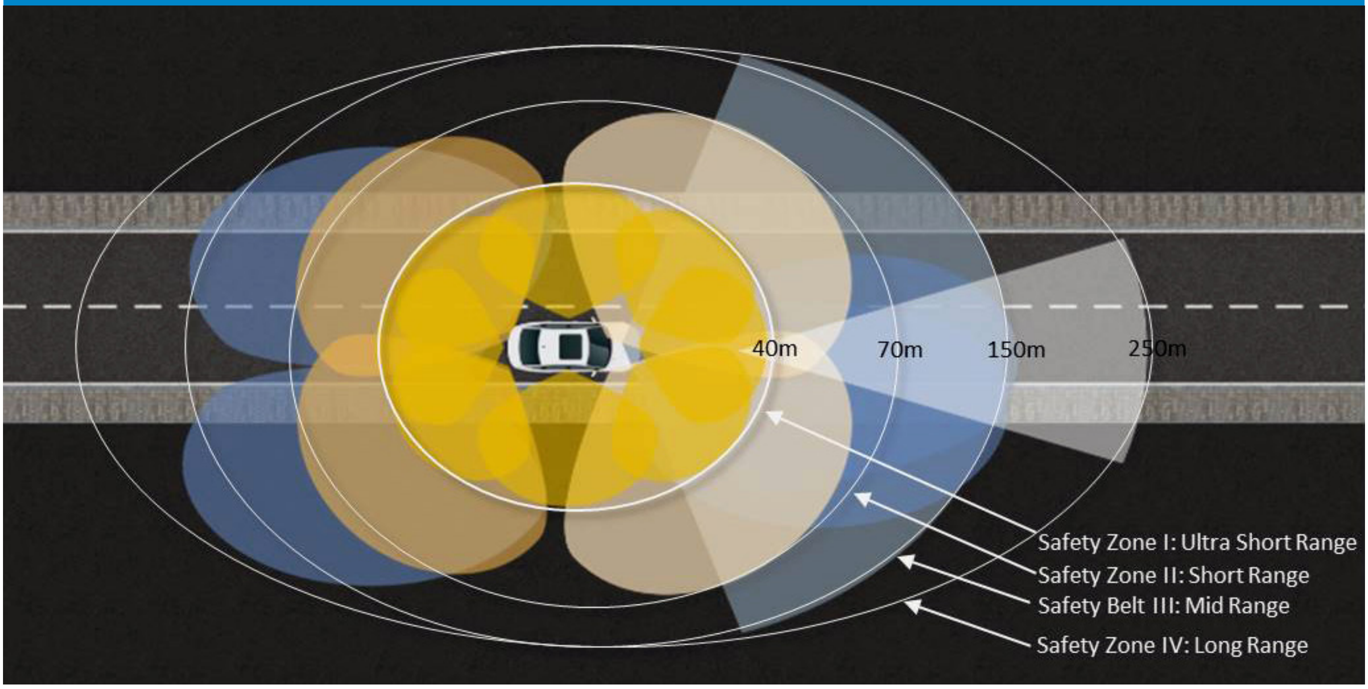
EGEA
EUROPEAN GARAGE EQUIPMENT ASSOCIATION

Best Practise for ADAS repair and calibration

EGEA WORKING GROUP 2 ADAS

Hello Reader,
Welcome to this EGEA Best Practise document for ADAS. This document has been contributed to by garage equipment experts with the EGEA Working Group and in cooperation with other interested groups. The document leads you, the reader, through the various topics concerning ADAS, right from all of the ADAS names, definitions and abbreviations to recommended practises of repair and calibration. We expect that reading this Best Practise document will assist you in the understanding of ADAS and a glimpse of what is to come. As this topic is developing at an exponential rate not all ADAS is covered at the time of publishing, however, it will provide you with the knowledge to understand what is ahead of all of us in this exciting and complex area.We hope you enjoy reading EGEA ADAS Best Practise. Note: ADAS systems or variants of such can be covered at the time of publishing and as such should not be considered as exhaustive. Future revisions will update the contentson new systems.



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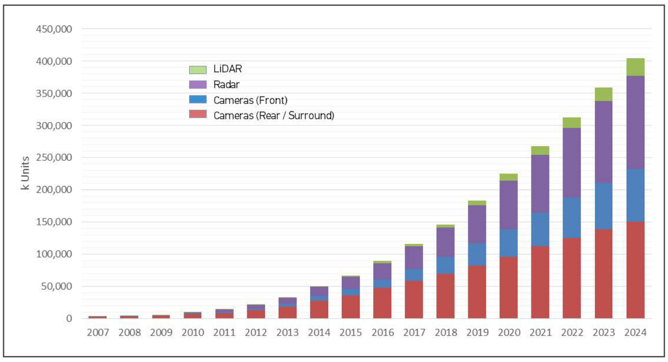
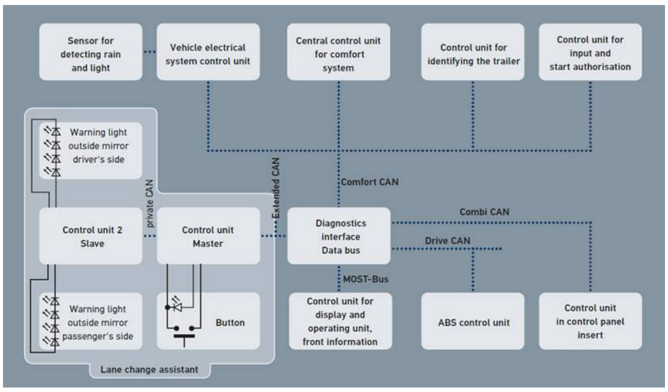
1. INTRODUCTION

WHY A BEST PRACTISE DOCUMENT

Today's vehicles have an increasing number of 'automated driver assistance systems' – normally abbreviated to ADAS. Tomorrow's vehicles will take this to another level, as vehicles becomes fully automated and autonomous. These automated systems all share the need to be functioning correctly and for this to be possible, they require to be calibrated correctly throughout the service life of the vehicle. During this time, it is likely that the vehicle will need replacement parts, mechanical adjustments, perhaps a replacement windscreen, or will have sustained accident damage. Any one of these is likely to create the need for re-calibration of an ADAS.

An increasing number of these driver assistance systems are being mandated in European legislation (e.g. (EU) 2019/2144)





and there are many more systems being implemented by individual vehicle manufacturers, either as a standard part of a vehicle's specification, or as a 'extra cost option'.

Many workshops are not yet fully familiar with all these automated assistance systems, and consequently the correct methods to re-calibrate them.

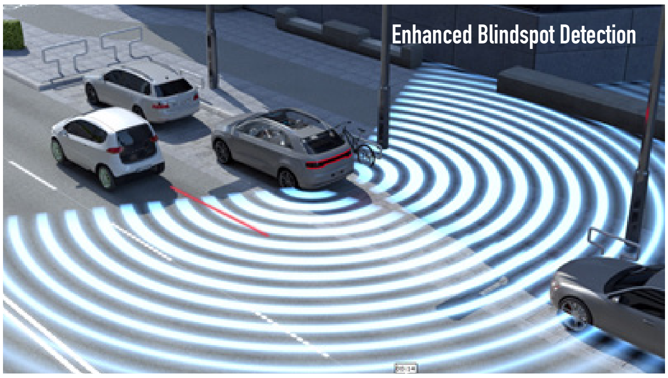
This document seeks to help explain the different grades of autonomy (levels 1, 2, 3, 4 and 5) and the corresponding differing technologies and functions, the testing and repairing of the systems and ultimately, how to re-calibrate them correctly.

The European Garage Equipment Association through those companies who are members of its European national associations, combine substantial expertise and experience in the design, operation and technical support of the specialist equipment required to diagnose, repair and re-cailbrate automated driver assistance systems.

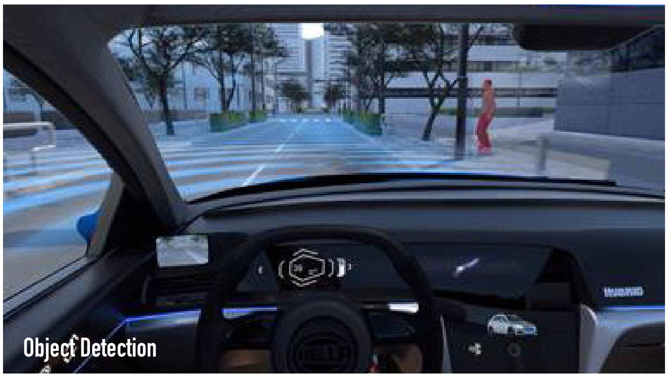
The following Best Practice document is intended to help technicians maintain and improve their professional knowledge and competence when working on automated driver assistance systems. The information contained in the Best Practice document is based on some of the practices, techniques and procedures, as well as the information, tools and equipment which have been commonly used in ADAS diagnosis, repair and recailbration procedures that ensure that a vehicle ADAS is able to function to its design criteria. This document is intended as a guide and does not deal with specific VM proceses etc.

2. DEFINITIONS AND SYSTEM DESCRIPTIONS

Although driver assistance systems are available in the most diverse forms and functional depths, they all have two things in common: They make driving a car safer and more comfortable. Modern sensors such as ultrasound and laser sensors (Lidar sensors) and, of course, surround-view cameras ensure safe distance recognition and also recognition of the driving environment. A (central) control unit processes the data and converts it into signals such as warning beeps, visual messages or even active reactions like braking intervention or acceleration impulses (speeding up).



Today these actions usually occur digitally and within a fraction of a second. The more extensively a driver assistance system engages in the actual driving operation, the more it begins to „virtually" replace the driver (the cue for driverless driving). Even if this only happens consciously in dangerous situations, the question of liability is still being raised. This is where manufacturers are bound by duty to minimize risks and prevent hazards of all kinds. An ethics commission has now embraced this subject and initial framework conditions have already been defined. But the dilemma of this issue still remains controversial. Driving assistance systems can, however, as a rule can be switched off or deactivated by the driver.



Because of the variety of systems available and all the individual solutions offered by different manufacturers, it is impossible to make a general statement as to which type of sensor and sensor generation would be suitable for use in any one particular application. Vehicle manufacturers use the most diverse driver assistance systems, practical combinations and new technologies in all the different vehicle classes.

Designations are not always identical and, to a certain extent, manufacturers use their own terminology and abbreviations. It is not possible here to examine all the technical details and every single manufacturer.

The following is a list of terms and definitions used within ADAS, some are general and some are VM specific (this is indicated where necessary). This list is not exhaustive.

A. AFS – ADAPTIVE FRONT LIGHTING

The task of adaptive bend lighting is to illuminate the streets and the sidewalk when vehicles turn off and drive around bends. A steering-angle sensor measures the angle of the steering wheel and transmits the signal to stepper motors which then accordingly adjust the headlamp elements.
A simple and mechanically less complex variant switches on an auxiliary lamp in order to illuminate the surrounding area when a certain steering angle is achieved.Bend lighting can be achieved more effectively with LED, matrix, laser or LCD headlamps. No mechanical system is required for this - the appropriate light sources are simply controlled. These systems perform in a highly intelligent way. See also fully adaptive light distribution.

B. ADAPTIVE CHASSIS

Adaptive chassis will adapt by almost anticipating possible road unevenness or dangerous bends. State-of-the-art systems are connected to a camera, among other things, which can identify the road situation. Passive systems are also common. These can be activated at the touch of a button inside the vehicle (comfort, standard, sport).
The chassis is then changed by means of electrically controlled valves in the shock absorbers. This means that either more or less oil flows into each shock absorber. A (temporary) transformation of the damper characteristics is the result.
The objective of an adaptive chassis is to improve driving characteristics by taking into account braking, steering and acceleration processes. This aims to increase safety for passengers and ramp up vehicle performance.

C. ADAPTIVE DISTANCE AND SPEED REGULATING (ACC)

Distance and speed regulating or also the automatic distance control (ACC=Adaptive Cruise Control) autonomously brakes and accelerates the vehicle depending on the flow of traffic. The vehicle „eases back" and brakes - e.g. when in bumper-to-bumper traffic - whenever necessary. Even a cutting in or merging of vehicles up ahead is recognised. The risk of pile-ups with rear end collisions is thus minimised and the driver is spared the constant stopping and starting action. This takes place within defined limits, e.g. up to a maximum speed and by observing a predefined safe distance. Such a process involves radar sensors monitoring the area next to and in front of the vehicle. The sensors measure the distance to the vehicle in front and accordingly trigger braking intervention or acceleration. These systems, in some instances, can apply the brakes to a vehicle completely – e.g. in traffic jams (ACC Stop & Go) - but without initiating an emergency brake procedure. In some systems, an alarm tone also signals and gives warning of a hazardous situation. ACC is also frequently combined with steering control systems or with lane tracking assistants such as Lane Assist.

D. ADAPTIVE HIGH BEAM (SEE ALSO GLARE-FREE HIGH BEAM)

With the adaptive high beam, i.e. the adaptive high beam assistant, the principle of a sliding headlamp leveling system applies. The xenon headlamps are coupled with a camera capable of providing intelligent image evaluation. Depending on the camera signal given (from oncoming traffic or from preceding vehicles), the system changes the illumination range, which can reach either up to 300 m or just to the anti-glare zone of the next vehicle. As soon as the camera no longer recognises any other road users, the system once again slowly and in a sliding motion switches to ‚high beam'.
Straightforward high-beam assistants with H7 lamps simply switch the high beam light on and off using a light sensor (camera sensor). The system also reacts to ambient lighting and partly to reflective road signs (See also light source recognition).
The so-called laser light, currently being used by BMW and Audi, also reacts in a fully adaptive way. And as this involves no movement of mechanical elements, the reaction speed is high. Adjustments for high beam, low beam and bend lighting are electronically controlled to suit individual requirements.

E. ADAPTIVE STEERING (ACTIVE STEERING)

With adaptive steering or also with active steering (AFS - Active Front Steering), the steering ratio is performed variably. This means that steering behaviour varies in accordance with the actual driving situation and with the speed traveling. In this way the steering assistant enables easier manoeuvring at low speeds or when a vehicle is being parked. When vehicles are driving on the motorway or at higher speeds, adaptive steering brings about improved directional stability. An actuator inside the steering wheel (Ford) ensures the appropriate conversion of the steering impulses. A different model (BMW, Servotronic) varies the hydraulic steering support and - depending on the speed - in this way can make the steering smoother or harder or more direct.
The adaptive steering or active steering does not generate the necessity for any active steering intervention as is the case, for example, with lane-keeping systems.

F. ANTI-LOCK BRAKING SYSTEM (ABS)

The anti-lock braking system (ABS) is one of the first ever driver assistance systems. As the first series vehicle, the Mercedes S-Class boasted an anti-lock braking system in 1978 (ABS 2 from Bosch). The BMW 7 series then followed suit. During braking the ABS prevents the wheels from blocking and thus ensures that the vehicle can still be kept under control. Furthermore, considerably shorter braking distances can be achieved and the vehicle neither skids nor swerves.
Individual RPM sensors on the wheel (inductive or more commonly today Hall generators) measure the relevant rpm differences across a perforated disk or a toothed disk. If the wheel speed drops disproportionately with respect to the other wheels, the brake pressure on each wheel is reduced but is re-established shortly afterwards (brake pressure modulation). The driver becomes aware of the pressure increase by means of pedal vibration. At the same time solenoid valves open and close in quick succession. This takes place in the central ABS control unit. It permanently utilises the signals received from the wheel speed sensors. It is made up out of the hydraulic block including the valves, an electric pump and also the low pressure reservoir and the electronic control unit.
Current ABS versions take over even more functions such as intelligent brakeforce distribution over all four wheels. In this way, depending on the driving situation and without the brakes being actively applied, other regulating intervention is possible with a view to keeping the vehicle stable on the road (See also ESP).

G. AUTOMATIC REPORTING OF ACCIDENTS (ECALL)

When an accident happens, crash sensors (which are also responsible for the opening of airbags) or collision sensors report and forward data to a central unit. Depending on the ACN system (Automatic Crash Notification), information such as the location, the severity of the accident and all relevant additional data is forwarded to the emergency centre. This emergency centre also endeavours to make contact with the driver. Necessary measures such as the making of emergency calls are then taken. These systems are also described as eCall and from April 2018 are compulsory for new vehicles. Their names are manufacturer-specific with examples such as OnStar (GM), BMW Assist, Safety Connect (Toyota) and Car-Net (Volkswagen).
As well as having a variety of connectivity functions, some of the systems also boast their own alarm systems, which monitor the doors and the ignition lock and also the functioning of an inclination and vibration sensor. In the case of Volkswagen, for example, any form of manipulation carried out on the vehicle, together with all details on the vehicle's position, is sent via text message to a central office.
Because the systems are also capable of transferring other data including vehicle and location-specific information or, if necessary, they can also create a driving profile, critical discussions revolving around the subject of data protection remain very much an issue. Independent workshops not bound to a certain manufacturer consider themselves to be at a disadvantage since vehicle-specific data (mileage, service levels, wear and tear information) (can) be sent to the manufacturer or to the nearest brand dealers.
There are also simple, retrofitable accident reporting systems on the market, tools which use an app to give information on any incidents or accidents.

H. BLIND SPOT ASSIST (BSD=BLIND SPOT DETECTION) (SEE ALSO LANE CHANGE ASSIST)

The term ‚blind spot' refers to the area which, despite side and rear-view mirrors, for a short time cannot be seen by the driver. This normally concerns traffic behind or those vehicles in the process of overtaking on the left.

Blind Spot Assist calculates the position, the distance and also the direction of travel of other vehicles and gives a warning about vehicles driving on adjacent lanes. The system facilitates changing lanes and prevents accidents. BSD systems (Blind Spot Detection) operate by default with radar sensors located on both sides of the vehicle, sensors which can also be used for parking aids and for the Park In Assist system.

I. BRAKE ASSIST (BRAKE ASSISTANT)

The first brake assistance system was launched around 30 years ago with ABS. Its purpose is to prevent the wheels from blocking during braking. Since November 24, 2009, a basic brake assistant has been compulsory for new vehicles throughout the EU. During a jerky emergency stop, the system increases brake pressure via the ABS and in doing so supports a prompt deceleration of the vehicle, sometimes even to the point of it coming to a standstill (DBC = Dynamic Brake Control). Forward-looking sensors do not play a role in this process.

J. EMERGENCY BRAKE ASSIST (EBA)

Monitors the area ahead of the vehicle by means of radar sensors or cameras. Should a pile-up or any collision with another road user or with an animal be imminent, then a warning is given to the driver. Brake pressure is also built up via ABS. Depending on the system, the vehicle triggers a deceleration and shortens the braking distance. If a collision is unavoidable, an emergency stop can also be initiated within the system limits. One such example is the Collision Prevention Assist Plus (CPAP) from Mercedes.
Other emergency brake assistants go by names such as Intelligent Brake Assistant (IBA, Infinity), Pre-Collision Safety System (PCS, Toyota) or quite simply Automatic Emergency Brake (AEB). Systems for town traffic like the City emergency brake function from Volkswagen, City Safety from Volvo or Active City Brake (PSA Group) lessen the impact during rear-end collisions in inner city bumper-to-bumper driving or, in the best case scenario, they prevent them completely. The front sensors of the systems also recognise pedestrians, cyclists and animals. Depending on the system definition, each of these brake assistants function up to a certain speed, for example up to 20mph. A visual, haptic or acoustic warning (Forward Collision Warning) precedes the active brake intervention.

K. BRAKE DISC WIPERS (BDW)

This term has absolutely nothing to do with a clean windshield. The brake disc wiper, as a result of light pressure being applied to the brake pads, ensures that the brake discs produce a „gentle" dry braking during heavy rain. The result is that braking response and performance are optimised. In order to initiate this procedure, the rain sensor sends the necessary signal to the ABS control unit

L. CAR-TO-CAR (COMMUNICATION)

So-called car-to-car communication models are being developed. This is where road users or vehicles communicate directly with one another via a self-sufficient system (no mobile phone network) and exchange traffic information even before their vehicles are within reach of one another. The individual drivers concerned – or their assistance systems on board – can then quickly prepare for a potentially dangerous situation such as a traffic jam even before they see the hazard.One example application is the electronic stop light.

M. CAS – COLLISION AVOIDANCE SYSTEM

The avoiding of collisions is the key requirement of any driver assistance system. In principle, even when it comes to parking assistance, it is always a question of systems designed to avoid a collision. But, for a long time now, technological development has been taking things quite a bit further. While emergency brake assistants, lane-keeping or intersection assistants have been making their way into modern vehicles, the vehicle manufacturers in collaboration with partners from the field of research and development have been developing more intelligent systems in order prevent collisions right from the start. We are referring to ACA=Advanced Collision Avoidance Systems. And the challenge is this: the achieving of an extended perception of the vehicle environment by means of long-distance radar and the intelligent expanding of existing systems. The main protagonist in all this is the amount of information supplied by the relevant sensors and cameras (in future also information which will be provided by other vehicles) and its intelligent processing and translation into appropriate measures to be taken. It is also worth mentioning that special attention is being given to the possibility that other road users could become endangered through the intervention of an assistance system. Not all vehicles are equipped with the same technology and could then unnecessarily be exposed to danger by a third party. If this subject is taken further to the level of autonomous driving, problems such as the above-mentioned dilemma will surely play a major role in all discussions.

N. CBC – CORNERING BRAKE CONTROL

BMW has been using Cornering Brake Control since 1997 - other manufacturers have followed suit. As steering into a bend means that pressure on wheels on the inner side of the bend is lessened (depending on the bend radius and on the speed), it can happen that when brakes are applied the result could be ‚over-revving' or ‚over-braking'. The vehicle can then get into a skid. This can be prevented by Cornering Brake Control. Such a system with the assistance of the ABS control unit (the speed of every wheel is measured by the ABS sensors) controls every wheel individually, thus regulating brake pressure individually. The vehicle then, within the system limits, remains stable even when braking in bends. The driver is totally unaware of this control procedure.

O. CONSTRUCTION ZONE ASSIST

Everyone knows the sometimes very tight, narrow lanes in the vicinity of roadworks on the motorway or side roads. Enter Construction Zone Assist which, with cameras (stereo cameras) and ultrasonic sensors, makes sure that the driver stays in the lane even when it is exceptionally narrow so that no collision with other road users can be caused. If required, the appropriate steering corrections are performed while, at the same time, it is ensured that a safe distance to the vehicle in front and to both sides is observed. Furthermore, some Construction Zone assistants give audible and visual warnings in good time if narrow stretches are expected.
These systems, however, are limited in their effectiveness. In thick fog or when the sun is low, such driver assistance systems switch off.

P. CROSS TRAFFIC ALERT

Cross Traffic Alert recognises critical cross traffic and warns the driver both visually and audibly. Almost all vehicle manufacturers offer such a cross traffic assistant, a tool which operates on the basis of a brake assistant and by using information from cameras (stereo cameras) or from radar sensors. Cross Traffic Alert is usually only active up until a defined speed is reached.

Q. DYNAMIC STEERING RESPONSE (DSTC) (SEE STEERING ASSIST)

The Dynamic Steering Response DSR and Dynamic Steering Traction Control make up a system which provides steering recommendations depending on the driving situation (e.g. if a vehicle oversteers in a bend). This manifests itself in a slight electromotive counter-steering, which stabilises the vehicle and improves its directional stability. During this process the DSTC operates together with the ESP and receives information via the four wheel speed sensors. It is hardly noticeable that the DSTC intervenes in the steering movements. Independent steering of the vehicle is no longer possible. The first to put this technology into serial production was Seat with the Cupra R.

R. ELECTRONIC STOP LIGHT

With the help of car-to-car communication, (in future) it will be possible to use information from several vehicles in order to make driving safer. One example of how this can work is the electronic stop light. It supplies information about a braking manoeuver carried out by vehicles traveling ahead, vehicles which are not yet even in the field of vision. In the worst case it could be an emergency brake situation. This means that the driver who is following can, in a way, ‚see ahead' what sort of potential danger is waiting for him - e.g. on narrow winding country roads - and then prepare himself accordingly. Another example is the Construction Zone Assist which can convey similar information about vehicles traveling ahead that are not in view (See also Car-to-Car Communication).

S. ESP (ELECTRONIC STABILITY PROGRAM)

Together with the ABS (1979), the ESP is regarded as ‚the classic' of the driver assistance systems. By way of brake intervention (and also intervention in engine management), it improves both directional stability and the stability of the vehicle in borderline situations (e.g. during understeering or oversteering). The ESP is seen as an extension of the ABS and the TCS (Traction Control System).
The term ESP is protected for use by Daimler. The first serial use of the Bosch system was seen in a Mercedes-Benz S Class in 1995. For this reason other manufacturers have chosen to use different designations such as DSC (Dynamic Stability Control, Jaguar and Mazda), VSA (Vehicle Stability Assist, Honda), VSC (Vehicle Stability Control, Toyota) or PSM (Porsche Stability Management).
ESP forms, for example, a basis which can be linked to other systems such as the electronic differential lock, the engine drag torque control, the hydraulic brake assistant including augmented braking power, trailer stabilisation and also the so-called brake disc wiper.

T. FATIGUE DETECTION

Permanent steering-wheel movements and corrections carried out in a sloppy way - even on a straight stretch of road - are clear signs of overtiredness. The steering angle sensor collects signals and compares them (depending on the expansion level of the system) with GPS data on the route's topography. Duration of the journey, the time of day and the amount of mileage covered all play a role, too. ‚Tired' drivers receive a warning in the form of a visual symbol or an audible signal, encouraging them to stop for ‚a coffee break'.

U. GLARE-FREE HIGH BEAM (SEE ALSO FULLY ADAPTIVE LIGHT DISTRIBUTION)

The glare-free high beam, also called the vertical cut-off line or Dynamic Light Assist, follows the principle of a constantly switched-on high beam that in no way dazzles other road users. The (earlier) xenon-based system automatically tailors light distribution to suit the traffic situation by using a small rotating drum and masking.
Today the glare-free high beam is created by means of LED headlamps. The principle, however, remains the same. Individual LEDs are selected and switched on and off. Examples of this are the Audi Matrix LED light and the Mercedes-Benz Multibeam LED light. An intelligent camera positioned behind the vehicle windshield is instrumental in the functioning of the control system. It recognises headlamps or rear lights of vehicles in front and takes over other tasks of surveillance (object detection).
With both these systems, the disturbing and dazzling effect of lights on other road users is masked out. But the side of the road and all other parts of the road remain illuminated. The result is that pedestrians or animals such as deer can be recognised more clearly and sooner without passengers in oncoming traffic or in vehicles up ahead being dazzled.
Attention!! The prerequisite of an optimally functioning headlamp system is the correct adjustment. This should always be carried out by a professional technician in a workshop.

V. HILL HOLD ASSIST

Hill Hold Assist prevents the vehicle from rolling back when starting up on a mountain road thanks to braking intervention applied on the rear axle. The brake (EPB= Electrical Parking Brake) is released as soon as clutch engagement completes the start. Vehicles with automatic or dual clutch transmission require the switch position to be set on ‚D'. In wintry conditions the Traction Control System provides the necessary grip for countless numbers of vehicles (See also Traction Control System - TCS).

W. INTELLIGENT BRAKE ASSIST (IBA)

The intelligent and anticipatory emergency brake assistant (IBA) prevents pile-ups and collisions with other objects by warning the driver in good time and also by triggering brake intervention right up to the point of a complete and autonomous emergency stop. Depending on the system in question, state-of-the-art camera systems and radar sensors monitor the front of the car. In parallel, messaging systems also help with the recognising of objects. If it is impossible to prevent a collision, airbags, seat belt tensioners and headrests are accordingly prepared and adjusted. Intelligent Brake Assist from

Infiniti also integrates, for example, a collision warning system (Forward Collision Warning).

X. LANE CHANGE ASSIST

With Lane Change Assist, radar sensors on the vehicle rear end complement the driver's ‚glance over the shoulder' when changing lanes. These sensors monitor the entire rear of the vehicle as far as the side parallel to the car including ‚the blind spot' where other vehicles might be driving. If the driver indicates because he wishes to change lanes, a warning is issued if any other vehicles are approaching. This can be a visual warning in the side mirror or - depending on the system -also an audible one (See also Blind Spot).

Y. LANE TRACKING ASSIST / LANE DEPARTURE WARNING

With the help of a camera mounted behind the windshield and which orients itself toward the road markings, Lane Tracking Assist sees to it that a vehicle remains in its lane. Differences in contrast between the road surface and lane stripes/hard shoulder stripe make this possible.
Systems are available with a haptic warning function such as a vibrating of the steering wheel (Lane Departure Warning) and there are also active systems (Lane Tracking Assist) which react by means of active steering intervention. If a vehicle leaves the ideal lane, first of all (depending on the system) a haptic or acoustic warning is given and then a ‚gentle' steering intervention follows in order to bring the vehicle back ‚on track'. When the vehicle actively and purposely departs from the lane, for example during an overtaking manoeuver using indicators, the system is suppressed.
At night the contrasts between the road markings and the road surface are slight and on some country roads there are no markings at all. When the detection limits have been reached, the lane tracking assistant or the lane departure warning system switches off. But the latest, intelligent systems with their state-of-the-art camera technology can even operate in dark and foggy conditions and they require fewer orientation guides (such as a median strip).

Z. LEFT (RIGHT) TURN ASSIST

Turning left (Right) on (busy), partly confusing junctions is always a source of latent danger. Left (Right) Turn Assist recognizes oncoming vehicles and warns the driver visually and audibly. It can also trigger brake intervention in order to lessen or completely prevent a potential collision. Ultrasound sensors, radar sensors or intelligent camera systems are tasked with the job of recognising oncoming vehicles. (See also Car-to-Car Communication).

AA. LIGHT SOURCE RECOGNITION

Sensor-based systems (light sensors) aimed at recognising the ambient light situation form the foundation of automatic or interactive measures designed to regulate vehicle lighting. Oncoming traffic is just as relevant a factor in this equation as those vehicles driving ahead. A part is also played by the boundary between daytime and nighttime and also by the recognition of street lighting and reflective road signs.
It is the recognising of light sources that has, for example, given rise to all the following: high beam assistant, instrument or screen illumination (fully digital information displays with Volkswagen's Active Info Display as a good example) and intelligent assistance systems such as adaptive bend lighting, adaptive light distribution (selective illumination of danger zones, AFS - Advanced Frontlighting System) or the glare-free high beam (adaptive cut-off line). And all the time an increasing number of camera-based lighting control is being implemented.
Tricky manoeuvring, for example in multi-level garages, or when lighting conditions are bad and especially as vehicles seem to be getting bigger, harbours the risk of scrapes or dents or even personal injury. With the help of environment sensors, Manoeuver Brake Assist is ready to monitor the immediate surroundings and, when and where necessary, intervenes by braking without delay. Manoeuver Brake Assist functions only at low speeds, e.g. below 10mph

BB. NIGHT VIEW ASSIST

So-called night view systems (thermal imaging cameras) are known for their use in a variety of applications. Binoculars which increase residual light can detect and identify, for example, wild animals even if it is completely dark. The prerequisite is that the necessary temperature differences are present.
In 2005 Mercedes launched on the market the first night view system for car applications. Other manufacturers followed suit. Today an infrared camera in conjunction with additional infrared headlamps enables objects to be registered and made visible: It captures not only people (people recognition) and animals but also (independent of temperature) branches and all kinds of other things. The image appears in the display of the vehicle or even better as a head-up display in the driver's field of vision.
The Night View assistant can be combined with brake, light, steering or chassis assistants. In this way active, safety-relevant corrections to the vehicle can be carried out in order to prevent accidents.

CC. PARK ASSIST AND GARAGE ASSIST (PARK IN/PARK OUT ASSIST)

With the Park Assist and Garage Assist (also Park In/Park Out Assist or Garage Pilot), ultrasonic sensors (and also surround-view cameras or laser scanners) of each individual vehicle type recognise suitable lengthwise and crosswise parking bays and then measure distances. The difference between Park Assist and Garage Assist and the simple Park In/Park Out parking aid (Distance Warning System) or rear view camera with its visual parking assistance function is the automated support given by the vehicle during the parking procedure.
With the usual, partially active systems, the driver is informed about the parking options as he slowly drives by. If the driver then stops and activates the parking pilot, the assistant steers the car autonomously into the space. But the driver remains in the vehicle in order to accelerate and brake.
With the passive combination of Park Assist and Garage Assist, the vehicle steers into a parking space totally autonomously (even in multi-level garages) or into a garage and then out again. Garage Assist can recognise obstacles such as bicycles and is able to park in very narrow garages. The driver is not obliged to sit in the vehicle (passive) - on the contrary, he can control the relevant system from outside using a smartphone app and ‚enjoy the parking show' so to speak. The only task left to him is the monitoring of the procedure and also a button in the app has to be permanently pressed otherwise the parking operation will be cancelled.

DD. PARK OUT ASSIST – EXITING

Park Out Assist for exiting a parking space (e.g. from Volkswagen) or the Rear Cross-Traffic Alert (RCTA, e.g. from Mazda) both use the radar sensors of the blind spot warning (Blind Spot Detection, BSD). When the car is pulling out of its parking space, the sensors recognise vehicles or pedestrians crossing from behind or indeed any other kinds of obstacles before the driver becomes aware of them. Warning is given in the form of an acoustic signal or via flashing LEDs (e.g. in the rear-view mirror). The angle of detection is usually 120 degrees.
If the driver assistance system recognises an imminent collision, it alerts the driver by means of a warning beep and/or a visual warning (e.g. using LEDs in the rear-view mirror). With some systems, automatic braking of the vehicle is also carried out (See also Park Assist and Garage Assist).
Park Out Assist for exiting a parking space is activated when the reverse gear is engaged or when the automatic gear transmission is set on ‚R'. If the vehicle is fitted with a hitch or coupling device and a trailer is being towed, then the Park Out Assist for exiting a space is deactivated.

EE. REAR END PRE-CRASH ASSIST

Rear End Pre-Crash Assist tracks vehicles approaching from behind and, in the event of an imminent collision, pre-activates safety devices such as airbags, seat belt tensioners or the automatic voltage shutdown of a high-voltage vehicle or of an electric vehicle. It also makes sense to have an appropriate warning beep sounding (in advance) so that the driver, where necessary, can react in the correct way.

FF. ROAD/TRAFFIC SIGN RECOGNITION

With the help of intelligent, image-processing software, camera systems can recognise important road signs such as speed restrictions (See Speed Limit Assist), overtaking restrictions or construction zone signs. The driver is warned visually and audibly. In this way, drivers can be prevented from missing a vital road sign.

GG. SAFE EXIT ASSIST

The Safe Exit Assist warns against the dangers of opening vehicle doors when traffic is approaching from behind. Radar sensors, which provide signals including those for Park In Assist, Lane Change Assist, Rear End Pre-Crash Assist or for Blind Spot Detection, recognise vehicles, cyclists or individual pedestrians as potential obstacles. Depending on the type of vehicle, either an audible warning is given or the hazard is visually indicated by means of a light signal in the field of view or in the door trim panel.

HH. SPEED LIMIT ASSIST

Modern camera systems recognise road signs indicating speed limits. With the aid of intelligent, image-processing software, the vehicle is able to warn about these speed restrictions in real time. The warning can be an audible alert and/or it can be visual. Some systems even recognise road signs in foreign countries or they can change/delete the warning in towns or when speed limits have been lifted.
Even recognition of other traffic signs is possible as is the linking up with more assistance systems.
Navigation systems similarly indicate any form of speed restriction but with a certain condition, i.e. their software/map data must be up to date!

II. TEMPOMAT

The Tempomat (a brand name of the Daimler AG) is one of the oldest driver assistance systems. A comparable system from Chrysler first came on the market in the USA in 1958 (Cruise Control). The RPM was kept steady by means of a Bowden cable and thus the speed, too. In 1962 Mercedes in Germany followed this development up with the Tempomat.
Modern tempomats regulate the speed electronically, taking charge of acceleration and deceleration so that the speed is maintained as exactly as possible. Assistance systems like ACC ensure that the necessary safe distance is kept to the vehicle in front. The Tempomat is immediately shut down when the brake pedal is operated or when a distance regulation system kicks in.
Classically, the Tempomat is controlled by an additional pitman arm. In the new S-Class control is carried out via buttons on the steering wheel. (cf. Speed Limit Assist).

JJ. TRACTION CONTROL SYSTEM (TCS)

A traction control system (abbreviated to TCS) prevents spinning of the drive wheels when driving off or during rapid acceleration on unpaved roads. The system is called different names by the various vehicle manufacturers. Here are some examples: Automatic Stability Control (ASC) at BMW, Traction Control System (TCS) at Mazda or Traction Control (TRC) at Toyota. Most of the other manufacturers, however, use the abbreviation TCS for traction control.
Traction control can either be put into practice by brake intervention or by intervening in engine control. Control signals are sent by the relevant ABS sensors (or RPM sensors) which, within defined system limits (slip angle, maximum 10-20 degrees), signal the slip slope of the wheels (ratio of torque to wheel slip). The system functions with front, rear or all-wheel drives.

KK. TRAFFIC JAM ASSIST

Depending on individual vehicle manufacturers, Traffic Jam Assist combines the automatic distance control (part of ACC), the brake assistant and the lane tracking assistant. Radar sensors observe the (bumper-to-bumper) traffic in front of their own vehicle and a camera orients itself toward the road markings. The vehicle stays in its lane, keeps a defined distance and, if necessary, (within defined system limits) triggers a braking action which can lead to a standstill. Automatic starting up again in bumper-to-bumper traffic is also intended in many systems (cf. Car-to-Car Communication).

LL. TRAILER BACKUP ASSIST

The manoeuvring and parking of a passenger car trailer is not everyone's idea of fun. So Volkswagen, for example, with its ‚Trailer Assist' offers drivers a parking or ‚manoeuvring/steering' aid. With the system activated and the vehicle combination in the correct position, the car and trailer steer in reverse into the parking space. Applying the brakes and stepping on the accelerator remain the responsibility of the driver. With the help of the outside mirror adjustment knobs, the driver can fix the desired direction of travel for the trailer.
The so-called Trailer Backup Assist takes things a step further. Drivers can park their car/trailer vehicle combination from outside by using a smartphone - as if by remote control. During this operation Trailer Backup Assist makes use of the functions of the electric power steering, of the ESP electronic stability program, of the electronic accelerator pedal and also of the trailer coupling with its articulation angle sensor. The steering angle of the trailer and the speed of the car/trailer vehicle combination can be defined by using an app - and thus the car-trailer can be successfully parked.

MM. VEHICLE RECOGNITION

Automatic vehicle recognition comes into its own during heavy traffic in inner cities and also on multi-lane roads. In such situations vehicles in front often brake unexpectedly or change lanes abruptly. Whenever these scenarios arise, brake assistants, thanks to information provided by a vehicle recognition system, can immediately trigger the necessary measures (a visual and acoustic warning or an immediate brake intervention, or even an emergency stop).

Monitoring of the driving environment, performed for instance by an intelligent camera system is in permanent operation. The system collects data on the position, direction and speed of other vehicles and then processes these details. Various types of vehicles like cars, trucks, buses, motor bikes or even scooters are recognised and classified. Their identification is not hampered by features such as the make, model or other any variations in appearance. This vehicle recognition continues to function even if adverse weather conditions prevail. Moreover, concealed vehicles can also be detected.

NN. VOICE CONTROL

Voice control replaces the manual input of function instructions where either a keyboard and dials or a touchscreen on an information display is used. In an ideal situation all the following operations could be controlled in this way: programing the air-conditioning system, calling up diverse vehicle information, selecting music or checking a contact in your phone address book to make a phone call. The driver states his instructions and the relevant system reacts. Speech recognition systems of the first generation often had difficulties with the intonation and the regional linguistic imagery of drivers. Today language assistants and electronic ‚translators' are not only integrated in our smartphones but they work well, too. Vehicle systems are also more intelligent and more sophisticated.

3. SYSTEM AND COMPONENTS STRUCTURE

The following describes how some ADAS works and the interaction with other vehicle systems:

Advanced Driver Assistance Systems (ADAS) aid the driver while driving and the main goal of these systems is to enable safer and better driving.

ADAS have the same structure than other systems with electronic control, that is, it is needed an ECU, sensors and actuators to interact with the driver through warning lamps, messages in the instrument panel, vibration of the steering wheel,… and of course, they are connected to the communication network in the vehicle to interact with other systems.

ADAS need different types of sensors which are required to obtain the necessary information to identify the potential hazards and try to actively avoid them. Here it is described some of them:
Ultrasonic sensors are devices that both transmit and receive ultrasonic pulses and acquire the distance by converting the ultrasonic pulse to an electrical pulse. The sensors are used for close proximity measures.
GPS are Odometry sensors estimate the changes of the position over time.
LiDaR (Laser Imaging Detection and Ranging) is used to monitor the surroundings of the car. The distance to objects is measured by using laser.
Cameras to monitor the cars surroundings. They provide vital detailed information about surrounding environment of the vehicle. The cameras can also be used in stereo vision applications providing depth information from multiple cameras combined.

Radar sensors also providing information about the vehicle surroundings. RADAR maps the environment using radio waves.

4. UNDERSTANDING DIFFERENT MANUFACTURER SYSTEMS AND DEFINITIONS.

A. SAFETY

Systems integrated in-vehicle which could improve road safety in terms of crash avoidance, crash severity mitigation, protection and post-crash phases;

B. ACTIVE

Those systems, as the term suggests, that play a preventive role in mitigating crashes and accidents by providing advance warning or by providing the driver with additional assistance in steering/controlling the vehicle, called also „Primary Safety System". Some examples: Anti-Lock Braking Systems (ABS), Electronic Stability Control (ESC), Tire Pressure Monitoring System (TPMS), Lane Departure Warning System (LDWS), Adaptive Cruise Control (ACC), Driver Monitoring System (DMS), Blind Spot Detection (BSD) and Night Vision System (NVS).

C. PASSIVE

Those systems that play a role in limiting/containing the damage/injuries caused to driver, passengers and pedestrians in the event of a crash/accident like Airbags, Seatbelts, Whiplash Protection System etc.
to date in the market there are different explanation about Active and Passive systems.

5. IDENTIFYING VEHICLE WITH ADAS FUNCTIONS AND THE RELATED COMPONENTS.

A. USE OF A DIAGNOSTIC DEVICE TO ESTABLISH FEATURES

Gateway / Global checks

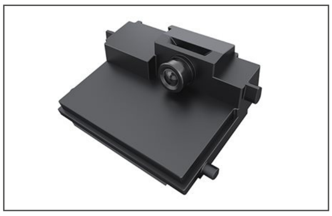
By performing a global check it is possible to identify if the systems responsible for ADAS functions are fitted in the vehicle, for example: Adaptive cruise control; traffic sign recognition; lane change assist; emergency braking; pedestrians detection; park assist; rear collision warning; surround view; blind spot monitoring; rear cross traffic alert)
Fault codes
Once identified the list of ADAS related systems, reading the fault codes of these systems allows to detect system anomalies or problems related to failed calibration.

Parameters

Through the live data it's possible to perform a specific diagnosis of the system, maybe guided from scantool. For example about cameras, relevant live data are related to roll, yaw and pitch angles.
Coding
The coding is in some case required if the components needs to be replaced due to failure. For example: Front camera, radar sensor, side radar sensor.

B. IDENTIFYING THE CAMERAS

Front Mono and Stereo

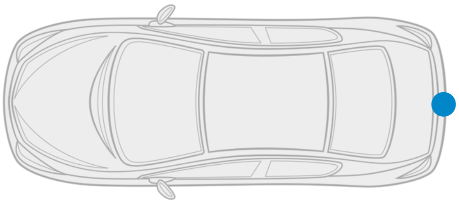


The mono and stereo camera are installed on the windscreen near the rearview mirror, and performs the following functions:

- Lane change assist
- Collision avoidance
- Pedestrian detection
- Traffic sign recognition

Normally, the mono camera can be identified because equipped with a single lens, while the stereo camera are equipped with twin lenses.With the diagnostic scantool it's possible to identify if the mono/stereo camera system is fitted and may also be possible to identify the kind of camera installed (with a global check). For example it's possible at least in some Mercedes vehicles that can fit alternatively both systems.

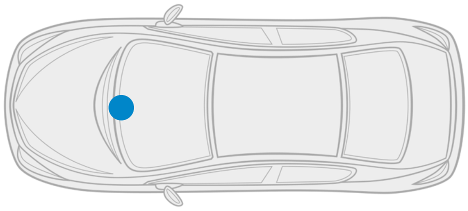
Rear



The rear camera is normally positioned near the license plate lights, and performs the following functions:
- Parking assist
- Surround view

With the diagnostic scantool it's possible to identify if the rear view camera system is fitted, performing a global check.

Front



The frontal camera is generally installed in central position over the front bumper, and performs the following functions:
- Parking assist
- Surround view

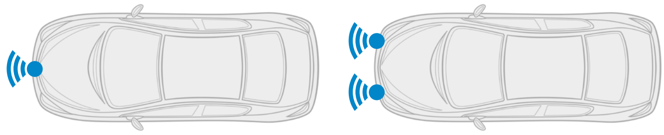
With the diagnostic scantool it's possible to identify if the front view camera system is fitted, performing a global check.

Exterior rear view mirror

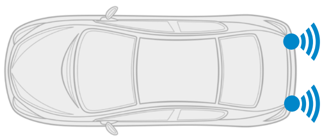
If the vehicle is equipped with the blind spot function, the external rear view mirror normally carries a specific lamp that warns the driver in case of a vehicle approaching from rear is in the blind spot. With the diagnosis it is possible to identify the blind spot system by global checks, the system consists of two medium / short radars positioned on the sides of the rear bumper or the two cameras positioned under the external rear view mirrors.
These cameras performs the following functions:
- Parking assist
- Surround view
- blind spot warning

C. IDENTIFY THE POSITION AND TYPE OF RADAR

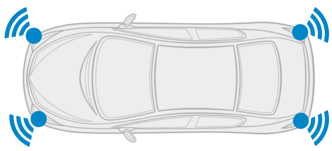
Front



Rear



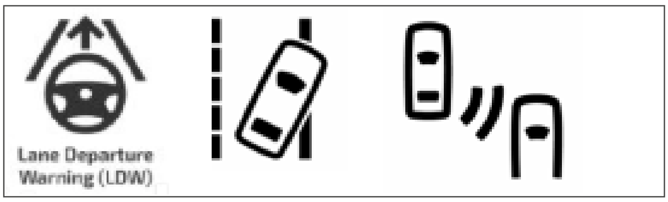
Side



Types

D. IDENTIFY SYMBOLS ON THE DASHBOARD OR DRIVER CONTROLS

LDW **Proximity**



6. TESTING AND DIAGNOSING OF ADAS

A. ADAS SENSOR CALIBRATION

ADAS sensor calibration is required whenever a sensor's aiming is disturbed in some way. This can occur after a collision, even a minor fender bender, or it can be a necessity of common service work such as windshield replacement, suspension repair or wheel alignment. Calibration is also needed whenever a sensor or its mounting bracket is removed and replaced, there is a change in tire size, a front airbag deflects off the windshield, or repairs are made to a car roof that has a sensor bracket mounted on it. Finally, sensor calibration is necessary when there is a related Diagnostic Trouble Code (DTC) in the car's computer memory, or when an automaker releases a technical service bulletin declaring that the calibration has to be done as part of another repair.

Sensor replacement and calibration are oftentimes part of collision repairs. Automakers recommend that dealerships now undertake a complete diagnostic scan on every vehicle before beginning repairs, and then again after the job has been completed. This will help the car body shop to confirm that all issues have been fixed, that ADAS sensor calibration is complete, and that the vehicle's control systems are properly communicating before the car is given back to the customer.

The calibration of ADAS sensors is a process requiring high precision, and it is often complex and time consuming. Some sensors can be calibrated in a repair shop, others require a vehicle to be driven on roads, and many others call for both procedures. The time involved can vary from 15 minutes to an hour or more, depending on the specific calibration requirements.

B. SHOP PREPARATION

Independent service providers who want to carry out sensor calibration must invest in some necessary tools:

Service information describing the equipment and the procedures required to calibrate ADAS sensors on any given year, make and model of vehicle. This information may be available from the aftermarket, but sometimes it must be obtained from the vehicle manufacturer. Calibration requirements can be determined by undertaking an OEM Calibration Requirements Search, or by using links to OEM service information.

A scan tool that supports ADAS sensor calibration. Vehicle manufacturer scan tools can handle the necessary operations for all vehicles and sensors from a specific vehicle manufacturer. Aftermarket scan tool capabilities vary considerably, but certain devices are capable of working with vehicles and sensors from a number of different vehicle manufacturer. Special tools designed exclusively for ADAS sensor alignment are also available.

A large, paved, indoor area with non-glaring lighting and a setting which is tidy and free from metallic objects (radar calibration) that could interfere with the calibration process plus a wheel alignment bay.

Some repair procedures may require or recommend a four-wheel alignment to be performed prior to ADAS sensor calibration, so as to ensure that the vehicle thrust line and the steering system are aligned according to the vehicle manufacturer's specification. ADAS sensors are then calibrated referring properly to this thrust line.

C. VEHICLE PREPARATION

Before calibrating an ADAS sensor, a vehicle must be prepared as defined by the automaker. Some common requirements include:

Load conditioning according to OEM Spec (No heavy items in the car, full fuel tank)

Tires inflated to recommended pressures;

Front and rear vehicle ride height within specifications;

Clean windshield in front of camera sensor (where applicable);

Protective cover removed from radar sensor (where applicable);

Centering of steering system

Four-wheel alignment performed (where specified).

D. CALIBRATION METHODS

There are two kinds of ADAS calibration, static and dynamic. In all cases, the vehicle manufacturer's specified procedures and instructions must be precisely followed.

In-Shop (Static) Calibration

Static sensor calibration begins with establishing the vehicle thrust line, by use of manual measuring methods and special tools. In many cases the tools are aligned with the front and rear wheel hubs. Laser projectors are often used to ensure perfect alignment.

Then, one or more special aiming targets are positioned in precisely defined locations relative to the thrust line and sensor. The targets must be at a specified height, and many of them are designed to be used with special adjustable mounting stands.

Camera aiming targets are usually black and white patterned images that are commercially avaialable or, in some cases, can just be downloaded from service information websites.

The final step consists of initiating the aiming process by using an OE scan tool or an aftermarket equivalent. The process then occurs automatically, and the scan tool indicates when it has been successfully completed.

On-Road (Dynamic) Calibration

Dynamic calibration is generally the preferred method for camera sensors, and sometimes it is the only one which is specified and needed. Radar sensors, instead, often require static adjustment followed by an on-road procedure. Dynamic calibration involves initiating the process with an OE scan tool, or an aftermarket equivalent, and then driving the car on roads with clear lane markings for 5 to 30 minutes within a certain speed range.

Certain systems can be best calibrated under conditions of very low traffic, while others calibrate more rapidly when sensors detect many objects. Vehicle manufacturer's calibration instructions will provide information on the optimal process. Often, the calibration cannot be carried out if there is rain or snow obscuring lane markings, or if other factors make it impractical or unsafe to drive at the required speeds.

Surround-View Camera Calibration
Calibration of the surround-view cameras is required when one or more cameras are replaced, or when a mounting part (grille, door mirror, door, bumper cover) is removed and replaced. Surround-view camera calibration is usually an in-shop static procedure. Large patterned mats are placed around the vehicle, and an OE scan tool is used to initiate the calibration process. Some surround-view systems use an on-road dynamic process during where the car has to be driven slowly down the road under specified driving conditions.

Steering Angle Sensor Calibration
Calibration of the steering angle sensor may be required after air bag deployment, structural repairs or wheel alignment. The process usually involves placing the wheel in a straight-ahead position, and then using an OE scan tool, or an aftermarket equivalent, to zero out the sensor signal.

7. REPAIRING OF ADAS

A. PRE-REPAIR SCAN PROCESS

It is also known as Pre-Scan or Health Scan. It is a step in the damage analysis/blueprinting process targeted to identify errors, faults, and/or damages which might or might not be related to the collision. It is also intended to capture Diagnostic Trouble Codes (DTCs): these are codes that the car's On-Board Diagnostics system (OBD) uses to detect possible issues. Each code corresponds to a fault detected in the car. When the vehicle identifies a problem, it activates the corresponding trouble code.
The Pre-Repair Scan is not possible if the 12-volt electrical system and the vehicle's communication networks are disabled or cannot be maintained throughout the whole process.
If the Pre-Repair Scan is not possible because of damage to the vehicle, it should be undertaken as soon as the repair progress allows it to be done safely.

B. THE PROCESS

Get customer approval for scanning the vehicle and for sharing data with the other parties involved such as sublet technician(s), insurer, and repair facility personnel.
Check Malfunction Indicator Lamps (MILs) and/or information display messages.
The 12-volt electrical system must be activated to detect any MILs.
Even if there is a damage, not all systems light up MILs.
Document any MILs and/or information display messages.
Identify ADAS, by the use of:

An OE scan tool.
- It identifies all modules and build data;
- It has current model year;
- It can perform all programs/scans/calibrations/initializations.
- An aftermarket scan tool.
- It may not have coverage of most current model year;
- It may not be able to identify/communicate with all modules;
- OEM may not test or approve aftermarket scan tools.
- OEM (Original Equipment Manufacturer) repair information and VIN (Vehicle Identification Number) build data.

Detect which ADAS features the vehicle is equipped with.
- Identify the positioning and the type of camera(s): mono, stereo, windshield, rear, front, exterior rear-view mirror.
- Identify the positioning and the type of radar(s): front, rear, side.

Document the ADAS features

Document any potential damage to ADAS

Identify calibration/initialization/aiming requirements for ADAS parts, including those subjected to Remove and Install (R&I) processes.
- Make use of OEM Calibration Requirements Search.
- OEM information is needed to carry out the operation.

Detect enable and disable switches.
- Enablement/disablement may be necessary for some calibration procedures.
- If the system is turned off, it may not be possible to perform the calibration.
- Systems that can be enabled/disabled should be documented.

Carry out the Pre-Repair Scan.

Document DTCs (Diagnostic Trouble Codes) and other data.
- Black box information and speed of accident/accident recreation are not included. If applicable
- Pending, current and past DTCs are included.

Access OEM information to identify which systems are affected by DTCs.

Determine potentially related and non-related DTCs.
- Highlight ADAS relevant DTCs
- Check key cycles, time stamps, and freeze-frame data.
- Examples can be found in ANNEX A

C. POST-REPAIR CALIBRATION(S) AND POST-SCAN PROCESSES.

Post-Repair Scan: definition
It is also known as Post-Scan. It is a process targeted to ensure that all vehicle system's DTCs, both those related or non-related to the collision and those set during the repair process, have been identified and cleared.
A test drive may be required before clearing some codes. Indeed, some of these may only appear once after certain driving distances, key cycles or other parameters have been reached.
Post-Repair Calibration/Initialization (PRC/I): definition

It is a required step subsequently to the removal, installation, and/or repair of many safety and driver convenience system parts. It may also be necessary if there is a damage/shock to the mounting locations, Remove and Install (R&I) or Remove and Replace (R&R) of the cameras/sensors/mounting locations, R&I or R&R of parts in front of or behind cameras and/or sensors, or R&I or R&R of closure/trim panels.
In order to determine whether Post-Repair Calibration is required, it is mandatory to access OEM information.
Even if an aftermarket tool manufacuturer confirms that his scan tool provides the required calibration/initialization capabilities for the vehicle and the model year involved, special tools and/or a test drive in accordance with the vehicle manufacturer's prescribed parameters may be required.
Post-Repair Calibration/Initialization may also be referred as health check, module setup, relearning, or zero-point calibration.

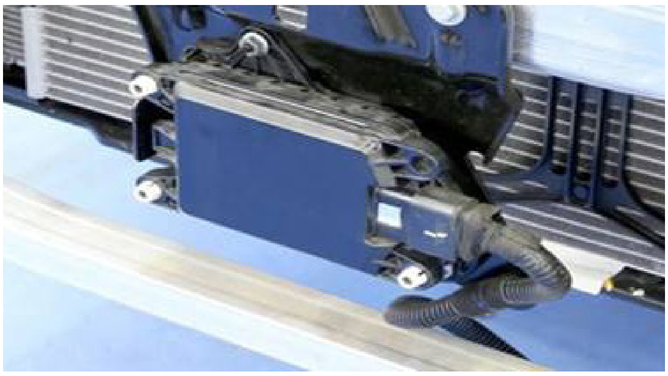
D. REPAIRING AND RECALIBRATING ADAS AFTER A HEAD-ON COLLISION

Head-on collision is one of the most severe types of accidents. Given that advanced driver assistance systems (ADAS) use parts found all over a car and a head-on collision can affect just about the whole vehicle, you will likely have to do calibrations for multiple systems when you repair a car after a head-on collision.

Adaptive Cruise Control

Adaptive cruise control is found on many new cars sold today and thus it is an ADAS you will frequently encounter in your repairs. This system uses radar sensors to detect the distance between the vehicle and traffic ahead, and it automatically maintains the optimal distance. When radar sensors detect that the speed of traffic has changed, the vehicle will automatically adjust its own speed. The radar sensors are typically positioned at the front of the vehicle, either near the bumper or hidden behind the grille. After front collision these sensors typically have to be replaced and afterwards they require proper calibration.

Forward-Collision Warning and Automatic Braking



This system is designed to avoid front-end impacts or at least help reduce the severity of an impact by decreasing the vehicle speed. This system uses radar sensors to detect the relative distance and the changing speed of the traffic ahead, and it can automatically brake if an imminent collision is detected. In addition to the damage of the radar sensors, a forward-collision can also affect the suspension and damage the brakes. This obviously will require ADAS systems to be calibrated.

Lane-Keeping Assist

Front-end collisions can often be serious enough to damage a car's windshield, meaning it will need to be replaced. Whenever a windshield is replaced, front-end cameras need to be recalibrated. Lane-keeping assist uses cameras to detect lane markings on the road. In the event the driver starts to depart the lane without signaling, the system provides an alert. If no corrective action is taken (by the driver), the system can provide small automatic adjustments in steering and braking to set the vehicle back on course. This system often requires static calibration, in which cameras are aimed at reflectors and pattern boards. Other times, this kind of repair involves dynamic calibration, which means somebody has to drive the car on the road and allow cameras to detect lane markings.
These calibrations are the most common repairs you will encounter when you repair a vehicle involved in a head-on collision, but you should check every system on the vehicle since head-on collisions often affect multiple systems because of the force of the impact.

E. REPLACEMENT AND REFITTING OF AUTOMOTIVE GLAZING FOR VEHICLES EQUIPPED WITH SCREEN-MOUNTED ADAS

Front-facing cameras fitted behind the windscreen are one of the most common sensors which ADAS safety features rely on to function properly, for example to detect pedestrians, cyclists, road signs and lane markings. Cameras need to know their own positioning in relation to the vehicle thrust line: only then they can accurately measure the coordinates of other objects on the road, and consequently help the vehicle's brain to take the adequate decision. If cameras are not well aligned, the systems could fail to intervene in a convenient way or to alert the driver about a dangerous or risky situation. This is why many manufacturers require these systems to be calibrated after the windscreen has been replaced.
The goal of this section is to set out best practice for undertaking windscreen replacement or refitting on vehicles equipped with screen-mounted ADAS sensors, and to ensure the proper functioning of ADAS features after one or both of the processes mentioned above have been completed.

Replacement Process
Understanding

- Understand whether the vehicle is equipped with ADAS features.
- Determine which ADAS function(s) require sensors calibration.
- Determine which kind of calibration is needed: static, dynamic, or a combination of the two.
- Define which are the required methods and equipment.

Awareness

- Make sure that the customer is aware of having a vehicle equipped with ADAS systems and that these ADAS systems

must properly work to maintain the vehicle's type approval.
- Make sure that the customer is made aware of the need for sensors to be calibrated in accordance with the vehicle manufacturer's recommendations after the windscreen replacement.
- Make sure that the customer is aware of the fact that the ADAS functions may be undermined and that he should not rely on their proper functioning, after the windscreen replacement, until the system is calibrated.

Clarify to the customer
- whether you can calibrate his ADAS features either by using your own technology or by calling on a sub-contractor;
- that otherwise he will be responsible for getting the system calibrated by using, for example, his local dealership; and
- that he may be held liable for any event resulting from his failure to calibrate.

Provide the customer with a written communication about his vehicle's ADAS technology, specifying:
- the need for calibration, including how his vehicle's ADAS systems will be calibrated if undertaken or managed by you as the service provider;
- the need to get the system calibrated by someone else if you are not able to do it as part of your service;
- that he should not rely on the correct operation of the ADAS systems until they have been successfully calibrated;
- that he may be held liable if any adverse event occurs as a result of his failure to calibrate; and
- that his insurance company should be informed about the situation.

Scheduling the Job
- Vehicles requiring Static Calibration need to be repaired in an appropriate facility.
- Make sure that the replace windshield being ordered/fitted meets the right optical quality for the ADAS systems to work as recommended by the vehicle manufacturer.
- Make the customer aware that, if his vehicle requires Dynamic Calibration, it will need a longer test drive on public roads in order to complete the calibration process.
- If the calibration cannot be carried out at the time of the windscreen replacement service, it will be necessary to schedule an alternative appointment.
- Make sure that the correct calibration technology is available at the time of service.

Performing the Job
- Make a pre-inspection, by the use of a Diagnostic Tool.
- Make the customer aware of non-ADAS fault codes (interpretation of fault codes and of customer issues, such as, for example, wrong button pressed).
- The calibration should only take place once the vehicle has achieved the adhesive system's minimum drive away time (MDAT).
- Calibrate the system as appropriate.
- Make sure to have at your disposal the necessary calibration equipment, which includes: (i) basic requirements; (ii) vehicle manufacturer's requirements; (iii) vehicle manufacturer's targets; (iv) doppler radars; (v) radar alignments; (vi) target mats for 360-degree systems, (vii) rear radar targets.
- Print the calibration certificate.
- Provide the customer with a copy of the calibration certificate and retain another copy for your records.

Calibration Solution
- For in-house calibration, you need to invest in the appropriate Diagnostic Tool and Calibration Tools.

F. BUMPER REPAIR
- Bumper Cover Painting Instructions in the Lane Change Assistance Control Module Area
- To avoid malfunctions of the radar related modules, you have to pay attention to the following parameters when it comes to paint the bumper cover:
- Do not exceed the maximum paint coat thickness of 150 µm in the area of the control module;
- A plastic repair may not be performed in this area at a minimum distance of 25 cm;
- Smoothing may not be performed in this area at a minimum distance of 25 cm;
- Triple painting is not permitted on the bumper cover;
- Before beginning painting, check, by the use of a grinding pattern, if the bumper cover has already been repainted;
- Spot repair of the area of the control modules is not permitted.

8. CALIBRATION OF ADAS

The calibration process for ADAS is vital for the performance of these systems and it is necessary to ensure its proper functioning and therefore the safety of people.
It is the responsibility of the technical services to acquire the relevant training and equipment to guarantee the correct performance of these works.
They must be calibrated when carrying out any maintenance, repair or adjustment in the vehicle that may influence the performance of the systems. Some examples are:

- Fitting of an incorrect specification windscreen wiper.
- After repairing or replacement of the Control Unit
- When the Control Unit shows a calibration error or similar in diagnosis
- After modifying the height of the suspension for the driving level

To ensure proper calibration, it is necessary to have adequate equipment prepared for this purpose. Depending on the manufacturer of the vehicle, it will be only the diagnostic tool. Additionally, combination with a special ADAS calibration equipment (panels, structure, laser, measuring scales, coupling tools for the wheels ...) could be required.

There are two types of calibration for these components, static and dynamic.

A. STATIC:

Carried out with parked vehicle and combining the diagnostic tool with the ADAS calibration equipment. It is necessary to align the ADAS equipment with the driving axle of the vehicle and rely on the diagnostic tool so that the Control Unit registers and learns the new objectives.

B. DYNAMIC:

It is carried out in driving with the support of the diagnostic tool. The vehicle traces a certain route at a certain speed until the Control Unit considers that it has already restored and learned the objectives for its perfect operation.

C. TYPICAL STEPS TO PERFORM A STATIC CALIBRATION:

It is necessary to fulfil some initial conditions:

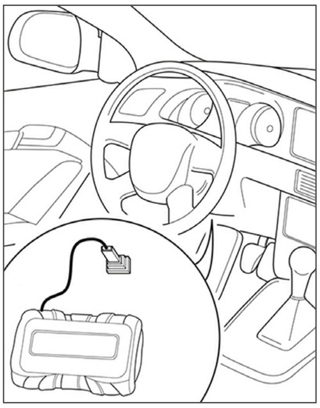
- Choose a place that is illuminated but protected from the rays of sunlight
- Vehicle parked on a flat and moderately level surface
- Tires in perfect condition and at an optimum pressure
- Centered direction
- Check the cleanness and perfect condition of the radar surface and the part of the windscreen wiper where the camera is installed
- Suspension at the driving level (Preferably downloaded)
- It is assumed that the vehicle has a correct alignment of the wheels and axles in perfect condition.
- Center and align structure with the help of kit devices.
- Calibrate radar inclination angles with the help of the laser and measurement scale available in the kit, and the diagnostic tool.
- Calibrate camera with the help of the ADAS panels and the diagnostic tool.
- Subsequent review of the correct behavior of the systems. Test drive.

9. CALIBRATION EQUIPMENT

A. BASIC REQUIREMENTS

To check and calibrate an ADAS systems is necessary:

i. Diagnostic scan tool device connected to EOBD port to cumunicate with ECU's sensor.



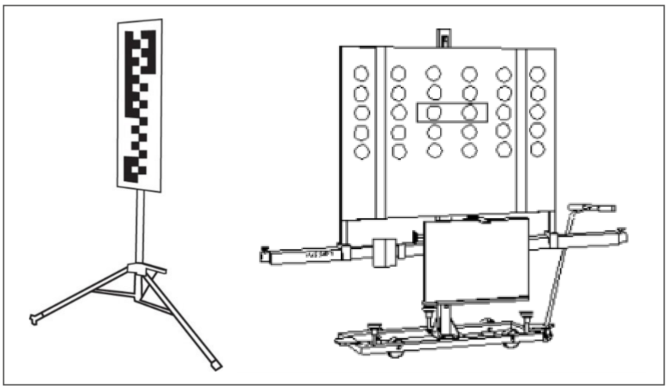
ii. A main-frame where to position the vehicle manufacturer's target references

iii. Specific vehicle manufacturer's target for the safety system/vehicle model to calibrate.

iv. Equipment to position correctly the target in terms of alignment, centering, height, distance respect to the vehicle according VM requirements: yardstick, distance laser pointers, blade laser, CCD sensors..

vii. Specific tools to regulate mechanically the safety system sensors: screwdriver, allen key, water level..

Example of main-frame



B. VM REQUIREMENTS

i. Check the vehicle's wheel alignment, camber and caster angles must be inside specific range value; The misalignment of a vehicle can effect on the not correct functionality of the ADAS sensors.

ii. Adjust the suspension manually by acting on the front and rear of the vehicle in order to stabilize the attitude.

iii. If there are electronic suspensions, start the engine and set them to Normal or Comfort and wait until the vehicle has performed the maneuver.

iv. The calibration has to be performed in a levelled surface

v. Tyre pressure value should be as indicated by the manufacturer.

vi. Tyre wears should be homogeneous

vii. The wheels must be straight and the steering wheel must be positioned in the center: check in the diagnostic tester that the value of the steering angle parameter in the power steering control unit or in the ABS control unit / steering angle sensor is 0 degrees.

viii. The windshield must be clean

ix. No one people inside the car

x. The parking brake must be applied with gearbox in neutral position

xi. The power supply must be above 12V.

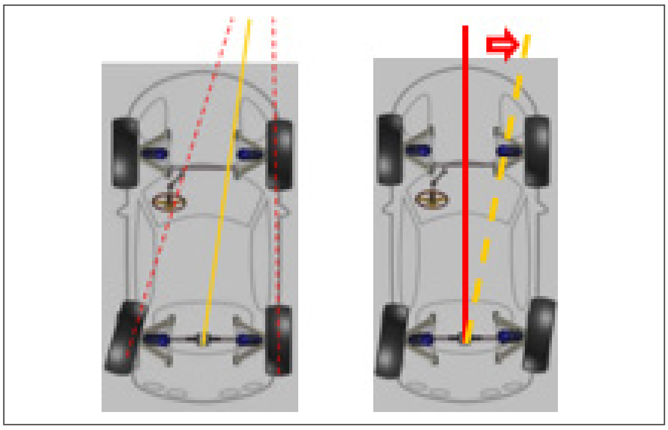
xii. Fuel tank full.

IMPORTANCE OF THE WHEEL ALIGNMENT

When the vehicle is in movement, during the different conditions of use, there are multiple forces which intervene to change the geometrical alignment of the vehicle itself. Adjusting the angles according to the manufactures data, these variations are taken into account to reach the perfect balancing of these forces and their application in movement.

A correct wheel alignment controls the reaction of the vehicles forces during movement. The wheel angles like Camber and Toe have effects on the driving. A thrust line condition exists when the rear individual toe is not equal. Thrust line maybe defined as a line bisecting rear toe, or simply it is the direction the rear wheels are pointed to. Thrust line dictates the "straight ahead" position of the front wheels: therefore, it is the most accurate reference when measuring or adjusting front wheels. Whenever a vehicle with four wheels start to move, the front wheels always follow position themselves parallel to the rear wheels. Don't ignore the thrust angle on non-adjustable rear suspensions!! Without measuring the thrust angle, you cannot set the steering wheel straight.

The thrust angle is formed by comparing the thrust line with the geometrical centreline.



The thrust line define the vehicle driving axis, so the thrust angle value have to be inside the VM range to guarantee the right direction of the vehicle.

C. THE VM TARGETS

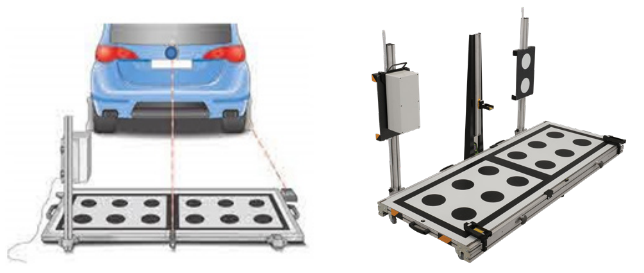
Vehicle manufacturer's targets are requested to calibrate functions like Lane Departing Warning, Lane Keep Assist, performed by a camera. Every vehicle manufacturer require a specific

target with his specific pattern, design and shape. It has to be positioned according VM specs.
The pattern depends on:

- Technology/kind of the safety system-component installed
- Geometry of the vehicle
- Positioning of the component in the vehicle
- Functionality and performance of the safety system

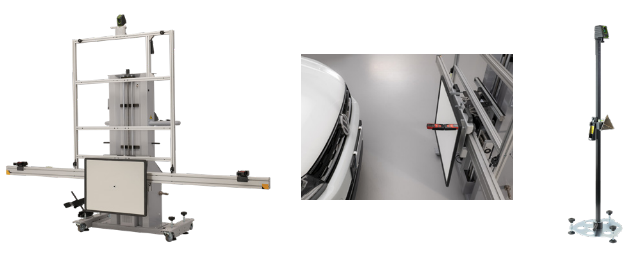
D. RADAR DOPPLERS

Used mainly for calibration of Blind Spot Detection and Lane Change Assist radar sensors



E. RADAR ALIGNMENTS

Used for calibration of Adaptative Cruise Control sensors for Blind Spot Detection systems calibration

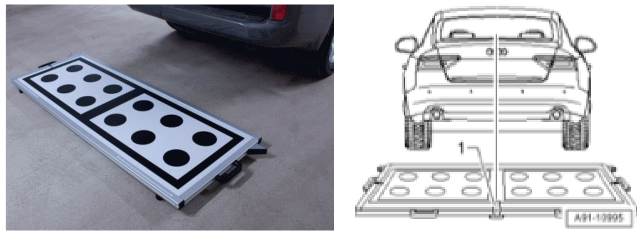


F. TARGET MATS

Used for 360 degree camera, around view monitoring camera calibration systems

G. REAR CAMERA TARGETS

Used for park assist function calibration

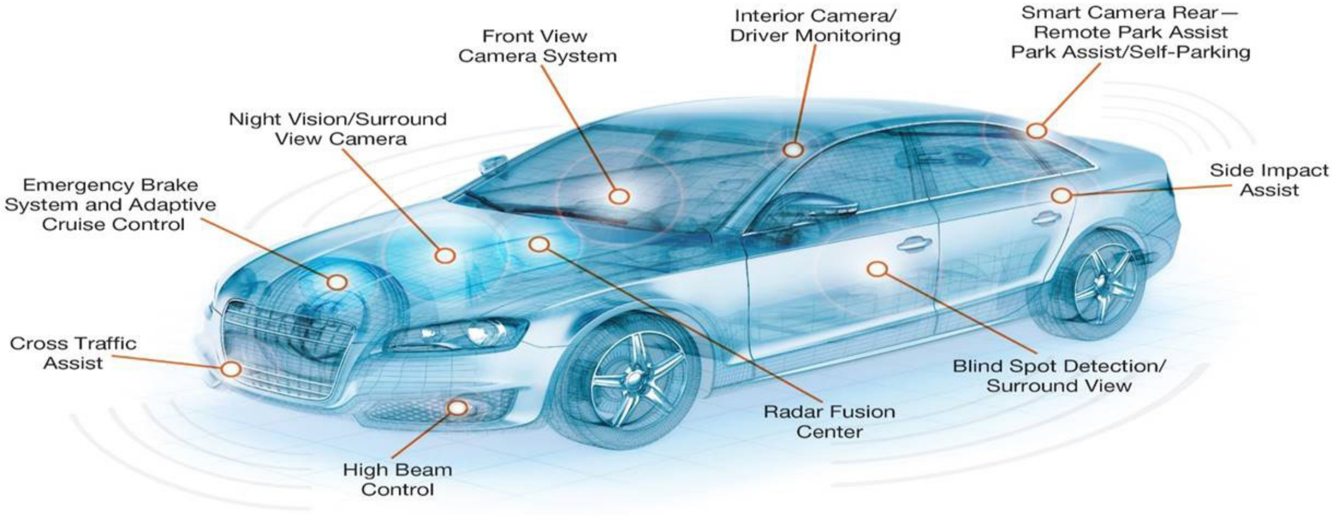


10. WHAT WE CAN EXPECT IN THE FUTURE

In the future, as vehicles become ever-more automated and autonomous, either as part of mandatory legislative requirements, or as new 'added-value systems offered by a vehicle manufacturer, the ability to diagnose and repair the ADAS components and systems will require new competencies for the workshop and the techncIain.

We can expect increased technical training requirements, specialist tools and repair procedures and the ability to unambiguously show that the repair and re-calibration has been fully and correctly conducted. These requirements are needed to show that the ADAS are operating to their original design criteria, that the vehicle is safe to operate on the road and that its insurance cover requirements are met.

EGEA will continue to support both its members and the necessary access at the workshop level to the diagnostic capabilities, technical tools, equipment and information needed to fulfil the correct repair procedures for these automated driver asistance systems.



11. SUMMARY AND CONCLUSIONS

Against the background of exponentially increasing vehicle technology, EGEA and its member companies continue to work hard to support the ability for both authorised and independent workshops to professionally repair today's and tomorrow's vehicles with state of the art equipment, technical information and support.

For all workshops and technicains, this Best Practice document will therefore help in the better understanding of the evolving design and consequent diagnosis, repair and calibration requirements of both today's and tomorrow's automated driver assistance systems

Please make yourself aware of any current reulations regarding ADAS.

12. REFERENCES AND ACKNOWLEDGMENTS

ACKNOWLEDGMENTS

EGEA would like to thank the W2-Diagnostics members for their contribution in the creation of this Best Practice document.

REFERENCES

ADAS Best Practice, EGEA
ADAS Best Practice Guidance, Brake and Autoglass, April 2017.
ADAS Recalibration, http://www.automotiveglasseurope.com/adas/, Automotive Glass Europe, 2019.
ADAS Sensor Calibration Increases Repair Costs, https://adas-services.com/adas-sensor-calibration-increases-repair-costs/, ADAS Services, 2018.
Advanced Driver Assist Systems (ADAS) Collision Repair Diagnostics Process, https://rts.i-car.com/best-practices/advanced-driver-assist-systems-adas-collision-repair-diagnostics-process.html, I-CAR Repairability Technical Support, 10 January 2017.
Code of Practice. For the Replacement & Refitting of Automotive Glazing for vehicles fitted with screen mounted Advanced Driver Assistance Systems (ADAS), Thatcham Research (in collaboration with ADAS Repair Group Members, July 2016.
Collision Repair Diagnostics Definitions, https://rts.i-car.com/best-practices/collision-repair-diagnostics-definitions.html, I-CAR Repairability Technical Support, 3 October 2016.
Damage Analysis for ADAS Identification and Calibration Requirements, http://rts.i-car.com/best-practices/damage-analysis-for-adas-identification-and-calibration-requirements.html, I-CAR Repairability Technical Support, 29 June 2017.
Repairing and Recalibrating ADAS After a Head-on Collision, https://adasservices.com/repairing-and-recalibrating-adas-after-a-head-on-collision/, ADAS Services, 2018.
VW: Lane-change assist can mean obligations, restrictions tied to bumper cover, https://www.repairerdrivennews.com/2019/03/27/vw-lane-change-assist-can-mean-obligations-restrictions-tied-to-bumper-cover/, John Huetter, Repairer Driven News, 27 March 2019.

ANNEX A

Example of DTC reading for front camera of NISSAN Micra K14 and Qashqai J11.

Code	Visible Code	Fehlerpfad	KTS-Text
5B00	C1B00	@85083	Camera control unit
5B01	C1B01	@206421	Camera calibration
5B09	C1B09	@85142	Internal power supply 1
5B0A	C1B0A	@85143	Internal power supply 2
C104	U0104	@31565	CAN communication with adaptive|cruise control
C122	U0122	@43067	CAN communication to ABS
C126	U0126	@31562	CAN communication with steering|wheel angle sensor
C405	U0405	@31565	CAN communication with adaptive|cruise control
C428	U0428	@31562	CAN communication with steering|wheel angle sensor
D000	U1000	@28477	CAN bus communication
D010	U1010	@42192	CAN control unit
D321	U1321	@23906	Configuration
D322	U1322	@23906	Configuration

The most significant DTC is the 5B001 but it does not provide important information. For gathering more information the user needs to refer to the live data, these live data explain why the calibration fails.

AIM_NG_REASON_K14_INVALID	Status: Unknown
AIM_NG_REASON_K14_7	Stat.: Pitch/yaw angle outs. toler.
AIM_NG_REASON_K14_4	State: Calibr. field size incorrect
AIM_NG_REASON_K14_3	State: Roll angle outside tolerance
AIM_NG_REASON_K14_2	State: Target not detected
AIM_NG_REASON_K14_14	Function: Not completed
AIM_NG_REASON_K14_13	Status: Calibration not started
AIM_NG_REASON_J11_T32_INVALID	Status: Unknown
AIM_NG_REASON_J11_T32_9	Stat.: Pitch/yaw angle outs. toler.
AIM_NG_REASON_J11_T32_8	Stat.: Pitch/yaw angle outs. toler.
AIM_NG_REASON_J11_T32_7	State: Calibr. field size incorrect
AIM_NG_REASON_J11_T32_63	Function: Not completed
AIM_NG_REASON_J11_T32_62	Status: Control unit fault
AIM_NG_REASON_J11_T32_61	Status: Control unit fault
AIM_NG_REASON_J11_T32_60	Status: Control unit fault
AIM_NG_REASON_J11_T32_6	State: Calibr. field size incorrect
AIM_NG_REASON_J11_T32_59	Status: Control unit fault
AIM_NG_REASON_J11_T32_58	Status: Control unit fault
AIM_NG_REASON_J11_T32_5	Status: Input parameter not OK
AIM_NG_REASON_J11_T32_4	Stat.: Pitch/yaw angle outs. toler.
AIM_NG_REASON_J11_T32_3	State: Roll angle outside tolerance
AIM_NG_REASON_J11_T32_22	Status: Control unit fault
AIM_NG_REASON_J11_T32_20	Function: Not completed
AIM_NG_REASON_J11_T32_2	State: Target not detected
AIM_NG_REASON_J11_T32_19	Status: Control unit fault
AIM_NG_REASON_J11_T32_16	State: Communication failure
AIM_NG_REASON_J11_T32_15	Function: Not completed
AIM_NG_REASON_J11_T32_14	Function: Not completed
AIM_NG_REASON_J11_T32_13	Status: Calibration not started
AIM_NG_REASON_J11_T32_12	Status: Time-out
AIM_NG_REASON_J11_T32_11	Status: Internal faults detected
AIM_NG_REASON_J11_T32_10	Status:Calibration field pos. not OK

Another example is from KIA Kia Sportage[QLE] 2019:
DTC: C272146 (System Calibration Required)
Sistema: MFC (Multi Function Camera)
DTC: C162078 (Alignment Failed)
Sistema: SCC/AEB (Smart Cruise Control / Autonomous Emergency Braking)

DTC Description
If the lane recognition camera has been shipped without being calibrated at the factory, the fault code C272146 is generated.
DTC Detecting Condition

Item	Detecting Condition	Possible Cause
DTC Strategy	➪ System monitoring	➪ Poor connector connection ➪ System calibration is not carried out ➪ MFC ECU
Enable Condition	➪ -	
Threshold Value	➪ Calibration process had not been executed ➪ Calibration result in NVM contains invalid data	
Detecting Time	➪ 0 (at once)	
Recovery Time	➪ 0 (at once)	
Function Limitation	➪ LKA : Disabled ➪ LDW : Disabled ➪ HBA : Disabled ➪ FCA-CAR/PED : Disabled ➪ ISLW : Disabled ➪ DAW : Disabled ➪ HDA : Disabled	

NOTICE
LKA : Lane Keeping Assist
LDW : Lane Departure Warning
HBA : High Beam Assist
FCA-CAR/PED : Forward Collision-avoidance Assist-CAR/PAD
ISLW : Intelligent Speed Limit Warning
DAW : Driver Attention Warning
HDA : Highway Driving Assist