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CHAPTER 6

Advanced Driver Assistance Systems

LEARNING OUTCOMES

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

- Explain the variation of terms used to describe ADAS and describe the movement toward a common terminology.
- Explain the purpose and effectiveness of ADAS in preventing and mitigating collisions.
- Define ODD and DDT.
- List and define common ADAS features.

TECHNICAL TERMS

adaptive cruise control (ACC)
adaptive light control (ALC)
automatic emergency braking (AEB)
blind spot detection (BSD)
cross traffic alert (CTA)
driver alert system
dynamic driving task (DDT)
head-up display (HUD)
hill descent control (HDC)
lane departure warning (LDW)
lane keeping assistance (LKA)
night vision (NV)
operational design domain (ODD)
parking assistance (PA)
surround view camera (SVC)

Introduction

As discussed in previous chapters, ADAS has become an umbrella term for systems that assist the driver and soon will provide automation of many driving tasks. When these systems first started emerging in the market, they gravitated toward adaptive cruise control (ACC), blind spot detection (BSD), and lane departure warning (LDW). Systems now include tire pressure monitoring systems (TPMS), hill descent control (HDC), parking assistance (PA), and so on. As technology has evolved, so has ADAS. The list of ADAS technologies is ever-expanding and ever-changing and are rooted in the perception systems explored in depth in Chapter 7, *Perception Systems*.

This chapter will discuss the most common ADAS, their acronyms, and their icons**.** Different manufacturers still call these systems by different names and use different acronyms; however, leading organizations dedicated to consumer safety and education have put forth standardized naming conventions to provide clarity to consumers. See **Figure 1-4** in Chapter 1, *Introduction to Advanced Driver Assistance Systems*, for the complete list of these terms and definitions.

Technicians are encouraged to spend time with owner's manuals and OEM materials to learn what vehicle manufacturers have branded their ADAS as well as the appropriate operational design domains and dynamic driving tasks for their specific operation. These terms are discussed further in this chapter.

Depending on the system, the purpose of ADAS is to increase driver and passenger safety and comfort by reducing various driving tasks; this also contributes to an increase in vehicle efficiency. People may become distracted or be unable to drive as effectively and ADAS are meant to address this, resulting in fewer accidents and reduced traffic. A study by General Motors and the University of Michigan found that if vehicles involved in collisions had utilized one of the 15 different ADAS functions involved in the study, accidents would have dramatically declined.

A 2020 Insurance Institute of Highway Safety report that studied ADAS-equipped trucks had the following similar findings:

- Reverse automatic braking resulted in 81% fewer backing-related accidents.
- Forward collision warning reduced vehicle crashes by 22%.
- Automatic emergency braking reduced vehicle crashes by 12%.
- Together, forward collision warning and automatic emergency braking reduced rear-end crashes by greater than 40%.

Operational Design Domain

Operational design domains (ODDs) are the conditions in which a system is designed to work. For example, on a camera-based system in heavy snow, neither the driver nor the camera would be able to see in those conditions. These conditions are outside of the system's ODD. On many systems, the vehicle manufacturer will build in a warning in the form of a warning light or tone or haptic alert to notify the driver that the system is not operating because of extreme conditions, and it will require fallback to the human driver to carry out the driving tasks.

Dynamic Driving Task

Dynamic driving tasks (DDTs) are the operational and tactical functions required to operate a vehicle. For instance, functions like steering, throttling, braking, and so on are DDTs because they are physically doing the work to provide safe vehicle operation.

ADAS Features

The following systems are some of the most common ADAS currently in use. The terms are named as they appear in AAA's 2022 proposed list of common terminology and definitions found in **Figure 1-4** in Chapter 1, *Introduction to Advanced Driver Assistance Systems*. It is important to note that this is not an exhaustive list of all available ADAS technologies and features. The goal is not that manufacturers replace their specific system names, but that vehicle manufacturers adopt the terminology when discussing their branded systems to limit confusion among consumers.

Adaptive Cruise Control

Adaptive cruise control (ACC) systems are cruise control systems that provide longitudinal vehicle control to maintain safe following distances between your vehicle and the vehicle ahead, as shown in **Figure 6-1**. A common symbol for ACC is shown in **Figure 6-2**.

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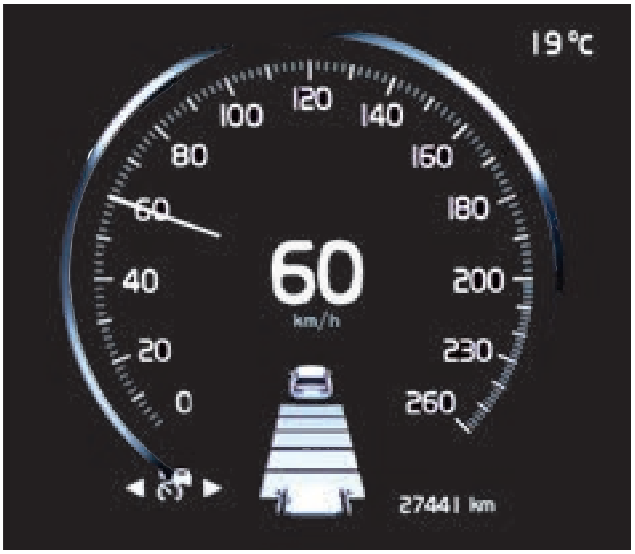
Figure 6-1. Adaptive cruise control in use. The following distance is reflected on the vehicle's dashboard.



Fast_Cyclone/Shutterstock.com

Figure 6-2. Common ACC symbol.

Early radar-based systems could only control the throttle and partial braking, but later systems evolved into *stop-and-go ACC*—sometimes referred to as *chauffeur mode*—which added the ability to bring the vehicle to a complete stop and resume again automatically. Many newer systems have evolved to use multiple computer vision techniques rather than pure radar; for example, Subaru, Honda, and other vehicle manufacturers accomplish DDTs with only cameras. Some vehicle manufacturers use multiple sensors such as radars, LiDAR, cameras, ultrasonic sensors, and so on in an attempt to provide superior ADAS and support future automated driving systems.

Some recent ACC systems have added hands-free operation, such as Ford's BlueCruise and GM's Super Cruise. These systems are combinations of ACC systems and lane keeping systems (LKS) and are classified as Level 2 systems by SAE; the levels of automation are shown in **Figure 1-11** in Chapter 1, *Introduction to Advanced Driver Assistance Systems.* These systems allow for hands-free driving by utilizing cameras that focus on the driver. When the driver looks away for too long, the system will provide warnings and eventually disengage the vehicle. However, these systems only function hands-free on specific roadways across the country; Ford and GM have created hyperaccurate maps using satellite information, digital maps, and LiDAR, but not for every road. Over time, the number of roadways on which these systems function will likely expand. One of the downsides of this strategy is that if road conditions change, such as construction occurring on a road that has already been mapped out and approved for use, the vehicle may have difficulty navigating through that area.

Case Study

2019 BMW 750Li (G12)

Concern:

Adaptive cruise control (ACC) is inoperative.

Details:

This vehicle is a 2019 BMW 750Li (G12). It came into the shop because the front ACC was inoperative.

Diagnosis:

A rock had hit the front ACC heater cover, shown in the exploded diagram in **Figure 6-3**; however, the sensor itself did not look damaged, shown in **Figure 6-4**. The vehicle had a fault code indicating a lack of visibility by the ACC.

Correction:

The technician replaced the broken ACC sensor heater cover, shown in **Figure 6-5**, and the ACC sensor bracket. As the sensor did not look damaged and is approximately $2500, it was not replaced. The technician performed the calibration and road tested the vehicle. The road test indicated that correct operation of the front ACC were restored.

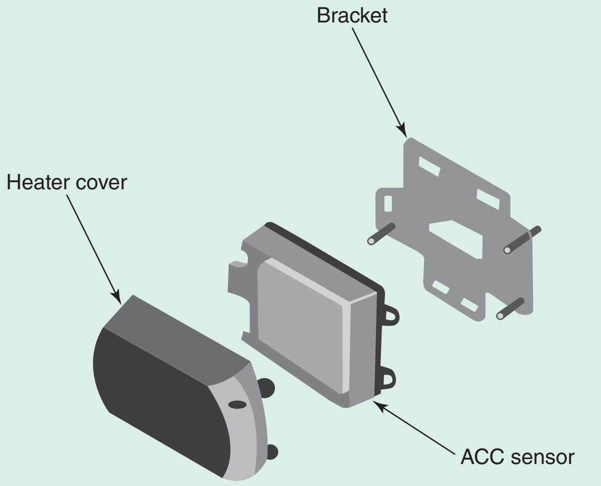


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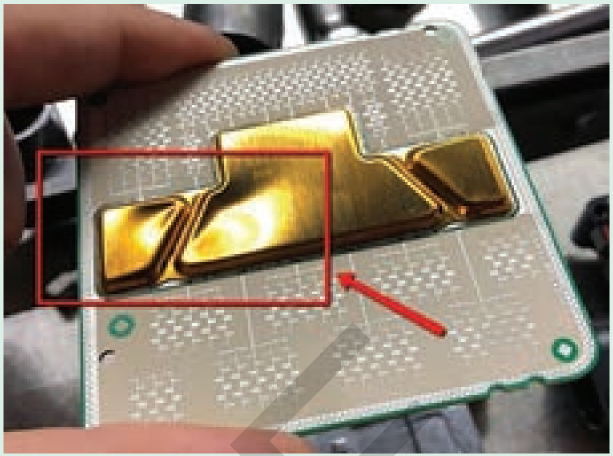
Figure 6-3. Exploded view of the forward-facing radar sensor.

Continued

Nelson Vargas, Head of ADAS Support and Systems, OPUS IVS-US

Figure 6-4. Minimal evidence of surface damage.



Nelson Vargas, Head of ADAS Support and Systems, OPUS IVS-US

Figure 6-5. Disassembly of the replaced sensor shows the impact damage.

Adaptive Light Control

There are multiple variations of adaptive light control systems, ranging from automatic high beams to light beam alterations. A common symbol for adaptive light control systems is shown in **Figure 6-6**. Versions of these systems have been around a long time and have evolved from a photocell to a camera-based system. In ***adaptive light control (ALC)*** systems, cameras recognize the taillights of vehicles in front of you or headlights of oncoming vehicles and automatically cycle the headlights from a high beam to a low beam. Some systems also block out certain headlight pixels to avoid blinding drivers ahead of you when applicable.

Joey001/Shutterstock.com

Figure 6-6. Common ALC symbol.

There are some manufacturers, such as Tesla, who have gone camera-based for many of their systems. Camera technology is advancing rapidly and is explained in depth in Chapter 7, *Perception Systems*. In recent years, low light visibility and depth perception have enabled camera systems to calculate distances, especially when multiple cameras are involved. This, coupled with embedded AI, is bringing more options to vehicle manufacturers.

Light beam alterations utilize motors in the headlight assembly that can move the light up, down, and horizontally based on the vehicle ride height, vehicle speed, and steering angle. Newer vehicles have even more abilities due to the use of LED lights, which can be individually controlled to alter the projected light beams and avoid blinding drivers in oncoming traffic and in vehicles being followed.

Blind Spot Detection

The *blind spot* is the area from roughly the B pillar back to a certain distance on either side of the vehicle. This area cannot be seen by the driver when using rearview mirrors. ***Blind spot detection (BSD)*** systems are also called blind spot monitoring and blind spot warning systems.

Early systems of BSD were primarily radar based. For example, by utilizing radar in the rear corners under the rear bumper cover, as shown in **Figure 6-7**, objects could be detected and would typically illuminate a light in the outside mirrors. However, depending on the application, the perception systems behind cameras, radars, ultrasonic sensors, or any combination of perception systems as per design requirements of the vehicle manufacturer can provide blind spot intelligence to the driver.

Roman Vyshnikov/Shutterstock.com

Figure 6-7. Common BSD symbol is selected.

For example, Kia uses cameras in their Blind-Spot View Monitor (BVM) feature to provide a live video feed of the blind spot in the instrument cluster. A driver trying to change lanes when a vehicle is present in the adjacent lane would receive either audio, visual, or haptic feedback, shown in **Figure 6-8**.

Lane Departure Warning

Lane departure warning (LDW) monitors where the vehicle is within the driving lane and alerts the driver as the vehicle approaches or crosses the lane markers. Early systems used cameras that would recognize the road lines. If the vehicle approached those road lines, not necessarily crossing over them, the system would provide passive feedback in the form of an audio, visual, or haptic warning, as shown in **Figure 6-9**. Some early systems struggled with inadequate lane markings and provided false warnings. For example, being in the right lane with an off-ramp could cause a false warning if the vehicle continues straight. Nissan deployed a lane departure warning system utilizing only the back-up camera for detection of vehicle lane departure. The system did not have a forward-facing camera, and LDW was only available at certain speeds.

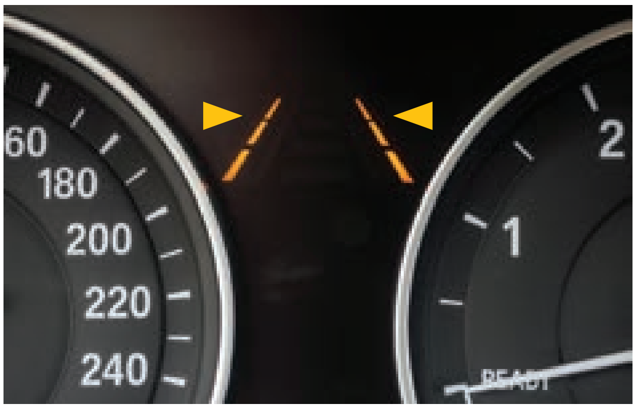
Natallia Boroda/Shutterstock.com

Figure 6-8. Blind spot detection in use. A visual signal is used to show that there is a vehicle in the car's blind spot.

Lane Keeping Assistance

Lane keeping assistance (LKA) helps the driver keep the vehicle in the lane by providing steering assistance. The system is only active if the vehicle approaches or leaves the lane.

Early systems utilized cameras and focused on lane centering, but the vehicles would often move side to side in the lane in a ping-pong effect.



supergenijalac/Shutterstock.com

Figure 6-9. Common LDW symbol.

Current systems still utilize cameras to maintain the vehicle in the lane, as shown in **Figure 6-10**. Later versions of LKA-equipped vehicles have improved software and maintain less active steering corrections. This operation has been incorporated into systems like Ford's BlueCruise, GM's Super Cruise, and Tesla's Autopilot.

The key to proper operation of LKA is the vehicle operator's use of the turn signal. When the system is active and the driver attempts a lane change without turn signal activation, the system will try to maintain the vehicle's place in the lane. The vehicle operator can, however, force the change and overcome the electric steering's efforts by utilizing the turn signals to temporarily suspend LKA.

Automatic Emergency Braking

Automatic emergency braking (AEB) detects potential collisions with a vehicle ahead; provides visual, audio, or haptic warnings; and automatically brakes to mitigate a collision. There are multiple variations of these systems. These systems started out radar based and evolved to either camera or both cameras and radar. The system monitors the latitudinal, longitudinal, and yaw rate of the vehicle; the vehicles ahead; and in some cases, pedestrians or objects. If the driver does not react quick enough, the system can provide warnings, as shown in **Figure 6-11**. If it reaches the point that there's almost no time left to avoid a collision, it will automatically apply the brakes, as shown in **Figure 6-13**.

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Figure 6-10. Common LKA symbol.

Joey001/Shutterstock.com

Figure 6-11. Common AEB symbol.

Case Study

All Vehicles: Component Programming

Concern:

Lane keeping assistance (LKA) does not work post-accident repairs. **Figure 6-12** shows an instrument cluster display with a warning indicating malfunction.

Daniel Krason/Shutterstock.com

Figure 6-12. Instrument cluster display with warning illuminated.

Diagnosis:

Components replaced during accident repairs may include ADAS perception system components such as a module, electric power steering rack, ABS control unit, and so on. While the ADAS system may complete a successful calibration, operation is still prevented.

Cause:

A component has been replaced but not properly programmed and initialized/encoded to the vehicle, preventing system operation.

Correction:

Perform applicable programming and initialization/encoding, road test the vehicle to ODD requirements, and ensure all functions operate as per manufacturer specifications.

alphabe/Shutterstock.com

Figure 6-13. The vehicle's AEB system helps it brake to avoid a collision.

A vehicle could have AEB, but not have pedestrian protection or detection; the difference is the system's design specifications. The programming that is needed to recognize pedestrians and objects is more involved than the programming needed to recognize a vehicle. As an automotive technician, it is important to establish the system capabilities and be fully prepared to advise customers about their advanced technology-equipped vehicles.

These systems will typically also incorporate *collision warning detection (CWD)*, a passive warning activated prior to AEB operation, and consist of radar, cameras, or both that are always surveying and providing data to modules. The modules will interpret the data and activate the response. They may precharge the brakes, meaning they run the ABS pumps to build pressure even though they don't activate the calipers. Some vehicles may also cinch up slack in the seat belts and change the ride height or stance of the vehicle to prepare for a potential impact. Collision warning detection can also be a stand-alone system on vehicles that do not have AEB.

Driver Alert Systems

Driver alert systems recognize characteristics of a drowsy, unfocused, or distracted driver. A common warning icon for this system is shown in **Figure 6-14**. These systems typically utilize either a capacitance sensor in the steering wheel, which looks for physical contact; steering angle sensor feedback, which senses the minuscule shaking of the steering by the driver; or cameras, which look at the driver's face or eyes.


Gartland/Shutterstock.com

Figure 6-14. Common symbol for driver alert systems.

By monitoring these inputs, the system recognizes a less-attentive driver and alerts the driver to take a break or pay more attention via passive actions—audio or visual—or active actions—such as steering wheel vibration or seat belt tension.

Some systems are now beginning to bring the vehicle to a safe stop if the driver fails to respond. Depending on the manufacturer, driver alert systems can be known as the following:

- Drowsy driver warning (DDW).
- Driver fatigue warning (DFW).
- Driver drowsiness detection (DDD).
- Driver monitoring system (DMS).

Cross Traffic Alert

A ***cross traffic alert (CTA)*** recognizes if something is coming that might impact the front of the vehicle, such as when the vehicle moves into traffic from a driveway or cross-street, **Figure 6-15**. This system typically utilizes cameras mounted on the fender sides to extend the field of view in both directions to areas the driver might not be able to see otherwise.

Rear Cross Traffic Alert

Rear cross traffic alert (RCTA) systems commonly utilize rear radar located at the corners of the vehicle under the bumper cover. As the vehicle starts to reverse, such as when exiting a parking space, the system can quickly detect vehicles and objects before the driver. A common icon for RCTA is shown in **Figure 6-16**. Some systems are passive, and the driver still has to step on the brakes. An active system will apply the brakes in an emergency braking situation.

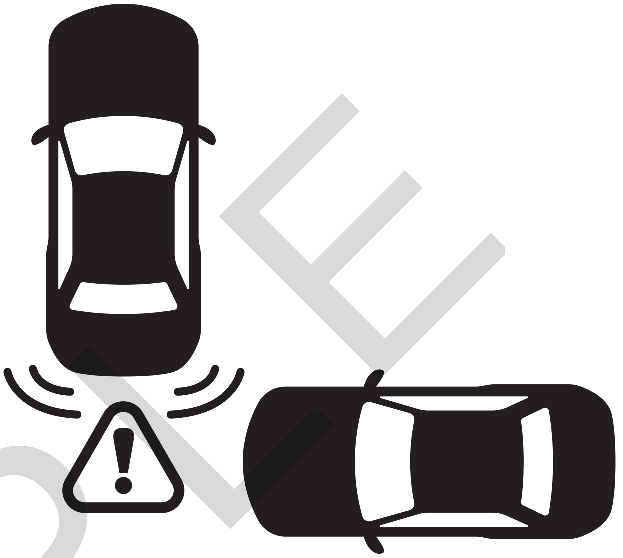

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Figure 6-16. Common RCTA symbol.

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Figure 6-15. Cross traffic alert in use.

Hill Descent Control

Utilized on trucks and SUVs for a slow speed downhill grade (typically under 20–25 miles an hour), ***hill descent control (HDC)*** systems will automatically apply brakes and manage engine torque to prevent traction loss. The driver maintains control of steering to make it a safer driving situation. See **Figure 6-17** for a common HDC symbol.

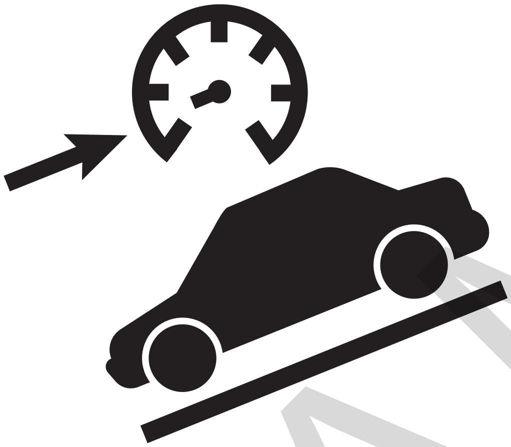
Parking Assistance Systems

Parking assistance (PA) systems are designed to help the driver park the vehicle. Some common terms also used to describe parking assistance systems are intelligent parking assist systems (IPAS) and park assist. The functions of these systems may vary between models and manufacturers.

Originally, these systems were based around parallel parking. A vehicle with activated parking assistance approaches and drives past the parking space. Ultrasonic sensors (**Figure 6-18**) measure the parking space, then the system indicates whether the space is adequate. If the driver chooses to park, they then follow the directions. Typically, these sensors are dime- to quarter-sized items placed around the vehicle and are usually painted to match the vehicle color.

When replacing these sensors, care should be taken to only apply the amount of paint specified in the vehicle manufacturer's service manual. Using the wrong type or too much paint can result in attenuation, and poor performance may result.

These systems vary as to the action controller. On some versions, once the driver activates the assist mode, shown on the dashboard as **Figure 6-19**, the driver places the vehicle in reverse and holds the button, and the car will do the steering, the brake, and the throttle. For other systems, the driver controls the brake, and the car controls the throttle and the steering. Functions vary by manufacturer. Recent versions of the systems have evolved to allow straight-in and angled parking, both forward and backward.



iconvectorstock/Shutterstock.com

Figure 6-17. Common HDC symbol.

Rauf Aliyev/Shutterstock.com

Figure 6-19. Common PA symbol.

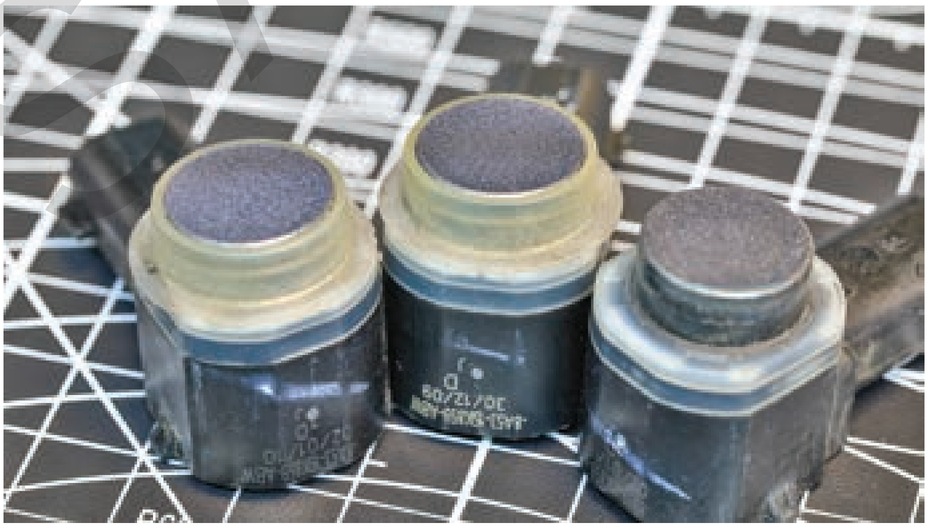


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Figure 6-18. Ultrasonic sensors.

Night Vision

Night vision (NV) systems aim to improve forward visibility at night by projecting images on a vehicle's dashboard or ***head-up display (HUD)***. A HUD projects relevant information into the driver's line of sight. An NV system increases the driver's awareness at night and during low-light or weather-impacted conditions. A common NV symbol is shown in **Figure 6-20**.

Early NV systems used a thermal-based camera to process the temperature differences between objects and their background; current systems use an infrared-based camera system to provide more detail. This technology is explored further in Chapter 7, *Perception Systems*. Night vision systems have a much longer viewing range compared to a camera- or radar-based system. Many also incorporate algorithms in which the system will recognize a profile of common road hazards, like animals or pedestrians, and will provide superimposed warnings displayed to the driver.

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Figure 6-20. Common NV symbol.

Surround View Camera

Surround view camera (SVC) systems utilize cameras located on the front, rear, and sides of the vehicle to project a 360-degree view that allows the driver to see any potential hazards. Some systems will display this as a top-down view, shown in **Figure 6-21**, versus an out-the-window view. An SVC system is best utilized at slow speeds and when parked to have better awareness of what is near the vehicle for safer maneuvering.

Pro Tip

It can be overwhelming to remember the specific manufacturer names for ADAS features and complete systems. What may help is knowing that the fundamental operations are all very similar. Focus on how systems work and what components are involved, and you will be able to apply this to every vehicle.

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Figure 6-21. SVC visualization for the driver.

Chapter Review

SUMMARY

- Acronyms and variations on system names are a challenge for owners and technicians. Leading organizations have put forth standardized naming conventions that still allow vehicle manufacturers to own their brands and technology.
- Operational design domain (ODD) describes the conditions in which the system works.
- Dynamic driving tasks (DDTs) are the physical systems and functions that operate the vehicle.
- Adaptive cruise control (ACC) helps control braking and acceleration between you and the vehicle ahead.
- In adaptive light control (ALC) systems, cameras recognize the taillights of vehicles in front of you or headlights of oncoming vehicles and automatically cycle the headlights whenever applicable.
- Blind spot warning (BSW) systems spot vehicles in the blind spot and warn the driver.
- Lane departure warning (LDW) monitors where the vehicle is within the driving lane and alerts the vehicle when it leaves the safety zone.
- Lane keeping assistance (LKA) helps drivers keep vehicles in the lane with steering assistance.
- Automatic emergency braking (AEB) detects potential collisions with a vehicle ahead, provides warnings, and brakes to avoid a collision.
- A cross traffic alert (CTA) recognizes if something might impact the front of the vehicle. Rear cross traffic alert (RCTA) provides the same information for the rear of the vehicle.
- Driver alert systems recognize characteristics of a drowsy or unfocused driver.
- Hill descent control (HDC) systems apply brakes and manage engine torque to prevent traction loss.
- Parking assistance systems are designed to help the driver park the vehicle.
- Night vision (NV) systems improve forward visibility at night by projecting images on the dashboard or HUD.
- Surround view camera (SVC) systems utilize cameras to project a 360-degree view.

CRITICAL THINKING

1. Describe how driver alert systems, AEB, and NV systems might protect pedestrians.

____

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2. Describe three situations in which CTA or RCTA could help prevent or mitigate a collision.

____

____

3. In what conditions does hill descent control operate? What is the role of the driver while hill descent control is activated?

____

____

4. Why might an SVC provide a top-down image as opposed to an out-the-window image?

____

____

5. Why are similar systems called by different names?

____

____

ASE-Type Questions

1. A failure of the rear radar sensor would affect what system?
   A. Lane departure warning.
   B. Adaptive cruise control.
   C. Blind spot warning.
   D. Parking assistance.
2. A vehicle with known good tires is being operated on a smooth road. The steering wheel shakes rapidly as a driver begins to change lanes. The vehicle then applies steering force to keep the vehicle in the lane it was in. What is this called?
   A. Driver alert system.
   B. Lane keeping assistance.
   C. Adaptive cruise control.
   D. Autonomous driving.
3. The customer states that the high beams come on intermittently when driving a high-feature vehicle.
   A. This could be caused by a short to power in the headlight assembly.
   B. This could be caused by a short to ground in the headlight assembly.
   C. This could be a normal function of adaptive light control.
   D. This could be caused by a defective light switch assembly.
4. A damaged rear bumper cover could affect what system?
   A. Active cruise control.
   B. Lane departure warning.
   C. Adaptive light control.
   D. Parking assistance.
5. Which of the following is an example of a DDT?
   A. Steering.
   B. Braking.
   C. Accelerating.
   D. All of the above.
6. Which of the following best describes the operational design domain (ODD)?
   A. The conditions in which the system is designed to work.
   B. The operational and tactical functions required to operate the vehicle.
   C. The specifications and tolerances of calibration target placement.
   D. All of the above.
7. Adaptive cruise control (ACC) systems that allow hands-free operation are utilizing what component to monitor driver awareness?
   A. Steering wheel corrections.
   B. Capacitance sensors in the steering wheel.
   C. Cameras.
   D. Seat occupancy sensors.
8. Technician A says that blind spot detection is commonly done utilizing radar sensors. Technician B says that cameras are utilized by some manufacturers for blind spot detection. Who is correct?
   A. Technician A only.
   B. Technician B only.
   C. Both technicians are correct.
   D. Neither technician is correct.
9. Two technicians are discussing adaptive light control (ALC). Technician A says that vehicle ride height can be compensated by utilizing electric motors in the headlight assembly. Technician B says that newer lighting technologies can alter the light beam due to the use of LEDs. 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 the lane departure warning systems can steer the vehicle and center it in the lane. Technician B says that lane keeping assistance systems will only provide passive feedback to the driver when the vehicle starts to leave the lane. Who is correct?
   A. Technician A only.
   B. Technician B only.
   C. Both technicians are correct.
   D. Neither technician is correct.

Hands-On ADAS

For hands-on ADAS practice, complete Job 4: System Operation Test.