

ADAS

Advanced Driver Assistance Systems

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Preface

Since its emergence in 1886, the automobile has progressed beyond the technology available in any other industry, even the airline industry—for example, a Boeing Dreamliner 787 only has 6.5 million lines of code, while modern vehicles contain nearly 20 times that. In fact, it is estimated that vehicles could contain 200–300 million lines of code by the year 2030. A large part of this development is because of the rapid evolution and growing availability of advanced driver assistance systems (ADAS) in vehicles. According to Strategic Market Research, of the nearly 16 million new passenger vehicles sold in 2021, 90% of them were equipped with at least one form of ADAS.

For this reason, ADAS training will provide technicians with an incredible opportunity for rapid advancement in the automotive industry. *Advanced Driver Assistance Systems (ADAS)* is geared toward current automotive technicians and students who have already undergone some basic vehicle system training. The content is designed to unpack the artificial intelligence, communication networks, and complex perception systems that are at the heart of ADAS features. In addition, the content provides additional knowledge on how fundamental vehicle systems and infrastructure have evolved and will continue to evolve to accommodate ADAS technology.

Chapters include safety recommendations; tools and equipment lists; facility and environmental requirements; liability and documentation information; and step-by-step guidance on repairing, programming, encoding, diagnosing, and calibrating specific ADAS features. To ensure that every learner has a basic understanding of the mathematical concepts used by ADAS technology, a chapter containing a review of math for automotive technicians is included. To expand knowledge within and beyond the text, Deep Dive features focus on specific events or concepts in ADAS development and implementation. Pro Tip features provide advice that has helped automotive technicians apply the textbook concepts in a shop setting.

In addition, the learner will gain hands-on experience by completing the job sheets associated with the chapter content. Case Study features explore real situations encountered by repair technicians and expose learners to what they might encounter when working in a shop. Finally, end of chapter critical thinking ASE-type questions help the user prepare for the ASE Education Foundation's Advanced Driver Assistance Systems Specialist (Test L4) certification.

About the Authors

Steve Zack has been a technician, technical engineer, and automotive technical instructor for most of his career. As an automotive technical instructor for Bosch, OTC, Mr. Zack taught technicians around the world how to use their electronic test equipment to diagnose difficult drivability and electronic issues using a hands-on approach. In 2017, Mr. Zack was the recipient of the ASE Training Managers Council (ATMC) National Excellence in Training Award. He held ASE Master and ASE L1 certifications and is a US EPA-certified Emission Master Instructor. He has been published many times, been featured in multiple diagnostic videos, and holds numerous automotive patents. Mr. Zack recently retired from Bosch, OTC after 28 years. He spends his time with family discovering how things work, riding his Moto Guzzi motorcycle, and thinking about the next great patent.

Kurt Shadbolt has over 37 years of experience as a technician and educator in the automotive industry. As a technician, he specialized in electrical, drivability, and diagnostics. Mr. Shadbolt has instructed at the high school, technical, and community college levels, and he has provided instruction at BMW/MINI and Lucid Motors manufacturer trainings as well as at numerous train-the-trainer and webinar events. Mr. Shadbolt is an ASE Master Technician with C1, L1, L3, and L4 certifications and is a California Bureau of Automotive Repair certified instructor. He is also a California licensed smog check inspector and repair technician and MACS-certified instructor. He has extensive experience in curriculum development and has completed work for multiple manufacturers, the State of California, regional grant projects, and various levels of public education. Currently, Mr. Shadbolt is a faculty member in the automotive department at Chabot College in Hayward, California, where he focuses on hybrid, EV, and ADAS.

Scott Brown is a professional automotive service technician and an independent automotive service and repair facility owner with over 38 years of professional experience. He is the owner of Connie and Dick's Service Center, Inc., an automotive service and repair shop and ADAS service training center. Dedicated to service industry relations, Mr. Brown is the former Industry Relations Manager and President of the International Automotive Technicians Network (IATN). He is also the founder of Diagnostic Network, an online community platform for automotive service industry professionals. Mr. Brown is currently an ASE Master Automotive Technician who holds L1, L3, and L4 certifications and is on the Board of Directors for NASTF, ASC-CA, and AMI. He is also a technical instructor with a strong focus on vehicle electronics; vehicle network communications; engine performance; automotive service information systems; and ADAS service, diagnostics, and repair.

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ASE Connections

Advanced Driver Assistance Systems (ADAS) is correlated, where applicable, to the Advanced Driver Assistance Systems (ADAS) Specialist (Test L4) established by the National Institute for Automotive Service Excellence (ASE). These standards were developed with input from industry experts to ensure they reflect the skills students and technicians must master to succeed in the automobile service and repair industry.

ASE certification is becoming the benchmark for automobile repair technicians. It is recommended that you seek ASE certification once you have sufficient knowledge and meet the work experience requirements. Visit the ASE website for more information on ASE certification.

The ASE Education Foundation has established a training program accreditation process designed to improve the quality of training offered at both secondary and postsecondary levels. This foundation grants accreditation to programs that comply with their evaluation procedure, meet established standards, and adhere to the policies set forth by the organization. To learn more about the accreditation process, visit the ASE Education Foundation website.

Reviewers

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Features of the Textbook

The instructional design of this textbook includes student-focused learning tools to help you succeed. This visual guide highlights these features.

Chapter Opening Materials

Each chapter opener contains a list of learning outcomes and a list of technical terms. Learning Outcomes clearly identify the knowledge and skills to be gained when the chapter is completed. **Technical Terms** list the key words to be learned in the chapter. **Introductions** provide an overview and preview of the chapter content.

Additional Features

Additional features are used throughout the body of each chapter to further learning and knowledge. **Deep Dives** explore a topic related to ADAS by providing additional information or suggested sources outside the textbook for more in-depth learning. **Pro Tips** provide advice and guidance that is especially applicable for on-the-job situations. **Case Studies** showcase real-life situations that professional automotive technicians have encountered when calibrating, diagnosing, or repairing ADAS-equipped vehicles.

Photos and Illustrations

Photos and illustrations have been chosen to clearly and simply communicate the specific topic and show the latest equipment.

CHAPTER 6
Advanced Driver Assistance Systems

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

- Explain the variation of terms 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)
hill descent control (HDC)
lane departure monitoring (LPM)
lane departure warning (LDW)
lane keeping assistance (LKA)
night vision (NV)
operational design domain (ODD)
parking assist system
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) and hill descent control (HDC), parking assistance, 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 uses. Different manufacturers still call these systems by different names and use different acronyms; however, leading organizations dedicated to consistency, safety, and education have put forth standardized naming conventions to provide clarity to consumers. See Figure 6-4 in Chapter 1, *Introduction to Advanced Driver Assistance Systems*, for the complete list of these terms and definitions.

Technical terms are used throughout the chapter to describe ADAS. Different manufacturers still call these systems by different names and use different acronyms; however, leading organizations dedicated to consistency, safety, and education have put forth standardized naming conventions to provide clarity to consumers. See Figure 6-4 in Chapter 1, *Introduction to Advanced Driver Assistance Systems*, for the complete list of these terms and definitions.

Figure 1-1: Perception systems 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 on 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.

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 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 6-3.

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 on the outside mirrors or cover blank 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.

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

The key to proper operation of LKA is the driver's use of the turn signal. When the system activates and the driver attempts a lane change without turn signal activation, the system will try to maintain the lane. The driver can, however, force the change by overriding 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 vehicles ahead, provides visual and/or haptic warnings, and automatically brakes to mitigate a collision. There are multiple variations of these systems. These systems are not on radar based and extend to other sensors or both camera and radar. The system monitors the lateral, longitudinal, and yaw rate of the vehicle, the vehicle ahead, and in some cases pedestrians or objects. If the driver does not react quickly 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 6-12.

Case Study
Component Programming
Concern: Lane keeping assistance (LKA) does not work post-accident repairs. Figure 6-11 shows an instrument cluster display with a warning indicating malfunction.

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 according to the vehicle, preventing system operation.

Correction: Perform applicable programming and initialization/reprogramming and test the vehicle to ODD requirements, and ensure all functions operate per manufacturer specifications.

Figure 1-7: Example of Subaru EyeSight cameras behind the front windshield of a 2018 Subaru Forester.

Figure 1-8: The ride height of a 2020 Hyundai Elantra is being measured.

Class may not meet the proper tolerance of the factory glass for thickness.

Black binders around the edges of the glass and around the camera may not be the correct size.

ODM glass can be quickly identified by the manufacturer information typically located at the lower corners near the A-pillar.

While inspecting the glass, look for cracks, pitting, window tint, discoloration, or other damage to the camera area. While looking from the outside, look at the camera area for any foreign objects or signs of moisture or discoloration in the camera box.

Vehicle Ride Height
Vehicle ride height is frequently measured from the center of the axle to the fender top, as shown in Figure 11-40. However, measuring ride height is done differently depending on the manufacturer, so it is important to always follow their procedures. Vehicle ride height plays a critical part in accurate ADAS calibration. Some vehicles may have modified their ride height to diverge from vehicle specifications. For example, four-wheel drive vehicles might have raised their ride height for off-road travel and sports cars may have lowered their ride height (refer to Figure 11-46) for better cornering. Without adjusting the vehicle's ride height prior to calibration, the four-wheel drive vehicle would be too high for calibration, and the camera would project above and beyond the target; the sports car would be too low for calibration, and the camera would project toward the ground before the target.

Tires and wheel axes play a very important part in vehicle ride height. Ensure that they are the correct size, have even wear, are at the proper pressure specifications, and are the same brand, because ride height measurements can vary by brand.

The technician can find the correct tire size and the proper tire pressure by checking the tire placard near the driver's door or checking the vehicle's owner's manual.

Figure 8-7: GPS satellites in Earth orbit.

Maps
Companies are now developing hyper-accurate mapping, also known as multimeter-scale mapping or **HD maps**, which stands for high-definition mapping. These ultra-precise maps use LIDAR, GPS, and other satellites to perform precise measurements, as shown in Figure 8-8. The HD maps allow vehicle systems to know where they are even when something is obstructing the signal coming from the satellites. This is similar to HD radio or TV satellite dishes; when a building or tree obstructs the path between your receiver dish and the satellite, you lose reception. While driving, the vehicle could lose line of sight due to buildings, trees, tall vehicles, mountain canyons, and so on.

Because of the potential loss of signal, vehicles cannot rely only on satellite mappings and still need to obtain an on-board map. The on-board maps would have to be hyper-accurate and updatable via over-the-air or a digitally altered location to keep exact means. Some companies, like Tesla, are collecting data from vehicles in service and constantly improving their mapping based on real-world use. Every time infrastructure is changed, such as the opening of a new bridge or the construction of an additional lane, map revisions are necessary to show those proper locations.

Figure 8-8: HD mapping is necessary for more precise vehicle locations.

Chapter Review

SUMMARY

- ADAS corrections are performed by existing vehicle systems, such as EPS, ETC, ESC, TCM, and others utilizing vehicle networks. The application of commands generated by the ADAS functions provide expanded capabilities beyond those of the driver.
- An ADAS technician must have a thorough knowledge of vehicle electronics to understand the electrical nature of many of the fundamental systems that interact with ADAS and to understand the computer programming behind the ADAS itself.

- The increased use of bus systems provides the necessary speed and volume of data flow to support timely determinations and actions. A gateway module manages the data flow across two or more networks that may or may not be operating on the same network protocols.
- A security gateway protects the network from threats. It secures communications from external sources, and it uses the DLC to secure communications from internal sources. It also separates the network into private and public segments, and it regulates access to the private segment.

CRITICAL THINKING

1. Describe the operation of electric power steering.

2. A technician is tasked with calibrating the radar sensor on a vehicle, but the scan tool is only able to communicate with the PCM. What could be wrong?

3. Explain why it is important for a vehicle to have a network of electricity and vehicle electrical systems.

4. Describe the operation of a transmission.

5. Describe the operation of vehicle electrical systems.

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ASE-Type Questions

1. The EPS system utilizes which of the following sensors during operation to determine assist requirement?
A. Forward-facing camera.
B. Front radar.
C. Torque sensor.
D. Wheel speed sensors.
2. A fault in the ETC system could result in operational problems in which of the following systems?
A. Traction control.
B. Stability control.
C. Cruise control.
D. All of the above.
3. The ESC system utilizes which of the following sensors?
A. Wheel speed.
B. Forward-facing camera.
C. Front radar sensor.
D. Torque sensor.
4. Which of the following vehicle networks utilize a single wire?
A. MOST.
B. FlexRay.
C. LIN.
D. CAN.
5. On a typical vehicle, the scan tool communicates directly with the _____ module.
A. engine control.
B. anti-lock brakes.
C. gateway.
D. body control.
6. Technician A says that EPS has the ability to make steering corrections without the driver's input in certain ADAS operations. Technician B says that EPS only provides assist, and the driver is still required to provide steering input in all ADAS operations. Who is correct?
A. Technician A only.
B. Technician B only.
C. Both technicians are correct.
D. Neither technician is correct.
7. Technician A says that ETC is not utilized for any ADAS corrections. Technician B says that a fault in the ETC system could inhibit some ADAS functions. Who is correct?
A. Technician A only.
B. Technician B only.
C. Both technicians are correct.
D. Neither technician is correct.
8. True or False? A fault in the ESC system would have no impact on ADAS operation.
A. True.
B. False.
9. Technician A says that bus system faults would not impact ADAS operation, as all ADAS components are directly wired to each other. Technician B says that bus system faults can affect multiple vehicle systems. 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 the security gateway is designed to only allow access to approved users for the public segments. Technician B says that the security gateway is designed to only allow access to approved users for the private segments. 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 3: Fundamental Systems ID.

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Chapter 5, Fundamental Vehicle Systems 13

End-of-Chapter Content

End-of-chapter material provides an opportunity for review and application of concepts. A concise **Summary** provides an additional review tool and reinforces key learning outcomes. This helps students focus on important concepts presented in the text. **Critical Thinking** questions develop higher-order thinking and problem solving.

ASE-Type Questions enable students to demonstrate knowledge, identification, and comprehension of chapter material in the question style of the Advanced Driver Assistance Systems (ADAS) Specialist Test (L4) established by the National Institute for Automotive Service Excellence (ASE).

Hands-On ADAS points the student to the associated **job sheets** for hands-on practice opportunities.

Name _____ Date _____ Class _____

JOB 12 Pre-Calibration Check

Make _____ Model _____ Year _____ VIN _____ Mileage _____

Objective:

To complete necessary pre-calibration checks prior to calibration.

Tools and Equipment:

- Shop or service facility
- ADAS-equipped vehicle

Instructions:

In this job, you will complete necessary checks on the shop or service facility and on the vehicle that is to be calibrated. You will need to read Chapter 10, *Facility and Environmental Requirements* and Chapter 11, *Calibration in the Advanced Driver Assistance Systems* textbook before starting the job.

Equipment Requirements

1. What system is being calibrated?
Answer: _____
2. Check the OEM materials. What calibration type is required?
____ Static
____ Dynamic
____ Both
3. Confirm proper equipment is available to perform the calibration (targets, stands, scan tool, power supply unit, and so on). List the necessary equipment for calibration.
Answer: _____
4. List the part number of the target or targets required.
Answer: _____

Facility Requirements

5. Is there proper shop space for uninterrupted calibration?
____ Yes
____ No
If no, what can you do to fix the problem?
Answer: _____

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6. If calibrating a radar system, confirm that there are no obstructions in the service bay that could interfere with radar calibration.

7. List the target locations.
Answer: _____

8. List the target-to-vehicle distances.
Answer: _____

Vehicle Requirements

9. Perform a visual inspection of the vehicle. Describe any areas of concern.
Answer: _____

10. Check for diagnostic trouble codes (DTCs) applicable to ADAS and related systems. List any applicable DTCs.
Answer: _____

11. Are the tires the correct size?
____ Yes
____ No
If not, explain how tire size can affect vehicle calibration.
Answer: _____

12. Do the tires show signs of wear?
____ Yes
____ No
If yes, describe how tire wear might affect calibration.
Answer: _____

13. List the tire pressure specifications.
Answer: _____

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TOOLS FOR STUDENT AND INSTRUCTOR SUCCESS

Student Tools

Student Text

Advanced Driver Assistance Systems (ADAS) is a comprehensive text that focuses on the information, technology, and procedures used by professional automotive technicians to service, diagnose, and repair ADAS-equipped vehicles.



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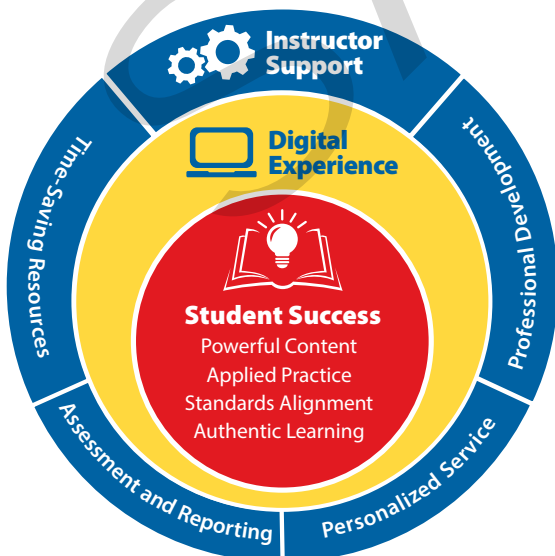
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See www.g-w.com/advanced-driver-assistance-systems-2024 for a list of all available resources.

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