or disengaging LCA or ACC

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Work Zone Lane Change with Barrels Test Results

Scenario	Vehicle	Number of Runs	Detected Barrels	Maneuvered through Barrels	Drove into Barrels/ Driver took control	LCA Disengaged
Baseline	A	8	0	0	8	8
	B	9	9	4	5	0
Daytime Wet	A	9	0	0	9	9
	B	10	10	8	2	0
Nighttime wet	A	10	0	0	10	10
	B	9	9	0	9	9
Crosswind	A	10	0	0	10	10
	B	11	11	10	1	0

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Work Zone Lane Change with Barrels Videos

Vehicle A followed lane markings, and the driver had to take control to avoid steering into the barrels during baseline conditions

Source: FHWA

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Work Zone Lane Change with Barrels Videos

Vehicle B detected the barrels and performed lane change during daytime wet conditions

Source: FHWA

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Work Zone Lane Change with Barrels Videos

Vehicle B followed lane markings, and the driver had to take control to avoid steering into the barrels during nighttime wet conditions

Source: FHWA

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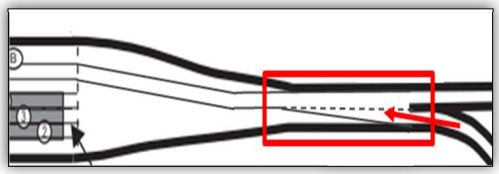
Scenario Tested – Work Zone Lane Closure with Lane Markings



Source: FHWA

- An on-ramp merging into a travel lane was used for emulating a work zone lane closure
- Both test vehicles should be able to detect the lane closure, cross the dashed right pavement marking, and complete the lane change maneuver without crossing the left solid pavement marking, without the test driver taking control, or merging to the left

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Work Zone Lane Closure with Lane Markings Test Results

Scenario	Vehicle	Number of Runs	Detected Solid Lane Ending	Changed Lane Successfully	Crossed Solid Lane	LCA Disengaged
Baseline	A	10	10	6	1	4
	B	10	10	0	10	0
Daytime Wet	A	10	10	10	0	0
	B	9	9	9	9*	0
Nighttime wet	A	9	9	6	1	3
	B	9	9	9	0	0

*Vehicle B marginally crossed the left solid lane before merging into the right lane during all daytime wet condition runs

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Work Zone Lane Closure with Lane Markings Videos

Vehicle A detected the lane closure and successfully performed the lane change maneuver into the right lane during daytime wet conditions

Source: FHWA

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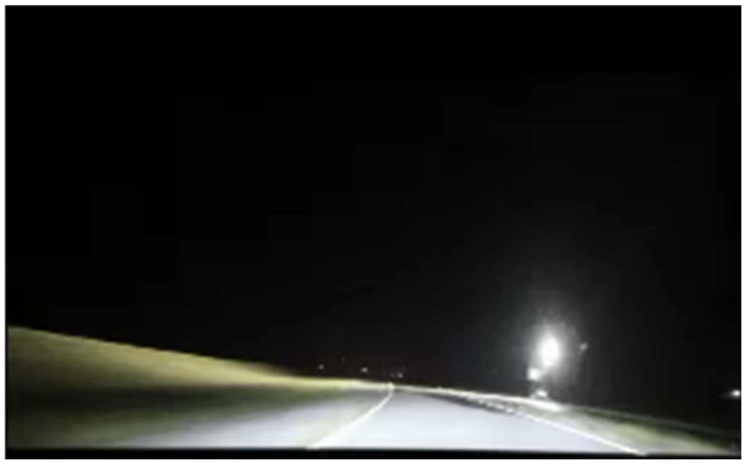
Work Zone Lane Closure with Lane Markings Videos



Vehicle B detected the lane closure and successfully performed the lane change maneuver into the right lane during nighttime wet conditions

Source: FHWA

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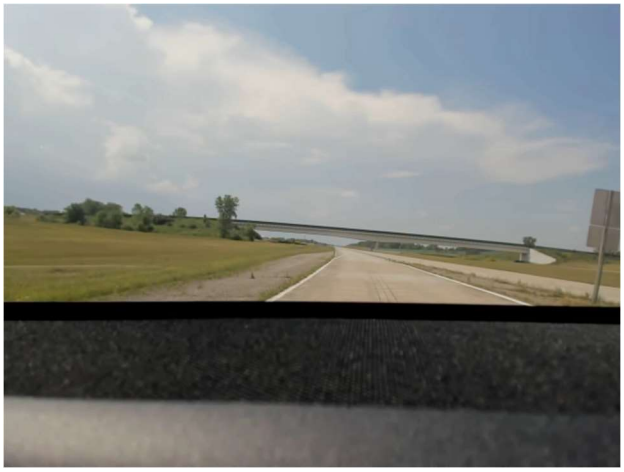
Work Zone Lane Closure with Lane Markings Videos



Vehicle B crossed the solid left pavement marking and merged into the left lane during baseline conditions

Source: FHWA

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Work Zone Lane Closure with Lane Markings Videos

Vehicle A crossed the solid left pavement marking and merged into the left lane during nighttime wet conditions

Source: FHWA

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Takeaways

- **Findings**
  - Test Vehicle limitations were successfully challenged in each of the scenarios
  - Test Vehicle performance inconsistency was found – potentially significant in both vehicle-to-vehicle and in some cases run-to-run in a single vehicle
  - There was no specific environmental condition that was more challenging for the vehicles tested
- **Additional Research**
  - Perform advanced testing using existing and open-source datasets on open-source SAE L3 algorithms (Autoware or CARMA)
  - Use vehicles equipped with sensors that enable insight into performance (e.g., Mobileye)
  - Expand the testing with more challenging traffic scenarios (e.g., oncoming traffic, signalized intersections, stop signs)

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Ram Boyapati
Boyapati@battelle.org

AVAW Phases 1 & 2: Final Report
https://rosap.ntl.bts.gov/view/dot/43772

BATTELLE
It can be done

800.201.2011 | solutions@battelle.org | www.battelle.org

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Breakout A: The Future of the Work Zone

It's 2050. Describe the perfect or ideal work zone.

Instructions:

- Discuss and capture ideas on sticky notes in Miro.

1 idea = 1 sticky note

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Breakout B: Obstacles in the Work Zone

What is getting in the way of innovation in the work zone?

Instructions:

- Discuss and capture ideas on sticky notes in Miro.

1 idea = 1 sticky note

63

Please return from lunch at 1:35!

Equipment Exhibition

Instructions:

- Breakout Rooms will be open from 12:15 – 1:30 pm
- Equipment Exhibitors will have an informational video and representative(s) for live Q&A
- You are in control of your experience; enter and leave breakouts at your leisure

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Breakout C: Solutions for the Future

What are ways we could remove those obstacles to achieve the future we envision?

Instructions:

- Referencing the obstacles generated in the last breakout, brainstorm solutions for removing those obstacles.
- Discuss and capture ideas on sticky notes in Miro.

1 idea = 1 sticky note

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Appendix D: Breakout Sessions Raw Data

Imagine it is 2050, how would you describe the perfect / ideal work zone?
Zero deaths
Fully automated work zone - equipment, traffic control
Infrastructure innovation - work zone that gets smarter as our society does
Technology integration
AI incorporated - a lot more communication involved
Providing alternative routes to avoid work zones without affecting the less traveled roads
Everyone buys into the safety culture - not having to remind contractors about safety
There is no live traffic (pedestrians, bikes, vehicles) adjacent to the work zones
100% positive work zone protection controls, including temporary work zones
Zero distractions from flaggers and public
Within the work zone, all workers will have a positive safety culture and have incorporated the latest safety protocols, equipment, processes, technology, policies, etc.
More awareness, better communication with communities that we are working with
No more work zones due to the design of freeways
Reinvention of driver training
Getting people off of foot within the work zone
Full freeway closure
More drones on work sites that monitor people using AI technologies to notify traveling public and workers on sites
Drone tech
Communication between AV and traffic control device to minimize intrusion
Self-healing construction material
Automated traffic enforcement (citations)
Automated vehicle warning systems
More automated or remote operated work equipment
Robots instead of people
A way to get feedback from all levels - forums / apps - valuing employee input, ideas and suggestions
Better public transportation to help decrease vehicle traffic
Speed reduction system
Training that is being taught to future drivers
All equipment remote-controlled
Lighter barriers that prevent intrusion with technology
Traffic control working with auto vehicle systems
100% detours
Zipper rail systems on all freeways
Caltrans require safety protocols in contract work
Connected vehicle technology to work zone
Smart Technology
Detail work plan-exact plan (safety in the design docs)
Positive Protection

Comprehensive lighting
100% exact closure plan
Minimum workers on the ground, in the work zone
Detours around project
Work zones included in mapping systems - Waze Google Maps
Work zone on vehicle GPS map systems
Corporate culture shift; all parties walking the walk not just talking the talk
OEM drive technology in automobiles
Total interconnected communication between vehicles, work zone, infrastructure
Automated speed enforcement approved
Zero incidents
No traffic congestion during construction
Separation of traffic and work zone
Coordination of GPS and navigation systems
Enhanced construction methods to reduce construction durations
Universal appreciation for the need for construction projects
Financial incentives for innovation and safety enhancements
Driver culture improvement
Fully remote or automated work
Work
Coordination of vehicle speed to increase throughput
Technological advancement in safety monitoring and enforcement
Alignment of safety culture between all parties
Zero Work Zone Fatalities
Behavior training through drivers' education
AV adjustment device that better detects work zones to slow traffic down
Drones - eye in the sky
Enforcement of current work-zone safety rules by inspectors
PSA, Google maps, Waze to move public away from work zones
Positive protection or full facility closure
Building/construction technology to reduce work zone exposures
Cell phones to inform drivers of work zones
Cell phone blockers to reduce distracted drivers
Phone signal block in the construction zone
Robots will become more prevalent in construction
Remote controlled of job-site operations by the contractor
Close down freeway
Pilot vehicles remotely through the jobsite
Use of tools to better understand effects and influences to build innovatively and durably
Positive barrier for work zone and public
Collaboration between private and public for development of automation of standardized construction zone delineation
Sophisticated modeling systems and programs needed for designing roadways

Use of digital technology to map a landscape and then run analysis to determine which designs best fit specific environmental conditions
Policies and laws
Improved automated vehicles
Legal ability to control or pilot private vehicles
Lack of collaboration between public and private naissance of road construction
Union buy-in of number of personnel utilized in construction site
Open collaborations with unions for workload in construction sites
Proprietary vs public domain technology
Cost
Low bid environment
CHP leniency on speeding
Collaborations with prosecutors
People detection systems
Zero deaths
Low exposure times
No traffic at all-utilizing full closures
Focus on the safe system approach
Focusing on the task on hand
One that utilizes technology to separate the work zone from the live traffic
Use of barriers and technologies
All industry working together to make the work zone safer
Fully connected vehicles to the work zone
Geo-fence around the work zone
Work zone that is fully adapted to the active transportation
Fully connected personal protective equipment in the work zone
All workers are rested, happy and working with no traffic around
Automation (remote equipment, self-driving cars)
Work zone intrusion alarm (more technology)
More positive barrier (for pedestrians and bikes, too)
Full closures
No distracted drivers, more respect from pubic for work zone
Bigger clear recovery zone
Res. / public avoid work zone altogether (detour)
Greater number of passing lanes or methods and larger shoulders
Greater accountability for public
More COZEEP/MAZEEP
More attenuator trucks
Full closure and protection from traffic
Only daytime closures; there will be fewer cars and other modes of transportation available to all
100% automation (Level 5) in construction with remotely controlled equipment, virtual/drone inspection

100% compliance with all traffic laws by all users
Auto correcting cones and barrels
Maintenance free cones or delineation
Delineation that doesn’t need refreshing or delineation that can be removed without damaging the pavement
Always full closure if required
Perhaps better-informed drivers; education
Flying cars and drones
2050 work zone is worked on separate from roadway and inserted when complete.
Caltrans maintenance using the newest heavy equipment available
No worker injuries
No workers on foot
Roads are raised and electric and can be fixed from underneath
Buffer zones that meet all standards on all roads
Easily adjustable, so they can be flexible
Cones or barrels that automatically place themselves
Safer closures with more buffer space
All work zones are designed for safe maintenance
Vehicles that can detect impaired, distracted and wrong way drivers
Steep fines for violating speed limits or for entering the work zone
Use of robotics to eliminate equipment/worker interface
Public understands what to do
safer closures with more buffer space
Build it offsite and just install it in the field like the bridges
Infrastructure that minimizes need for maintenance and rehabilitation
Speeding is dealt with and mitigated
Real time signage only (sign fatigue)
TMC has more control over all work zones and TMC controls real-time signage
Speeds in work zones are realistic based on conditions - TMC could control these as well
Signs are on the mainline when work isn't happening
CAVs are communicating with each other
CAVs should be able to recognize pedestrians or workers and stop based at appropriate buffer zones
CHP has a kill-switch opportunity to either stop or slow a vehicle to appropriate speed
Automatically controlling speed of vehicles to prevent speeding; conforming to speed limit sign
Highways are communicating back to CAVs (Smart Freeways) - could assist with congestion or delays as well
Drones or other methods of reinforcement
Workers may be less involved on site or not involved at all; remove boots on ground
Caltrans should make a shift to precast concrete, limit cast-in-place operations for bridges, box culverts, and retaining walls, for example, which limits time in construction
Billboards of "dads at work" are closer to work zone

Vehicles notify drivers prior to work zones that they're about to enter (human factor)
Driver training (new drivers, old drivers)
DMVs are including educational items, tests
Bicycles and motorized bicycles and vehicles are separated
Motorcyclists are not allowed to lane split
Remote detection of speeds through work zones; penalty of a point on driver's license
Public and private partnership to reduce vehicle miles
Longer term closures: such as 40-day closures and 55-hour or 79–hour closures
Connected work zones that actively communicate with drivers on the road
Control of vehicles entering the work zone both traveling public and workers
Increasing the type of work that can be done within a vehicle instead of on foot
Automatic radar speed enforcement
Automated workers presence notification to drivers
Notification to workers of work zone intrusions
Physical flaggers replaced by devices, such as AFADs
Mandated driver training on work zone safety
Full freeway closures
Additional PSAs - bring back "Give 'em a brake" - National campaign
All vehicles receive an automated warning of entering a closure and slow down
Remote control or robotics on all construction equipment
No workers on foot
Work zones behind positive barriers
CCTV cameras on all projects to capture vehicle behavior
Improve signage to reflect an active work zone; differentiate or distinguish "active" work zones
Importance of community outreach
Eliminate workers on foot through any means, autonomy, barriers, full closures
Improve lighting in work zones; Illuminate everything
Use technology to improve driver experience through work zones and "crowd source" data to provide real-time road conditions to alert drivers
Freeway cameras for enforcement
An automated conveyor belt of traffic
Positive barrier, such as K-rail, that can be placed as easily as cones
Cars that won't start if alcohol or drug impairment are detected
Automated vehicles can pick up PCMS messages for work zones
Robots doing the work so no humans are exposed to traffic
No vehicular or pedestrian traffic
Phones cannot send or receive calls or texts in vehicles
LCS can send messages directly to AV for work zone closures
Zero Fatality
Drone/camera technology for inspection
Additional buffer zones
Partner with vehicle manufacturers to move away from work zones

Automatic controlled speed reduction in vehicles entering work zone
No night work!
Partner with other agencies for longer windows to do work in same closures
Smart road technology and systems
Safe Speeds
Work is completed quickly; minimum exposure from working days
Artificial Intelligence to predict safe risks before any operations
Automated speed enforcement during times work zone is active
Zero deaths and serious injuries
Virtual reality for construction
Fully autonomous cars with no issues
Digitized work zone
Easier to place positive barriers
Fewer vehicles on the roadway during construction
No public access to work zone
Timely and accurate status of lane closures
Fully automated lane closures; no workers in harm's way of speeding traffic
No drunks
360-degree visibility for equipment
Enforcement where you need it
Special permit or license to enter a work zone
All contractors meet a safety standard for operations/eqt
Automated speed enforcement
Clear and highly visible lane markings and striping
No workers on foot exposed to traffic
Work zones will be removed from potential access by the public, and control will be by the contractor and able to protect the public
Get work done as quickly as possible
Movable transfer barrier and protect the work zone
Remote automated equipment
Aligned safety culture throughout: subcontractors, suppliers, and consultants
More driver accountability
Autonomous equipment operated from safe locations
Full freeway closure; no live traffic
Engineers' estimates take true account of safety cost
More equipment so it is available when needed
More traffic, well lighted
Make cars slow down when entering work zone; have work zones control vehicle speed
Automated technology for heavy or freight vehicles
Make sure rules are being enforced
Work zone fully protected or isolated, use moveable systems: Technology will be the catalyst
Perimeter around projects to control vehicle speed
In addition to speed reduction, vehicle steering control for traveling public

Automated traffic control vehicles
24-hour work zone, AC construction, use pre-cast elements, get in and get out fast. Contractor incentives
Automated pilot cars for low volume periods
CHP getting better tools for enforcement: radar guns that can capture speeders, or as other states use automated speed enforcement
Try to reduce the human factor; more full closures more of a norm
As automated braking becomes more prevalent, this should help with accidents in moving closures
Phones could be regulated to limit their distraction to drivers
Automated striping by an autonomous vehicle
Is it possible to have complete closures?
Connected vehicles avoiding work zones
Complete separation between workers and motorists
Stiffer penalties—electronic enforcement
Get serious about work zone incursions
Change specification for room between K-rail and lane line
No boots on the ground.; work remotely
Redundant safety systems: more than one TMA
Find ways to reduce speeds if there is an intrusion: automated vehicles or virtual rumble strip
Enhanced auto speed enforcement: geofence with notice of possible citation
Full freeway closure; convoluted entry
No traffic
Automated cone placement
Remotely controlled equipment
Efficient approval of new technology
Consistent application of rules
Use BIM
Traffic is separated from the work zone
100% positive protection, no cones
No human element in vehicles
Utilize drones
Collision avoidance technology
Automated detours for vehicles
Line item and incentives for safety
Only good contractors awarded work
Equipment communicating with each other
Enhanced lighting on our highways
Virtual element for young drivers of working on the freeway
Increase use of Artificial Intelligence
Disable intoxicated and distracted drivers' vehicles
Auto detection in vehicles for slowing then braking
Enhanced safety for workers on foot

Zero deaths
Remote speed override when entering a work zone
Perfect pavement conditions
Worker safety for equipment operation, fall hazards, traffic control establishment
Remote lane queuing when entering closure
Virtual barrier to isolate or restrict work zone from travelled way
Compartmentalize construction into modular construction work zones
No work zone. Complete closure. No traffic. Complete isolation. Automated
Remote operations
More drone inspections
Addressing pedestrian and cyclist safety
Blind spot elimination and spatial awareness
AI: collision prevention measures
0 Traffic in the work zone
Interactive smart technology
Automatic speed reduction change in the work zone
Positive protection barriers that can be easily added and removed
Quicker deployment of temporary traffic control
Automated deployment of traffic control
Automated warning of construction or roadside hazard in all vehicles
Automated vehicle RoR notification for construction workers
Improved vehicle automated detection for intrusion
Full closures
Lower decibel equipment in the work zone; can't hear other noise for alarms or awareness
Haptic safety vests; physical attention to worker
Supervisor or superintendent sits in bird’s-eye view of work zone for better safety visibility for workers
Mini-traffic management center with site cameras to provide work zone safety surveillance, monitor traffic, enforcement, and warning
Field office locations in safe locations
More automated or unmanned equipment
Use of drones or CCTV cameras for visual safety from higher vantage point
Will we have roadways...?
With increased automation will we need to have staff on site
At the least, provide a larger buffer zone for workers
Automated, intelligent, and interactive
Safety specifications and plans are ingrained in every practice; enforcement is not needed because the required practices are common practice
Vehicle to infrastructure and vehicle to vehicle communication for driver awareness
Less personal technology distractions
ZEV vehicles announced when coming through the site; they are very quiet and can't be heard like petroleum vehicles
Positive protection barrier standard if boots on the ground

What is getting in the way of innovation in the work zone?
With low bidder type of work, how can we compete with low bidder while investing in safety innovations and automations?
Lack of consistency
Cost of technology is expensive for Caltrans and contractors
Legislation that prevents us from automated enforcement and implementing new technology within the state government.
Human error
Public and elected officials' acceptance on longer travel delays during lane closures or full closures
Legislation transportation committee should join the safety summit
The way contracts are awarded does not incentivize safety
Caltrans implementation of certain things, such as telling smart cars what our CMS signs say
General public buy-in: no innovation without buy-ins
Lack of education
Complacency of our workers when working along our roadways and risking their own safety and the traveling public
Not enough training before sending new people out to the field
Not enough staff on Caltrans side, they are too busy to enforce or think about safety
Flaggers not seen as the most important person on the road
The process to implement and utilize new innovations is too long, we need to streamline this
Politics gets in the way of innovation
The alignment between Caltrans and agencies, certification requirements
Switching from natural resources to renewable energy, finite resources will be available for the amount being consumed
Establishing a voice for the workers about safety
Money
Not enough manpower - CHP
Operating procedures for COZEEP, having more than one office at a time
Outsource to other law enforcement for COZEEP
A lack of incentives
Not enough room
Lack of or need for public awareness for work zone safety
Legislation
Technology that is still in progress
Motorists traveling at work zone speed
Worker and public awareness training
Insurance premiums
Public convivence
Lack of traffic enforcement
Specifications, processes

Lack of affordable transportation
Lack of convenient transportation
Who uses the tech
Lack of safe transportation
Theft
Where to store the equipment and products on the job site
Lack of contingency plan
General public
Lack of buy-in design or traffic ops
Contractor lacks clear schedule
Turnaround time on legislation
Resistance to try new things (because they just don't want to)
lack of space or too much space limiting positive protection
Resistance to change
Friction between construction and maintenance
Recognize safety steps for project size and scope
Expand operational window hours or traffic
Conflict between funding and safety
Lacking smart safety equipment or infrastructure
Lack of training
Safety is not considered an investment
Public stealing equipment
Efficiency in the design
Driver behavior
Cost
Politics
Concern for public convenience
Resistance to change
Raising the level of expectation on construction projects
Risk aversion
Confrontational relationships between owner, contractor
Us vs them
Lack of teamwork
Procurement method of sole source
Timeliness of approval of new technologies
Create environment of introducing new technologies
Public perception of overuse of speed reduction in construction
Resistance to using automated speed control
Existing laws and regulations; vehicle code, for example
Bureaucracy, slowing down progress
Cost, cost, cost!
Production is more important than safety
Liability: no one wants to be held liable

Practical Safety
Employee complacency, false sense of safety
Past practice – this is how we've always done it
Fear of innovation failure
Electronics failure from solar flares
Contractor and owner split cost on safety devices
The owner
Union issues due to technology
Enforcement consistency
CHP does not have enough resources
Competence for the drivers and workers
Still not looking at all the innovative products
Not fully thinking out of the box
Be cautious with automation
Process of Innovation needs to be streamlined
Buy-off time from the management or leaders
Not Looking at the cons of innovation
Taking too big of a step on automation
Money
Laws and regulations may hinder further innovations
Innovation takes time
Who would you connect with to start the conversation about innovation and technology?
The technology has not caught up to innovation
Lack of collaboration between the industry and agencies
Time restrictions, which technology to dedicate time to, and funding, planning restrictions
Too many regulations
Red tape: limitation by specifications during construction creates lack of flexibility
Cost prohibitive, also constraint from "low bid" model
Having good training
Mentality to implement, resistance to adapt; both internal and from public to accept restriction of freedoms or convenience
Trust effectiveness of product, equipment, means or methods
Construction and design work together
More ROW
Available technology not yet ready for use, adaptation to technology
Taking the wrong risks: risk adverse, willingness
Lack of qualified people to do the work
Anticipate need
Coordinating with everyone, such as product requirements or training
Environmental concerns
Closure charts only allow very limited closures and there are many conflicting projects limiting availability of closures
Not enough funding to purchase newer heavy equipment for maintenance

Caltrans acceptance and approval process for new technology
Perfect is the enemy of the good
Caltrans culture and hesitancy to change; easier to follow old ways
Prioritizing vehicle travel
Make it easier to bring new technologies, must go through DRISI for a pilot before it gets implemented
Existing laws and need for legislation such as automated speed enforcement
As mentioned with bridges being pre-built and assembled onsite, one obstacle to make this normal would be access
No clear mechanism for new employees, externals, partners for challenging the process
Inadequate enforcement
Bureaucracy for approvals, pilots
Environmental restrictions limit options, even temporary
Lack of collaboration and coordination with all agencies involved in approval process such as Cal/OSHA to adopt or make changes
Caltrans legal and liability concerns
Resistance from labor organizations and OSHA; risk adverse and loss of jobs
Lack of funding for new technology
Lack of available right-of-way
Drivers would need to be retrained and certified; other modes as well
Low wages; Caltrans Maintenance
Lack of education, awareness and compliance by the public
Politics interfering with funding
Allow for more flexibility in Caltrans manuals that allow for innovation
Lacking time needed to develop initiatives or technology
Amount of training for outside contractors to comply with Caltrans standards
Caltrans IT and DPAC make it very difficult!!!
Precast spans are long for bridges
Torts law and lawsuits at agencies put risk ownership on agencies instead of the pubic
Difficult to change direction due to lawsuits
Limited funds limits opportunities to partner with private firms to see what innovations they may have
New technology takes a long time to get approved, likely caused by lawsuits
Allowing for full lane closures: traveling public is prioritized over worker safety
No real partnership with DMV
Speed enforcement is not happening
Bureaucracy and legislative roadblocks (see Penn DOT for proactive)
Precast drainage can be difficult to install
Partnering with vehicle manufacturers to build in those work zone features
Waze and Google relationship could be strengthened to offer guidance through work zone
Environmental restrictions, such as lighting, species protection, force in advantageous times, slopes you're working at, how the project is designed
Motorcycles do not have the same amount of control over them as vehicles

Cooperation between agencies instead of competing priorities
Distance between cities and housing
Prioritizing vehicular traffic in our infrastructure
Modal shift isn't realistic with current public transportation infrastructure
Motorcyclist culture, such as splitting lanes, speeding, wheelies
Driving culture prevents Californians from choosing public transportation even if viable
Education of inspectors, resident engineers to enforce proper flagging of all modes of traffic
Work zones flag vehicles, not much concentration on re-routing pedestrians and bicycles
Real estate, funds, prioritized planning for bicycle paths
Lane closures are not variable based on operation
Individualism when driving, lack of empathy for workers
Safety devices are not a separate pay item
Technology is not there yet
Specifications, limits on what can be done, takes time to change
Push-back from management on actually doing full closures as they may affect traffic
Government investment in the safety changes
Business and political pressure to not implement longer closures during the day or full closures
Reluctance of the traveling public to slow down
Not enough funds available to add safety elements
Legislative change is needed for auto speed enforcement and mandated training
Infrastructure changes are needed for connected work zones
National buy-in of the work zone data exchange
People do not want to change
Reluctance from traffic management to allow longer closures
Risk averse when thinking outside the box with closure windows and full closures and holiday work
Cost of adding technology to vehicles
Internal policy constraints within DOTs
Cost
Public numbness. Who cares?
Barriers within specifications; unspecified requirements enable cost savings by cutting corners
Inability to procure necessary safety items due to policy
Legislative barriers
Assuming we are 90% there, the last 10% is the hardest to obtain
Understanding the purpose of innovation: what are the goals and how do we direct change?
Public misconception that work zones are "safe"
Severity of penalties is insufficient
Our own perceptions of what's necessary, culture
High vehicle speed remains a problem. How do we equate the importance of our work zones with the need to slow down? Attentiveness
Insurance has been slow to require changes

Personal commitment
Lack of integrations between vehicle manufacturers and roadway designers
Lack of tax dollars allocated
Public inconvenience
Regulation on no automated speed enforcement
Lack of political fortitude
Testing requirements
Unlevel playing field for bidding
No safety outreach on social media
Need to bring car manufacturers, ITS elements together
Time to get products on APL
Lack of outreach for full closures
Poorly trained work force
Need politicians to see the importance of worker safety
No cost of human life was calculated
Politicians and Lawyers
Barriers that don't allow Caltrans to help fund safety products and innovations from private companies to allow faster development
Huge costs to upgrade and modify equipment
Public acceptance of automated speed enforcement
Negligence of employees properly following protocol
Public and professional buy -n
100% safety may not be considered by public or politics as more desirable than delays
Older public vehicles without latest technology
Balancing the effect to the traveling public
Lengthiness of implementation process of new technologies and policies
Reluctance to change
Cost
Old ways
Available funding
Human errors and becoming complacent
Driver and public may distrust government; leads to apathy for compliance
Red tape
Legislative support for automated speed and DUI enforcement
Legislation
Cost and benefit data
Underutilization of engineering judgment and documentation of decisions
Social culture: speeding, distraction, DUI, discourteous behavior
Silver tsunami and new staff
Lifespan of equipment leads slow turnover of technology within the inventory
Competing priorities
Low bid environment for majority of projects
Cellphone use

Skills and training
Limited national best practices or standards inhibits the ability to justify a more expensive or time-consuming approach
Public fear of "big brother" taking control
Limited staff resources to develop change
Buy-in by public and workers
Policy and legislation
Public pushback
Cost being passed on to public works to use new innovations
Lack of knowledge about safety requirements and department policies
Labor organization pushback
Culture resistance to change
Contracts should call out safety item specifically
Infrastructure gap
Formulating policy or specifications, such as the last mile; how to implement in the field
Technology
Buy -n from public, purchasing the vehicles that have technology
Getting contractors to bid same or consistent equipment and materials
Getting ideas formulated and pushed through red tape
Funding for equipment or materials; cost to contractors to upgrade equipment
Updating specifications
Funding: contractors switching such products as rumble strips
Standardization across the board
Large learning curve to new technologies; get training to adapt and be ready
Timing for getting products approved In California takes too long
Education and outreach to public about safety to workers.
Current means and methods; contractors adopting new technologies
Why did California get rid of red light cameras
Affordability for the public for new technologies. Some are options and not standard (vehicles).
Get politics out of safety
Purchasing processes are lengthy and we are behind
Politics: top-down policy needs to be louder
Resources: lack of personnel
Changing legislation has to be done
Time
Buy-in for changing work times night and day
Team discussions
CHP enforcement: need the public to see
Supply chain issues
Need conversation about innovation process changes
Cost for detours on county roads
More discussions with CHP needed

Too many varying conditions: speed, weather conditions
Rural locations lacking connections
Cost in general
Need dedicated personnel that only works on work zone innovations
Fear of risking money and time on project
Fear of the unknown
Training: need more tech savvy people
Working remotely: not having access
Information into project development early on: lack of early communication
Bureaucracy
Red Tape
Competing priorities
Politics
Laws lagging behind technology.
Procurement model
Cost of technology for smaller contractors
Labor and unions
People's attitudes, old school thought
Lack of technology
Supplies to support changes
Insufficient enforcement
Cost of projects to add technology
Competing solutions
Lack of vision with new ideas
Complacency
Lack of training for new hires with new technology
Agility with processes
Fear of change
Lack of ownership; let the other guy try it
Lack of sharing among other states
Restriction on out-of-state travel
Cost with a more level playing ground
Lack of attention from the boots on the ground individuals
Political will
Cost of innovation, research and development, testing new things.
Time to go through the bid process
Public convenience, public education
Speed and law enforcement, available staff
Bid process: California's low bid process
Current laws and the length to pass future laws for enforcement measures
Legislation
Government process: "red tape"
Timeliness of innovation adoption; lag if too slow to adopt

Training or understanding: only one trained person vs. widespread training or trainers
Limits to technology, such as battery life, data throughput.
A clearinghouse for sharing innovative ideas for work zones that were adopted in other areas: how are these ideas being disseminated?
Availability of trained staff
Legacy training or passing on "good" experience
Risk preconceptions or ambivalence
Preventing bad habits being passed on by transferring appropriate training on to new employees
Ineffective training; need for virtual training simulations with real world scenarios
Cost to implement
Lack of partnering with big tech
Technology doesn't exist
Policy change
Cost on contractor to deploy
Lack of incentive for big technology to develop
Change laws that mandate more safety
Lack of incentives for new technology training
Changes to the laws that promote safety innovation
Stronger incentive to incorporate new safety measures
Not using all of our resources for innovation
Public acceptance or opposition
Mix of new and old technology getting in the way of full integration
Industry lag
Integration of safety innovation through laws that influence owners, users, or contractors
Inertia and habit; same old, same old
Hard to initiate same safety excesses from project to project
Enforcement; larger projects seem to have more accountability that smaller projects don't get
Fear of change
Increasing distraction for drivers and workers
Low-bid contract history that doesn't account for safety instead of best value that considers safety record of contractor
Department has tough time purchasing new technology
Cost of new technology; smaller contractors have a tougher time keeping up
Tragedy of commons: many people playing the low odds of someone being injured there is no incentive for safer action
Lowest bidder isn't always the safest; cost over partnering and safe practices
Hard to quantify safety. Even with safety bid items, it's hard to put a price on safety. No funding for safety performance or improvement
Money
Technology needs further advancement
Stepping over good for great

No incentive for safety

Owner not embracing the innovation. Especially when it comes to a VECP

Innovators vs laggards issue with innovation adoption

New technology adoption is on different levels between owner, contractor, driver, or supplier

Policy and procedures not changing as quickly as best practices

What are ways we could remove those obstacles to achieve the future we envision?
Autonomous driving
Promote buy-in: partner with federal and state agencies to get the public message out on a mainstream level
Management to be willing to take risks that the public may not like, such as longer traffic delays and detours
Bidder prequalification for safety such as FHWA projects
Putting safety innovations into the plans and specifications
Need to find a state and federal elected officials to champion legislation changes that will improve safety in our work zones
Target new drivers to influence safe driving in work zones
Leverage proven successes on public outreach when we implement full closures or lane closures, such as providing incentives for the traveling public to use other modes of transportation, such as transit, rail, active transportation, and early and meaningful engagement with the communities, industry, and organizations
Starting the safety conversation early: discussions on flagging, automated or not, full freeway closure options, and other safety initiatives when the contractors are bidding the project and when they start the project, so that they know what options they have
Develop a streamlined process to implement innovations through IT & DPAC, and Legal
More resources in the field: employees, training programs, and personal safety equipment
Increased training for new employees
Building in bid items for safety, implementing safety devices
Safety incentives built into projects
Take new training, test to renew license
Add a section for work zone driving in the DMV that adequately addresses work zone concerns
Include the costs of safety enhancements or safety features, including the cost to improve the safety of the traveling public through construction staging beyond our standards, such as wider shoulders between barriers, thus include all these costs in our programming documents (PIDs or PIRs) up front so we have the money and do not need to request more after starting construction
Standalone CHP COZEEP division
100% Detours
Outsource to other law enforcement agencies
Collaborating with FTO with the region
Get the lawmakers on board and expedite needed legislation
Public awareness and campaign
Incentivizing safety and advanced technology over lowest bid
Past performance criteria
Incorporate work zone awareness training into the driver license program by the DMV
Work with the AI & hardware industry to figure solutions for our unique needs
Policy of safety and equal consideration over public convenience

Amber alerts
Tie into applications such as Google maps, Waze
Best practice clearinghouse on Caltrans website
Funding pilots for safety
Secure laydown yards
Statewide consistent approach to safety
Focus on quality
More consistent enforcement; take action with fines
Mandate safety through contract language
Partner with DMV on work zone safety
Combine projects to dollar cost average the cost of safety strategies
Use alternative delivery: CM/GC & Design Build to explore Safety Opportunities & Innovations
Standardization, plans, specifications
Add information into drivers handbook, training and exams
Look to the successes in other states or countries
Invite Design and Traffic Operations to next meeting
Take advantage of funding for enhanced safety
Leverage new technologies and try them
Recognize that there are opportunities associated with risk and not just threats
Work with Project Management to get safety funded in the beginning of the project lifecycle
Extended work windows: 55-hour closure; add a public information officer to the project team to think outside the box
Change scoring criteria for alternative delivery
Reward contractors with good safety records
Cost sharing between Caltrans and contractors
Sometimes the simplest answer is the best answer
Closing the roadway may be the best solution
Changing driver behaviors
Faster rate of adoption of certain technologies
Collaboration between owners, contractors and vendors or suppliers
Overcoming us vs them mentality
Find a way to reduce speeds
Increased enforcement of traffic violations
Legislative changes to allow for increased enforcement
Focus on positive protection
Reduced tolerance for risk and exposure
Use of COZEEP in combination with enhanced enforcement
More significant temporary speed reduction while work is taking place
Legislative changes
Training for workers
Training for the motorist though DMV
Generational change, younger professionals who understand technology advancements

Better communication with all partners, face to face
Pre-bid obstacles
Think outside the box, but work within the container
Educate the workforce on their value, how important they are to change
Collaboration with Caltrans, CHP, DMV, and contractors
Look less at EMR and TRIR and more at SIF
Union's need to actually provide the training involved with their scope of work. Contractors are tasked with recruiting, and training. Hourly fringes include "training," yet we don't see anything in return
Look less at cost, look into solutions
Increase training with staff due to departure
Clear and concise scope
Assign clear roles and responsibilities
Improve public outreach and participation
Minimize construction delays and schedule
Going over budget
Improved fundings and management methods, such as CMCG, Design-Build
Flaws and deficiency during constructability review
More conversations with judges and law enforcement
Flexibility and planning
Risk management
Plans during construction
Scheduling contractors' work in advance
More testing and pilot projects
Traffic management plans for contingencies
Campaigning for public awareness for big projects or full closures
Establish clear communications between parties, such as unions, private, public
More communication among team members
Everyone needs to work together on the safety goal of zero deaths
Streamline the process; not too many cooks in the kitchen
More transparency and detailed directions from the agencies
Collaboration
Spend the money and get the buy-off
Safety over time and costs
More time to test the innovations on the projects
Agencies to come forward and be proactive in their goals
More pilot projects on innovation
Smaller scale innovations
Don't set too large of a goal
Adopting proven technologies from the other states and DOTs, and other countries
Define exactly what is being tested and what are we looking to achieve from the results
Fully transparent test results
Safety on everyone's mind

Prioritize safety
Try to deal with legislators to make it easier for implementation
Good leadership: model approach and method
Don't reinvent the wheel: look to other DOTs
More alternative delivery methods, such as Design-Build CMCG; low bid, quote may not be what's most beneficial, decide as a team
Education and collaboration; public, industry, partners
Encourage and be willing for risk to be taken: leadership take lead
Invest in increasing more ROW, look how to better channel money overall
Take it up to Sacramento or DC, and sell it; Everyone pushes: department, contractors, vendors
Partner with private industry more to be proactive with needs, research and development direction
Engage everyone including the public; give them information so they can understand, be creative in communication, for example using new avenues, social media, new approaches, more personal perspective: “It’s my dad out there”
More flexibility through joint ventures, funding; remove constraints
Give a public tour day for sites to get them familiar with the work and make them invested
Allow more inconvenience to the public to prioritize safety
Streamline Caltrans acceptance and approval process for new technology; Lean Six Sigma
Create a multifunctional task force to implement new ideas and technology
Support new curriculum in grade school and HS to educate students
Partner with university system to develop and pilot innovations
Double down on partnering with other DOTs; such as Pennsylvania and speed enforcement
Engage other divisions within Caltrans, such as the Public Information Office, Design, to assist with effort
Proactively work with self-help agencies and leadership to get message to legislature and the governor’s office to make change happen
Find ways to secure more money for safety
Enforce our standards; don’t allow shortcuts, deviations
Make automated flagging devices a requirement where appropriate on conventional highways
Proactively evaluate what's working and what isn't; adjust as needed through processes or procedures, may lose effectiveness
Contract or bid incentives for contractors that actually adhere to and have innovative safety protections. Safety record?
Make full closures a requirement
Penalties in contracts for safety related noncompliance
Have a more intensive public education campaign to educate the public about construction zones
Reaching out to DMV to make changes in their manuals people use to study to get their driver’s license to learn more about safety through construction zones
Significant financial rewards for safety practices and innovation
Expedite safety prequalification for bidding

Reach out to law enforcement, judges, the legal system to help us
Enforcement
Standardized Caltrans processes with lane closures to reduce stylistic differences
Legislative action to allow for these kinds of changes or risks
Expediting federal and state approval process for new technology
Standardize MUTCD amongst states, particularly with respect to CAVs
Elephant tracks vs 8" stripe, oreo vs dashed - need more standardization in striping
Paint tape product reduces maintenance
Standardize vehicles to all have capabilities to notify drivers of work zones or other hazards
Attenuator on site during lane closures, requires more than 1; low bid
Truck mounted attenuator (TMA) supply issue needs to be addressed: agency recognition of damage of TMAs
Consider TMA as a standard change order
Zipper barrier as a movable barrier during construction, Design would need to consider
Balsa beam
Wider mountain roads
Wider shoulders would allow for diverted traffic
Automation for cone pick-up and drop-off and allow for a full lane separation
Litter or trash pickup during construction is mostly on-foot work: Is there a way to automate this?
LMNTECH: automatic system that reads plan and lays out striping could be perfected with respect to signal
Centralized neighborhoods and city planning reduce need for driving
Automated inspections
Executive and Project Management support for the legislative items
Program advisors need to include additional funding for temporary safety items, especially new innovations
Public buy-in
Educational outreach program for work zone safety
Continual education of the travelling public
Early buy-in from local businesses in the project development process for the full closures, benefits of longer closures, and how closures relate to contract duration
Additional awareness for traffic management on the benefits of longer work windows and full closures
Modify California driver’s license testing to include work zone safety
Develop a traffic mitigation plan for sensitive political areas
Public awareness about work zones
Partnering with industry on getting safety devices approved timely
Safety incentives for bidders
Additional bid items for safety devices so that they are included in the project
Have to include safety in the bid
Price preference tied to safety record
Create unified safety specifications and requirements.

Continued collaboration and meetings to discuss our future
More contractor, government, manufacturer partnerships to implement products
Incentivize the industry to implement innovation, safety, and product prequalification measures
Continue data collection and analysis to assure we are on the right track
Early education of safety principles and awareness
Share personal accounts of those who paid the price when safety was neglected; make stories "relatable" to convey accountability
Improve the public's perception of the need for safety and don't live in a reactionary environment
Push for legislative changes for automated fines and increase fines in work zones
Identify car manufacturers to partner with designers and ITS elements
Unlimited funding
Specification changes need to move quicker
Contractor involvement in design phase, CMGC, to discuss safety approach in the work
Allow contractors to propose new safety ideas and facilitate implementation during construction
Continued communication and collaboration between stakeholders
Be committed to continuous improvement
Allow Caltrans to fund innovative safety products by private companies
Provide incentives tied to safety performance
Increased partnership between contractors and Caltrans
Streamline procedure for new products to get on lists of approved products
Expedited funding and new contract approvals
Work with public information office, industry for worker safety campaign; create mascot and social media campaign
Make OSHA 30 a mandatory certificate
Training for all state work
Allow Lane Closure System to push notifications for closures to public
Include all approved new systems in project specifications
Use more pilot projects to try out new technology
Increase promotion of roadway safety to the public
Include set penalty when contractor violates safety provision, such as placing an noncompliant barricade
More public involvement to push politicians to make changes
Have someone to review and push new technology
Pilot projects
Public outreach through the Public Information Office and media
Stricter fines and regulations
Industry to sponsor legislation
Continued communication through working groups and Safety Summits
Align competing objectives
Work together

Develop safety incentives for bidding process
Marketing
Modern public campaigns, such as ads on streaming services, that appeal to the emotional level: “what if this was your family?”
Ballot propositions?
Strategic Highway Safety Plan action items to show collaboration
Fast track changes
Partnership meetings with enforcement and Legal
Budget for and market the benefits of full closures
Develop joint strategic plans for work zone safety with CHP and DMV at agency level
Leverage what has worked in other states or countries
Continue to share personal stories on the importance of work zone safety
CMS safety campaigns with visual enhancements
Develop some sort of public and private work zone safety coalition to strategize and implement the best of these ideas
Driver education on how excessive speed does not equal time saved
Requirements on vehicle industry to leverage technology
Work zone safety as a topic in the driver's license tests
Reconsider how we lower work zone speed limits for maximum effect, so drivers don't learn to ignore it
Legislation to target a reduction of distracted and impaired drivers on highways through more severe consequences
Lobbying and legislation for additional funding
Education and training
Certification and annual refresher
Contractor incentives to utilize future technologies
Public outreach
Make awareness and knowledge for construction zone mandatory part of driver’s license
Personal connection about risk created by speeding
Get rid of red tape and speed up process
CHP needs to hire more staff to handle the workload
Make innovation mandatory so all companies are on level playing field
Incentivize or subsidize new technologies into the projects, for example project schedules, cost of computers)
Need to continue to test and pilot the innovations. make this a priority
Need people with construction experience to weigh in on process to get sniff test on viability of innovations
Incentive for safety items and some form of measurement for safety and incentivize safety
Pilot projects to test out new innovations and technologies
Some ideas sound great on paper, but reality can be a different story; some ideas cause more exposure than what is being mitigated
Engineers to put new technology into their designs

Public awareness: better job describing how to transit through work zones, including lane configuration changes and outreach to educate the public
Money pulled out of equation; as an example, traffic control paid by day vs lump sum
Subsidize new technology; when changing from old to new through rebates to contractors to purchase
When innovations are introduced, there is also a lot of extra duties and responsibilities, such as reporting, and presenting, which somewhat disincentivizes the desire from the state perspective to work on these.
Safety and traffic be more fluid; use specifications as guideline not rule
Need a legislative champion
Training and mentoring new resident engineers
Incentive during bid process for contractors trying innovation
Project rollout on smaller scale, to address supply chain issues
Invite CHP and community leaders to project kickoffs for input
Secure funding related to safety; current funding is limited to safety updates
Incentive for resident engineer to work through Value Engineering Change Proposals
Make freeway closures an option
Day work instead of night
Lobby CHP to adopt automatic speed enforcement
Eliminate Friday nights on the freeway
Higher budget for pilot projects to test ideas
Ability to negotiate schedules at the job site
Implement buffer lanes
Full closures
Share innovations between districts
Research technology to stop errant motorists before they get to job site
Research how to create a "maze" ahead of work zone to slow traffic down
More public messaging
Education to public of dangers in the work zone
Consistent RFPs on the bidding process
Proactive partnering before and after the bid process
Splitting the costs between the contractor and state
Expedite the IT process
Expedite the red tape
Invest in our future for safety
Provide funding to implement new technology
Retrain the employees to work with technology
Keep the workforce so not to lose employees
Remove budget constraints
Reward the good, and more positive reinforcement
Changing the workforce to help innovation
Education from fear of change
Encourage innovation

An effective education of the effects to management and legislation
CMGC: true partnering from contractor early on in the design process
Change in specification and bidding process; more industry interaction in the design process
Partnership with local agencies to help expedite the process
Streamlining workflows for approval process
Sharing tragic stories for emotional effect for change; putting a face to the story for legislation to relate with real-life examples.
Early educational material for awareness and buy-in
Mentorship, training, succession planning in conjunction with industry feedback
Gamification of training to appeal to next generation
Select and incentivize our experienced staff to develop or present training to new employees
Idolizing or glamorize construction to entice recruitment
Financially reward construction, industry, government and make it known
Promote trades for which a degree isn't needed and which can be financially rewarding
Restore wood and machine shop in school. Not just STEM-focused and higher education
Improved marketing or public-relations campaigns to promote apprenticeships, internships, and mentorships with hands-on recruitment
Federal grants
Incentive to develop
Contractor reward for safety innovations
Safety innovations built into the contract
Tax credit for big technology safety development
Partnership with technology companies to identify safety needs
Partnership with universities with big technology sponsors to develop student competition to solve work zone safety issues, similar to concrete canoe or bridge building competitions.
Make safety technology and development desirable
Identify required policy changes to implement innovations
Identify what policy changes could be changed to promote innovation
More partnership and involvement with law makers with regards to new safety tech
Make sole source approvals easier
Put additional resources toward research, and leverage proven safety measures globally
What are other nations doing that we might be able to incorporate, and what resources are needed to accomplish.
Single focus contact in Caltrans
Start every meeting with a safety moment; put safety at the forefront of every discussion to change the culture
Better safety education for pre-Construction Project Delivery tasks
Partnering on everything
No electronics in work zones; zero distractions for drivers and workers
Robotic painting tools
Lessons learned from CMGC project successes
More safety pilots on projects, and get ideas to market
Haptic vests that give physical notification of danger

More connectivity of safety devices; haptic over audio and visual
Robotic crack sealing tools
More transit options
More telework opportunities to remove cars
Enhance current public transportation to reach disconnected communities
Serve heavy traffic areas with better public transit options and remove cars from road
Cobots, or robots designed to work cooperatively with people and supplement workers actions on the ground
Incentivize safety
Public education on safety
Promote change and innovation
Owner, DOT, or project support costs to improve contractor abilities
Provide grant and funding support to smaller contractors to innovate and build inventory for safety innovations
Federal government set aside money to support contractor innovations
Automated machine guidance
SHOPP process improvement to regard safety as an asset and give credit for placing safety items for asset management
Update regulatory climate to allow contractors to buy and deploy capital equipment cooperatively