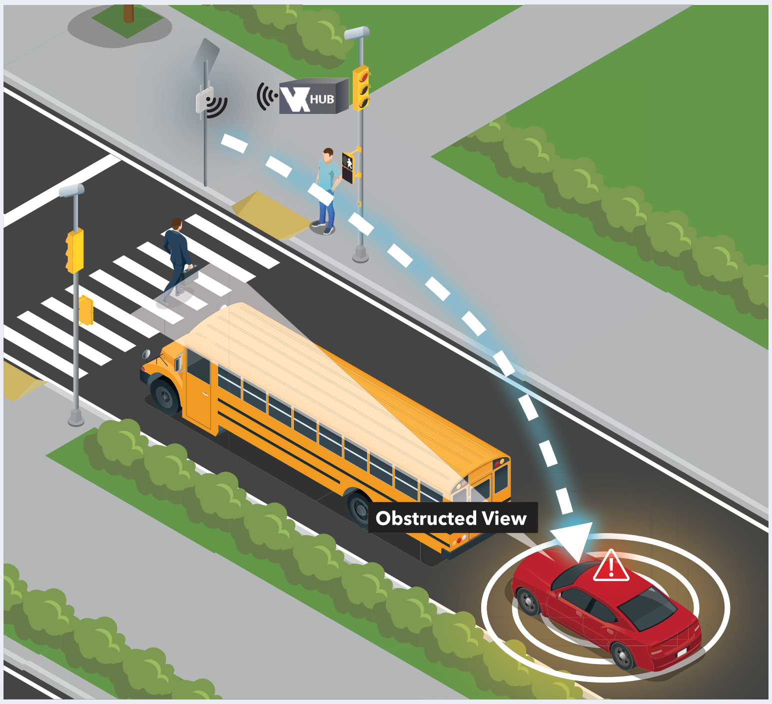
U.S. Department of Transportation
Federal Highway Administration

Office of Safety and Operations Research and Development

© Getty Images Plus.

Perception Sharing for Cooperative Driving Automation (CDA) Using Sensor-Data-Sharing Messages

Pedestrians and bicyclists face challenges navigating intersections safely. Limited lines of sight and blind spots can make detecting pedestrians difficult for drivers and automated vehicles; each year, pedestrians and bicyclists account for roughly 20 percent of all traffic fatalities.[1] Because pedestrians and bicyclists are especially at risk for fatalities and serious injuries, improving their safety at intersections is key to ensuring that roadways are safe for all road users.



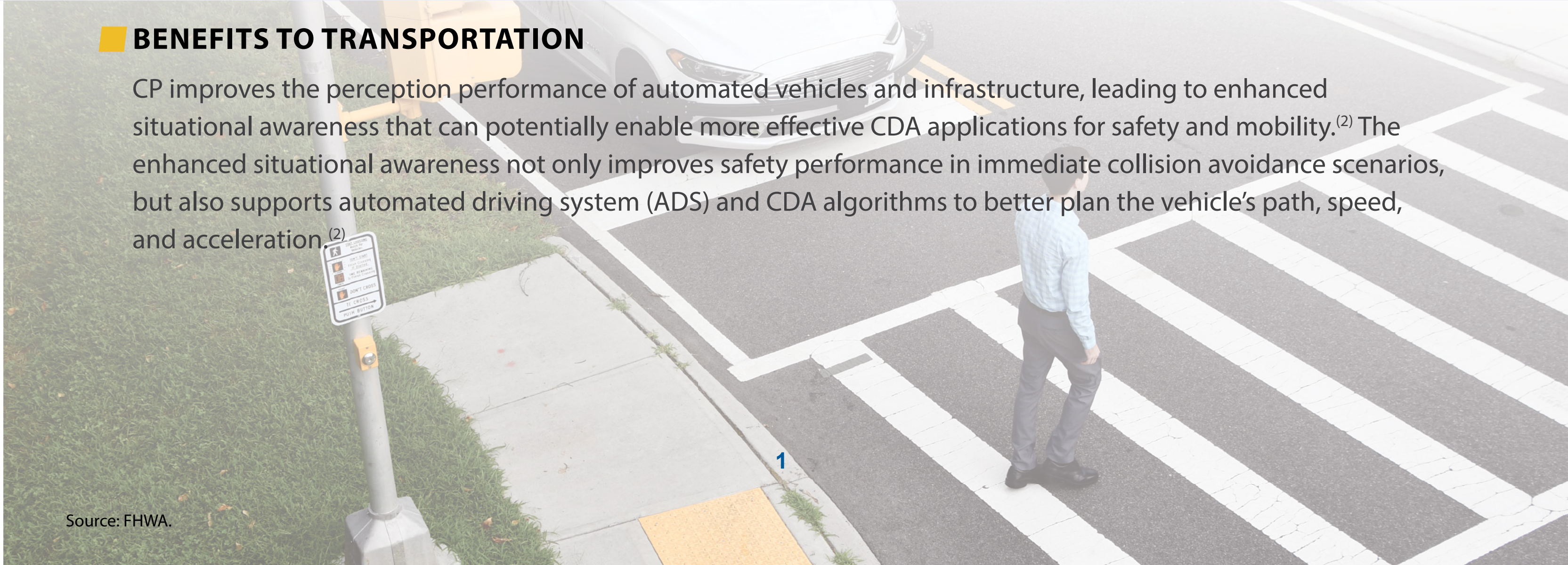
Source: FHWA.

Figure 1. Illustration. CDA and CP technologies alerting a vehicle to an obstructed pedestrian at a signalized intersection.

CDA and cooperative perception (CP) technologies are improving the safety of pedestrians and bicyclists at signalized intersections. CP can help drivers and automated vehicles perceive all road users and obstacles on the road by sharing location data based on measurements from sensors of other vehicles and the roadside. The vehicles can then assess whether the pedestrian or bicyclist poses a potential hazard and, if necessary, warn the driver or take automated action to help avoid a collision. For example, a roadside sensor can detect a pedestrian in a crosswalk and send a message to nearby vehicles, alerting them to the pedestrian's presence (figure 1).

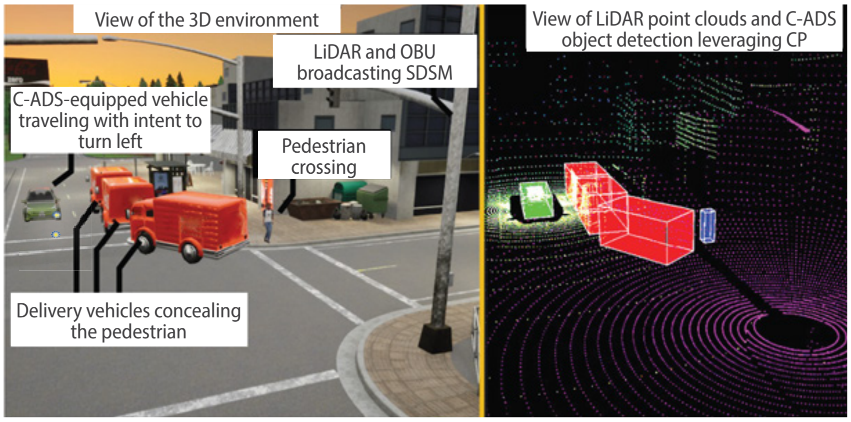
BENEFITS TO TRANSPORTATION

CP improves the perception performance of automated vehicles and infrastructure, leading to enhanced situational awareness that can potentially enable more effective CDA applications for safety and mobility.[2] The enhanced situational awareness not only improves safety performance in immediate collision avoidance scenarios, but also supports automated driving system (ADS) and CDA algorithms to better plan the vehicle's path, speed, and acceleration.[2]



Source: FHWA.

RESEARCH FOCUS



Source: FHWA.
3D = three dimensional; C-ADS = cooperative ADS; LiDAR = light detection and ranging; OBU = onboard system.

Figure 2. Illustration. Simulation of a pedestrian detection by C-ADS-equipped vehicle, despite no line-of-sight, using J3224 SDSM broadcast by the infrastructure.[3]

This research explores how CDA and CP technologies can work together to improve the safety of pedestrians and bicyclists at signalized intersections. Using sensors, such as LiDAR, radar, and camera, vehicles and roadside infrastructure detect objects in their surroundings and share this information through vehicle-to-everything (V2X) communication. The SAE International® J3224™ sensor data sharing message (SDSM) format enables the exchange of detailed sensor data among V2X participants.[3] By improving how vehicles and infrastructure detect, track, and combine information about objects—such as bicyclists and pedestrians—SDSMs help create a more complete and accurate understanding of the intersection environment, supporting safer and more coordinated responses to avoid crashes.

The research team first simulated a scenario[2] in CDASim,[4] a low-cost and efficient simulation tool for testing CDA technology. CDASim integrates a C-ADS-equipped vehicle running CARMA Platform[SM(5)]—an open-source software that provides navigation and guidance functions for automated vehicle motion—with CARMA Streets[SM(6)] as the roadway infrastructure component, V2X Hub[7] as the communications component, and a traffic simulator. The CARMA Platform vehicle was integrated with CARLA®,[8] enabling vehicle control algorithms to be tested in realistic simulated environments. The simulation, as shown in figure 2, depicts a pedestrian being hidden from the view of nearby vehicles by large delivery trucks. Despite having no direct line of sight to the pedestrian, a nearby C-ADS-equipped vehicle detects the pedestrian via J3224 SDSMs broadcast by the infrastructure.

FROM SIMULATION TO LIVE DEMONSTRATION

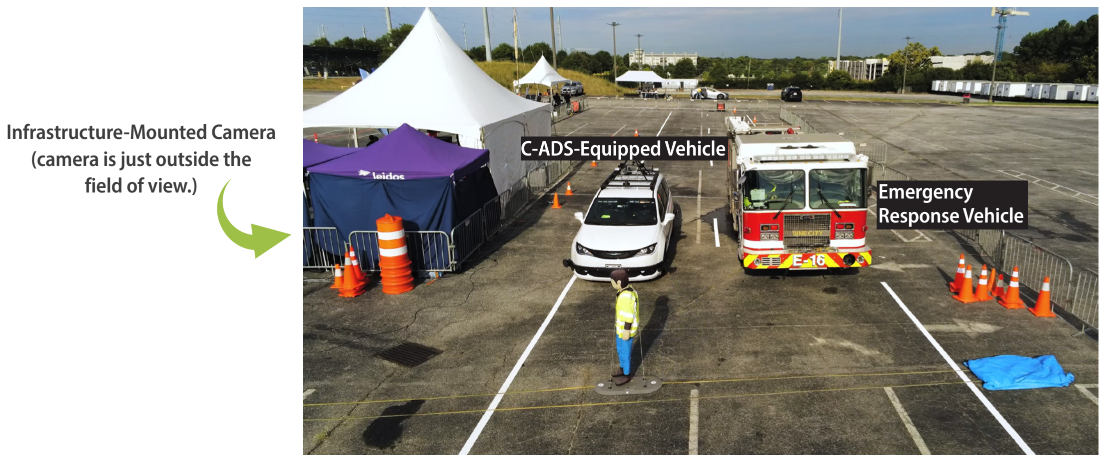
This technology was demonstrated in real vehicles during a live demonstration at the 2025 ITS World Congress in Atlanta, GA.[9] The event focused on deployment-ready technologies and how these technologies are reshaping the surface transportation roadmap. The demonstration offered a ride-along experience in a CARMA Platform vehicle for more than 500 participants, who represented original equipment manufacturers, infrastructure owner-operators (IOOs), V2X vendors, and engineering consultants.

In the demonstration, an infrastructure-mounted camera detected a pedestrian crossing in front of an emergency response vehicle (figure 3-A). The camera sent this detection to a roadside unit connected to V2X Hub, which generated an SDSM and broadcast it through the roadside unit. A C-ADS-equipped vehicle approaching from behind the emergency vehicle received the message and detected the pedestrian in advance, allowing the C-ADS-equipped vehicle to smoothly yield, despite not having a direct line of sight (figure 3-B). To showcase the benefits of the technology, the demonstration included two scenarios: one without CDA and one with CDA, both conducted by a facilitator inside the vehicle.

Source: FHWA.

Source: FHWA.

A. Infrastructure components detecting a hidden pedestrian crossing in front of an emergency response vehicle.



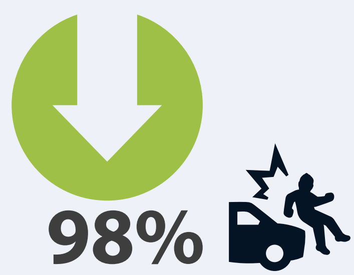
Source: FHWA.

B. Nearby C-ADS-equipped vehicle yielding to the pedestrian.

Figure 3. Photos. Live demonstration at ITS World Congress in Atlanta, Georgia.[9]

RESULTS

- The simulations and live demonstration showed how CDA technology can prevent a pedestrian collision in the CP scenario.
- CP simulation achieved up to a 98-percent reduction in pedestrian collisions for the specific test scenarios. The approach also smoothed yielding trajectories in most simulation runs.
- The C-ADS-equipped vehicle successfully received real-time SDSM data from infrastructure-based cameras detecting pedestrians and then automatically yielded to the pedestrians during the live demonstration.



CP simulation achieved up to a 98-percent reduction in pedestrian collisions for the specific test scenarios.

Source: FHWA.

FUTURE WORK

- Expand simulation and live vehicle testing across varied roadway environments, geometries, and traffic conditions to evaluate CP performance under varying latency, packet loss, and sensor error conditions.
- Advance interoperability and standard alignment by coordinating with the industry and SAE International.
- Explore scalable deployment and industry transition pathways, including integration with IOOs, to move from demonstrations to deployment-ready solutions.
- Conduct follow-up demonstrations and collaborative testing with stakeholders to inform deployment strategies and ensure CDA technologies meet real-world operational needs.

Source: FHWA.

REFERENCES

1. FHWA. n.d. "Pedestrian and Bicycle Safety" (web page). https://highways.dot.gov/safety/pedestrian-bicyclist, last accessed October 29, 2025.
2. Lou, Y., A. Ghiasi, M. Jannat, S. Racha, D. Hale, W. Goforth, and P. Bujanovic. 2022. *Cooperative Automation Research: CARMA Proof-of-Concept TSMO Use Case Testing: CARMA Cooperative Perception Concept of Operations*. Report No. FHWA-HRT-22-062. Washington, DC: Federal Highway Administration. https://www.fhwa.dot.gov/publications/research/operations/22062/22062.pdf, last accessed October 29, 2025.
3. SAE International®. 2022. *V2X Sensor-Sharing for Cooperative and Automated Driving*. SAE J3224™_202208. Warrendale, PA: SAE International. https://www.sae.org/standards/content/j3224_202208/, last accessed October 29, 2025.
4. FHWA. n.d. "usdot-fhwa-stol/cdaSim" (CDASim software and configuration files in GitHub® repository). https://github.com/usdot-fhwa-stol/cdasim, last accessed October 29, 2025.
5. FHWA. n.d. "usdot-fhwa-stol/carma-platform" (CARMA Platform software and configuration files in GitHub repository). https://github.com/usdot-fhwa-stol/carma-platform, last accessed October 29, 2025.
6. FHWA. n.d. "usdot-fhwa-stol/carma-streets" (CARMA Streets software and configuration files in GitHub repository). https://github.com/usdot-fhwa-stol/carma-streets, last accessed October 29, 2025.
7. FHWA. 2023. "usdot-fhwa-OPS/V2X-Hub" (V2X Hub software and configuration files in GitHub repository). https://github.com/usdot-fhwa-OPS/V2X-Hub, last accessed November 5, 2025.
8. CARLA. 2022. *CARLA* (software). Version 0.9.14.
9. ITS America. 2024. "2025 ITS World Congress: August 24–28, 2025" (web page). https://itsa.org/event/2025-its-world-congress-august-24-28-2025/, last accessed November 5, 2025.

TO LEARN MORE AND FOLLOW UPDATES:

V2X GitHub
https://github.com/usdot-fhwa-OPS/V2X-Hub

CARMA Platform
https://github.com/usdot-fhwa-stol/carma-platform

U.S. Department of Transportation
Federal Highway Administration

For more information, please contact Pavle Bujanovic, HRSO-40, (202) 493-3271, pavle.bujanovic@dot.gov

FHWA-HRT 26-028

Recommended citation: Federal Highway Administration, *Perception Sharing For Cooperative Driving Automation (CDA) Using Sensor-Data-Sharing Messages* (Washington, DC: 2026) https://doi.org/10.21949/ypw2-wn65