Cooperative Driving Automation: Is this the Missing Link for Widespread AV Deployment?

The rush to deploy fully automated driving functions is faced with increased scrutiny. Recent events have led to a push back from communities and agencies that fear robotaxis are not ready for prime time. Most AV deployments rely exclusively on environmental sensors and lack situational awareness with other road users including maintenance and emergency vehicles, law enforcement, vulnerable road users, and the general population at large.

SAE J3216, also known as Cooperative Driving Automation (CDA), is a relatively new approach to V2X that has the potential to enable AV deployment at scale.

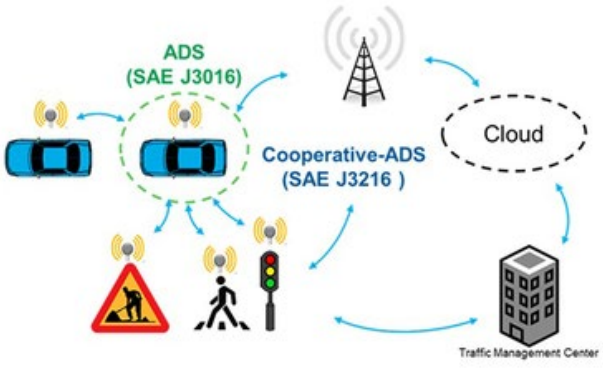
Introduction

Cooperative Driving Automation (CDA) is an emerging technology that will impact a variety of automotive segments—ranging from Automated Driving Systems (ADS) to connected vehicles and Intelligent Transportation Systems (ITS).

SAE published its first version of the "Taxonomy and Definitions for Terms Related to Cooperative Driving Automation for On-Road Motor Vehicles" in July 2017. The SAE J3216 was revised in May 2020 and again in July 2021.

Cooperative Driving Automation is often confused with V2X, but they are not mutually exclusive. CDA is really a subset of applications. CDA applications are all about efficiency and achievement of safety through cooperative information sharing.

As illustrated below, CDA enabled vehicles and infrastructure are in constant communication.



The next table is an overview of various aspects of CDA technology. CDA can provide improved driving automation from information-based coordination with other road users and infrastructure.

CDA Overview		
	Key Information	**Other Information**
What is CDA?	Better driving automation via coordination with road infrastructure and road users Definitions in a SAE taxonomy document	Coordination via M2M communication Variety of functionality and impact SAE J3216: Updated July 2021
Who is CDA champion?	U.S. DoT organizations such as: FHWA and NHTSA	Need to improve automotive safety Due to expertise in V2X R&D
CDA tech overlaps	Impact on ADS or autonomous vehicles Impact on ADAS features (Ex: CACC) Impact on C-V2X apps and systems Impact on ITS and traffic infrastructure	Improves ADS functionality: L3-L4-L5 Improves ADAS functionality: L1-L2 Better safety via communication Better safety and less road congestions
Future perspectives	Expected to improve safety & capability of ADS vehicles: Cooperative-ADS Similar advantages for ADAS vehicles Leverage C-V2X infrastructure Improve ITS via all CDA functionality	Better situational awareness to control all driving tasks via DDT software & hardware Via cooperative apps features Improved safety for VRUs & all road users Better safety & traffic flow & operations
M2M=Machine-to-Machine; DDT= Dynamic Driving Task; FHWA=Federal Highway Administration; CACC=Cooperative Adaptive Cruise Control: VRU=Vulnerable Road User		
Source: VSI Labs, November 2023		

A common factor in emerging technologies is who is the champion(s) that drive the acceptance and growth of the new technology. The U.S. Department of Transportation is probably the closest to play this role. There are at least two groups within DoT, FHWA and NHTSA, that are involved. Both groups are focused on road safety and were involved in developing DSRC-based V2X.

VSI expects CDA to improve safety and capabilities of ADS vehicles through Cooperative-ADS technology. These advantages are due to better situational awareness from a variety of other CDA capable devices.

CDA will leverage the C-V2X infrastructure being deployed as part of 5G networks. VSI believes this will be especially important to Vulnerable Road Users (VRUs) via future smartphone or wearable devices.

ITS technology is expected to see advances as CDA functionality is deployed such as better road safety, traffic flow and operational efficiency.

CDA Cooperation and Levels of Automation

The next table describes the relationship between cooperation and automation. For driver support features, SAE L1 and L2, only limited cooperation is achievable because automation features are restricted and relies on the human driver to do some of these

functions, and to supervise feature performance in real time. For C-ADS (L3 through L5), more substantial cooperation may be achieved, where the C-ADS performs the complete DDT under defined conditions.

<table>
<tr><th colspan="6">Relationship between Classes of CDA Cooperation and Levels of Automation</th></tr>
<tr><th>Automation:</th><th>L1: ADAS</th><th>L2: ADAS</th><th>L3</th><th>L4</th><th>L5</th></tr>
<tr><th>CDA Classes:</th><td>Longitudinal or Lateral control</td><td>Longitudinal & Lateral control</td><td>Conditional Automation</td><td>High Automation</td><td>Full Automation</td></tr>
<tr><td>No cooperative</td><td colspan="2">Relies on driver to complete DDT and supervise real-time performance</td><td colspan="3">Relies on ADS to perform DDT under defined conditions by L3-L4-L5</td></tr>
<tr><td>Class A: Status sharing:
Here I am & what I see</td><td colspan="2">Limited cooperation: Human is driving and must supervise (and may intervene at any time), and sensing capabilities may be limited</td><td colspan="3">Improved C-ADS situational awareness beyond on-board sensor capabilities and increased awareness of C-ADS state by nearby road users and road operators</td></tr>
<tr><td>Class B: Intent-sharing:
This is what I plan to do</td><td>Limited cooperation. Longitudinal or lateral intent may be overridden by human</td><td>Limited cooperation. Longitudinal and lateral intent may be overridden by human</td><td colspan="3">Improved C-ADS situational awareness through increased prediction reliability, and increased awareness of C-ADS plans by surrounding road users and road operators</td></tr>
<tr><td>Class C: Agreement-seeking:
Will do this together</td><td>N/A</td><td>N/A</td><td colspan="3">Improved ability of C-ADS and transportation system to attain mutual goals by accepting or suggesting actions in coordination with surrounding road users and road operators</td></tr>
<tr><td>Class D: Prescriptive:
Will do as directed</td><td>N/A</td><td>N/A</td><td colspan="3">C-ADS decides actions except for very specific circumstances in which it is designed to accept prescriptive communication</td></tr>
<tr><td colspan="6">Data Source: SAE J3216; Table Source: VSI Labs: November 2023</td></tr>
</table>

CDA devices within a transportation network may be described by the class of CDA cooperation that they support. For example, a C-ADS feature operating at Level 4 automation and capable of utilizing agreement-seeking CDA cooperation is a Class C cooperation system. This means that the C-ADS can engage in coordinated planning with other CDA devices in the transportation network. Similarly, a traffic signal CDA device capable of sharing signal phase and timing information (i.e., engaging in status-sharing and intent-sharing cooperation) may be described as having Class A and B features.

Summary

Cooperative driving automation technologies enable mobility applications that are not achievable by individual operated ADS vehicles. CDA technologies do so by sharing information that can be used to increase safety, efficiency, and reliability of the transportation system. CDA is likely to accelerate the deployment of driving automation due to better safety capabilities and increased functionality.

Driving automation and connected vehicles provide opportunities to deploy multiple cooperative automation strategies. Successful deployment of multiple CDA strategies depends on coordination among diverse stakeholders. These include infrastructure

owners/operators, ITS technology providers, ADS and ADS-equipped vehicle manufacturers, suppliers, and ADS fleet operators.

Currently the U.S. ADS industry is not doing much to incorporate CDA functionality in their testing and piloting operations. The auto industry has also been slow to embrace CDA technology. This is probably due to the failure of establishing DSRC-based V2X as a mandate in 2016.

China is a believer in CDA—at least in C-V2X and it is part of most ADS development, pilots, and early deployment phases. This should be a clear signal to the U.S. ADS industry that CDA will be important for future success.

There is no doubt that CDA will add safety and functionality to all ADS use-cases. Will recent safety issues convince the industry that CDA is part of the solution? It would be a good strategy to add CDA to ADS—the sooner, the better.

Such a strategy also requires rapid deployment of communication infrastructure, and this means C-V2X is the key to early and rapid technology deployment. All overlapping and competing industry segments must cooperate for the best results.

About VSI Labs

Since 2014, VSI Labs has been a leading researcher of active safety and automated driving technologies. VSI Labs also serves the ITS community with ITS Insights, a dedicated research and advisory service that provides you with insights and perspective on the interaction of automated vehicle technologies and the surrounding infrastructure. Learn more about VSI Labs at https://vsi-labs.com/.

VSI offers various research and testing services to clients that want to get their technologies tested or demonstrated.