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CHAPTER 1

Introduction to Advanced Driver Assistance Systems

LEARNING OUTCOMES

After studying the chapter, the reader should be able to:

- Define and explain the purpose of ADAS.
- Compare and contrast active safety systems and automated driving systems.
- List benefits and drawbacks of ADAS.
- Describe the SAE levels of driving automation.

TECHNICAL TERMS

active safety system
active system
advanced driver assistance system (ADAS)
automated driving system (ADS)
autonomous system
dedicated short-range communication (DSRC)
passive system

Introduction

Advanced driver assistance systems (ADAS) was initially used to describe additional safety features. It is now an umbrella term for advanced technological systems that assist drivers with their driving experience.

History of ADAS

Advanced driver assistance systems based on internet technology go back to the early 1990s, when some vehicle manufacturers in Japan started to use a form of adaptive cruise control (ACC). At the time that ACC was evolving in Japan, European and US manufacturers were still offering vehicles with very limited systems. Vehicles with advanced systems started to become more available in the US and Europe in the mid-2000s. These more advanced systems were primarily adaptive cruise control (ACC), blind spot detection (BSD), and parking assistance (PA). While PA was available and common, ACC and BSD were rare at that time because of the cost; they were typically limited to higher-end European brands. The official term *advanced driver assistance systems (ADAS)* did not come into use until 2014.

Overview of ADAS

Advanced driver assistance systems (ADAS) are electronic systems that use advanced technology to improve the driving experience. Some ways that ADAS affect a driving experience include the following:

- Increase driving safety.
- Make the drive more comfortable.
- Improve vehicle efficiency.

Some examples of features that increase driving safety are the head-up display (HUD), tire pressure monitoring system (TPMS), and hill descent control (HDC). Environmental sensors, such as those that detect the temperature of the inside of the vehicle, can improve vehicle comfort. Fuel efficiency can also be improved by leveraging traffic, weather, and high-resolution terrain mapping. Many more ADAS features are shown in **Figure 1-1**.

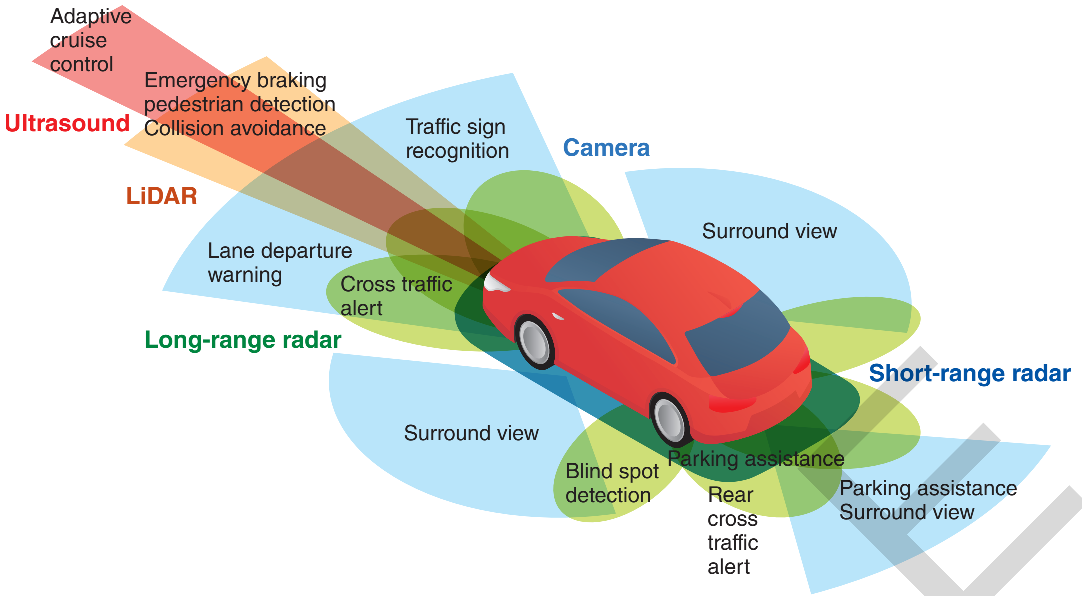

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Figure 1-1. Perception systems and features of a typical ADAS-equipped vehicle.

Deep Dive

Early autonomous systems emerged in the first part of the twentieth century. In 1925, Charles Adler installed an electromagnetic device in the road to shut down the engine's ignition system and slow the vehicle around a very sharp bend. This was a very early version of what today would be considered a smart road.

In the 1950s, more early autonomous systems emerged. In 1952, Cadillac and Oldsmobile incorporated General Motors's automatic headlight dimmer, marketed as the Autotronic Eye, into their vehicles. In addition, at the 1956 Motorama, the Firebird II, shown in **Figure 1-2**, had an exhaust heat regenerator that lowered exhaust temperature by one third and improved the fuel economy. Capable of following wire embedded in the roadway, Firebird II navigated autonomously.

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Figure 1-2. The 1956 Firebird II concept car on display as part of the GM Heritage Collection.

Manufacturer Branding

In many cases, manufacturers apply their own branding to ADAS used in their vehicles. Some brand names for comprehensive ADAS offerings are the Toyota Safety Sense, Tesla Autopilot, Cadillac Super Cruise, Ford Co-Pilot360, and the VW IQ.DRIVE. The wide variety of names extends down to individual systems and is showcased in a survey of 34 vehicle brands conducted by the American Automobile Association (AAA), shown in **Figure 1-3**.

The terminology for ADAS is still evolving in the automotive industry. Organizations with an interest in ADAS have proposed a universal terminology based on the definitions of systems, shown in **Figure 1-4**. This proposed terminology eliminates the various acronyms used to describe similar systems with the goal of standardized ADAS terms and definitions. Manufacturers are encouraged to use these terms and definitions when describing their branded systems.

Pro Tip

To become more familiar with identifying ADAS-equipped vehicles, walk around every vehicle that comes in for service. Look for blind spot detection (BSD) indicators in the outside mirrors or cover blanks, lenses in the center grill area in the front of the vehicle, forward-facing cameras, and ultrasonic sensors in the bumpers. Within the interior, look at the control buttons on the dash and steering wheel for ADAS-related symbols.

Survey of Unique ADAS Feature Names

ADAS Feature	Number of Unique Names
Automatic Emergency Braking	40
Adaptive Cruise Control	20
Surround View Camera	20
Lane Keeping Assistance	19
Blind Spot Warning	19
Automatic High Beams	18
Rear Cross Traffic Warning	15
Driver Monitoring	13
Semi-Automated Parking Assist	12
Forward Collision Warning	8
Night Vision and Pedestrian Detection	5

AAA—The American Automobile Association, Inc.

Figure 1-3. Survey results from the AAA showing the number of different names 34 brands had for specific ADAS.

Collision Warning

Terminology	Definition
Blind Spot Warning	Detects vehicles in the blind spot while driving and notifies the driver to their presence. Some systems provide an additional warning if the driver activates the turn signal.
Forward Collision Warning	Detects a potential collision with a vehicle ahead and alerts the driver. Some systems also provide alerts for pedestrians or other objects.
Lane Departure Warning	Monitors vehicle's position within the driving lane and alerts driver as the vehicle approaches or crosses lane markers.
Parking Collision Warning	Detects objects close to the vehicle during parking maneuvers and notifies the driver.
Rear Cross Traffic Warning	Detects vehicles approaching from the side at the rear of the vehicle while in reverse gear and alerts the driver. Some systems also warn for pedestrians or other objects.

Collision Intervention

Terminology	Definition
Automatic Emergency Braking	Detects potential collisions with a vehicle ahead, provides forward collision warning, and automatically brakes to avoid a collision or lessen the severity of impact. Some systems also detect pedestrians or other objects.
Automatic Emergency Steering	Detects potential collisions with a vehicle ahead and automatically steers to avoid or lessen the severity of impact. Some systems also detect pedestrians or other objects.
Lane Keeping Assistance	Provides steering support to assist the driver in keeping the vehicle in the lane. The system reacts only when the vehicle approaches or crosses a lane line or road edge.
Reverse Automatic Emergency Braking	Detects potential collisions while in reverse gear and automatically brakes to avoid or lessen the severity of impact. Some systems also detect pedestrians or other objects.

AAA—The American Automobile Association, Inc.

Figure 1-4. Proposed terminology and definitions for ADAS.

Continued

Driving Control Assistance

Terminology	Definition
Adaptive Cruise Control	Cruise control that also assists with acceleration and/or braking to maintain a driver-selected gap to the vehicle in front. Some systems can come to a stop and continue while others cannot.
Lane Centering Assistance	Provides steering support to assist the driver in continuously maintaining the vehicle at or near the center of the lane.
Active Driving Assistance[1]	Simultaneous use of **Lane Centering Assistance** and **Adaptive Cruise Control** features. The driver must constantly supervise this support feature and maintain responsibility for driving.

Parking Assistance

Terminology	Definition
Backup Camera	Displays the area behind the vehicle when in reverse gear.
Surround View Camera	Displays the immediate surroundings of some or all sides of the vehicle while stopped or during low-speed maneuvers.
Active Parking Assistance	Assists with steering and potentially other functions during parking maneuvers. Driver may be required to accelerate, brake, and/or select gear position. Some systems are capable of parallel and/or perpendicular parking. The driver must constantly supervise this support feature and maintain responsibility for parking.
Remote Parking Assistance[1]	Without the driver being physically present inside the vehicle, provides steering, braking, accelerating and/or gear selection while moving a vehicle into or out of a parking space. The driver must constantly supervise this support feature and maintain responsibility for parking.
Trailer Assistance	Assists the driver with visual guidance while backing toward a trailer or during backing maneuvers with a trailer attached. Some systems may provide additional images while driving or backing with a trailer. Some systems may provide steering assistance during backing maneuvers.

Driver Monitoring

Terminology	Definition
Indirect Driver Monitoring System	Observes vehicle states, motions and/or driver performance indicators to estimate driver distraction, inattention, or misuse. This may include monitoring steering wheel input, vehicle sway within the lane, or a combination of other factors monitored by the vehicle systems. Some systems may provide a warning to the driver and/or limit the use of other features.
Direct Driver Monitoring System	Detects the driver's eye and/or head movement to estimate where the driver is looking. Some systems may provide a warning to the driver and/or limit the use of other features.
Driver Re-engagement System	A series of escalating warnings and interventions attempting to engage an unresponsive driver. If the driver does not respond, the system brings the vehicle to a full stop while maintaining steering control. Some systems may steer the vehicle to the side of the road and/or make an emergency call if the driver fails to respond.

Other Driver Assistance Systems

Terminology	Definition
Automatic High Beams	Switches between high and low beam headlamps automatically based on lighting and traffic.
Head-Up Display	Projects information relevant to driving into the driver's forward line of sight.
Night Vision	Improves forward visibility at night by projecting enhanced images on instrument cluster or head-up display.

[1] Classified as Level 2 Driving Automation by SAE J3016

AAA—The American Automobile Association, Inc.

Figure 1-4. Continued.

Purpose of ADAS

The primary purposes of ADAS are to increase vehicle safety and reduce the driver's workload, which can result in a driver who is less stressed, less distracted, and better prepared to support other driving tasks. This creates a safer driving experience.

Drivers get distracted by activities or dangerous habits, such as texting while driving, as in **Figure 1-5**. That is when ADAS are particularly advantageous; they do not become distracted and can either avoid or mitigate a collision. The ADAS monitor the road, the blind spots, and the lane lines even if the driver becomes distracted.

Passive systems alert the driver with audio or visual signals and haptic warnings, and ***active systems*** take action, such as steering or activating brakes. These systems make for a much safer driving environment and will continue to improve well into the future.

Applications of ADAS

Advanced driver assistance systems are not limited to passenger vehicles, light trucks, and SUVs; they are also in use in public transportation vehicles; medium and heavy-duty trucks, as shown in **Figure 1-6**; off-road equipment; and farm machinery, such as the autonomous harvester in **Figure 1-7**.

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Figure 1-5. A driver's focus is dangerously taken off the road as they text while driving.

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Figure 1-6. Perception systems on a Class 8 truck classification.

Scharfsinn/Shutterstock.com

Figure 1-7. An autonomous harvester at work on a sugar beet field.

With the broad application of these systems and the transition to autonomous vehicles, service technicians for all applications will need to become fluent in these systems and the applicable servicing. While there will be application-specific variables, the foundational operation, components, diagnosis, and servicing will be very similar. This will allow service technicians to work on multiple vehicle applications of ADAS.

Active Safety Systems and Automated Driving Systems

Active safety systems are a type of ADAS designed to prevent or mitigate vehicle collisions using sensors and vehicle mechanical systems. Some examples of active safety systems are anti-lock braking systems (ABS), electronic stability control (ESC), and electric power steering (EPS), discussed in Chapter 5, *Fundamental Vehicle Systems*. While these systems can decrease the number of collisions and the severity of a vehicle collision if it does occur, they cannot overcome the laws of physics.

When systems are introduced into the marketplace, their *operational design domains (ODDs)* are specified. Operational design domains are the parameters within which the system can perform. It also specifies any system limitations. The automotive technician should always reference the vehicle's operation manual for specifics on ODD for each vehicle.

Automated driving systems (ADS) are systems designed to operate independent of driver input. These systems are more commonly referred to as ***autonomous systems***. Autonomous systems utilize the same perception and mechanical vehicle systems as ADAS, but they require higher levels of AI, computing power, and vehicle communications to operate. These systems utilize both passive and active systems to notify the driver and mitigate collisions. Autonomous systems are discussed in more detail later in this chapter.

Human versus Machine

Humans process large amounts of information from their surroundings every waking moment, such as sound, smell, and feel; however, they are easily distracted. In today's world, people—especially drivers—are bombarded with distractions that can break their concentration. A lapse in concentration results in an amount of time and distance that the vehicle has traveled while the driver was distracted.

The corrective action applied by an ADAS controller to avoid a collision is typically more accurate than a human's ability to avoid the collision. The human eye can process 24 frames per second, and the human brain can process that data at a speed of up to 40Hz. Once processed, the human brain can command a muscle reaction to move at 390 feet (119 meters) per second to avoid an issue.

In contrast, some ADAS controllers can process multiple camera feeds at up to 60 frames per second and perform computations on those inputs at speeds in the millions of times per second. This will only get faster as technology evolves. **Figure 1-8** shows how humans and computers react in the same driving situation given their processing speeds.

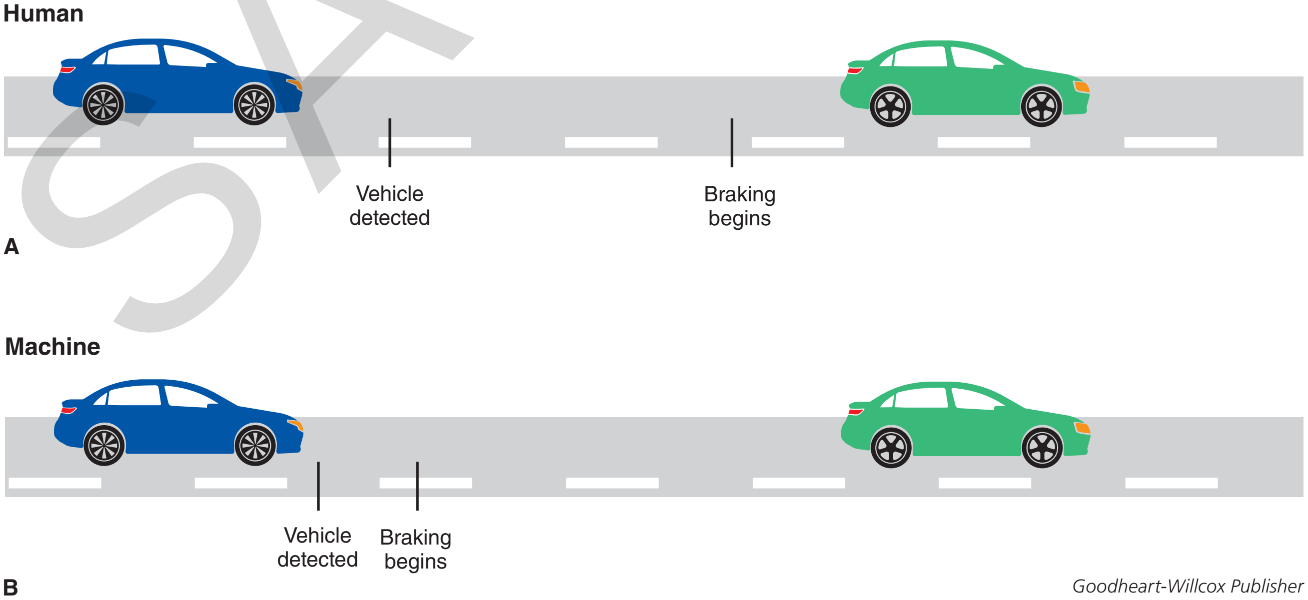

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Figure 1-8. Comparison of human and computer reactions to a driving situation. A—A human sees and processes the vehicle in front slower than a machine does and may not be able to apply the brake in time. B—The machine detects the vehicle in front of it sooner and is able to apply the brakes quickly.

For example, **Figure 1-9** shows that when traveling at 60 miles (96.6 kilometers) an hour, the human driver has 1.14 seconds to respond to an object 100 feet (30.5 meters) away, but it takes them 0.03 seconds to do so—if they are not distracted. On the other hand, the computer is never distracted and will complete that response in far less time. The closer the object is, the less time is available for a successful response. This excludes other variables that might add to vehicle and driver reaction time, such as weather or road conditions, the condition of the vehicle, and the concentration of the driver. This is why ADAS can have such an impact on reducing collisions and injuries.

A human with an average reaction speed can respond to objects in about 0.75 seconds. If a vehicle is moving at 60 mph (96 km/h), the average driver can easily avoid an object 500 feet (152.4 meters) away. This is because they have 5.68 seconds to react to and avoid the object. The human brain will process the data in 0.14 seconds, leaving plenty of time for the driver to react. If the object is 50 feet (15.24 meters) away, the average driver may not be able to respond in time because they will only have 0.57 seconds to react. However, the ADAS controller is still capable of making a decision at this distance, as it will process and react at a speed of 0.00000002 seconds. A vehicle equipped with ADAS can detect and respond to objects over 328,205 times faster than a vehicle without one, making them far safer than a vehicle that relies solely on human response time.

Benefits of ADAS

The following are some benefits of ADAS:

- *Driver and passenger safety.* If someone or something is paying better attention to the driving environment, it results in a safer situation.
- *Safety of vulnerable road users (VRUs).* Vehicles with enhanced perception systems benefit pedestrians as well. Perception systems performing object detection, classification, pose detection, and so on can help the vehicle monitor the environment and increase safety.
- *Reduction of collisions.* If someone or something is paying better attention to the road because of warnings and alerts, there are going to be fewer collisions. See **Figure 1-10** for an example of a collision warning that uses a HUD to keep eyes on the road.
- *Traffic improvement.* If the driver of a vehicle is not paying attention to the road and slows down to see something, they are impacting traffic flow. An ADAS can maintain a better traffic flow. Adaptive cruise control, for example, can maintain a better margin between vehicles that could reduce the stop-and-go that happens in traffic. In addition, ADAS may one day be so ubiquitous that infrastructure changes adapted to ADAS will be implemented everywhere, improving traffic flow even further.

Ultimately, the purpose of ADAS is to help drivers by carrying out mundane tasks such as lane-centering and safe vehicle-to-vehicle following gaps.

Human Decision Speed versus Computer Decision Speed

MPH (km/h)	Distance to Object [ft (m)]	Time to Object (seconds)	Human Brain Processing Time (seconds)	Computer Processing Time (seconds)
60 (96.6)	1000 (304.80)	11.36	0.28	0.000000406
60 (96.6)	500 (152.40)	5.68	0.14	0.000000203
60 (96.6)	250 (76.20)	2.84	0.07	0.000000101
60 (96.6)	100 (30.48)	1.14	0.03	0.000000041
60 (96.6)	50 (15.24)	0.57	0.01	0.000000020
60 (96.6)	25 (7.62)	0.28	0.01	0.000000010
60 (96.6)	15 (4.57)	0.17	0.00	0.000000006
60 (96.6)	10 (3.48)	0.11	0.00	0.000000004
60 (96.6)	5 (1.52)	0.06	0.00	0.000000002

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Figure 1-9. This chart compares human decision speeds and computer decision speeds when reacting to an object at various distances and a constant speed. The average human can process data and make decisions at a rate of about 40Hz, or 40 events per second. A computer can perform computations to reach decisions at a rate of 24MHz, or 24 million events per second.

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Figure 1-10. Collision warnings are just one advantage of ADAS that helps keep drivers safe.

Cons of ADAS

Early systems had some reliability issues, but these have improved with time. These early issues were related to software or the result of collision damage or improper repairs. Today's systems have proven to be very reliable. However, there are still some cons associated with ADAS:

- *Purchase cost.* While some ADAS features are becoming standard equipment on most vehicles, the systems with greater functionality are available at an additional premium.
- *Repair cost*. Labor costs are higher because of the additional service operations required.
- *Calibration cost.* Repairs like windshield replacement and suspension repairs now typically require a camera and radar calibration, adding an additional cost beyond that of parts and repair.
- *Lack of standardization.* As mentioned earlier in the chapter, different manufacturers frequently call similar systems by different names and utilize different acronyms. While this is being worked on, it may be some time, if ever, before there are common terms used by all manufacturers.
- *Equipment level identification.* It is difficult to easily identify what systems the vehicle has and if these systems are passive or active. It can be especially confusing for drivers to understand what their vehicle does and does not do. For example, while some vehicles might have lane keeping assistance (LKA), an active system, other vehicles might have lane departure warning (LDW), a passive system. If the driver doesn't understand the difference, a collision could happen, or they could become very upset that their vehicle doesn't do something they thought it did.
- *Customer perception.* One of the challenges with any new technology adoption is to gain the public's trust, especially in something like ADAS, in which their safety is on the line. Customers may not realize that ADAS is there to act for you in situations when you are not paying attention, not all the time. In addition, drivers who have had negative experiences with early systems may be reluctant to rely on future systems even though performance has improved.
- *Trust in technology.* Customer perception regarding the safety of ADAS may be skewed, as media has typically only shown failures—which may not be accurate depending on the situation and system—and do not show the countless times they worked correctly and nothing negative happened as a result.
- *Driving experience.* Some people prefer to drive their car, and an ADAS makes them feel like more of a passenger. There is concern that the more ADAS comes into play or transitions to autonomous, the more likely it is that the hands-on driving experience will be lost.

Autonomous Vehicles

The foundations of autonomous operation are ADAS and the following fundamental vehicle systems:

- Electric steering.
- Dynamic stability control for braking.
- Electronic throttle control.
- Electronic transmission control.
- Buses/networks.

In many cases, these fundamental systems are in cars that do not have ADAS. Autonomous vehicle technology and ADAS utilize existing vehicle systems to perform corrective actions.

The Society of Automotive Engineers (SAE) created *J3016 Levels of Driving Automation,* shown in **Figure 1-11**, which defines the levels of vehicle automation from 0–5. A Level 0 vehicle will utilize sensors to provide warnings with the possibility of providing minor assistance; at this level, the driver has full control of the vehicle. On the opposite end of the spectrum, a Level 5 vehicle is issued a command by the passenger, and the car does everything. The vehicle may not even have driving controls. Most cars today fall between SAE Levels 0–2, with SAE Level 3 on the horizon.

Pro Tip

Be sure to fully read service information when working on any system.

A 2004 Toyota Sienna (handicapped retrofitted) was in the shop with an MIL because of an air-fuel ratio sensor issue. Technical service bulletin (TSB) EG001-05 stated that in addition to sensor replacement, an updated calibration of the engine control module (ECM) was needed because of improved diagnostics. A cautionary note stated that if the vehicle was equipped with laser cruise control, then the ABS control module would need to be replaced as well, because the ABS system would be unable to carry out commands from the new ECM software; this is because the commands related to adaptive cruise control.

SAE INTERNATIONAL

SAE **J3016**™ LEVELS OF DRIVING AUTOMATION™

Learn more here: sae.org/standards/content/j3016_202104

	SAE LEVEL 0™	SAE LEVEL 1™	SAE LEVEL 2™	SAE LEVEL 3™	SAE LEVEL 4™	SAE LEVEL 5™
What does the human in the driver's seat have to do?	**You <u>are</u> driving** whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			**You <u>are not</u> driving** when these automated driving features are engaged – even if you are seated in "the driver's seat"		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
	These are driver support features			**These are automated driving features**		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/acceleration support to the driver	These features provide steering AND brake/acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met		This feature can drive the vehicle under all conditions
Example Features	• automatic emergency braking • blind spot warning • lane departure warning	• lane centering OR • adaptive cruise control	• lane centering AND • adaptive cruise control at the same time	• traffic jam chauffeur	• local driverless taxi • pedals/steering wheel may or may not be installed	• same as level 4, but feature can drive everywhere in all conditions

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Figure 1-11. The levels of driving automation from 0–5 show the driver support features and automated driving features associated with each level.

As you can see, vehicles are just at the beginning of full driving automation. There are many other improvements that are necessary as part of the transition from ADAS to autonomous, such as the following:

- *Increased processing.* Tesla claims that their ADAS computer has the capability to process 1.2 terabytes of data per second with inputs coming from eight cameras, one radar sensor, eight ultrasonic sensors, and numerous other inputs. Other manufacturers are moving to add LiDAR, infrared and other advanced perception sensors that will place higher demands on computers. These are discussed in detail in Chapter 7, *Perception Systems.*
- *Software.* Artificial intelligence (AI) is constantly improving and getting closer to imitating human thought patterns. In humans, what is seen goes through a layer of identification to recognize objects or situations. Then, a decision is made based on that information. With AI, the process is similar. As the system becomes more confident with what it senses, its decisions will become more accurate and take less time.
- *Highly accurate mapping.* There are already HD maps, also known as hyper-accurate maps and millimeter maps, in use; however, for an autonomous vehicle to really function, it needs to always know its location in space. This gives it better perception of and ability to focus on the changing environment around it. Improving the hard maps that are loaded into the car as well as satellite navigation are a couple of ways to provide the necessary accurate mapping. However, changing road conditions, such as construction, could introduce conflicts with aged map data.
- *Vehicle communication.* Increased vehicle communications through wireless technology such as ***dedicated short-range communication (DSRC)*** could include *vehicle-to-vehicle (V2V)*, *vehicle-to-grid (V2G)*, or *vehicle-to-everything (V2X)*. Vehicle-to-everything communication is when the vehicle talks to the infrastructure, transportation items, other vehicles, and so on. This would also address vehicle location improvements.

All these improvements provide more data to the vehicle to increase spatial awareness. Cellular network capacity and speed improvements will be needed to support such improved technologies to move large amounts of data very quickly and easily. There are some manufacturers that have used Wi-Fi for their vehicle communications, but this type of technology doesn't work as well as a deep level of cellular networks would once you get out of cities and less supported areas.

Artificial intelligence is no doubt slated to provide solutions that will ultimately lead to vehicles capable of performing all the driving tasks humans carry out today. However, human intellect and decision-making processes will continue to be hard to beat. The sensors and systems found on the automobiles of today and tomorrow will continue to evolve through advancements in computer vision supported through advanced camera systems and other sensory inputs. With more sensors overlapping each other along with advanced-level AI, these systems will be able to continuously fine-tune their calibrations so that the vehicle's situational awareness is always at its highest level. This properly supports an important goal of ADAS and autonomous vehicles: Always keep the vehicle and its occupants safe.

Chapter Review

SUMMARY

- While ADAS as it is known in modern times came about in the 1990s and early 2000s, early autonomous systems have slowly emerged throughout the twentieth century.
- ADAS is intended to assist drivers to increase safety and improve vehicle comfort and efficiency.
- Universal terminology and definitions for ADAS have been proposed. Many manufacturers brand their own systems with unique names, resulting in many names and acronyms describing similar or even identical technologies.
- The purpose of ADAS is to reduce the driver's workload and create a safer driving experience. Passive systems warn the driver, while active systems allow the vehicle to act.
- Active safety systems are dependent on a driver. Automated driving systems (ADS), or autonomous systems, can operate independently.
- The computer in an ADAS has a far superior reaction time compared to the human brain.
- Some benefits of ADAS are that they improve occupant safety and traffic flow and can reduce collisions. Some cons of ADAS are that they are relatively new and not fully trusted by the consumer yet; costly to purchase, service, and repair; and lack standardization.
- SAE levels provide a method to standardize identification of the levels of driving automation with which a vehicle is equipped. Autonomous vehicles are on their way, but need improvements in processing, software, mapping, and communication to reach their full potential.

CRITICAL THINKING

1. If a vehicle is approaching another vehicle and an action needs to be taken to avoid a collision, how might a human driver respond? How does their response differ from an ADAS computer?

2. List some of the systems that fall under the term ADAS.

3. What are some of the benefits of ADAS?

4. What are some of the negatives related to ADAS?

5. What is a Level 3 vehicle?

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ASE-Type Questions

1. Which of the following driver alerts can be performed by ADAS?
   A. Warning lights.
   B. Audible warnings.
   C. Haptic feedback.
   D. All of the above.
2. What is the lowest level of classification for a vehicle with partial driving automation?
   A. Level 5.
   B. Level 4.
   C. Level 2.
   D. Level 3.
3. What does the acronym ADAS stand for?
   A. Automotive driving assistance systems.
   B. Advanced driver assistance systems.
   C. Advanced driving automotive safety.
   D. Advanced driving automotive systems.
4. What is the definition of an automated driving system (ADS)?
   A. It is a system that can handle all driving tasks automatically, without driver input.
   B. It is another term for adaptive cruise control, automatic emergency braking, and lane-keeping systems.
   C. It is a system that controls the vehicle only when required to, assisting the human driver.
   D. It is a system that can only operate in limited conditions.
5. Technician A says that ADAS can provide an active correction depending on the vehicle and system. Technician B says that ADAS can provide a passive warning depending on the vehicle and system. Who is correct?
   A. Technician A only.
   B. Technician B only.
   C. Both technicians are correct.
   D. Neither technician is correct.
6. Which of the following are examples of perception systems used by ADAS?
   A. Cameras.
   B. Radar.
   C. Ultrasonic sensors.
   D. All of the above.
7. Technician A says that there is mandatory standardization in the naming of ADAS. Technician B says that there is no required standardization of ADAS names. Who is correct?
   A. Technician A only.
   B. Technician B only.
   C. Both technicians are correct.
   D. Neither technician is correct.
8. Which of the following applications might utilize ADAS features?
   A. Passenger vehicles.
   B. Public transportation vehicles.
   C. Agricultural equipment.
   D. All of the above.
9. Technician A says that a human driver can recognize and react to a potentially dangerous situation faster than the AI. Technician B says that the AI can recognize a potentially dangerous situation sooner than a human can react much sooner to prevent or mitigate a collision. Who is correct?
   A. Technician A only.
   B. Technician B only.
   C. Both technicians are correct.
   D. Neither technician is correct.
10. Technician A says that ADAS can prevent all collisions. Technician B says that ADAS can help reduce the severity of a collision if it occurs. Who is correct?
    A. Technician A only.
    B. Technician B only.
    C. Both technicians are correct.
    D. Neither technician is correct.