

# Human-Centric Virtual Reality (VR) for Advancing Roadway Work Zone Safety

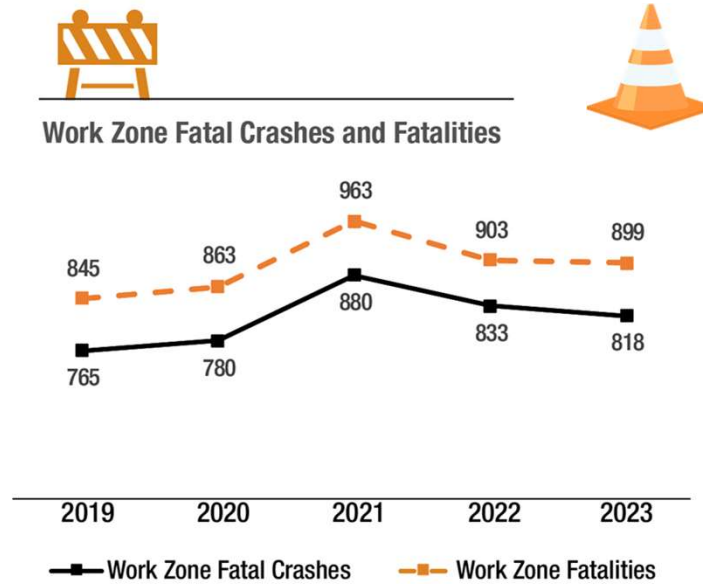
**Presenters:**

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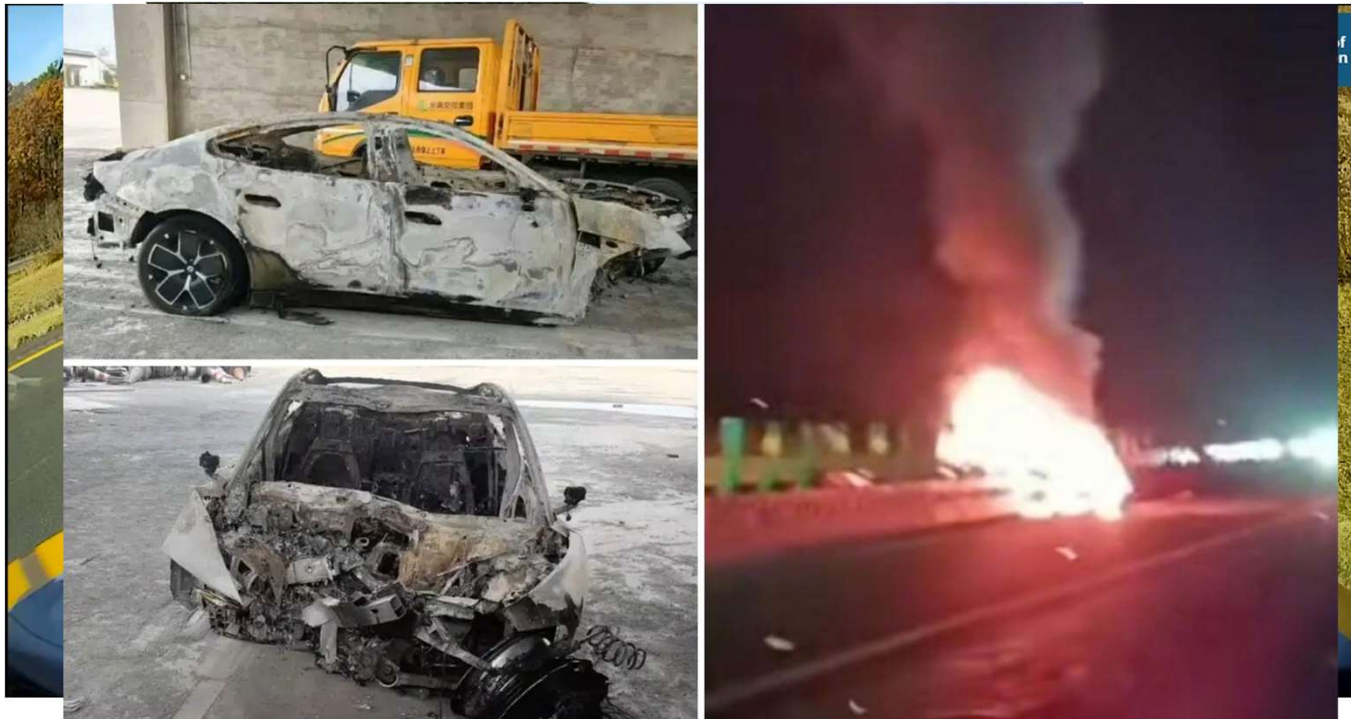
# Roadway Work Zone Safety Remains a Critical Challenge



[1] Source: Fatality Analysis Reporting System (FARS), NHTSA



# Roadway Work Zone Safety Remains a Critical Challenge

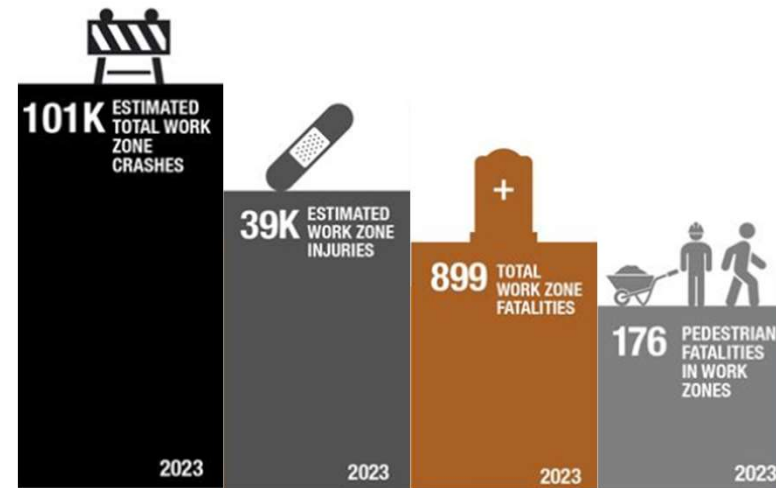
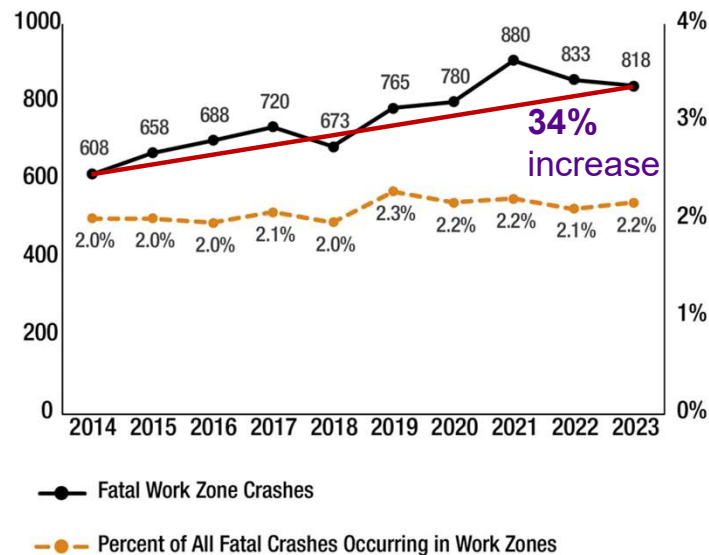


[2] Car news China, 20254021



# Work zone crashes with fatalities are on increase: 34% increase since 2014 (USA)

Work Zone Fatal Crashes and Percent of Fatal Crashes Occurring in Work Zones, 2014-2023



[1] Source: Fatality Analysis Reporting System (FARS), NHTSA

## Current approaches emphasize retrospective inspections over proactive investigations

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To effectively enhance safety, we require a safer, necessary environment to **recreate dangerous roadway scenarios** and capture detailed **multi-user interactions**.

[5] Zhang et al. ICRA workshop, 2024

[6] Tsai, Yichang James, et al. University of Florida report, 2022

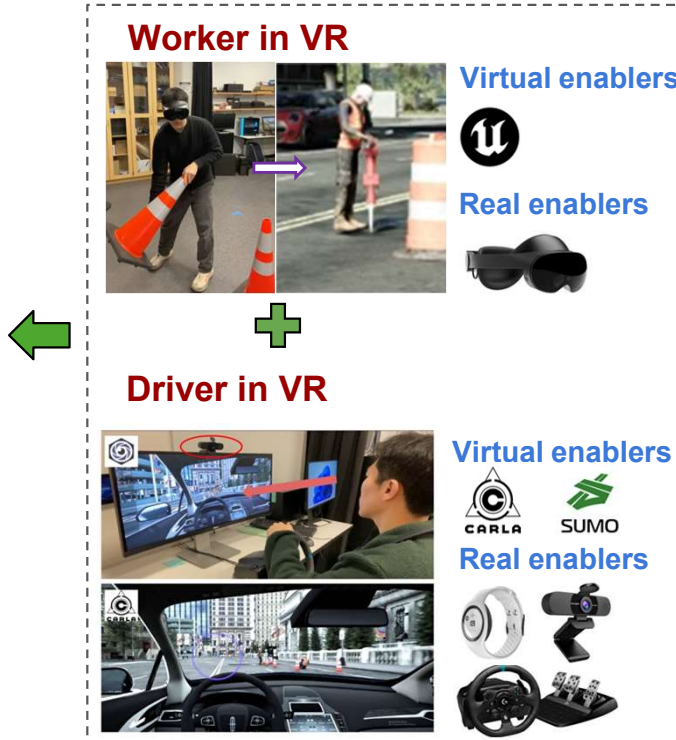


# Vision: A Mixed-User Immersive Virtual Reality (VR) Platform

Stage 2: Understand **drivers' attention** around roadway work zones

Stage 1: Mixed-user immersive VR platform

Stage 3: Understanding work zone settings & interactions on safety



Stage 4: A calibration model for self-driving around roadway work zones



# System Design



Gaze movement

(i) gaze movement of workers and drivers



Biometrics data

(ii) physiological responses of drivers during driving



Driver inputs

(iii) driver control inputs: steering and pedal angles



XYZ location



Sensor data

(iv) perception data and vehicle trajectories

## Real enablers



For Worker

## Virtual enablers



## Real enablers



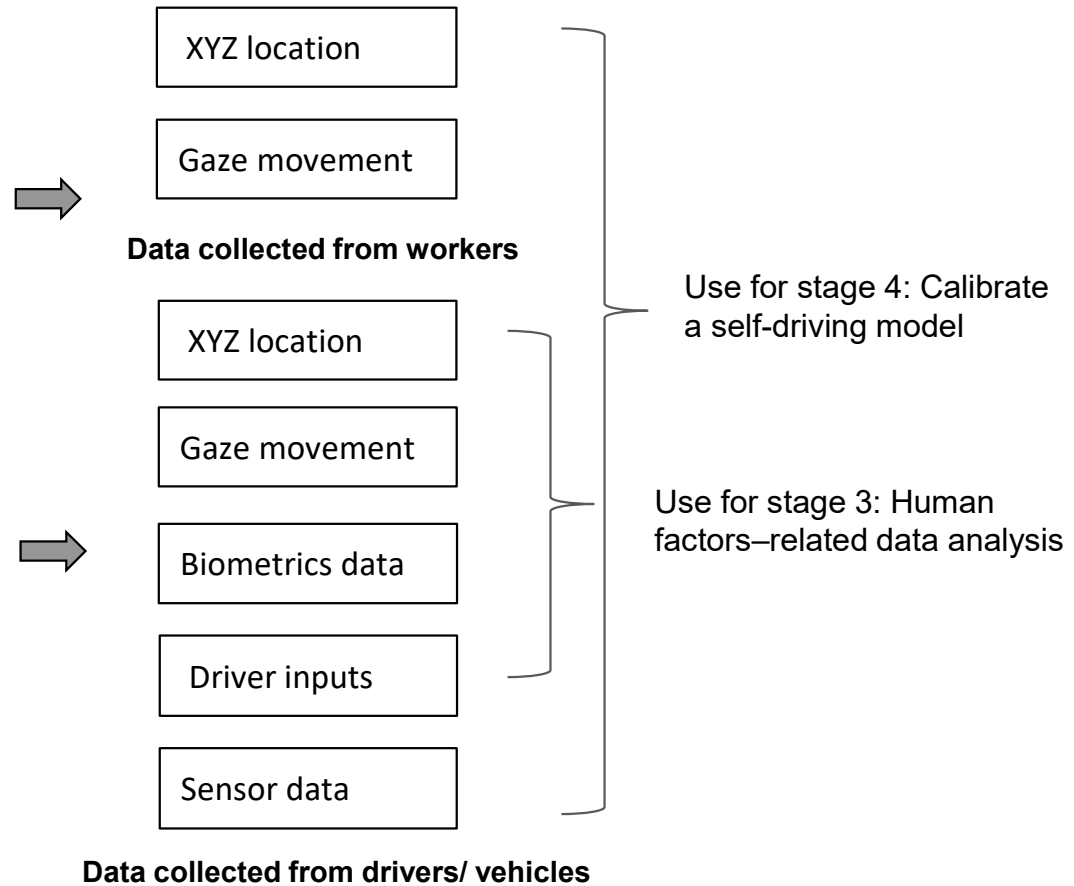
For Driver

## Virtual enablers

Traffic simulation  
softwares



# System Integration and Communication



# Demo: RGB Cameras

front



left



right

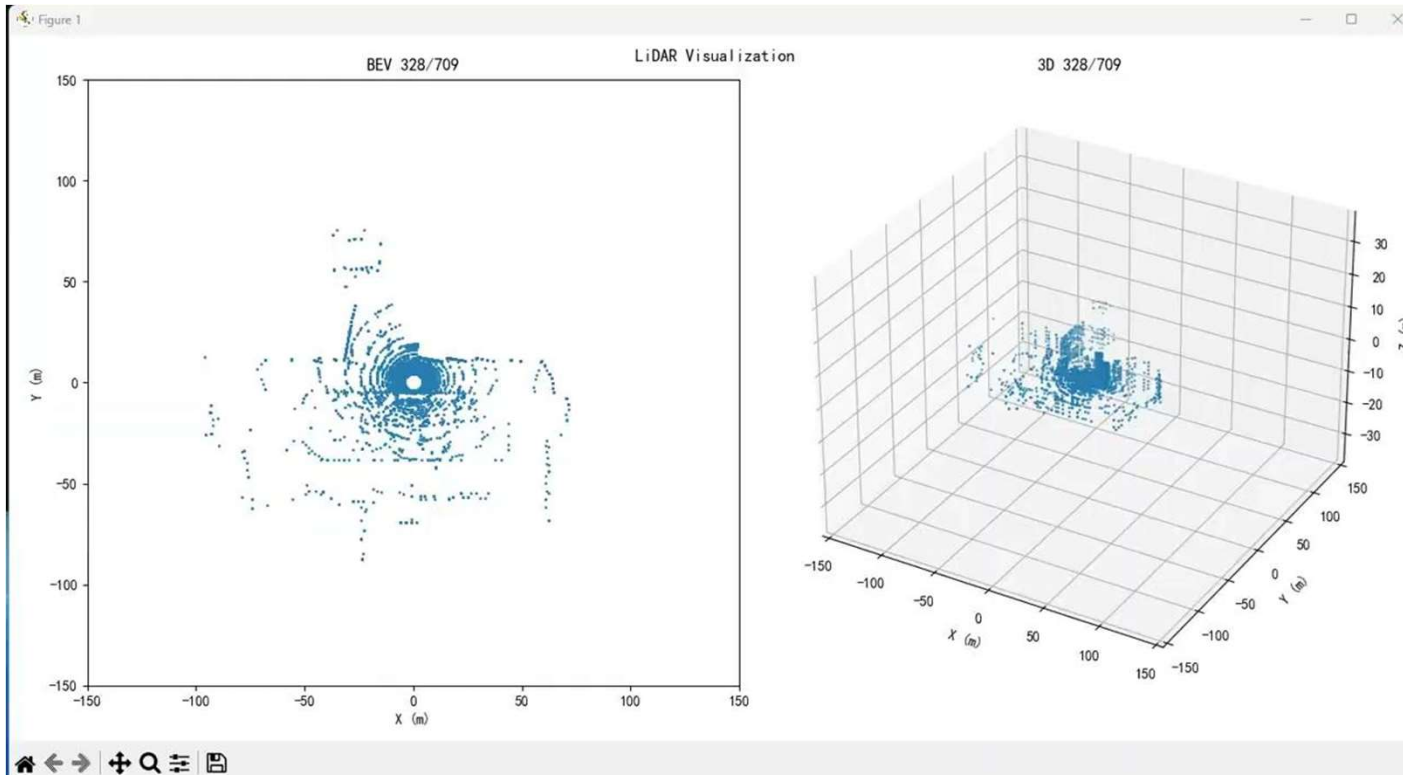


rear



Sensor data: RGB cameras x4

# Demo: LiDAR



Sensor data: LiDAR x1

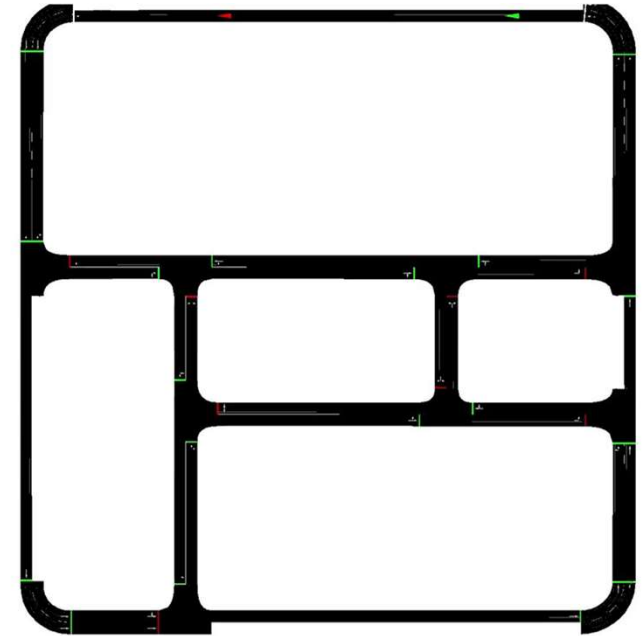
# Demo: Co-Simulation and Traffic Generation

Co-simulation links specialized programs, such as SUMO and CARLA, to simultaneously exchange data and combine traffic modeling with realistic physics and sensor data.

3D Simulator: CARLA

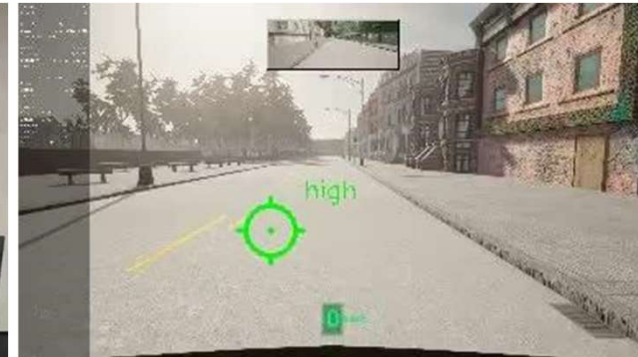


Traffic Simulator: SUMO



# Demo: Beta Test and Gaze Alignment

Beta-test: **Two users** (a worker using VR + a driver using simulator) in the system



Driving UI screenshots + gaze

## Key Takeaways:

- Provide a high-fidelity, mixed-user human-centric VR platform to safely analyze complex roadway interactions.

## Immediate Applications:

- **Worker Training:** Immersive training for construction crews.
- **Device Testing:** Validate new safety apps and real-time alert systems.
- **Safety Data:** Generate novel work-zone safety data to inform policymaking.
- **Expansion:** Ready to model other vulnerable road users, such as **analyzing pedestrian interactions** with emergency and automated vehicles.

## We Welcome Your Input:

- We are actively seeking collaborators, testers, and experiment participants. If you have any specific safety challenges or use cases in mind, we would love to hear your ideas!

## Contributors:

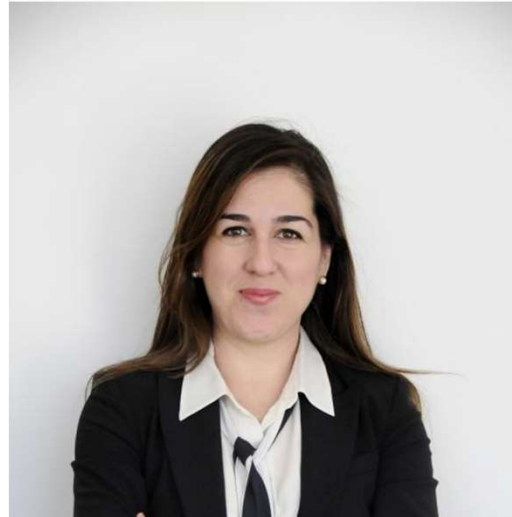


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# THANK YOU

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3. "Rental truck slams into NY work zone, just missing highway worker on I-81 (video)" Central NY news, 2024.
4. "First fatal accident involving Xiaomi SU7 claims three lives on Chinese highway" Car news China, 2025.
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6. Tsai, Yichang James, et al. Quantitatively Evaluate Work Zone Driver Behavior Using 2D Imaging, 3D LiDAR, and Artificial Intelligence in Support of Congestion Mitigation Model Calibration and Validation. No. Project G2. 2022.
7. Zhang, Shuo, et al. "Improving work zone safety: Integrating VR-CARLA co-simulation and eye tracking for behavior analysis of drivers around work zones." *Journal of Transportation Safety & Security* (2025): 1-24.
8. Zhang, Shuo, et al. "VR-WISE: VR based work zone immersive simulation with eye tracking and biometric sensors for capturing driver's awareness." *Proceedings of the 17th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. 2025.