



# Connected and Automated Vehicle Terminology

---

## Texas CAV Task Force White Paper

Authors:  
Texas Connected and Autonomous Vehicles Task Force  
Brittney Gick, Texas A&M Transportation Institute  
Johanna Zmud, Texas A&M Transportation Institute

June 3, 2021



## Table of Contents

List of Figures.....	ix
Acknowledgments.....	xi
Disclaimer.....	xi
Texas CAV Task Force Charter .....	xi
Terminology Note .....	xi
# .....	1
4G.....	1
4G LTE .....	1
5G.....	1
A .....	1
Access Control.....	1
Access Management (AM).....	1
Adaptive Cruise Control .....	1
Advanced Collision Avoidance Technologies (ACAT).....	1
Advanced Driver Assistance System (ADAS) .....	1
Aerial Easement.....	1
Aftermarket.....	1
Aftermarket Safety Device (ASD) .....	2
Anonymity .....	2
Antilock Braking System (ABS).....	2
Artificial Intelligence.....	2
Assured Position, Navigation, and Timing (A-PNT).....	2
Automated Delivery System .....	2
Automated Driving System (ADS).....	2
<i>Automated Driving Systems: A Vision for Safety 2.0</i> (ADS 2.0).....	2
Automated Emergency Braking (AEB) .....	2
Automated Highway System (AHS) .....	2
Automated Motor Vehicle .....	2
Automated Vehicle .....	2
Automated Vehicle/Connected Vehicle (AV/CV) Bandwidth Requirements .....	2
Automatic License Plate Recognition (ALPR).....	3
Automation .....	3
Autonomous Aerial System .....	3
Autonomous Delivery Vehicle.....	3
Autonomous Vehicle .....	3
Autonomy.....	3
Avigation Easement .....	3

B.....	3
Bandwidth.....	3
Basic Safety Message (BSM) .....	3
Beacon.....	3
Bicycle.....	3
Bicycle Data.....	3
Bit (b) .....	3
Bus Signal Priority (BSP).....	3
Byte (B) .....	3
C.....	3
Carsharing .....	3
Cellular Communication Technology .....	4
Cellular Vehicle to Everything (C-V2X).....	4
Cloud Computing.....	4
Collision Avoidance System.....	4
Collision Prevention System .....	4
Commercial Driver License (CDL) .....	4
Commercial Motor Vehicle .....	4
Conditional Automation (Level 3).....	4
Connected Device .....	4
Connected Freight.....	4
Connected Vehicle .....	4
Connected Vehicle Reference Implementation Architecture (CVRIA): .....	4
Cooperative Adaptive Cruise Control (CACC).....	4
Cooperative Automated Transportation (CAT) Coalition.....	5
Cooperative Automation .....	5
Cooperative Lane Change and Merge .....	5
Crash Avoidance Technology.....	5
Curve Speed Warning (CSW) System.....	5
Cybersecurity.....	5
D.....	5
Data .....	5
Data Governance .....	6
Data Lake .....	6
Data Store .....	6
Data Warehouse .....	6
Dedicated Short-Range Communication (DSRC).....	7
Demand Scheduling .....	7
Digital Mapping .....	7
Driver .....	7

Driver Assistance (Level 1).....	7
Driver Assistance Technologies .....	7
Driver License.....	7
Driverless Carsharing.....	7
Driverless Operation .....	7
Dynamic Driving Task (DDT).....	8
Dynamic Driving Task (DDT) Fallback.....	8
E .....	8
Edge Computing.....	8
Electronic Control Unit (ECU).....	8
<i>Ensuring American Leadership in Automated Vehicle Technologies: Automated</i>	
<i>Vehicles 4.0 (AV 4.0)</i> .....	8
Entire Dynamic Driving Task .....	8
Exabyte (EB) .....	8
Extremely High Frequency (EHF).....	8
F .....	8
Far Infrared Sensor (FIRS).....	8
Federal Aviation Administration (FAA) .....	8
Federal Aviation Regulations (FAR).....	9
Federal Communications Commission (FCC).....	9
Federal Communications Commission (FCC) Spectrum .....	9
Federal Highway Administration (FHWA).....	9
Federal Motor Carrier Safety Administration (FMCSA) .....	9
Federal Motor Carrier Safety Regulation (FMCSR) .....	9
Federal Motor Vehicle Safety Standard (FMVSS) .....	9
Federal Transit Administration (FTA) .....	9
First Mile .....	9
First-Mile/Last-Mile Problem.....	9
Freight.....	9
Freight Signal Priority (FSP).....	9
Full Automation (Level 5).....	10
Fully Autonomous Vehicle .....	10
Fusion .....	10
G.....	10
Geofence .....	10
Geofencing .....	10
Gigabyte (GB) .....	10
Global Positioning System (GPS) .....	10
Graphics Processing Unit (GPU).....	10
Gross Vehicle Weight Rating (GVWR) .....	10

H.....	10
High Automation (Level 4).....	10
High-Definition Mapping.....	10
Host Vehicle.....	10
Human-Machine Interface (HMI) .....	10
Human Operator .....	10
I.....	11
In-Vehicle Fallback Test Driver (IFTD).....	11
Incident Scene Pre-arrival Staging Guidance for Emergency Responders (RESP-STG).....	11
Inertial Measurement Unit (IMU) .....	11
Infrared Camera .....	11
Intelligent Transportation System (ITS) .....	11
Intelligent Transportation System (ITS) Architecture.....	11
Intelligent Transportation System (ITS) Standards.....	11
Internet of Things (IoT).....	11
Interoperability .....	11
J.....	11
Just in Time (JIT).....	11
Just-in-Time (JIT) Delivery .....	11
K.....	11
Kilobyte (KB).....	11
L.....	12
Last Mile .....	12
Last-Mile Connectivity to Transportation Management Centers .....	12
Latency .....	12
Liability.....	12
License Plate Recognition (LPR) .....	12
Light Imaging, Detection, and Ranging (LiDAR) .....	12
Location Beacons.....	12
Locationing.....	12
Logistics.....	12
Logistics Management System .....	12
Long-Range Radar (LRR) .....	12
M.....	12
Machine Learning .....	12
Machine Vision.....	12
Manufacturer.....	12
Map Data Message (MAP).....	12
Megabyte (MB).....	13

Memorandum of Understanding (MOU) .....	13
Metadata .....	13
Microwave .....	13
Middle Mile.....	13
Mid-range Radar (MRR).....	13
Millimeter Wave .....	13
Minimal Risk Condition.....	13
Mobile Carrying Device .....	13
Mobility .....	13
Mobility as a Service (MaaS).....	13
Mobility on Demand.....	13
Motor Carrier .....	13
N.....	13
National Highway Traffic Safety Administration (NHTSA).....	13
National Intelligent Transportation System (ITS) Architecture.....	14
Natural Language Processing (NLP) .....	14
No Automation (Level 0).....	14
O.....	14
Object Event Detection and Response (OEDR).....	14
Obstacle Detection.....	14
On-Demand Scheduling.....	14
Onboard Equipment (OBE) .....	14
Onboard Unit (OBU).....	14
Operational Design Domain (ODD) .....	15
Operator.....	15
Original Equipment Manufacturer (OEM) .....	15
Over-Size/Overweight Warning .....	15
Over-the-Air (OTA) Update.....	15
Owner:.....	15
P.....	15
Partial Automation (Level 2).....	15
Pedestrian .....	15
Pedestrian Data .....	15
Pedestrian Walkway.....	16
Personal Delivery Device .....	16
Personal Vehicle Sharing (PVS).....	16
Personally Identifiable Information (PII) .....	16
Petabyte (PB).....	16
Platooning.....	16
Position, Navigation, and Timing (PNT) .....	16

<i>Preparing for the Future of Transportation: Automated Vehicles 3.0 (AV 3.0)</i> .....	16
Privacy.....	16
Private Carrier .....	17
Privately Owned Vehicle (POV) .....	17
Proprietary Information.....	17
Public Liability .....	17
Q.....	17
R.....	17
Radar .....	17
Radio Spectrum .....	17
Real-Time Data (RTD) .....	18
Real-Time Kinematics (RTK).....	18
Real-Time Traffic Information (RTTI).....	18
Regional Intelligent Transportation System (ITS) Architecture .....	18
Registered Owner.....	18
Reliability .....	18
Remote Driver .....	19
Remote Vehicle .....	19
Responsibility .....	19
Retrofit Device.....	19
Ride Hailing .....	19
Ride Share Service.....	19
Ridesourcing.....	19
Right of Way .....	19
Risk .....	19
Risk Management.....	19
Road.....	19
Roadside.....	19
Roadside Equipment (RSE) .....	19
Roadside Unit (RSU) .....	19
Roadway .....	20
Roadway User.....	20
Robotaxi.....	20
S.....	20
SAE Level of Automation .....	20
Safety.....	20
Safety Operator .....	20
Security .....	21
Security Credential Management System (SCMS) .....	21
Self-Driving Vehicle .....	21



Sensor Fusion (Fuse) .....	21
Shared Mobility .....	21
Shared Service .....	21
Short-Range Radar (SRR) .....	21
Short-Range Wireless Communications .....	21
Sign .....	21
Signal .....	21
Signal Phase and Timing (SPaT) .....	21
Signal Priority .....	21
Signalized Intersection Approach and Departure .....	21
Smart Parking Facilities for Connected and Autonomous Vehicles .....	22
Smart Work Zone System .....	22
Social Equity .....	22
Software Development Kit (SDK).....	22
Speed Harmonization .....	22
T.....	22
Tele-assist.....	22
Telematics .....	22
Teleoperated Driving System .....	22
Teleoperations.....	22
Terabyte (TB) .....	22
Traffic Management.....	22
Transfer Hub.....	22
Transit Signal Priority (TSP) .....	22
Transport as a Service (TaaS) .....	22
Transport Hub .....	23
Transportation Demand Management (TDM) .....	23
Transportation Management Center (TMC) .....	23
Transportation Network Company (TNC) .....	23
Transportation System Management and Operations (TSMO) .....	23
Transportation Worker Identification Credential (TWIC).....	23
U .....	23
Ultrasonic Sensor .....	23
Unmanned Aircraft (UA) .....	23
Unmanned Aircraft System (UAS) .....	23
U.S. Department of Transportation (USDOT).....	23
U.S. Department of Transportation Automated Vehicles Activities .....	23
V .....	24
Vehicle Platooning .....	24
Vehicle Safety.....	24

Vehicle to Cloud (V2C) .....	24
Vehicle to Device (V2D) .....	24
Vehicle to Everything (V2X).....	24
Vehicle to Infrastructure (V2I) .....	24
Vehicle to Network (V2N).....	24
Vehicle to Pedestrian (V2P).....	24
Vehicle to Vehicle (V2V).....	24
Vision Processing.....	24
Vulnerable Road User .....	24
W .....	24
Wide-Area Wireless Communications.....	24
Wireless Access for Vehicular Environments (WAVE).....	24
Wireless Local Area Network (WLAN) .....	24
Work Zone .....	25
X .....	25
Y .....	25
Yottabyte (YB).....	25
Z .....	25
Zero-Occupancy Vehicle .....	25
Zettabyte (ZB).....	25
References .....	25

## List of Figures

Figure 1. Data Measurement Definitions.....	6
Figure 2. U.S. Frequency Allocations on the Radio Spectrum. ....	18
Figure 3. SAE-Defined Levels of Automation.....	20



## **Acknowledgments**

The Texas Connected and Autonomous Vehicles (CAV) Task Force would like to acknowledge and thank all of its voting and participating membership and the members of all subcommittees for their hard work and many hours dedicated to developing this white paper. We would especially like to thank the contributing authors of this paper for taking the thoughts of so many and combining them into one well-written document. In addition, special thanks go to Beverly Kuhn, Ed Seymour, and Robert Brydia of the Texas A&M Transportation Institute for their management, creativity, and patience in assisting the Texas CAV Task Force Texas Department of Transportation team and subcommittee chairs. Finally, the Texas CAV Task Force would like to thank Texas Governor Greg Abbott and his staff for their guidance and vision in creating this Texas CAV Task Force. Texas is better prepared for CAVs due to their leadership.

## **Disclaimer**

The contents of this white paper reflect the views of the Texas CAV Task Force members, who are responsible for the information presented herein. The contents do not necessarily reflect the official views or policies of the State of Texas or any Texas state agencies. The white paper does not constitute a standard, specification, or regulation, nor does it endorse standards, specifications, or regulations. This white paper does not endorse practices, products, or procedures from any private-sector entity and is presented as a consensus broad opinion document for supporting and enhancing the CAV ecosystem within Texas.

## **Texas CAV Task Force Charter**

The Texas CAV Task Force was created at the request of Texas Governor Greg Abbott in January 2019. The Texas CAV Task Force is responsible for preparing Texas for the safe and efficient rollout of CAVs on all forms of transportation infrastructure.

The primary functions are:

1. Coordinating and providing information on CAV technology use and testing in Texas.
2. Informing the public and leaders on current and future CAV advancements and what they mean in Texas. This process includes reporting on the current status, future concerns, and how these technologies are changing future quality of life and well-being.
3. Making Texas a leader in understanding how to best prepare and wisely integrate CAV technologies in a positive, safe way, as well as promoting positive development and experiences for the state.

The Texas CAV Task Force is composed of a voting group of no more than 25 members and represents the full spectrum of CAV stakeholders.

## **Terminology Note**

The Texas CAV Task Force addresses the full spectrum of connected, automated, and autonomous vehicles. An *automated vehicle* refers to a vehicle that may perform a subset of driving tasks and require a driver to perform the remainder of the driving tasks and supervise each feature's

performance while engaged. A *fully autonomous vehicle* refers to a vehicle that can perform all driving tasks on a sustained basis. These definitions are still blurred in common discussions and language. Currently, the industry is developing automated vehicle capability while pursuing fully autonomous vehicles. The white papers generally use the term *autonomous* to refer to the vehicles with fully autonomous capabilities and the term *CAV* to refer to the grouping of connected, automated, and autonomous vehicles. This white paper includes a full listing of terms and definitions used in this developing technology ecosystem.

## #

**4G:** the short name for fourth-generation wireless broadband mobile communications. According to the International Telecommunication Union, a 4G network requires a mobile device to be able to exchange data at 100 Mbps although some technologies branded as 4G do not offer this level of performance (1).

**4G LTE:** the short name for the fourth-generation long-term evolution designed to exchange data 10 times the speed of 3G, at approximately 150 Mbps download and 50 Mbps upload. 4G LTE was created to bridge the gap between the 3G and 4G mobile communication networks (2).

**5G:** the short name for fifth-generation wireless broadband mobile networks, with performance loads between 100 and 1,000 times that of existing 4G networks (1). 5G is expected to be able to deliver 10 Gbps and be able to process a high volume of data without delay (3).

## A

**Access Control:** mechanisms and policies that restrict access to computer resources. An access control list, for example, specifies what operations different users can perform on specific files and directories (1).

**Access Management (AM):** the proactive management of vehicular access points to land parcels adjacent to all manner of roadways. Good AM promotes safe and efficient use of the transportation network. AM encompasses a set of techniques that state and local governments can use to control access to highways, major arterials, and other roadways (4).

**Adaptive Cruise Control:** a driver assistance system that automatically adjusts a vehicle's speed to maintain a set following distance from the vehicle in front (as defined by the National Highway Traffic Safety Administration) (5).

**Advanced Collision Avoidance Technologies (ACAT):** a National Highway Traffic Safety Administration program designed to develop a standardized process for evaluating the performance and effectiveness of the technologies that prevent and mitigate vehicle crashes (6).

**Advanced Driver Assistance System (ADAS):** a system designed to help drivers with certain driving tasks (e.g., staying in the lane, parking, avoiding collisions, reducing blind spots, and maintaining a safe headway). ADASs are generally designed to improve safety or reduce the workload on the driver. With respect to automation, some ADAS features could be considered SAE Level 1 or 2, but many are Level 0 and may provide alerts to the driver with little or no automation (5).

**Aerial Easement:** see *Avigation Easement*.

**Aftermarket:** equipment installed on a vehicle after purchase and not involving the original equipment manufacturer (6).

**Aftermarket Safety Device (ASD):** a connected device in a vehicle that operates while the vehicle is mobile but is not connected to the data bus of the vehicle (1). The connected device is capable of sending and receiving messages installed on a vehicle after purchase (6).

**Anonymity:** lacking individuality, distinction, and recognizability within message exchanges (1).

**Antilock Braking System (ABS):** a system that automatically controls the brakes to prevent the vehicle wheels from locking up (6).

**Artificial Intelligence:** the intelligence that is learned, exhibited, and executed by a machine (3).

**Assured Position, Navigation, and Timing (A-PNT):** a form of position, navigation, and timing that is accurate and always available (7).

**Automated Delivery System:** any vehicle equipped with an automated driving system that delivers goods.

**Automated Driving System (ADS):** hardware and software that are collectively capable of performing the entire dynamic driving task on a sustained basis, regardless of whether the task is limited to a specific operational design domain. This term is used specifically to describe a Level 3, 4, or 5 driving automation system (as defined by SAE J3016) (5). ADS is defined in Title 7 §545.451 of the Texas Transportation Code as “hardware and software that, when installed on a motor vehicle and engaged, are collectively capable of performing, without any intervention or supervision by a human operator: (a) all aspects of the entire dynamic driving task for the vehicle on a sustained basis; and (b) any fallback maneuvers necessary to respond to a failure of the system” (8).

***Automated Driving Systems: A Vision for Safety 2.0 (ADS 2.0):*** the U.S. Department of Transportation’s cornerstone voluntary guidance document for automated driving systems (9).

**Automated Emergency Braking (AEB):** a system that can detect an impending forward crash with another vehicle in time to avoid or mitigate the crash. The system first alerts the driver to take corrective action and supplements the driver’s braking to avoid the crash. If the driver does not respond, the AEB system may automatically apply the brakes to assist in preventing or reducing the severity of a crash (10).

**Automated Highway System (AHS):** an intelligent transportation system facility with predetermined routes intended mainly for autonomous vehicles (6).

**Automated Motor Vehicle:** see *Automated Vehicle*.

**Automated Vehicle:** any vehicle equipped with automated driving system technologies (as defined by SAE J3016). This term can refer to a vehicle fitted with any form of driving automation (SAE Level 1 through 5) (5).

**Automated Vehicle/Connected Vehicle (AV/CV) Bandwidth Requirements:** see *Radio Spectrum*.



**Automatic License Plate Recognition (ALPR):** an identification method that uses optical character recognition on images to read license plates on vehicles (11).

**Automation:** the use of electronic or mechanical devices to operate one or more functions of a vehicle without direct human input (5).

**Autonomous Aerial System:** see *Unmanned Aircraft System (UAS)*.

**Autonomous Delivery Vehicle:** any vehicle that delivers goods without the need for a human driver.

**Autonomous Vehicle:** a vehicle in which no driver is needed in a particular operational design domain. All driving functions are controlled by the vehicle itself, and the vehicle is able to sense its environment (6).

**Autonomy:** the quality or state of being self-governing.

**Avigation Easement:** a grant of a property interest in land over which a right of unobstructed flight in the airspace is established (12).

## **B**

**Bandwidth:** see *Radio Spectrum*.

**Basic Safety Message (BSM):** the set of location and vehicle information transmitted between connected vehicles and connected infrastructure (13).

**Beacon:** a radio transmitter that produces guiding signals (14).

**Bicycle:** a vehicle having two tandem wheels, propelled solely by human power, upon which any person or persons may ride (Title 23 §217 of the U.S. Code of Federal Regulations) (15).

**Bicycle Data:** data pertaining to bicyclists.

**Bit (b):** a binary digit of computer information that has a value of zero or one (16).

**Bus Signal Priority (BSP):** see *Transit Signal Priority (TSP)*.

**Byte (B):** a sequence of 8 bits (16).

## **C**

**Carsharing:** a program where individuals have temporary access to a vehicle without the costs and responsibilities of ownership. Individuals typically access vehicles by joining an organization that maintains a fleet of cars and light trucks deployed in lots located within neighborhoods, public transit stations, employment centers, and colleges/universities. Typically, the carsharing operator provides insurance, gasoline, parking, and maintenance. Generally, participants pay a fee each time they use a vehicle (17).

**Cellular Communication Technology:** the systems that operate mobile phones. See 4G, 4G LTE, and 5G.

**Cellular Vehicle to Everything (C-V2X):** the cellular technology that enables the communication between vehicles and other objects and services (18).

**Cloud Computing:** data storage and services accessed through the internet (6).

**Collision Avoidance System:** see *Collision Prevention System*.

**Collision Prevention System:** the set of features that detect, prevent, mitigate, and/or warn drivers of potential front, rear, and side collisions (13).

**Commercial Driver License (CDL):** defined in Title 7 §522.003 of the Texas Transportation Code as “a license issued to an individual that authorizes the individual to drive a class of commercial motor vehicle” (8).

**Commercial Motor Vehicle:** defined in Title 7 §522.003 of the Texas Transportation Code as “a motor vehicle or combination of motor vehicles used to transport passengers or property that: (a) has a gross combination weight or a gross combination weight rating of 26,001 or more pounds, including a towed unit with a gross vehicle weight or a gross vehicle weight rating of more than 10,000 pounds; (b) has a gross vehicle weight or a gross vehicle weight rating of 26,001 or more pounds; (c) is designed to transport 16 or more passengers, including the driver; or (d) is transporting hazardous materials and is required to be placarded under 49 CFR Part 172, Subpart F” (8).

**Conditional Automation (Level 3):** the SAE definition for the automation driving level where a vehicle is equipped with an automated driving system for all dynamic driving tasks, but the human driver is expected to remain engaged in order to be able to take back control of the driving task (5).

**Connected Device:** any device used to transmit to or receive messages from another device (1).

**Connected Freight:** commercial motor vehicles that interact with each other, the roadside, and beyond via wireless communications.

**Connected Vehicle:** vehicles that interact with each other, roadside equipment, and beyond via wireless communications (19).

**Connected Vehicle Reference Implementation Architecture (CVRIA):** a set of system architecture views that describe the functions, physical and logical interfaces, enterprise/institutional relationships, and communications protocol dependencies within the connected vehicle environment. The CVRIA defines functionality and information exchanges needed to provide connected vehicle applications (20).

**Cooperative Adaptive Cruise Control (CACC):** vehicle-to-vehicle communication technology combined with adaptive cruise control that allows vehicles to synchronize acceleration and braking, and decrease the following distance to improve traffic stability (13).

**Cooperative Automated Transportation (CAT) Coalition:** the collaboration of federal, state, and local officials to address the technical issues associated with connected and automated vehicles (21).

**Cooperative Automation:** the ability of automated vehicles to communicate with each other and with infrastructure to coordinate their movements (5).

**Cooperative Lane Change and Merge:** a dynamic driving task for automated vehicles that uses communications to enable negotiations between vehicles to provide safe gaps for a manual or automated lane change or merge maneuver on a roadway (as defined by the Federal Highway Administration) (5).

**Crash Avoidance Technology:** see *Collision Prevention System*.

**Curve Speed Warning (CSW) System:** the use of the global positioning system and digital mapping that warns a driver of an upcoming curve that is approaching too quickly (22).

**Cybersecurity:** the practice of protecting computers, data, networks, programs, and software from an attack, damage, theft, or unauthorized access (6). Cybersecurity includes the prevention of damage to, protection of, and restoration of computers, electronic communications systems, electronic communications services, wire communication, and electronic communication, including information contained therein, to ensure its availability, integrity, authentication, confidentiality, and nonrepudiation (16).

## **D**

**Data:** distinct pieces of digital information that have been formatted in a specific way (16). Figure 1 defines some data measurements.

Abbreviation	Unit	Value	Size (in bytes)
b	bit	0 or 1	1/8 of a byte
B	bytes	8 bits	1 byte
KB	kilobytes	1,000 bytes	1,000 bytes
MB	megabyte	1,000 <sup>2</sup> bytes	1,000,000 bytes
GB	gigabyte	1,000 <sup>3</sup> bytes	1,000,000,000 bytes
TB	terabyte	1,000 <sup>4</sup> bytes	1,000,000,000,000 bytes
PB	petabyte	1,000 <sup>5</sup> bytes	1,000,000,000,000,000 bytes
EB	exabyte	1,000 <sup>6</sup> bytes	1,000,000,000,000,000,000 bytes
ZB	zettabyte	1,000 <sup>7</sup> bytes	1,000,000,000,000,000,000,000 bytes
YB	yottabyte	1,000 <sup>8</sup> bytes	1,000,000,000,000,000,000,000,000 bytes

Figure 1. Data Measurement Definitions.

**Data Governance:** the collection of procedures that encompass the official management of an organization’s data assets (23).

**Data Lake:** see *Data Store*.

**Data Store:** a reservoir in which data can be held for an indefinite period. Data stores are shown on data flow diagrams where data repositories are required to support data aggregation or archival services (1).

**Data Warehouse:** a data storage facility that supports the input (deposit) and retrieval (delivery) of clearly defined data objects. This can be designed and implemented in a variety of ways, including publish/subscribe and a traditional query-based database, also known as a data distribution system (1).

**Dedicated Short-Range Communication (DSRC):** a two-way short- to medium-range wireless communications capability that permits very high data transmission critical in communications-based active safety applications (19). According to the Federal Communications Commission (FCC) (Dedicated Short Range Communications of Intelligent Transportation Services—Final Rule, *Federal Register* Doc. No. 99-30591), DSRC is “the use of non-voice radio techniques to transfer data over short distances between roadside and mobile radio units, between mobile units, and between portable and mobile units to perform operations related to the improvement of traffic flow, traffic safety and other intelligent transportation service applications in a variety of public and commercial environments.” DSRC is a technology designed for the transmission of information between multiple vehicles and between vehicles and the transportation infrastructure using wireless technologies (20). FCC has issued a ruling to reallocate the spectrum that is dedicated to transportation safety. While there was a 75-MHz allocation for DSRC, FCC has made the lower 45 MHz of the 5.9-GHz band available for unlicensed operations such as Wi-Fi and allocated the upper 30 MHz for cellular-vehicle-to-everything operations (24). Existing DSRC licenses are able to continue operating in the upper 30 MHz; however, existing operations in the lower 45 MHz are required to cease operations after the one-year transition period.

**Demand Scheduling:** see *Just-in-Time (JIT) Delivery*.

**Digital Mapping:** the process of formatting a series of data into a virtual image (13).

**Driver:** a person who operates a motorized vehicle. If more than one person drives on a single trip, the person who drives the most miles is classified as the principal driver. It also means an occupant of a vehicle who is in physical control of a motor vehicle in transport (15).

**Driver Assistance (Level 1):** the SAE definition for the automation driving level where the vehicle is equipped with driver assistance technologies that execute either steering or acceleration and deceleration but requires human interaction for the remaining driving tasks (5).

**Driver Assistance Technologies:** cameras and sensors in vehicles that help drivers see more than they can with the naked eye and warn of a possible collision. Driver assistance technologies can help drivers with backing up and parking, maintaining safe distances from other vehicles, preventing forward collisions, and navigating lanes safely (as defined by the National Highway Traffic Safety Administration) (5).

**Driver License:** a license issued by a state or other jurisdiction to an individual that authorizes the individual to operate a motor vehicle on highways (Title 49 §383 of the U.S. Code of Federal Regulations) (15).

**Driverless Carsharing:** a driverless vehicle that can be shared or rented for individual use (6).

**Driverless Operation:** a vehicle that is able to navigate to destinations without input from a human (6).

**Dynamic Driving Task (DDT):** all of the real-time operational and tactical functions required to operate a vehicle in on-road traffic, excluding the strategic functions such as trip scheduling and the selection of destinations and waypoints (as defined by SAE J3016) (5).

**Dynamic Driving Task (DDT) Fallback:** the response by the user or by an automated driving system to either perform the DDT or achieve a minimal risk condition after occurrence of a DDT performance-relevant system failure(s) or upon operational design domain exit (as defined by SAE J3016) (5).

## **E**

**Edge Computing:** the process of using computer servers and data analytics to prioritize information on demand (18, 25).

**Electronic Control Unit (ECU):** a unit that is embedded in the vehicle that controls one or more electrical systems, such as the human-machine interface or engine control unit (3).

***Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0 (AV 4.0):*** a U.S. Department of Transportation guidance document that builds upon *Preparing for the Future of Transportation: Automated Vehicles 3.0* and expands the scope to 38 relevant U.S. Government (USG) components that have direct or tangential equities in the safe development and integration of automated vehicle technologies. AV 4.0 seeks to ensure a consistent USG approach to automated vehicle technologies, and to detail the authorities, research, and investments being made across the USG so that the United States can continue to lead automated vehicle technology research, development, and integration (26).

**Entire Dynamic Driving Task:** defined in Title 7 §545.451 of the Texas Transportation Code as the “operational and tactical aspects of operating a vehicle. The term: (a) includes: (i) operational aspects, including steering, braking, accelerating, and monitoring the vehicle and the roadway; and (ii) tactical aspects, including responding to events, determining when to change lanes, turning, using signals, and other related actions; and (b) does not include strategic aspects, including determining destinations or waypoints” (8).

**Exabyte (EB):** 1,000 petabytes.

**Extremely High Frequency (EHF):** the highest band of radio frequency, between 30 and 300 GHz (14).

## **F**

**Far Infrared Sensor (FIRS):** a piece of equipment used at night or times of poor visibility that senses heat to detect pedestrians or living objects on or near a roadway (6).

**Federal Aviation Administration (FAA):** a federal agency charged with regulating air commerce to promote its safety and development; encouraging and developing civil aviation, air traffic control, and air navigation; and promoting the development of a national system of airports (12).

**Federal Aviation Regulations (FAR):** the set of regulatory obligations contained in Title 14 of the U.S. Code of Federal Regulations, which the Federal Aviation Administration is charged to enforce in order to promote the safety of civil aviation both domestically and internationally (15).

**Federal Communications Commission (FCC):** an independent regulatory agency overseen by Congress that administers the spectrum and has primary authority for communications law (27).

**Federal Communications Commission (FCC) Spectrum:** see *Radio Spectrum*.

**Federal Highway Administration (FHWA):** an agency of the U.S. Department of Transportation. FHWA administers the Federal-Aid Highway Program, which provides financial assistance to states to construct and improve highways, urban and rural roads, and bridges. FHWA also administers the Federal Lands Highway Program, which provides access to and within national forests, national parks, Indian Tribal lands, and other public lands (1).

**Federal Motor Carrier Safety Administration (FMCSA):** the agency of the U.S. Department of Transportation that is responsible for regulating and providing safety oversight of commercial motor vehicles (CMVs). FMCSA's mission is to reduce crashes, injuries, and fatalities involving large trucks and buses. FMCSA partners with industry, safety advocates, and state and local governments to keep the nation's roadways safe and improve CMV safety through regulation, education, enforcement, research, and technology (28).

**Federal Motor Carrier Safety Regulation (FMCSR):** defined in Title 7 §644.001 of the Texas Transportation Code as "a federal regulation in Subtitle A, Title 49, or Subchapter B, Chapter III, Subtitle B, Title 49, Code of Federal Regulations" (8).

**Federal Motor Vehicle Safety Standard (FMVSS):** the minimum specifications issued by the National Highway Traffic Safety Administration to comply with Federal Motor Vehicle Safety Regulations (29).

**Federal Transit Administration (FTA):** an agency of the U.S. Department of Transportation. FTA is the principal source of federal financial assistance to America's communities for the planning, development, and improvement of public or mass transportation systems. FTA provides leadership, technical assistance, and financial resources for safe, technologically advanced public transportation that enhances mobility and accessibility, improves the nation's communities and natural environment, and strengthens the national economy (1).

**First Mile:** the initial movement of goods along a transportation system.

**First-Mile/Last-Mile Problem:** the challenges with not having adequate access to transportation at the beginning or end location of a trip, which increases the time needed for transportation, such as walking from a bus stop to an end location.

**Freight:** defined in Title 2 §7.001 of the Texas Transportation Code as "baggage and other property transported by a common carrier" (8).

**Freight Signal Priority (FSP):** an operational strategy that grants freight vehicles the right of way with the goal of improving travel time and reliability (6).

**Full Automation (Level 5):** the SAE definition for the automation driving level where a vehicle is equipped with an automated driving system and completes all dynamic driving tasks under all conditions without the need for human intervention (5).

**Fully Autonomous Vehicle:** a vehicle that can perform all driving tasks on a sustained basis.

**Fusion:** see *Sensor Fusion (Fuse)*.

## **G**

**Geofence:** an electronic set of geographic reference points that form a bounded geographic region (1).

**Geofencing:** the practice of using the global positioning system or radio frequency identification to define an area or location (30).

**Gigabyte (GB):** 1 billion bytes.

**Global Positioning System (GPS):** the satellite-based navigation system that uses location and time information to triangulate position (13). The system determines position by comparing radio signals from several satellites (16).

**Graphics Processing Unit (GPU):** a specialized electronic circuit designed to accelerate image and graphics processing. GPUs excel at parallel processing (3).

**Gross Vehicle Weight Rating (GVWR):** the maximum rated capacity of a vehicle, including the weight of the base vehicle, all added equipment, driver and passengers, and all cargo (15).

## **H**

**High Automation (Level 4):** the SAE definition for the automation driving level where a vehicle is equipped with an automated driving system for all dynamic driving tasks, but the human driver does not need to respond to a request to intervene in a driving task (5).

**High-Definition Mapping:** maps that use extremely high precision, at the centimeter level, for use in self-driving vehicles (31).

**Host Vehicle:** a connected vehicle that receives messages from a remote vehicle. Sometimes, the host vehicle is also used to describe the originator of a vehicular transmission of information to the roadside unit (1).

**Human-Machine Interface (HMI):** an interface that is responsible for two-way communication between a vehicle and the occupants. The HMI may include touchscreen displays, voice recognition, or integration with mobile devices (3). See *Natural Language Processing (NLP)*.

**Human Operator:** defined in Title 7 §545.451 of the Texas Transportation Code as “a natural person in an automated motor vehicle who controls the entire dynamic driving task” (8).



## I

**In-Vehicle Fallback Test Driver (IFTD):** a human operator that provides oversight of a fully autonomous vehicle that can intervene if needed.

**Incident Scene Pre-arrival Staging Guidance for Emergency Responders (RESP-STG):** an application that safely and efficiently guides public safety responders to an incident scene (6).

**Inertial Measurement Unit (IMU):** a device that tracks the position of unmanned aerial vehicles and other aircraft, and records the orientation, velocity, and gravitational forces (32).

**Infrared Camera:** a camera that detects and converts surface temperature into an electronic image (33).

**Intelligent Transportation System (ITS):** the system composed of the electronics, communications, or information processing in transportation infrastructure and in vehicles used singly or integrated to improve transportation safety and mobility and enhance productivity. ITS encompasses a broad range of wireless and wire line communications-based information and electronics technologies (1). These technologies are used by different modes of transport and traffic management (11).

**Intelligent Transportation System (ITS) Architecture:** an architecture of interrelated systems that work together to deliver transportation services. An ITS architecture defines how systems functionally operate and the interconnection of information exchanges that must take place between these systems to accomplish transportation services (1).

**Intelligent Transportation System (ITS) Standards:** the documented technical specifications sponsored by a standards development organization to be used consistently as rules, guidelines, or definitions of characteristics for the interchange of data (1).

**Internet of Things (IoT):** a concept that built infrastructure is linked and dynamic, often displaying intelligence via integrated sensors and adaptive controls (19).

**Interoperability:** the ability of two systems to work together (14).

## J

**Just in Time (JIT):** cargo or components that must be at a destination at the exact time needed. The container or vehicle is the movable warehouse (15).

**Just-in-Time (JIT) Delivery:** a logistics management strategy intended to increase efficiency and reduce waste that involves the coordination between producers and suppliers so that suppliers only order the components they need to meet the current demand.

## K

**Kilobyte (KB):** 1,000 bytes.

## **L**

**Last Mile:** the final movement of goods to their designated destination.

**Last-Mile Connectivity to Transportation Management Centers:** connectivity solutions to address the first-mile/last-mile data exchange problems and provide real-time data on the availability of platforms. Examples include micro-mobility applications, transit-oriented development, and just-in-time delivery.

**Latency:** a measure of time delay experienced in a system, the precise definition of which depends on the system and the time being measured. For a data element in this context, latency is the time difference between the time that data value is acquired by the source and the time the message is transmitted (15).

**Liability:** the quality of being obligated by law (14).

**License Plate Recognition (LPR):** see *Automatic License Plate Recognition (ALPR)*.

**Light Imaging, Detection, and Ranging (LiDAR):** an extremely precise laser-based form of radar used in autonomous vehicles, usually located on the top of a vehicle to provide a 360-degree view of the area around the vehicle (6).

**Location Beacons:** see *Beacon*.

**Locationing:** the process of locating an object. See *Position, Navigation, and Timing (PNT)*.

**Logistics:** all activities involved in the management of product movement: delivering the right product from the right origin to the right destination, with the right quality and quantity, at the right schedule and price (15).

**Logistics Management System:** see *Logistics*.

**Long-Range Radar (LRR):** a system that uses a transmitter and receiver, operating at 77 GHz with a detection range of 0.36 to 250 meters, with six fixed radar antennae for use in detecting objects. LRR is often used in driver assistance technologies, such as adaptive cruise control (34).

## **M**

**Machine Learning:** a subset of artificial intelligence that gives machines the capability to learn on their own, resulting in algorithms that make data-driven decisions (3).

**Machine Vision:** the process of using image-based inspection and analysis tools to complete automated applications (6).

**Manufacturer:** see *Original Equipment Manufacturer (OEM)*.

**Map Data Message (MAP):** provides the road geometry at an intersection (1).

**Megabyte (MB):** 1 million bytes.

**Memorandum of Understanding (MOU):** a document providing a general description of the responsibilities that are to be assumed by two or more parties in their pursuit of some goal(s). More specific information may be provided in an associated statement of work (15).

**Metadata:** a set of data that describe and give information about other data (19).

**Microwave:** a short electromagnetic wave between 1 millimeter and 1 meter in wavelength (14).

**Middle Mile:** the segment of the transportation system that connects the origin of goods, or first mile, to the final destination, or last mile.

**Mid-range Radar (MRR):** a system that uses a transmitter and receiver, operating at 77 GHz with a detection range of 0.36 to 160 meters, with four independent channels and digital beam forming for use in detecting objects. MRR is often used in driver assistance technologies, such as side view assist (35).

**Millimeter Wave:** see *Extremely High Frequency (EHF)*.

**Minimal Risk Condition:** a condition to which a user or an automated driving system may bring a vehicle after performing the dynamic driving task fallback in order to reduce the risk of a crash when a given trip cannot or should not be completed (as defined by SAE J3016) (5).

**Mobile Carrying Device:** defined in Title 7 §552A.0001 of the Texas Transportation Code as “a device that: (a) transports cargo while remaining within 25 feet of a human operator; and (b) is equipped with technology that allows the operator to actively monitor the device” (8).

**Mobility:** the ability to move or be moved from place to place (15).

**Mobility as a Service (MaaS):** the movement away from personal vehicle ownership to on-demand transportation services, often using app-based subscription technologies (6, 36).

**Mobility on Demand:** the innovative transportation concept for the ability to access transportation services on an as-needed basis, often using an app-based shared service (36).

**Motor Carrier:** defined in Title 7 §643.001 of the Texas Transportation Code as “an individual, association, corporation, or other legal entity that controls, operates, or directs the operation of one or more vehicles that transport persons or cargo over a road or highway in this state” (8).

## **N**

**National Highway Traffic Safety Administration (NHTSA):** an agency of the U.S. Department of Transportation established to:

- Carry out a congressional mandate to reduce the mounting number of deaths, injuries, and economic losses resulting from motor vehicle crashes on the nation’s highways.

- Provide motor vehicle damage susceptibility and ease of repair information, motor vehicle inspection demonstrations, and protection of purchasers of motor vehicles having altered odometers.
- Provide average standards for greater vehicle mileage per gallon of fuel for vehicles under 10,000 pounds (gross vehicle weight) (15).

**National Intelligent Transportation System (ITS) Architecture:** a systems framework to guide the planning and deployment of ITS infrastructure. The national ITS architecture is a blueprint for the coordinated development of ITS technologies in the United States. It is unlikely that any single metropolitan area or state would plan to implement the entire national ITS architecture (15).

**Natural Language Processing (NLP):** a form of artificial intelligence that enables a vehicle to understand and respond to natural human speech (3).

**No Automation (Level 0):** the SAE definition for the driving level that requires complete human interaction for all driving tasks (5).

## **0**

**Object Event Detection and Response (OEDR):** the subtasks of the dynamic driving task (DDT) that include monitoring the driving environment (i.e., detecting, recognizing, and classifying objects and events and preparing to respond as needed) and executing an appropriate response to such objects and events (i.e., as needed to complete the DDT and/or DDT fallback) (as defined by SAE J3016) (5).

**Obstacle Detection:** an advanced driver assistance system feature that detects slow-moving or stationary objects in front of a vehicle and alerts the driver to use the brakes (6).

**On-Demand Scheduling:** see *Just-in-Time (JIT) Delivery*.

**Onboard Equipment (OBE):** computer modules, display, and a dedicated short-range communications radio, which are installed and embedded into vehicles and provide an interface to vehicular sensors and a wireless communication interface to the roadside and back-office environment (1). The Federal Communications Commission (FCC) has issued a ruling to reallocate the spectrum that is dedicated to transportation safety. While there was a 75-MHz allocation for DSRC, FCC has made the lower 45 MHz of the 5.9-GHz band available for unlicensed operations such as Wi-Fi and allocated the upper 30 MHz for cellular-vehicle-to-everything operations (24). Existing DSRC licenses are able to continue operating in the upper 30 MHz; however, existing operations in the lower 45 MHz are required to cease operations after the one-year transition period.

**Onboard Unit (OBU):** a vehicle-mounted device used to transmit and receive a variety of message traffic to and from other connected devices (other OBUs and roadside units). Among the message types and applications supported by this device are vehicle safety messages used to exchange information on each vehicle's dynamic movements for coordination and safety (1).

**Operational Design Domain (ODD):** the specific conditions under which a given driving automation system or feature thereof is designed to function, including but not limited to driving modes. This can incorporate a variety of limitations, such as those from geography, traffic, speed, and roadways (as defined by SAE J3016) (5).

**Operator:** defined in Title 7 §642.001 of the Texas Transportation Code as “the person who is in actual physical control of a motor vehicle” (8).

**Original Equipment Manufacturer (OEM):** a company that designs and produces a product (6).

**Over-Size/Overweight Warning:** a system that detects if vehicles are over-size or overweight, typically using weigh in motion, lasers, global positioning system, and connected devices to inform drivers (37).

**Over-the-Air (OTA) Update:** software or firmware updates for a vehicle that are downloaded from the cloud (3).

**Owner:** the person or entity having administrative and fiscal responsibility for the owned element and the right to exclusively control and use it for one’s own purposes. Ownership is the state or fact of having exclusive possession or control of some object, facility, intellectual property, or some other kind of property (1). The Texas Transportation Code has the following definitions of owner:

- Title 7 §541.001 defines the owner as “a person who has a property interest in or title to a vehicle. The term: (a) includes a person entitled to use and possess a vehicle subject to a security interest; and (b) excludes a lienholder and a lessee whose lease is not intended as security.”
- Title 7 §501.001 defines the owner as “a person, other than a manufacturer, importer, distributor, or dealer, claiming title to or having a right to operate under a lien a motor vehicle that has been subject to a first sale.”
- Title 7 §502.001 defines the owner as “a person who: (a) holds the legal title of a vehicle; (b) has the legal right of possession of a vehicle; or (c) has the legal right of control of a vehicle” (8).

## **P**

**Partial Automation (Level 2):** the SAE definition for the automation driving level where the vehicle is equipped with one or more driver assistance technologies that execute both steering or acceleration and deceleration, but requires human interaction for the remaining driving tasks (5).

**Pedestrian:** any person not in or on a motor vehicle or other vehicle, excluding people in buildings or sitting at a sidewalk cafe. The National Highway Traffic Safety Administration also uses another pedestrian category to refer to pedestrians using conveyances and people in buildings. Examples of pedestrian conveyances include skateboards, nonmotorized wheelchairs, roller skates, sleds, and transport devices used as equipment (15).

**Pedestrian Data:** data about and pertaining to pedestrians.

**Pedestrian Walkway:** a continuous way designated for pedestrians and separated from the through lanes for motor vehicles by space or barrier (Title 23 §217 of the U.S. Code of Federal Regulations) (15).

**Personal Delivery Device:** defined in Title 7 §552A.0001 of the Texas Transportation Code as “a device that: (a) is manufactured primarily for transporting cargo in a pedestrian area or on the side or shoulder of a highway; and (b) is equipped with automated driving technology, including software and hardware, that enables the operation of the device with the remote support and supervision of a human” (8).

**Personal Vehicle Sharing (PVS):** the sharing of privately owned vehicles where companies broker transactions among car owners and renters by providing the organizational resources needed to make the exchange possible (e.g., online platform, customer support, driver and motor vehicle safety certification, auto insurance, and technology) (17).

**Personally Identifiable Information (PII):** information about a human being, living or deceased, regardless of nationality, that permits identification of that individual to be reasonably inferred by either direct or indirect means (38).

**Petabyte (PB):** 1,000 terabytes.

**Platooning:** the method of grouping vehicles together through artificial intelligence, which enables vehicles to accelerate and brake simultaneously (6).

**Position, Navigation, and Timing (PNT):** a combination of three distinct, constituent capabilities:

- Positioning, the ability to accurately and precisely determine one’s location and orientation two-dimensionally (or three-dimensionally when required) referenced to a standard geodetic system (e.g., World Geodetic System 1984).
- Navigation, the ability to determine the current and desired position (relative or absolute) and apply corrections to course, orientation, and speed to attain a desired position anywhere around the world, from subsurface to surface and from surface to space.
- Timing, the ability to acquire and maintain accurate and precise time from a standard (e.g., Coordinated Universal Time), anywhere in the world and within user-defined timeliness parameters (39).

***Preparing for the Future of Transportation: Automated Vehicles 3.0 (AV 3.0):*** a U.S. Department of Transportation (USDOT) guidance document that builds upon *Automated Driving Systems: A Vision for Safety 2.0* and expands the scope to provide a USDOT framework and multimodal approach to the safe integration of automated vehicles into the nation’s broader surface transportation system (5).

**Privacy:** the ability of individuals to seclude information about themselves and thereby reveal information about themselves selectively (1).

**Private Carrier:** a carrier that provides transportation service to the firm that owns or leases the vehicles and does not charge a fee (15).

**Privately Owned Vehicle (POV):** a privately owned vehicle or privately operated vehicle (15).

**Proprietary Information:** information owned by an individual or organization that is protected by copyright, patent, trademark, or trade secret laws (40).

**Public Liability:** defined in Title 49 §387 of the U.S. Code of Federal Regulations as “liability for bodily injury or property damage and includes liability for environmental restoration” (15).

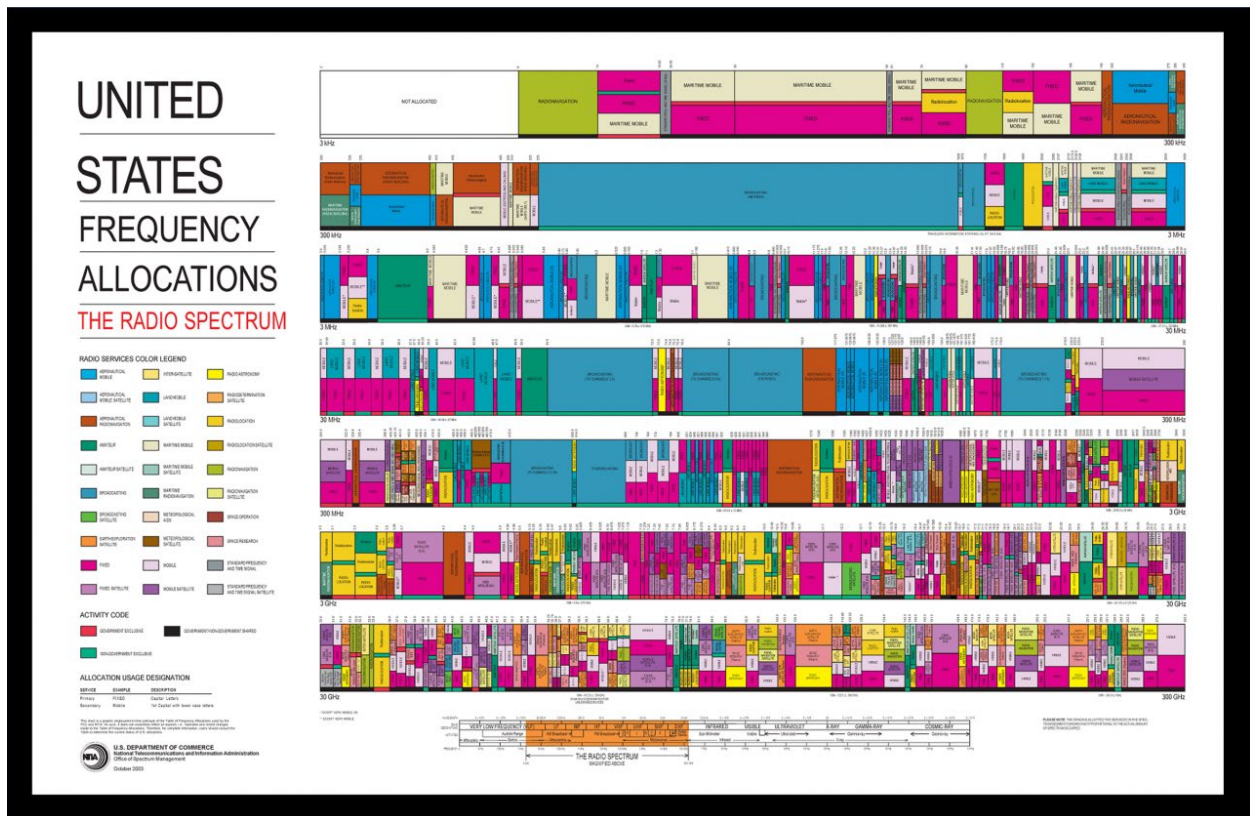
## **Q**

No terms.

## **R**

**Radar:** a system that emits radio waves and processes the reflections to detect and locate objects (14).

**Radio Spectrum:** the radio frequency portion of the electromagnetic spectrum, specifically the part ranging from 1 Hz to 3,000 GHz (3 THz). Currently, only frequency bands between 9 kHz and 275 GHz have been allocated (i.e., designated for use under specified conditions) (27). The spectrum is divided into different frequency bands, and each band has been allocated for a specific application, ranging from aeronautical and maritime communication to AM and FM radio stations (41). Figure 2 shows the frequency allocations on the radio spectrum.



Source: U.S. Department of Transportation

Figure 2. U.S. Frequency Allocations on the Radio Spectrum.

**Real-Time Data (RTD):** immediately available data that are collected continuously (6).

**Real-Time Kinematics (RTK):** a navigation positioning technique using carrier measurements and the transmission of corrections from the base station that provides a precise position location (6).

**Real-Time Traffic Information (RTTI):** a service that provides current information about the roadway to drivers (6).

**Regional Intelligent Transportation System (ITS) Architecture:** a specific, tailored framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects in a particular region. The architecture functionally defines what pieces of the system are linked to others and what information is exchanged between them (1).

**Registered Owner:** see *Owner*.

**Reliability:** the degree of certainty and predictability in travel times on the transportation system. Reliable transportation systems offer some assurance of attaining a given destination within a reasonable range of an expected time. An unreliable transportation system is subject to unexpected delays, increasing costs for system users (15).



**Remote Driver:** a driver who is not seated in a position to manually exercise in-vehicle braking, acceleration, steering, and transmission gear selection of input devices (if any) but is able to operate the vehicle (as defined by SAE J3016) (5).

**Remote Vehicle:** a connected vehicle that periodically and dynamically broadcasts a message about its general situation to a host vehicle (1).

**Responsibility:** the state of being morally, legally, or mentally accountable (14).

**Retrofit Device:** a piece of equipment installed on a vehicle after the purchase (6).

**Ride Hailing:** see *Transportation Network Company (TNC)*.

**Ride Share Service:** see *Transportation Network Company (TNC)*.

**Ridesourcing:** see *Transportation Network Company (TNC)*.

**Right of Way:** defined in Title 7 §541.001 of the Texas Transportation Code as “the right of one vehicle or pedestrian to proceed in a lawful manner in preference to another vehicle or pedestrian that is approaching from a direction, at a speed, and within a proximity that could cause a collision unless one grants precedence to the other” (8). This is the land (usually a strip) acquired for or devoted to highway transportation purposes (15).

**Risk:** defined in Title 23 §515.5 of the U.S. Code of Federal Regulations as “the positive or negative effects of uncertainty or variability upon agency objectives” (42). Risk is the potential for positive or negative effects based on actions taken.

**Risk Management:** defined in Title 23 §515.5 of the U.S. Code of Federal Regulations as “the processes and framework for managing potential risks, including identifying, analyzing, evaluating, and addressing the risks to assets and system performance” (42).

**Road:** an open way for the passage of vehicles, persons, or animals on land (15).

**Roadside:** the strip of land along the side of the roadway (14).

**Roadside Equipment (RSE):** the complement of equipment to be located at the roadside. The RSE prepares and transmits messages to the vehicles and receives messages from the vehicles for the purpose of supporting vehicle-to-infrastructure applications (20).

**Roadside Unit (RSU):** a connected device that is only allowed to operate from a fixed position (which may in fact be a permanent installation or temporary equipment brought on site for a period of time associated with an incident, road construction, or other event). Some RSUs may have connectivity to other nodes or the internet (1, 19).

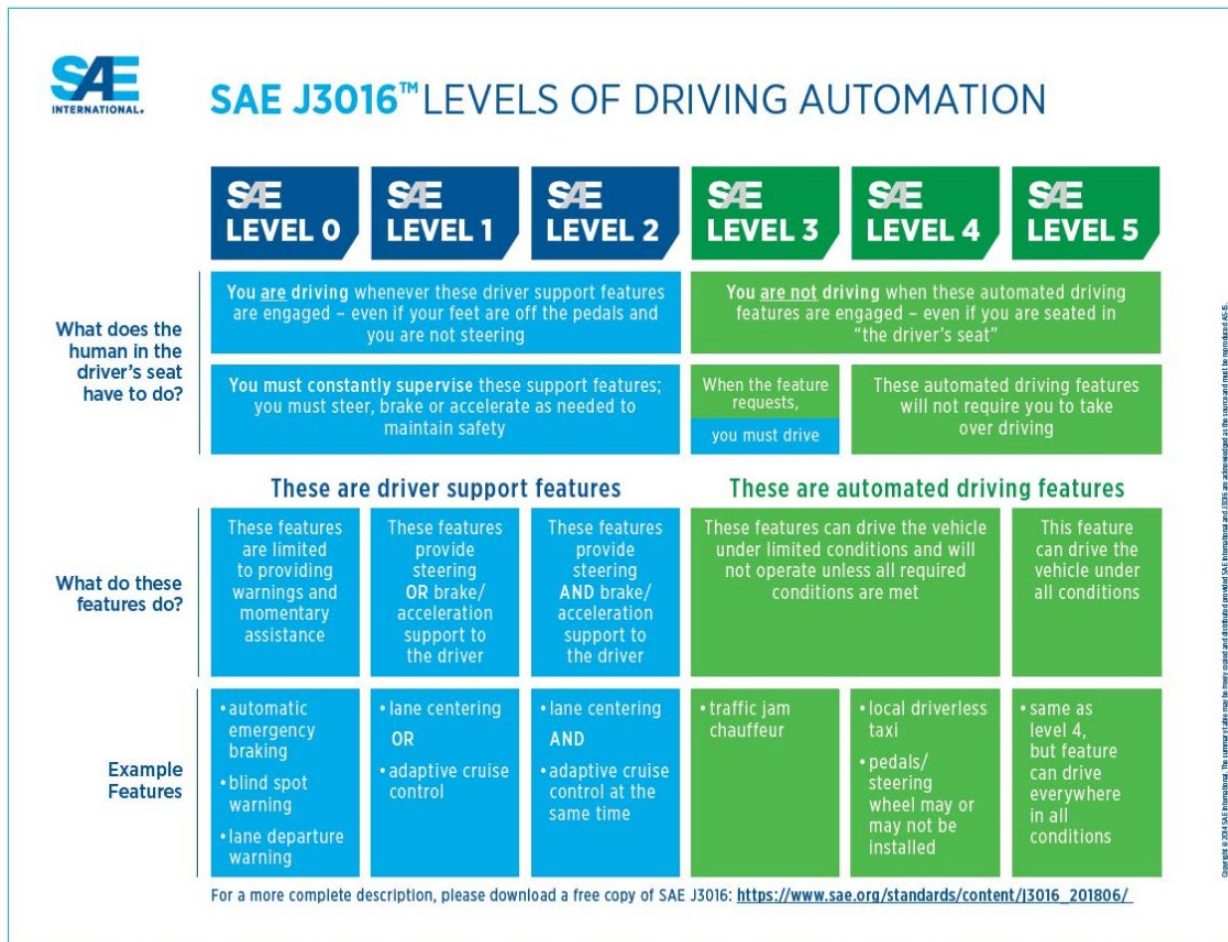
**Roadway:** defined in Title 7 §541.001 of the Texas Transportation Code as “the portion of a highway, other than the berm or shoulder, that is improved, designed, or ordinarily used for vehicular travel. If a highway includes at least two separate roadways, the term applies to each roadway separately” (8).

**Roadway User:** an individual that has access to and operates on a roadway.

**Robotaxi:** any vehicle that delivers people without the need for a human driver.

**S**

**SAE Level of Automation:** see *No Automation (Level 0), Driver Assistance (Level 1), Partial Automation (Level 2), Conditional Automation (Level 3), High Automation (Level 4), and Full Automation (Level 5)*. Figure 3 illustrates the different levels of automation.



Source: SAE International

Figure 3. SAE-Defined Levels of Automation.

**Safety:** the state of being free from hurt, injury, or loss (14).

**Safety Operator:** see *In-Vehicle Fallback Test Driver (IFTD)*.

**Security:** the state of being free from danger, fear, or anxiety (14).

**Security Credential Management System (SCMS):** a message security solution for vehicle-to-vehicle and vehicle-to-infrastructure communication that uses a public-key infrastructure-based approach that employs highly innovative methods of encryption and certificate management to facilitate trusted communication (43).

**Self-Driving Vehicle:** a vehicle that is able to drive by itself using onboard sensors and is equivalent to high automation (Level 4) (6).

**Sensor Fusion (Fuse):** the second of the three stages of in-vehicle computing that is used for autonomous driving. The vehicle compares and combines sensor data to build a model of its environment (3).

**Shared Mobility:** the shared use of a motor vehicle, bicycle, or other low-speed transportation mode (17).

**Shared Service:** see *Shared Mobility*.

**Short-Range Radar (SRR):** a high-performance sensor, operating at 77 GHz, that is used in forward and backward applications (44).

**Short-Range Wireless Communications:** a wireless communications channel used for close-proximity communications between vehicles, mobile/personal devices, and the immediate infrastructure. Short-range wireless communications supports location-specific communications for intelligent transportation system capabilities such as vehicle safety, transit vehicle management, driver information, roadway payments, and automated commercial vehicle operations (1).

**Sign:** defined in Title 6 §393.001 of the Texas Transportation Code as “an outdoor sign, display, light, device, figure, painting, drawing, message, plaque, poster, or other thing designed, intended, or used to advertise or inform” (8).

**Signal:** an object used to convey information (14).

**Signal Phase and Timing (SPaT):** a message type that describes the current state of a signal system and its phases and relates this to the specific lanes (and therefore to movements and approaches) in the intersection. SPaT is used along with Map Data Message (MAP) messages to describe an intersection and its currently allowed movements (1).

**Signal Priority:** see *Bus Signal Priority (BSP)*, *Freight Signal Priority (FSP)*, and *Transit Signal Priority (TSP)*.

**Signalized Intersection Approach and Departure:** an automated vehicle application that communicates with infrastructure using signal phase and timing and Map Data Message (MAP) messages to automate the movement of single or multiple automated vehicles through intersections to increase traffic flow and safety (as defined by the Federal Highway Administration) (5).

**Smart Parking Facilities for Connected and Autonomous Vehicles:** a facility used to contain fully autonomous vehicles while not in use. The vehicles could park very close together because no humans would need to enter or exit the vehicle at the parking location, so the spacing between vehicles would not need to be large.

**Smart Work Zone System:** the application of computers, communications, and sensor technology designed to improve the safety of highway workers and the traveling public by predicting travel time, delay, or speed on a freeway work zone in real time (45).

**Social Equity:** equal access for all people to the use of technologies and products (6).

**Software Development Kit (SDK):** the set of tools that decrease the time developers need to build software (6).

**Speed Harmonization:** a strategy to increase traffic flow enabled by communications between an automated vehicle and infrastructure to change the traffic speed on roads that approach areas of traffic congestion, bottlenecks, incidents, special events, and other conditions that affect flow (as defined by the Federal Highway Administration) (5).

## **T**

**Tele-assist:** see *Telematics*.

**Telematics:** the process of sending, receiving, and storing information through communication technologies that enables the monitoring, management, and potentially control of objects remotely (6).

**Teleoperated Driving System:** see *Autonomous Delivery Vehicle*, *Remote Driver*, and *Zero-Occupancy Vehicle*.

**Teleoperations:** the operation of an object or device from a distance.

**Terabyte (TB):** 1,000 gigabytes.

**Traffic Management:** the management of the movement of all types of vehicles, travelers, and pedestrians throughout the transportation network. Traffic management deals with information collection, dissemination, and processing for the surface transportation system. Traffic management covers automated monitoring and control activities, decision-making processes (both automated and manual) that address real-time incidents and other disturbances on the transportation network, and management of travel demand as needed to maintain overall mobility (1).

**Transfer Hub:** see *Transport Hub*.

**Transit Signal Priority (TSP):** an operational strategy that grants transit vehicles the right of way at signalized intersections with the goal of improving travel time and reliability (46).

**Transport as a Service (TaaS):** see *Mobility as a Service (MaaS)*.

**Transport Hub:** the location where multiple modes of transportation connect to allow passengers and cargo to change transportation modes or services (e.g., bus stops, parking lots, or truck terminals).

**Transportation Demand Management (TDM):** programs designed to reduce demand for transportation through various means, such as the use of public transit and alternative work hours (1).

**Transportation Management Center (TMC):** a center that provides real-time highway monitoring, incident detection, response coordination/support, and distribution of traveler information. Normally, TMCs are open 24 hours a day and 7 days a week but are at least open during peak periods (11).

**Transportation Network Company (TNC):** a ridesourcing service (also known as ride hailing) that provides prearranged and on-demand transportation services for compensation, connecting drivers of personal vehicles with passengers. Smartphone mobile applications are used for bookings, ratings (for both drivers and passengers), and electronic payment. TNCs can offer a variety of vehicle types including sedans, sport utility vehicles, vehicles with car seats, wheelchair-accessible vehicles, and vehicles where the driver can assist older or disabled passengers (17).

**Transportation System Management and Operations (TSMO):** a set of strategies that focus on operational improvements that can maintain and even restore the performance of the existing transportation system before extra capacity is needed (47).

**Transportation Worker Identification Credential (TWIC):** defined by Title 49 §1570.3 of the U.S. Code of Federal Regulations as “a Federal biometric credential, issued to an individual, when TSA [the Transportation Security Administration] determines that the individual does not pose a security threat” (42).

## **U**

**Ultrasonic Sensor:** a sensor with a frequency above 20,000 Hz (14).

**Unmanned Aircraft (UA):** any aircraft operated without a pilot on board (48).

**Unmanned Aircraft System (UAS):** an unmanned aircraft and the equipment that is used to operate it remotely (48).

**U.S. Department of Transportation (USDOT):** the principal direct federal funding agency for transportation facilities and programs in the United States. USDOT includes the Research and Innovative Technology Administration, the Federal Highway Administration, the Federal Transit Administration, the Federal Railroad Administration, and others (1).

**U.S. Department of Transportation Automated Vehicles Activities:** see *Automated Driving Systems: A Vision for Safety 2.0 (ADS 2.0)*, *Preparing for the Future of Transportation: Automated Vehicles 3.0 (AV 3.0)*, and *Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0 (AV 4.0)*.

## V

**Vehicle Platooning:** defined by the Federal Highway Administration as a group of automated vehicles, with and without human drivers, that use communications to enable negotiations between vehicles to support organized behavior and safe close following (5).

**Vehicle Safety:** addresses vehicle safety for automated, connected, and non-equipped vehicles. The focus of vehicle safety is on the enhancement of safety, security, and efficiency in vehicle operations, by warnings and assistance to users or input to the operation of the vehicle (1).

**Vehicle to Cloud (V2C):** a communication system designed to wirelessly exchange information between a vehicle and the cloud (49).

**Vehicle to Device (V2D):** a communication system designed to wirelessly exchange information between a vehicle and any smart device (49).

**Vehicle to Everything (V2X):** the convergence of automotive and information technology, often using sensors and mobile technology that allows a vehicle to communicate with another device or system (49).

**Vehicle to Infrastructure (V2I):** a communication system designed to wirelessly exchange information between a vehicle and the infrastructure (20).

**Vehicle to Network (V2N):** a communication system using dedicated short-range communications and cellular networks to communicate with the vehicle-to-everything management system (49).

**Vehicle to Pedestrian (V2P):** a communication system designed to wirelessly exchange information between a vehicle and pedestrians (49).

**Vehicle to Vehicle (V2V):** a communication system designed to transmit basic safety information between vehicles to facilitate warnings to drivers concerning impending crashes (20).

**Vision Processing:** the technologies used to provide image-based analysis (3). See *Machine Vision*.

**Vulnerable Road User:** the individuals, such as pedestrians and bicyclists, that are most at risk in traffic operations because they are less protected from injury (50).

## W

**Wide-Area Wireless Communications:** a communications link that provides communication via a wireless device between a user and an infrastructure-based system (1).

**Wireless Access for Vehicular Environments (WAVE):** a radio communications system intended to provide seamless, interoperable services to transportation (20).

**Wireless Local Area Network (WLAN):** commonly referred to as Wi-Fi, a local radio network that operates under IEEE-802 (6).

**Work Zone:** an area of a highway with construction, maintenance, or utility work activities. A work zone is typically marked by signs, channelizing devices, barriers, pavement markings, and/or work vehicles. A work zone extends from the first warning sign or high-intensity rotating, flashing, oscillating, or strobe lights on a vehicle to the END ROAD WORK sign or the last temporary traffic control device (according to the *Manual on Uniform Traffic Control Devices for Streets and Highways* 2009, Section 6C.02) (1).

## **X**

No terms.

## **Y**

**Yottabyte (YB):** 1,000 zettabytes.

## **Z**

**Zero-Occupancy Vehicle:** see *Autonomous Delivery Vehicle*.

**Zettabyte (ZB):** 1,000 exabytes.

## **References**

1. U.S. Department of Transportation. Glossary. The National ITS Reference Architecture. <http://local.iteris.com/arc-it/html/glossary/glossary-a.html>.
2. Dykes, A. 4G LTE Meaning and Definition. Webopedia. [https://www.webopedia.com/TERM/4/4G\\_LTE.html](https://www.webopedia.com/TERM/4/4G_LTE.html).
3. Intel. *Autonomous Driving Glossary*. <https://newsroom.intel.com/wp-content/uploads/sites/11/2017/05/Autonomous-Driving-Glossary.pdf>.
4. Federal Highway Administration Office of Operations. What Is Access Management? [https://ops.fhwa.dot.gov/access\\_mgmt/what\\_is\\_accsmgmt.htm](https://ops.fhwa.dot.gov/access_mgmt/what_is_accsmgmt.htm).
5. U.S. Department of Transportation. *Preparing for the Future of Transportation: Automated Vehicles 3.0*. October 2018. <https://www.transportation.gov/av/3>.
6. Park, H., Z. Khattak, and B. Smith. *Glossary of Connected and Automated Vehicle Terms*. University of Virginia Center for Transportation Studies, March 2018. <http://www.cts.virginia.edu/wp-content/uploads/2018/03/Glossary-of-CAV-Terms-Ver1.0-03052018-1.pdf>.
7. Geodetics Inc. Assured PNT. <https://geodetics.com/navigation-systems/>.
8. Texas Transportation Code. <https://statutes.capitol.texas.gov/?link=TN>.

9. National Highway Traffic Safety Administration. *Automated Driving Systems: A Vision for Safety 2.0*. September 2017. [https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0\\_090617\\_v9a\\_tag.pdf](https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf).
10. National Highway Traffic Safety Administration. *Driver Assistance Technologies*. <https://www.nhtsa.gov/equipment/driver-assistance-technologies>.
11. Federal Highway Administration Office of Operations. *Roles of Transportation Management Centers in Incident Management on Managed Lanes: Glossary of Terms*. <https://ops.fhwa.dot.gov/publications/fhwahop14022/glossary.htm>.
12. Federal Aviation Administration. *Land Use Compatibility and Airports*. [https://www.faa.gov/about/office\\_org/headquarters\\_offices/apl/noise\\_emissions/planning\\_toolkit/media/III.B.pdf](https://www.faa.gov/about/office_org/headquarters_offices/apl/noise_emissions/planning_toolkit/media/III.B.pdf).
13. Williams, T., J. Wagner, C. Morgan, K. Hall, I. Sener, G. Stoeltje, and H. Pang. *Transportation Planning Implications of Automated Vehicles on Texas Highways*. Research Report 0-6848-1. Texas A&M Transportation Institute, April 2017. <https://static.tti.tamu.edu/tti.tamu.edu/documents/0-6848-1.pdf>.
14. Merriam-Webster. Dictionary. <https://www.merriam-webster.com/>.
15. Federal Highway Administration Office of Planning, Environment, and Realty. *Planning Glossary*. [https://www.fhwa.dot.gov/Planning/glossary/glossary\\_listing.cfm?TitleStart=B](https://www.fhwa.dot.gov/Planning/glossary/glossary_listing.cfm?TitleStart=B).
16. National Institute of Standards and Technology Computer Security Resource Center. *Glossary*. <https://csrc.nist.gov/glossary>.
17. Shaheen, S., A. Cohen, and I. Zohdy. *Shared Mobility: Current Practices and Guiding Principles*. Federal Highway Administration, April 2016. <https://ops.fhwa.dot.gov/publications/fhwahop16022/index.htm>.
18. GSMA. *Cellular Vehicle-to-Everything (C-V2X)*. [https://www.gsma.com/iot/wp-content/uploads/2017/12/C-2VX-Enabling-Intelligent-Transport\\_2.pdf](https://www.gsma.com/iot/wp-content/uploads/2017/12/C-2VX-Enabling-Intelligent-Transport_2.pdf).
19. Federal Highway Administration Office of Operations. *Scoping and Conducting Data-Driven 21st Century Transportation System Analyses: Glossary*. <https://ops.fhwa.dot.gov/publications/fhwahop16072/glossary.htm>.
20. Intelligent Transportation Systems Joint Program Office. *Module I261: Vehicle-to-Infrastructure (V2I) ITS Standards for Project Managers*. ITS Professional Capacity Building Program. <https://www.pcb.its.dot.gov/StandardsTraining/mod43/sup/m43sup.htm>.



21. National Operations Center of Excellence. Cooperative Automated Transportation (CAT) Coalition. <https://transportationops.org/CATCoalition>.
22. University of Michigan Transportation Research Institute. Curve Speed Warning Systems. <http://www.umtri.umich.edu/our-focus/curve-speed-warning-systems>.
23. Knight, M. What Is Data Governance? Dataversity, Data Topics, December 18, 2017. <https://www.dataversity.net/what-is-data-governance/>.
24. Federal Communications Commission. FCC Seeks to Promote Innovation in the 5.9 GHz Band. December 12, 2019. <https://www.fcc.gov/document/fcc-seeks-promote-innovation-59-ghz-band>.
25. Knight, M. What Is Edge Computing? Dataversity, Data Topics, August 12, 2020. <https://www.dataversity.net/what-is-edge-computing/>.
26. U.S. Department of Transportation. *Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0*. January 8, 2020. <https://www.transportation.gov/av/4>.
27. Federal Communications Commission. Radio Spectrum Allocation. <https://www.fcc.gov/engineering-technology/policy-and-rules-division/general/radio-spectrum-allocation>.
28. Federal Motor Carrier Safety Administration. Who We Are. <https://www.fmcsa.dot.gov/mission/who>.
29. National Highway Traffic Safety Administration. Laws and Regulations. <https://www.nhtsa.gov/laws-regulations>.
30. Chamberlain, L. GeoMarketing 101: What Is Geofencing? GeoMarketing, March 7, 2016. <https://geomarketing.com/geomarketing-101-what-is-geofencing>.
31. Vardhan, H. HD Maps: New Age Maps Powering Autonomous Vehicles. Geospatial World, September 22, 2017. <https://www.geospatialworld.net/article/hd-maps-autonomous-vehicles/>.
32. Sparton. What Is an IMU? September 16, 2015. <https://www.spartonnavex.com/imu/>.
33. Fluke. How Infrared Cameras Work. <https://www.fluke.com/en-us/learn/best-practices/measurement-basics/thermography/how-infrared-cameras-work>.

34. Bosch Mobility Solutions. Long-Range Radar Sensor. <https://www.bosch-mobility-solutions.com/en/products-and-services/passenger-cars-and-light-commercial-vehicles/driver-assistance-systems/automatic-emergency-braking/long-range-radar-sensor/>.
35. Bosch Mobility Solutions. Mid-range Radar Sensor (MRR Rear). <https://www.bosch-mobility-solutions.com/en/products-and-services/passenger-cars-and-light-commercial-vehicles/driver-assistance-systems/lane-change-assist/mid-range-radar-sensor-mrrrear/>.
36. Shaheen, S., A. Cohen, B. Yelchuru, and S. Sarkhili. *Mobility on Demand Operational Concept Report*. U.S. Department of Transportation Intelligent Transportation Systems Joint Program Office, September 2017. <https://rosap.ntl.bts.gov/view/dot/34258>.
37. Middleton, D., Y. Li, J. Le, and N. Koncz. *Accommodating Oversize and Overweight Loads: Technical Report*. Research Report O-6404-1. Texas A&M Transportation Institute, July 2012. <https://static.tti.tamu.edu/tti.tamu.edu/documents/O-6404-1.pdf>.
38. U.S. Department of Transportation. Information Technology (IT). <https://www.transportation.gov/transition/information-technology>.
39. U.S. Department of Transportation. What Is Positioning, Navigation and Timing (PNT)? <https://www.transportation.gov/pnt/what-positioning-navigation-and-timing-pnt>.
40. Law Insider. *Proprietary Information* Definition. <https://www.lawinsider.com/dictionary/proprietary-information>.
41. U.S. Department of Transportation. What Is Radio Spectrum? <https://www.transportation.gov/pnt/what-radio-spectrum>.
42. Electronic Code of Federal Regulations. Homepage. <https://www.ecfr.gov/>.
43. Intelligent Transportation Systems Joint Program Office. *Security Credential Management System (SCMS)*. [https://www.its.dot.gov/factsheets/pdf/CV\\_SCMS.pdf](https://www.its.dot.gov/factsheets/pdf/CV_SCMS.pdf).
44. Continental. Short Range Radar. <https://www.continental-automotive.com/en-gl/Passenger-Cars/Autonomous-Mobility/Enablers/Radars/Short-Range-Radar>.
45. Pant, P. *Smart Work Zone Systems*. Federal Highway Administration Office of Operations. [https://ops.fhwa.dot.gov/wz/workshops/accessible/Pant\\_paper.htm](https://ops.fhwa.dot.gov/wz/workshops/accessible/Pant_paper.htm).
46. Intelligent Transportation Systems Joint Program Office. *ITS ePrimer*. <https://www.pcb.its.dot.gov/eprimer/default.aspx>.
47. Federal Highway Administration. What Is TSMO? <https://ops.fhwa.dot.gov/tsmo/index.htm>.

48. Skybrary. Unmanned Aerial Systems (UAS).  
[https://www.skybrary.aero/index.php/Unmanned Aerial Systems \(UAS\)](https://www.skybrary.aero/index.php/Unmanned_Aerial_Systems_(UAS)).
49. RGSBI. 7 Types of Vehicle Connectivity. <https://blog.rgsbi.com/7-types-of-vehicle-connectivity>.
50. Organization for Economic Cooperation and Development. *Safety of Vulnerable Road Users*. Directorate for Science, Technology and Industry, August 1998.  
[http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/DOT/RTR/RS7\(98\)1/FINAL&docLanguage=En](http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/DOT/RTR/RS7(98)1/FINAL&docLanguage=En).