

# Key Terms for Connected & Automated Vehicles (CAV)

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**Advanced Driver Assistance Systems (ADAS):** The hardware and software in new vehicles sold today that is collectively capable of supporting or providing alerts to the driver (blind spot detection, lane departure warning, front collision warning, etc.) or assisting the driver to automatically perform some of the real-time operational and tactical functions in on-road traffic (steering, accelerating, braking, etc.).

*Note: This term is used specifically to describe SAE driving automation levels zero, one and two. Note, for vehicles equipped with ADAS, the driver is still responsible for performing most or all the driving tasks, thus active driver performance, supervision and/or intervention is required.*

**ADS-Equipped Vehicle:** A motor vehicle that is equipped with an automated driving system.

**Automated Driving Systems (ADS):** The hardware and software in vehicles being researched, developed and tested today that are collectively capable of performing all of the real-time operational and tactical functions required to operate a vehicle in on-road traffic on a sustained basis, regardless of whether it is limited to specific conditions under which it is designed to function.

*Note: This term is used specifically to describe SAE driving automation levels three, four and five. For level three ADS, the driver is responsible to perform all fallback provisions. For level four and five ADS, the ADS performs all fallback provisions. For levels three and four ADS, there are specific conditions under which the ADS is designed to function. For level five ADS, the ADS is designed to function in any condition. See definitions below for level three ADS, level four ADS and level five ADS for more information.*

**Automated Vehicle (AV):** A vehicle that possesses hardware and software collectively capable of performing part or all the real-time operational and tactical functions required to operate a vehicle in on-road traffic.

*Note: This includes all driving automation levels (zero to five) as defined by the Society of Automotive Engineers International (SAE International).*

**Cellular-V2X:** The current generation cellular and internet protocols for CV is typically referred to as C-V2X, which builds on the IEEE's 802.11p standard for DSRC and uses the 5.9 GHz ITS spectrum.

*Note: A significant portion of non-safety related CV functions (e.g. applications that are not reliant on high-speed communications) can be supported to a large degree by today's 3G and 4G cellular networks. Commercially available cellular connections may be leveraged to obtain data from remote or mobile equipment and provide CV datasets to central or Internet-connected systems. Information can then be accessible to end users or third-party data providers via applications. Such an approach is an established and technically well-supported solution for communicating CV information and requires minimal infrastructure technology investment.*

**Connected and Automated Vehicle (CAV):** A vehicle equipped with various hardware and software that are collectively capable of wirelessly communicating with the world around it (other vehicles, traffic

signals, the cloud, etc.) and performing part or all of the real-time operational and tactical functions required to operate in on-road traffic.

*Note: The term “CAV” has a broad range of meanings. On one end of the range, it implies a potential future transportation network where a significant percentage of the share of vehicles in service communicate with nearly everything around them and can operate with little to no human control. However, the exact timing, impacts and full extent of this scenario are uncertain at this point. On the other end of the range, incremental CAV technological advances are being incorporated into the transportation network today. These technological advances come in the form of driver assistance technology defined below that is standard in most new model year vehicles, as well as automated driving systems (ADS) and connected vehicle (CV) communications that are currently being developed, tested and deployed by automakers and researchers in closed course environments and on limited public roadways around the world.*

**Connected Vehicle (CV):** A vehicle that uses a variety of communication technologies to wirelessly communicate with other vehicles, roadside infrastructure, pedestrians, and the cloud.

**Cooperative Automation:** An approach that attempts to keep the user in the control loop by means of a continuous interaction during task execution. In the AV context, cooperative automation keeps the human operator engaged, while also harmonizing the user’s interaction with the AV and other onboard systems. The human machine interface is designed to maximize safety and engagement, including interactions with other vehicles or AVs, and road user, including cyclists and pedestrians.

**Dedicated Short Range Communication (DSRC):** A communications protocol developed to address the safety-critical issues associated with sending and receiving V2X data. Although limited in transmission range (roughly 1,000 feet with minimal obstructions), DSRC-based communications offer ultra-low-latency (high-speed) message updates 10 times per second and high-resolution transmissions that make possible both safety-critical and high-precision CV applications that otherwise would not be possible utilizing typical (slower and less precise) cellular communications modes. However, security issues with DSRC—especially around user authentication and spoofing—do remain and must continue to be assessed.

*Note: Over the last few decades DSRC has operated in a protected band on the 5.9 GHz radio spectrum. USDOT originally envisioned DSRC to be “the” enabling communications protocol for CVs. However, in recent years USDOT has altered its policy to take more of a technology neutral approach, putting more emphasis on industry competition to choose the most effective transportation mobility solutions. In late 2019, the Federal Communications Commission (FCC) proposed to split the 5.9 GHz band for use by intelligent transportation systems (ITS) and WIFI, despite its current use for transportation purposes across the U.S. The FCC argues that the splitting of the frequency maintains its use for ITS and opens the remaining frequency for unlicensed use, primarily in the form of additional Wi-Fi frequency. Additionally, the FCC reasoned that the safety critical communications DSRC provides could be provided by C-V2X and future 5G. Multiple transportation organizations, including trucking companies, ITS America, and AASHTO have voiced their concerns about the splitting of the band, saying that it has safety implications, creates market instability, and hampers state and local government investment in connected vehicle projects and programs that are already underway or have been completed to date.*

**Dynamic Driving Task (DDT):** The real-time operational and tactical functions required to operate a motor vehicle on highways, excluding the strategic functions such as trip scheduling and selection of destinations and waypoints, including without limitation, including: lateral vehicle motion control via steering;

longitudinal motion control via acceleration and deceleration; monitoring the driving environment via object and event detection, recognition, classification, and response preparation; object and event response execution; maneuver planning; and enhancing conspicuity via lighting, signaling, and gesturing.

**Dynamic Driving Task Fallback (DDT-Fallback):** The response by the driver to either perform the dynamic driving task or achieve a minimal risk condition after occurrence of a dynamic driving task performance-relevant system failure or upon operational design domain exit, or the response by an automated driving system to achieve minimal risk condition, given the same circumstances.

**Fallback-Ready User:** The driver of a vehicle equipped with an engaged level three ADS who is able to operate the vehicle and is receptive to ADS-issued requests to intervene, and to evident dynamic driving task performance-relevant system failures in the vehicle compelling the driver to perform the dynamic driving task fallback.

**Highway:** Any state or other public highway, road, street, avenue, alley, driveway, parkway, place or dedicated roadway for bus rapid transit service, under the control of the state or any political subdivision of the state, dedicated, appropriated or opened to public travel or other use.

*Note: This is a Connecticut state statute definition from Section 14-1.*

**Level One Driver Assistance:** The sustained and ODD-specific execution by a driving automation system of either the lateral or the longitudinal vehicle motion control subtask of the DDT (but not both simultaneously) with the expectation that the driver performs the remainder of the DDT.

**Level Two Partial Driving Automation:** The sustained and ODD-specific execution by a driving automation system of both the lateral and longitudinal vehicle motion control subtasks of the DDT with the expectation that the driver completes the object and event detection and response (OEDR) subtask and supervises the driving automation system.

**Level Three ADS or Conditional Driving Automation:** The sustained and operational design domain-specific performance by an automated driving system of the entire dynamic driving task with the expectation that the dynamic driving task fallback-ready user is receptive to automated driving system-issued requests to intervene and to dynamic driving task performance-relevant system failures in other vehicle systems and will respond appropriately.

**Level Four ADS or High Driving Automation:** The sustained and operational design domain-specific performance by an automated driving system of the entire dynamic driving task and dynamic driving task fallback, without any expectation that a user will respond to a request to intervene.

**Level Five ADS or Full Driving Automation:** The sustained and unconditional performance by an automated driving system of the entire dynamic driving task and dynamic driving task fallback without any expectation that a user will respond to a request to intervene.

**MAP Message:** Describes the static physical geometry of one or more intersections; i.e., lane geometries and the allowable vehicle movements for each lane, and introduces the idea of “intersection data frame” which describes barriers, pedestrian walkways, shared roadways and rail lines that may affect vehicle movements.

**Minimal Risk Condition:** A condition to which a driver or an automated driving system may bring a vehicle after performing the dynamic driving task fallback to reduce the risk of a crash when a given trip cannot or should not be completed.

**Motor Vehicle:** Any vehicle propelled or drawn by any nonmuscular power, except aircraft, motor boats, road rollers, baggage trucks used about railroad stations or other mass transit facilities, electric battery-operated wheel chairs when operated by persons with physical disabilities at speeds not exceeding fifteen miles per hour, golf carts operated on highways solely for the purpose of crossing from one part of the golf course to another, golf-cart-type vehicles operated on roads or highways on the grounds of state institutions by state employees, agricultural tractors, farm implements, such vehicles as run only on rails or tracks, self-propelled snow plows, snow blowers and lawn mowers, when used for the purposes for which they were designed and operated at speeds not exceeding four miles per hour, whether or not the operator rides on or walks behind such equipment, motor-driven cycles as defined in section 14-286, special mobile equipment as defined in section 14-165, mini-motorcycles, as defined in section 14-289j, electric bicycles and any other vehicle not suitable for operation on a highway.

*Note: This is a Connecticut state statute definition from Section 14-1.*

**Operate:** The activities performed by a driver or by an automated driving system to perform the entire dynamic driving task for a given vehicle during a trip.

**Operational Design Domain:** The operating conditions under which a given automated driving system is specifically designed to function, including, but not limited to, environmental, geographical and time-of-day restrictions and the requisite presence or absence of certain traffic or roadway conditions.

**Operator:** A driver or automated driving system that operates a motor vehicle.

**Operator's License:** A valid Connecticut motor vehicle operator's license or a license issued by another state or foreign jurisdiction authorizing the holder thereof to operate a motor vehicle on the highways.

*Note: This is a Connecticut state statute definition from Section 14-1.*

**Owner:** Any person holding title to a motor vehicle, or having the legal right to register the same, including purchasers under conditional bills of sale.

*Note: This is a Connecticut state statute definition from Section 14-1.*

**Person:** Any individual, corporation, limited liability company, association, copartnership, company, firm, business trust or other aggregation of individuals but does not include the state or any political subdivision thereof, unless the context clearly states or requires.

*Note: This is a Connecticut state statute definition from Section 14-1.*

**5G (Emerging):** In conjunction with the development of the next-generation 5G standards, the telecom industry is also developing C-V2X specifications designed specifically for high-speed, mission-critical automotive and safety applications. These emerging specifications are being positioned as an alternative to the Wi-Fi standards based DSRC. However, at this point, 5G is still very much an emerging technology and is not available for usage currently for CVs.

**Request to Intervene:** Notification by an automated driving system to a fallback-ready user indicating that the fallback-ready user should promptly perform the dynamic driving task fallback, which may entail resuming manual operation of the vehicle, or achieving a minimal risk condition.

**SAE J3016:** The "Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles" published by SAE International, as updated from time to time.

**Signal Phasing and Timing (SPaT) Message:** Describes the signal state of the intersection and how long this state will persist for each approach and lane that is active. The SPaT message sends the current state of each phase, with all-red intervals not transmitted. Movements are given to specific lanes and approaches by use of the lane numbers present in the message.

**System Failure:** A malfunction in an automated driving system or other vehicle system that prevents the automated driving system from reliably performing the dynamic driving task on a sustained basis, including the complete dynamic driving task, that it would otherwise perform.

**Testing:** Operating a motor vehicle equipped with an automated driving system for the purpose of demonstrating or evaluating the automated driving system on highways.

**Trip:** The traversal of an entire travel pathway by a vehicle from the point of origin to a destination.

**User:** A person who performs the human role in driving automation.

**Vehicle-to-Everything (V2X) Communications:** Collective exchange of connected vehicle information between all CV communications, including V2V, V2I, V2P and V2N.

**Vehicle to Infrastructure (V2I) Communications:** Exchange of connected vehicle information between vehicles and roadside equipment such as traffic signals, video message signs, and other roadside infrastructure.

**Vehicle to Network (V2N) Communications:** Exchange of connected vehicle information between vehicles, cellular infrastructure and the cloud.

**Vehicle to Pedestrian (V2P) Communications:** Exchange of connected vehicle information between vehicles and pedestrians via cell phone.

**Vehicle-to-Vehicle (V2V) Communications:** Exchange of connected vehicle information between vehicles.