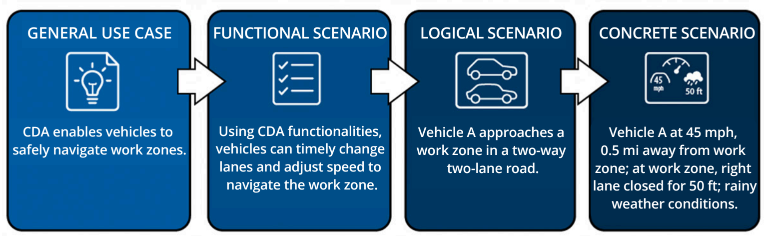
June 2026

Scenario Development for Cooperative Driving Automation (CDA) Prototypes

FACT SHEET

CDA enables automated vehicles, infrastructure, and other road users to cooperate through vehicle-to-everything (V2X) communication, with the goal of improving the safety and mobility of transportation systems. To realize these benefits, CDA systems need to perform reliably not only under typical operating conditions but also in edge cases that do not occur as frequently. Developing structured scenarios allows agencies to test these conditions in a consistent, reproducible manner across use cases, such as work zones and traffic incident management, and provides the foundation for prototypes that assess readiness for CDA pilot deployments. This fact sheet presents a recommended framework (figure 1) that agencies can use to develop functional, logical, and concrete scenarios across use cases to test the capabilities and readiness of SAE International® (SAE) Level 1™ and SAE Level 2™[1] automated vehicles equipped with CDA for real-world deployment.



Source: FHWA.

Figure 1. Illustration. Structured framework for developing test scenarios for CDA prototypes.

BENEFITS TO TRANSPORTATION

- Enables agencies to test CDA functionality under conditions that closely replicate real-world traffic variability, different technology configurations, and various weather and mixed traffic situations.
- Supports consistent, repeatable testing in closed test facilities across CDA use cases to verify reliable, robust system performance before testing in pilot projects.

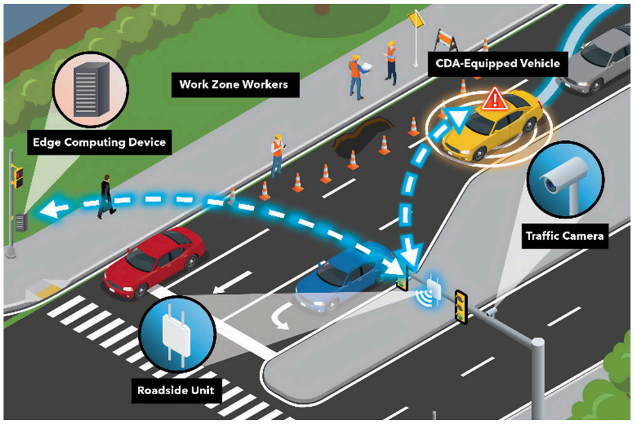
THREE SCENARIO TYPES

- **A functional scenario** provides a high-level outline of testing conditions in clear, nontechnical language.
- **A logical scenario** incorporates variables and defines their permissible ranges to map out potential variations within the scenario.
- **A concrete scenario** describes a specific instantiation of the logical scenario that transforms the abstract scenario into a tangible, executable test case.

RECOMMENDED SCENARIO DEVELOPMENT FRAMEWORK

Step 1: Functional Scenario

- Define the overall use case goal, such as improving safety in a work zone.
- Create a nontechnical description that explains what happens in the scenario and the interactions among vehicles, pedestrians, and infrastructure. For example, the description in the work zone use case might say, “A CDA-equipped vehicle navigates through a work zone and needs to change into an adjacent lane to avoid workers standing in the work zone. Using the work zone information shared with the CDA-equipped vehicle, the vehicle could safely move to the adjacent lane and reduce its speed to avoid colliding with the workers.” Figure 2 shows an example of these CDA capabilities.



Source: FHWA.

Figure 2. Illustration. A CDA-equipped vehicle receives real-time work zone information via V2X communication to avoid workers.

Step 2: Logical Scenario

Incorporate measurable variables and define their parameter ranges. For example, parameters in the work zone use case might include the following:

- Vehicle parameters: allowed vehicle type, positions, and velocities (i.e., speed and direction).
- Roadway parameters: number of lanes and speed limit.
- Traffic parameters: traffic flow and density.
- Communication parameters: communication method and latency.
- Vulnerable road user parameters: position and velocity.

Step 3: Concrete Scenario

- Define a specific test objective that details the CDA functionality to be evaluated, such as a performance characteristic or safety mechanism.
- Assign realistic and precise values to each parameter to explore the parameter ranges defined in the logical scenario. For example, selected values in the work zone use case would include specific lane width, positions, and velocities of vehicles and workers, as well as the number of work zone workers and construction vehicles present.
- Define specific technical success criteria and pass–fail benchmarks. Examples of technical acceptance criteria for the work zone use case would include minimum time-to-collision or a 95-percent successful packet delivery ratio for V2X messages.

KEY CONSIDERATIONS WHEN DEVELOPING SCENARIOS

Before developing scenarios, agencies can document specific operational needs or CDA capabilities the prototype aims to address. Agencies can then consider the following aspects that might affect the CDA system's performance and safety, as well as ensure the scenario will work within the operational design domain:

- **Actor interactions:** Consider how the vehicles and people will interact and cooperate within the scenario by defining their properties (position, velocity, acceleration, and dimensions). Examples of actors include subject and secondary vehicles, pedestrians, bicyclists, and background traffic.
- **Parameters:** Categorize variables to ensure appropriate test coverage, including vehicle and vulnerable road user parameters (type, position, velocity, and communication capabilities) and roadway parameters (number of lanes and speed limit).
- **Ranges:** Assign each parameter a realistic and relevant range of values to encompass the potential conditions the CDA functionality might meet, capturing typical operations and edge cases.
- **Values:** Based on the concrete scenario's objective, select the correct values to cover edge cases near the bounds of the parameter ranges. To choose plausible values, also consider dependencies between parameters.
- **Traceability mapping:** Ensure every component of the concrete test case can be directly linked back to a documented need or capability of CDA functionality to validate correct system behavior.

This scenario framework enables agencies to:

- Develop prototypes that evaluate not only typical operations but also edge cases that might otherwise be overlooked.
- Adapt scenarios for different objectives or regions by adjusting the parameter ranges in the logical layer for scalability of outcomes.
- Reduce uncertainty about whether prototypes have truly addressed high-priority risks, helping to promote participation and adoption.

REFERENCES

1. SAE International. 2021. *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles*. J3016_202104. Warrendale, PA: SAE International. https://doi.org/10.4271/J3016_202104, last accessed December 12, 2025.

For more information, please contact:
Sudhakar Nallamothu, HRSO-40, s.nallamothu@dot.gov

Recommended citation: Federal Highway Administration, *Scenario Development for Cooperative Driving Automation (CDA) Prototypes* (Washington, DC: 2026) https://doi.org/10.21949/jz0h-7102
FHWA-HRT-26-060
HRSO-40/06-26(WEB)E

250
U.S. Department of Transportation
Federal Highway Administration

Turner-Fairbank
Highway Research Center

FACT SHEET