OnGuardACTIVE™

WABCO

Table of contents

Table of contents

1 General information

ABBREVIATION	MEANING
ABS	Anti-Lock Braking System
ACC	Adaptive Cruise Control
AEBS	Advanced Emergency Braking System
AEB	Advanced Emergency Braking
BOM	Brake Only Mode
CC	Cruise Control
CMS	Collision Mitigation System
DW	Distance Warning
DR	Driveline Retarder
DSC	Downhill Speed Control
EBA	Extended Brake Assist
ER	Engine Retarder
ESC	Electronic Stability Control
EXR	Exhaust Retarder
FCW	Forward Collision Warning
HCW	Haptic Collision Warning
RSC	Roll Stability Control
TSC1	Torque/Speed Control 1
XBR	External Brake Request

Purpose of this document

This publication applies to employees of vehicle manufacturers and workshops for repairing and retrofitting utility vehicles with a knowledge of vehicle electronics. This explains the installation and start-up of the WABCO OnGuardACTIVE brake assist system in commercial vehicles.

Symbols used

⚠ WARNING	**Indicates a potentially hazardous situation** Failure to observe the safety instruction can result in severe injuries or death. – *Follow the instructions in this warning note to avoid injury or death.*
CAUTION	**Specifies possible material damage** Not observing the safety instruction can lead to material damage. – *Follow the instructions in this warning note to avoid any material damage.*

! Important information, instructions and/or tips that you must always observe.

Reference to information on the internet

– Action step

⇨ Consequence of an action

■ List

• List

Technical documents

– Open the WABCO INFORM online product catalogue: http://inform.wabco-auto.com
– Search for documents by entering the document number in the search field *Product number*.

The WABCO online product catalogue INFORM provides you with convenient access to the complete technical documentation.

All documents are available in PDF format. Please contact your WABCO partner for printed versions.

Please note that the publications are not always available in all language versions.

DOCUMENT TITLE	DOCUMENT NUMBER
OnGuardACTIVE System description	815 XX0 218 3

*Language code XX: 01 = English, 02 = German, 03 = French, 04 = Spanish, 05 = Italian, 06 = Dutch, 07 = Swedish, 08 = Russian, 09 = Polish, 10 = Croatian, 11 = Romanian, 12 = Hungarian, 13 = Portuguese (Portugal), 14 = Turkish, 15 = Czech, 16 = Chinese, 17 = Korean, 18 = Japanese, 19 = Hebrew, 20 = Greek, 21 = Arabic, 24 = Danish, 25 = Lithuanian, 26 = Norwegian, 27 = Slovenian, 28 = Finnish, 29 = Estonian, 30 = Latvian, 31 = Bulgarian, 32 = Slovakian, 34 = Portuguese (Brazil), 98 = multilingual, 99 = non-verbal

Choose genuine WABCO parts

Genuine WABCO parts are made of high quality materials and are rigorously tested before they leave our factories. You also have the assurance that the quality of every WABCO product is supported by an outstanding WABCO customer service network.

As a leading supplier to the industry, WABCO collaborates with the world's leading original equipment manufacturers, and has the experience and capacities required to also satisfy the most stringent production standards. The quality of every genuine WABCO part is supported by:

■ Tooling made for serial production

■ Regular audits of suppliers

■ Exhaustive end-of-line tests

■ Quality standards < 50 PPM

Installing replica parts can cost lives – genuine WABCO parts protect your business.

General information

WABCO additional services

The package you will get with a genuine WABCO part:

- 24-month product warranty
- Overnight delivery
- Technical support from WABCO
- Professional training courses from the WABCO Academy
- Access to diagnostics tools and support from the WABCO Service Partner network
- Straightforward claims handling
- Confidence that the vehicle manufacturer's rigorous quality standards are met.

WABCO Service Partner

WABCO Service Partners – the network you can rely on. You can access 2000 high quality workshops with more than 6000 specialist mechanics, all trained to WABCO's exacting standards and equipped with our most up-to-the-minute systems diagnostic and support technology.

Your direct contact to WABCO

In addition to our online services, trained members of staff are there to help you at our WABCO Service Partners to directly answer any technical or business-related questions you may have.

Contact us if you need assistance:

- Find the right product
- Diagnosis support
- Training
- System support
- Order management

You can find your WABCO partner here:
http://www.wabco-auto.com/en/how-to-find-us/contact/

2   Safety information

⚠ **Observe all required provisions and instructions:**

■ Read this publication carefully.
Adhere to all instructions, information and safety information to prevent injury to persons and damage to property.
WABCO will only guarantee the safety, reliability and performance of their products and systems if all the information in this publication is adhered to.

■ Always abide by the vehicle manufacturer's specifications and instructions.

■ Observe all accident regulations of the respective company as well as regional and national regulations.

■ Driver assistance systems do not release the driver from his duty to actively follow the traffic regulations.

⚠ **Make provisions for a safe work environment:**

■ Only trained and qualified technicians may carry out work on the vehicle.

■ Use personal protective equipment if required (safety goggles, respiratory protection, ear protectors, etc.).

■ Pedal actuations can lead to severe injuries if persons are in the vicinity of the vehicle. Make sure that pedals cannot be actuated as follows:

  ■ Switch the transmission to "neutral" and actuate the park brake.

  ■ Secure the vehicle with brake wedges.

  ■ Fasten a visible note to the steering wheel indicating that work is being performed on the vehicle and that the pedals are not to be actuated.

3 Functional description

3.1 Introduction

OnGuardACTIVE is an advanced driver assistance system with the following functions:

- ACC (Adaptive Cruise Control)
- DW (Distance Warning)
- FCW (Forward Collision Warning)
- CMS (Collision Mitigation System)
- AEBS (Advanced Emergency Braking System)
- EBA (Extended Brake Assist)

Each of these functions can be activated or deactivated by parameter settings, depending on the requirements of the respective market in which the vehicle is registered with OnGuardACTIVE. Not all combinations are possible because some functions depend on others. Table 1 shows all possible combinations. DW is completely independent of all other functions and can therefore be activated without any restrictions.

Function	POSSIBLE COMBINATIONS OF THE OnGuardACTIVE FUNCTIONS								
	1	2	3	4	5	6	7	8	9
ACC		x	x	x	x				
FCW			x	x	x	x	x	x	x
CMS/AEBS*				x	x		x	x	
EBA					x			x	x
DW	x	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)

Table 1   Possible combinations of the OnGuardACTIVE functions

---

! *) CMS and AEBS cannot be combined, which means that the system is either equipped with a CMS or with an AEBS.

The functions mentioned above use object data from a forward-facing radar sensor, which is mounted at the front of the host vehicle. This radar sensor creates an object list of the six closest objects on each lane (two objects respectively for its own lane, the adjacent lane to the right and to the left) for the above functions. The AEBS, EBA, CMS and FCW functions take all these objects into account, while ACC and DW only use one object – the closest object on the host vehicle's lane.

3.2 Adaptive Cruise Control (ACC)

3.2.1 General description

The adaptive cruise control function is an extension of the conventional cruise control (CC) function. Cruise control is not part of OnGuardACTIVE but is generally included in the engine control system.

In contrast to cruise control, which maintains a speed defined by the driver, ACC automatically adjusts the vehicle speed to maintain a safe following distance to any object in front of the vehicle (further information ▸ Chapter "3.2.2 HMI operation (Human-Machine Interface)", page 11). The ACC function helps to improve driving comfort.

The system also helps to optimise general fuel efficiency. The habits of individual drivers should have as little impact on fuel savings and vehicle wear as possible. Although accident statistics do not represent a system requirement, they indicate that the distance control of ACC also contributes to road safety.

ACC only responds to moving and stopped objects driving in the same direction. It does not respond to stationary or oncoming objects. An object that was initially detected as moving and then stops is classified as a stopped vehicle.

Example: ACC controls the distance to the vehicle driving ahead. When approaching a red traffic light, the vehicle ahead brakes until it is at a standstill. This is object is thereby classified as stopped. ACC thus keeps responding to this object and continues distance control in relation to it.

An object that has never before been detected as moving is classified as a stationary object.

Example: ACC approaches a red traffic light where stationary vehicles are already waiting. For this reason ACC will not respond to these vehicles.

This measure is necessary to prevent ACC inadvertently responding to irrelevant stationary objects such as traffic signs, manhole covers or bridges.

The ACC function has been specified for a speed range between 5 km/h and 125 km/h. Below or above these threshold values an activated ACC will be deactivated automatically regardless of driver requests.

To control the distance to the vehicle driving ahead, ACC limits the engine torque requested by the cruise control function and controls the endurance brakes (depending on design and availability) as well as the wheel brakes. For this reason ACC cannot accelerate a vehicle of its own accord. The drive torque for acceleration is only requested by the cruise control function. Further information about retarder and wheel brake control ▶ Chapter "Retarder control", page 15 and ▶ Chapter "3.2.3.5 Wheel brake request", page 15.

3.2.2 HMI operation (Human-Machine Interface)

3.2.2.1 Input from driver

If the vehicle is equipped with a CC/ACC selector switch, its status is transmitted by the instrument panel in the ACC2 message by means of the respective signal. In this case ACC is always activated when the driver activates cruise control (CC) himself. If the CC/ACC selector switch is in the CC position, ACC remains passive when cruise control (CC) is activated.

If no CC/ACC selector switch is installed, ACC is always activated when CC is switched on. In this case the respective signal must always be transmitted as valid.

The driver can deactivate ACC at any time by deactivating cruise control via his operating elements. In particular, the cruise control function (CC) is deactivated when the driver presses the brake pedal, activates a retarder or deactivates cruise control directly by means of a switch.

Normally ACC is deactivated together with cruise control (CC), but there are some exceptions (due to safety criteria) such as the "Freeze" function (▶ Chapter "3.3.3.3 "Freeze" function", page 16) and BOM (▶ Chapter "3.3.3.4 Brake only mode (BOM)", page 16). If ACC is in one of these modes, it remains active when cruise control has already been switched off. In these special modes, ACC can only brake the host vehicle, because cruise control (CC) is deactivated and ACC cannot accelerate independently.

If the vehicle is equipped with an ACC distance switch, the requested distance mode is transmitted by the instrument panel in the ACC2 message via the "distance selection" signal. The driver can use this switch to define a desired following distance and influence the distance behaviour of ACC. OnGuardACTIVE supports up to 5 possible distance modes.

The driver can override ACC at any time by pressing the accelerator pedal. Retarder and wheel brake requests are suspended in this phase. ACC nevertheless remains active during this period, i.e. it remains in monitoring mode. Once the driver releases the accelerator pedal, ACC is activated again and continues its control. When active control is no longer necessary, ACC remains active and continues to monitor the distance/speed of the object in front of the vehicle. An override by the accelerator pedal in the ACC is processed depending on the architecture of the engine ECU.

3.2.2.2 Signal outputs of ACC

ACC transmits its operating status via the ACC1 message. Unless stated otherwise in this document, all specified signals of ACC1 are supported.

ACC transmits its current status in the "ACC mode" signal. Table 2 below shows the different modes and their meaning.

VALUE	MODE	DESCRIPTION
0	Off	ACC is switched off / in standby mode, but can be activated. No or only passive control messages (TSC1, XBR) are transmitted.
1	Speed control	ACC is activated and cruise control maintains the set speed as long as no vehicle driving ahead necessitates an intervention by ACC. No or only passive control messages (TSC1, XBR) are transmitted.
2	Distance control	ACC is active and attempts to reach or maintain the desired following distance. Cruise control is limited by the engine torque, retarder control or activation of the wheel brake. The ACC transmits active control messages.
3	Steering	The driver overrides ACC by pressing the accelerator pedal. For this reason the driver's request is executed and ACC is passive. Depending on the system architecture, ACC can also continue sending active TSC1 limiting messages to the engine. XBR is passive.
4	Stopping	ACC sends active control messages (TSC1, XBR) due to the following functions: ■ Object loss limitation ▸ Chapter "3.2.3.4 Object loss", page 14 ■ Lateral acceleration limitation ▸ Chapter "3.3.3.2 Lateral acceleration limitation", page 16 ■ "Freeze" function ▸ Chapter "3.3.3.3 "Freeze" function", page 16
5	End	ACC sends active control messages (TSC1, XBR) due to the following functions: ■ There is no object driving ahead that would necessitate an ACC intervention and the current speed of the host vehicle is below the set speed of the cruise control (CC) function. This means ACC hands control back to cruise control (CC). ■ ACC was switched off and increases/reduces any existing torque or deceleration requests for a seamless transition of control to the driver.
6	Fault	ACC is in a fault sate and is therefore not available. No or only passive control messages (TSC1, XBR) are transmitted.

Table 2   ACC modes and their meaning

If cruise control (CC and therefore ACC as well) was deactivated for reasons other than a driver's request, a switch-off warning is signalled.

Examples for actions not initiated by the driver: ACC is switched off due to a fault or CC/ACC switches off due to the host speed being too low.

The maximum deceleration that ACC can request from the braking system is -2.5 m/s². If the traffic situation necessitates a more intense deceleration, ACC warns the driver with what is referred to as a system limit warning, i.e. he must assume control and also brake himself. This system limit warning is transmitted by means of a signal in the ACC1 message. To deduce a system limit warning, ACC additionally evaluates the "ABS (Anti-Lock braking system)" and the "deceleration limitation" signals.

If ABS carries out an active control process while ACC control is also active, ACC could issue a system limit warning, even when the maximum deceleration of -2.5 m/s² has not yet been reached. In this

case an active ABS control process is interpreted to mean that ACC may not be able to execute a high deceleration request due to a road surface with an insufficient friction coefficient.

If the braking system reduces the deceleration limitation (e.g. due to brake temperature monitoring), ACC uses this reduced level to deduce a system limit warning.

Apart from ACC, the system limit warning is also used for the DW function. Details on this subject and information about the distinction between an ACC system limit warning and a DW ▶ Chapter "3.4 Distance warning (DW)", page 17.

The ACC system limit warning also differs from an FCW ▶ Chapter "3.5 Collision warning (FCW)", page 17.

3.2.3 ACC control behaviour

The ACC function supports three different main control mechanisms, depending on the current driving manoeuvre. It distinguishes between continuous follow-on driving, approach manoeuvres with a lower than the set distance to a slower object and the removal of an object (e. g. after an approach manoeuvre or due to an object that is moving into the current follow-on distance).

3.2.3.1 Follow-on driving

Based on the distance mode selected by the operator (i.e. temporal distance to the object driving ahead) and the current speed of the host vehicle, ACC calculates the required distance ▶ Table 3 on page 13. ACC calculates a deceleration request by comparing the currently measured distance to the object driving ahead with the requested distance, taking into account the differential speed to the object. This deceleration request is converted into a torque request relative to the vehicle weight which is then used for an engine torque limitation and retarder brake torque control. During subsequent control processes, ACC responds very gently and economically. If the distance between the host vehicle and the target object is too small, or the relative speed is too high (i.e. one is approaching the object too fast), ACC switches into a different mode and adjusts the control strategy accordingly.
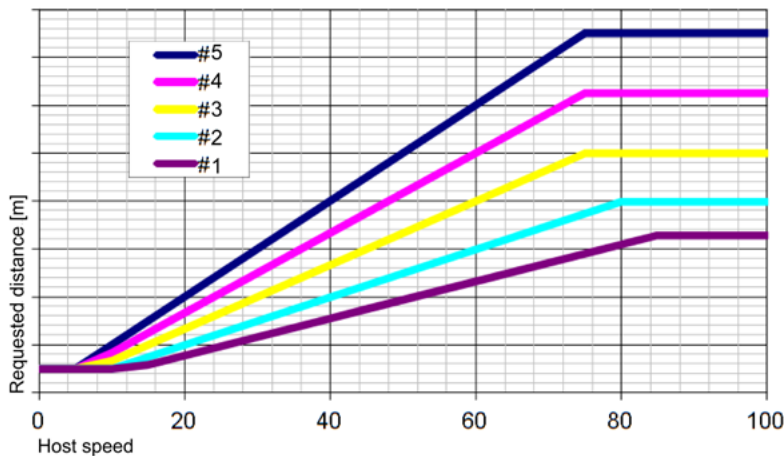
DISTANCE MODE	DEFAULT	MIN.	MAX.
#1 (shortest)	5 m	5 m	33 m
#2	5 m	5 m	40 m
#3	5 m	5 m	50 m
#4	5 m	5 m	63 m
#5 (longest)	5 m	5 m	75 m

Table 3   ACC following distances (depending on the speed of the host vehicle)

To optimise fuel efficiency even further, ACC monitors the driving behaviour of the vehicle driving ahead while following it. If a speed fluctuation of the vehicle driving ahead is detected, ACC increases the standard following distance. This compensates speed fluctuations without the need to change the host speed. If the vehicle in front starts to accelerate und moves further away, this function can lead to a one-off excessive following distance before catching up again later.

3.2.3.2 Approaching

When the host vehicle approaches a slower vehicle, ACC ensures that the requested following distance is maintained (▶ Chapter "3.2.3.1 Follow-on driving", page 13) by reducing the engine torque. If this is not possible without using the retarder or wheel brakes, ACC detects a fall below the following distance, which inevitably does not correspond with the following distance requested by the driver.

To improve fuel efficiency and reduce lining wear on the wheel brakes, ACC briefly tolerates such a fall below the following distanceduring an approach manoeuvres like this. These reduced approach distances and time gaps can be parameterised by the OEM or during retrofitting (also by the OEM). In approach mode, ACC can use the retarder as well as the wheel brakes if limiting the engine torque proves insufficient to reach the shorter following distance.

DISTANCE MODE	DEFAULT	MIN.	MAX.
#1	5 m	5 m	27 m
#2	5 m	5 m	29 m
#3	5 m	5 m	31 m
#4	5 m	5 m	34 m
#5	5 m	5 m	38 m

Table 4   ACC following distances in approach mode

ACC uses the wheel brakes as little as possible, i.e. the retarders are requested first. However, if the situation requires a faster response (e.g. little distance and/or high relative speed), ACC requests immediate activation of the wheel brake ▶ Chapter "3.2.3.5 Wheel brake request", page 15.

3.2.3.3 Moving away

If the reduced following distance mentioned in the previous chapter is reached or the distance is even smaller because the object driving ahead slows down or an object cuts into the host vehicle's lane, ACC switches to moving away mode.

When a faster vehicle (e.g. an overtaking car) moves into the lane of the host vehicle, ACC offers a special behaviour. If the distance produced by the manoeuvre is very small, ACC's response would normally be very sharp. In the situation described above, such a drastic reaction would not be desired, however, because overtaking manoeuvres should not influence the dynamics of the host vehicle. This is less fuel-efficient and uncomfortable. If a faster objects moves into lane and remains faster, ACC will not react at all in most cases.

Once the following distance is reached again, ACC switches from 'moving away' to 'follow' mode.

3.2.3.4 Object loss

Due to a curve or a hilltop, the radar may no longer detect a relevant object driving ahead. In this case ACC does not become passive immediately but switches into limiting mode due to object loss. Because it is probable that the object will be detected again after a brief period, ACC remains in limiting mode for a period that can be defined in the parameters and limits the acceleration of the host vehicle without transferring control back to cruise control (CC).

If the object is lost on a straight road, the acceleration limitation is set to +0.4 m/s², i.e. ACC continues to limit the engine torque and therefore also the cruise control function (CC) even if no relevant object is currently detected by the radar. If the object is lost in a curve, the acceleration limitation is set to +0.05 m/s². The period for processing an object loss on straight roads is 4 seconds and 12.5 seconds in curves. ACC also switches on between the two periods and implements a limitation if the relevant object is lost on a straight road but the host vehicle enters a curve shortly afterwards.

If the limitation mode is active due to object loss, the ACC mode is transmitted as mode 4 ("Hold" mode).

Retarder control

ACC supports three different retarder types (ER, EXR and DR) ▶ Chapter "3.2.1 General description", page 10. Which retarders are installed in the vehicle, i.e. which retarders are available to ACC, can be defined in the parameters.

ACC can control all three retarder types independently, and all combinations of installed retarders are possible. ACC uses separate TSC1 messages for each retarder to control them independently.

It can be defined in the parameter setting which retarder should be prioritised: ER, EXR or DR.

If ER is defined in the parameters as the retarder to be used first, ACC always uses EXR as the second retarder, if available. If EXR is defined as the first retarder, the behaviour is similar, i.e. the ER is used as the second retarder. If the braking torque of the ER/EXR was exceeded, ACC additionally requests the DR, i.e. it requests the full braking torque from EX/EXR and the rest from DR.

If the DR is defined as the retarder to be used first and the maximum braking torque of the DR was exceeded, ACC requests the maximum torque from the ER/EXR (in this case there is not separate control of ER/EXR – even when both could be controlled separately) and the remaining torque from the DR.

EX/EXR and DR have advantages and disadvantages that can affect the decision which of these retarders to use first.

The response of ER and EXR is very fast. On the other hand, they control their braking torque in a stepped manner. For this reason it is almost always the case that the braking torque ACC requests cannot be implemented with precision by ER/EXR. This results in over- or underbraking, which has an impact on the comfort of deceleration control interventions.

The DR can implement a continuous torque request, i.e. torque control is much more uniform, comfortable and precise. However, the response time of the DR is much slower than that of ER/EXR.

3.2.3.5 Wheel brake request

While engine and retarder are controlled by means of braking torque requests, an XBR message with a deceleration request is transmitted for activation of the wheel brakes. The XBR message is only used for wheel brake requests. This means that the braking system's endurance brake integration is deactivated. An actively transmitted XBR message does not necessarily mean that the wheel brakes implement the requested deceleration values for the braking system. Based on the actual vehicle speed as compared to the decelerations requested via XBR, the braking system decides how much pressure is applied into the brake cylinders.

ACC uses the wheel brakes if a fast response is necessary due to the current traffic situation. After such a deceleration was requested, ACC increases the braking torque requested of the retarders. The aim is to substitute friction braking und thus wear for the respective brake by endurance braking as early as possible.

ACC also requests the wheel brakes when the maximum available braking torque of the retarders is reached and additional braking force is needed.

The maximum deceleration that ACC requests from the braking system is -2.5 m/s². If the traffic situations requires a greater deceleration, ACC warns the driver with a system limit warning.

3.3 ACC special functions

3.3.3.1 Driving downhill

If the maximum available braking power was exceeded during downhill driving, i.e. the following distance to the vehicle driving ahead cannot be maintained through limiting the engine torque and using the retarder, ACC additionally requests the wheel brakes – but in a different manner from that of a normal wheel brake request. A continuous wheel brake request risks overheating the wheel brakes,

which must be avoided at all cost. For this reason ACC requests the wheel brakes only in short and intense intervals. This simulates a realistic driving situation executed by the driver. While the wheel brake is applied, the distance increases and decreases again when the brake is released.

ACC does not include a downhill driving speed control function (also known as brake control). This function is generally included within engine control or the driveline retarder. ACC only maintains the following distance to an object driving ahead. This means that without a relevant object driving ahead and without a separate DSC, the vehicle could become faster than the nominal speed for driving downhill.

3.3.3.2 Lateral acceleration limitation

ACC provides an additional comfort function called lateral acceleration limitation. This function is no substitute for an electronic stability control system such as ESC or RSC.

When the lateral acceleration actually begins to exceed the parameterised threshold value (the default value is 2 m/s²), ACC limits the engine torque to prevent further acceleration and thus a further increase in lateral acceleration. Under certain conditions the lateral acceleration limitation function can also request the retarder and/or the wheel brakes.

An example of such a situations is driving into a motorway access road with a sharp curve while cruise control (CC) accelerates and ACC is activated. Exceeding the lateral acceleration limitation means that the vehicle is no longer accelerated.

The lateral acceleration limitation function is always active (i.e. ACC monitors the lateral acceleration and intervenes as required) when ACC is activated, even when there is no object driving ahead. If ACC limits the engine torque due to the lateral acceleration limitation, the transmitted ACC mode is set to 4.

3.3.3.3 "Freeze" function

ACC is normally deactivated together with cruise control (CC) ▶ Chapter "3.2.1 General description", page 10. The "Freeze" function is an exception. This function is activated when the driver manually operates the brake in addition to ACC and the brake is already in use via an active request (to retarder - or wheel brakes). The function ensures that the driver receives a clear response from the vehicle when he activates a brake manually. This is why ACC freezes his current torque request to the endurance brake(s) and only gradually begins to transfer the deceleration request back to the braking system. Immediately cancelling the ACC braking request (retarder and wheel brakes) would surprise the driver because his manual operation of the brake could be less intense than the previous operation through ACC. Instead, the "Freeze" function provides a comfortable and safe method to hand control of the brake back to the driver.

An **example of a situation for the "Freeze" function** is the approach to a red traffic light behind a vehicle that is coming to a standstill. The vehicle ahead brakes so that ACC actively controls the retarder and wheel brakes. The driver presses the brake pedal because he knows that cruise control/ ACC is deactivated below a certain minimum vehicle speed (generally this threshold value is set to between 5 and 30 km/h). Pressing the brake pedal immediately deactivates cruise control and would normally have deactivated ACC as well. Instead, ACC remains active and freezes its brake request for retarders. The wheel brake request increases linearly with a gradient of +0.4 m/s³. With an EBS braking system, ACC also requests this deceleration in an "addition mode" to improve the driver's subjective impression when the brake pedal is pressed.

The "Freeze" function is activated when the driver manually operates the available endurance brakes or the wheel brake while ACC already actively requests retarder and/or wheel brakes.

In the "Freeze" function, ACC mode 4 ("Hold mode") is transmitted. The "Freeze" function is exited once the driver ends the manual brake activation or the vehicle comes to a standstill.

3.3.3.4 Brake only mode (BOM)

Apart from the "Freeze" function described in the previous chapter, there is another special ACC mode called "brake only mode" where ACC remains active and continues its distance control even though cruise control (CC) was deactivated. Because cruise control is deactivated, the vehicle can no longer be accelerated so that only the retarders and/or wheel brakes are applied in BOM.

There are two applications with corresponding conditions for activating the BOM:

■ Cruise control (CC) is deactivated because the current speed of the host vehicle drops below the minimum speed for cruise control. In this situation BOM ensures a comfortable and safe distance control to the target driving ahead. An already commenced ACC brake activation will not be cancelled when cruise control (CC) is switched off.

■ Cruise control (CC) is deactivated due to an ESC intervention. Normally ACC is always deactivated together with cruise control (CC). If deactivation of cruise control (CC) is caused by an ESC event, however, an immediate deactivation of ACC is not always the safest procedure. If braking is activated during an active ESC control process, a deactivation of distance control would at least surprise the driver, because he would need to assume control without advance warning. For this reason ACC remains active and continues to brake in this situation. WABCO always activates this mode for safety reasons if cruise control is configured to be deactivated due to an ESC event.

In comparison to the "Freeze" function, where ACC no longer performs a closed control loop, the behaviour within the BOM is identical to normal ACC distance control with respect to endurance and wheel brake requests. The ACC mode transmitted during BOM is 2 "Distance control" (▶ chapter Chapter "3.2.2.2 Signal outputs of ACC", page 12).

The termination conditions for both cases of application (i.e. activation due to minimum speed of cruise control or ESC event) are identical.

3.4 Distance warning (DW)

DW is an extension of ACC and, like ACC, only responds to moving and stopped objects that drive on the same lane and in the same direction as the host vehicle. It does not react to stationary of oncoming objects.

During manual driving - which means ACC is deactivated or the driver overrides ACC via the accelerator pedal - DW informs the driver when the following distance falls below a certain value that is considered a safe following distance. This threshold value is derived from a time gap and only takes effect for vehicles driving ahead which have approximately the same speed or a lower speed than the host vehicle. For this reason DW does not notify the driver of a faster vehicle overtaking and moving into the host vehicle's lane even though this object is closer than the distance value based on a time gap. DW only informs the driver when he approaches a target vehicle and is faster than this vehicle.

Notification is implemented by means of a distance warning signal in the ACC1 message. Since ACC also uses this message for its system limit warning (▶ Chapter "3.2.1 General description", page 10), a further condition needs to be taken into account to distinguish the meaning of this signal. If the distance warning signal assumes the value 1 and the ACC mode is in "Off", "Override" or "Fault" mode, a distance warning is output. In all other cases a system limit warning is transmitted through ACC.

DW is automatically activated once the host vehicle exceeds a defined speed threshold. DW then starts to monitor the following distance and is automatically deactivated once the host vehicle speed falls below the threshold value for the deactivation speed.

DW is active if the current time gap between the host vehicle and the object falls below the warning threshold while the host vehicle is faster than the object.

DW is activated by the OEM via EEPROM parameters. No provisions have been made for the driver to activate or deactivate this function during operation. At present, only WABCO can change the threshold values.

3.5 Collision warning (FCW)

FCW warns the driver in situations where there is the risk of an impending collision. For this purpose FCW calculates the movement for the host vehicle and the vehicles driving ahead. By taking into account the estimated response time of the driver and a prognosis of his ability to brake, the system generates a corresponding FCW if the driver needs to brake strongly to prevent an impending collision. In general, FCW uses the same algorithms as the FCW as part of the complete AEBS function and thus

prompts the driver to actively intervene and, if necessary, brake harder in order to prevent an impending collision. ▶ 3.7 on page 18.

FCW monitors the traffic driving ahead independently of whether the driver activated ACC or not.

In the default setting FCW does not support any brake intervention or engine torque limitation: it only outputs a collision warning via the instrument panel. The warning is either communicated via the "FCW" signal in the ACC1 message or via the "FCW" signal in the AEBS1 message.

3.6 Collision Mitigation System (CMS) incl. collision warning (FCW)

CMS automatically initiates partial braking of max. -3.5 m/s² in order to reduce the total collision energy if the system assumes that a collision is unavoidable. CMS cannot prevent the accident.

For its function CMS calculates the likely movement for the host vehicle and the vehicles driving ahead. Taking into account the estimated response time of the driver to carry out emergency braking or an evasive manoeuvre, the CMS initiates automatic braking if a collision is assessed as unavoidable by braking or steering action through the driver. In general, the CMS uses the same algorithms as the AEBS function, but is configured differently.

CMS only responds to object sthat are detected as moving or stopped. It does not react to stationary or oncoming objects.

CMS monitors the traffic driving ahead independently of whether the driver activated ACC or not. The options and the means for the driver to override or deactivate the CMS can be defined in the parameters ▶ Chapter "3.7.6 Deactivation and override conditions", page 26. CMS is always combined with FCW. A previously activated FCW is required to start automatic partial braking for collision mitigation through the CMS.

CMS differs from a full AEBS function with respect to the following items:

■ no brake intervention and no engine limitation with stationary objects – warning only

■ later response in curves

■ CMS is activated after a minimum speed is exceeded

■ CMS uses a greater safety span for the brake criterion ▶ Chapter "3.7.2 Evaluation of a situation through AEBS", page 19.

3.7 Emergency braking assistance (AEBS)

In 2009 the European Union published the General Safety Regulation that makes AEBS mandatory for trucks for medium to heavy duty road transport and coaches from 10/2013 (with new type approval) and 10/2015 (new registrations).

According to this regulation, AEBS is a system that automatically detects an emergency situation and activates the vehicle's braking system to brake the vehicle and avoid or mitigate a collision. A technical definition of an AEBS is available in the European Commission Regulation.

The AEBS included in OnGuardACTIVE comprises the subsidiary functions described in the chapters below.

3.7.1 "FCW" function

3.7.1.1 Warning levels

OnGuardACTIVE supports a multi-level warning cascade so that the vehicle manufacturer can configure the vehicle's instrument panel to support visual, acoustic or haptic warnings or combinations thereof. FCW of the "AEBS" function can support up to three different collision warning levels, which can be variously critical. In the standard set-up the system only uses one level.

3.7.1.2 Haptic collision warning (HCW)

Apart from the warning signals described in the previous chapter, HCW also outputs a haptic warning to the driver by briefly activating the wheel brakes (i.e. braking pressure) to intensify the FCW. HCW is used during an active FCW, with different parameters for each collision warning level. With the standard parameter setting HCW starts 0.6 s after the FCW and requests a deceleration of -2.5 m/s² for 0.5 s.

3.7.1.3 Applying the brake

While the FCW is active, OnGuardACTIVE initiates application of the wheel brakes using the XBR message. If this is not supported by the braking system, at least the stop lights must be activated during the brake request to comply with the functional safety concept of the system.

The reason for applying the wheel brakes is to prepare the callipers by inducing application pressure to overcome the air gap between the brake linings and the brake disks or drums so that they respond faster at the start of emergency braking, whether initiated by the driver or AEBS. In addition, the activated brake lights are seen by the driver of a vehicle driving behind, who is therefore also prepared for braking.

For moving or stopped objects AEBS attempts to reduce the speed of the host vehicle by up to 70 km/h to avoid an accident. For stationary objects AEBS attempts to reduce the speed of the host vehicle by up to 20 km/h prior to collision to mitigate the accident.

Due to the various influencing factors such as the coefficient of friction of the road surface, AEBS cannot guarantee accident avoidance even for moving objects ▶ Chapter "3.7.4 Limitations of the AEBS", page 23.

3.7.1.4 Restricted emergency braking assistance (AEBS)

In some situations AEBS can only provide restricted performance ▶ Chapter "3.7.4 Limitations of the AEBS", page 23. From a legal perspective this restricted AEBS is not an emergency braking procedure - instead it is classed as a warning with braking.

3.7.2 Evaluation of a situation through AEBS

The fundamental principle of AEBS is to initiate automatic braking only when a collision-critical situation can no longer be defused by the driver of the truck. To recognise such a situation, the "FCW" and "AEBS" functions behave in a similar way and apply the same criteria to assess and classify a given critical situation – but with different parameter settings.

An overview of the applied criteria can be found below. To analyse these criteria, AEBS must predict the current traffic situation for the immediate future. This prognosis is made by predicting the longitudinal and lateral movements of the detected objects and the host vehicle.

- Steering criterion: Based on the different steering trajectories and the predicted position of the objects driving ahead, AEBS decides whether it is still possible for the driver to avoid a collision with the object by evasive manoeuvres.

- Braking criterion: The braking criterion calculates the longitudinal acceleration of the host vehicle that must be executed by the driver to avoid an impending collision with the object driving ahead, taking into account his response time. Based on the result, AEBS decides whether it is still possible for the driver to avoid a collision by braking.

The driver's response times used for these projections is influenced by the actual response of the driver. If he is already pressing the brake pedal, AEBS assumes that he knows the traffic situation and is already responding to it. In order to avoid false warnings or brake interventions in this situation, a shorter driver response time is used, which no longer takes the time fractions for eye movement or foot movement on the brake pedal into account.

AEBS terminates its brake activation under the following conditions:

- the host vehicle has reached standstill

- The braking criterion no longer evaluates the situation as critical and the object in front has the same speed or is faster

- The object is no longer relevant because it has moved away from the direction of movement of the host vehicle - due to the steering of the object or an evasive manoeuvre of the host vehicle, for example.

If the object disappears in an inexplicable manner, AEBS does not immediately stop braking but continues its deceleration request for an additional 2 seconds ▶ Chapter "3.7.3.2 Normal response with stationary objects", page 21.

3.7.3 Warning and braking cascade

This chapter describes the sequence in which FCW, HCW and AEBS perform their warning and braking activities.

The typical standard sequence (e. g. while enabled) of a complete AEBS response looks like this:

- Start of FCW with brake application

- 0.6 s after starting the FCW, HCW is executed for a duration of 0.5 s

- The FCW is then active during a short pause in braking of approx. 0.5 s.

- Finally, automatic emergency braking is activated

3.7.3.1 Normal response with moving or stopped objects

Figure 1 shows an example of the warning and brake cascade for a moving or stopping object. This is the optimum warning cascade that prevents a collision. Emergency braking is terminated as soon as there is no longer any risk of an accident - regardless of the speed of the host vehicle at this point in time. After emergency braking, the speed of the host vehicle is higher or lower than the activation speed of the AEBS ▶ see section "Speed range of AEBS" on page 26 – which also depends on the speed of the object. Active emergency braking is not terminated, even if the host vehicle's speed falls below the activation speed of the AEBS.
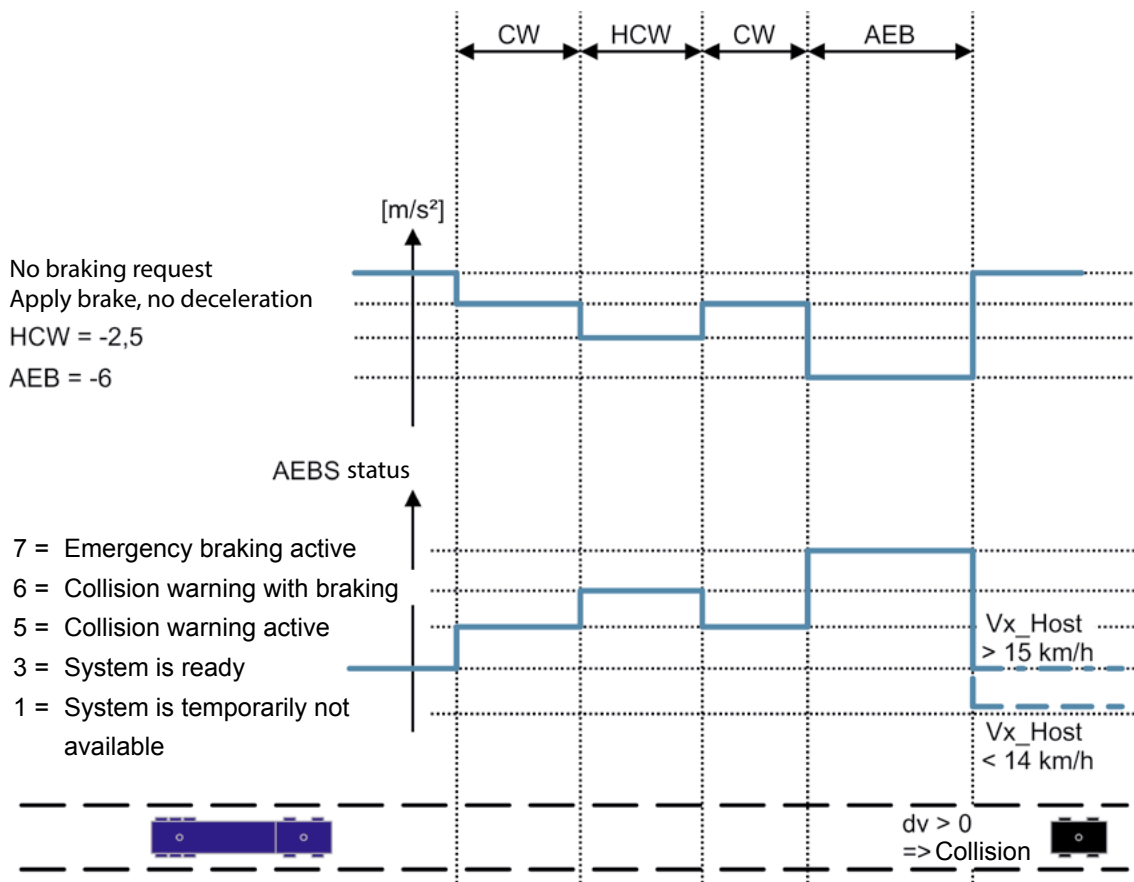
Figure 1   Example for a warning and braking cascade for moving/stopped objects

3.7.3.2   Normal response with stationary objects

The normal warning cascade for stationary objects is similar to the one shown in Figure 2. In contrast to the situation with moving/stopping objects, less deceleration is requested during emergency braking and for the behaviour after the event – an accident is expected in this case. Figure 2 shows an example of the respective sequence for stationary objects.

After the event, three different behaviours are possible, which are described below (they can also be identified by the numbers given below in Figure 2).

1. During emergency braking, the sensor is damaged and communication with the braking system is lost. If assisted by the installed braking system, "braking during the accident" is kept active and the last emergency braking is continued for an adjustable period of time.

2. The sensor is not damaged and the object has been lost in an inexplicable manner

In this case, emergency braking is continued for a short moment (usually 2 s).

3. The sensor is not damaged and the object has been lost in an explicable manner (e.g. if it was steered away from). Automatic braking is stopped and AEBS is temporarily not available.

Usually, an emergency braking procedure on stationary objects leads to an accident. After such an accident, the system switches itself off automatically for the next 20 s with the actively executed emergency braking procedure, because it assumes that it was misguided in its braking decision and therefore tries to avoid another incorrect braking immediately after the first one.
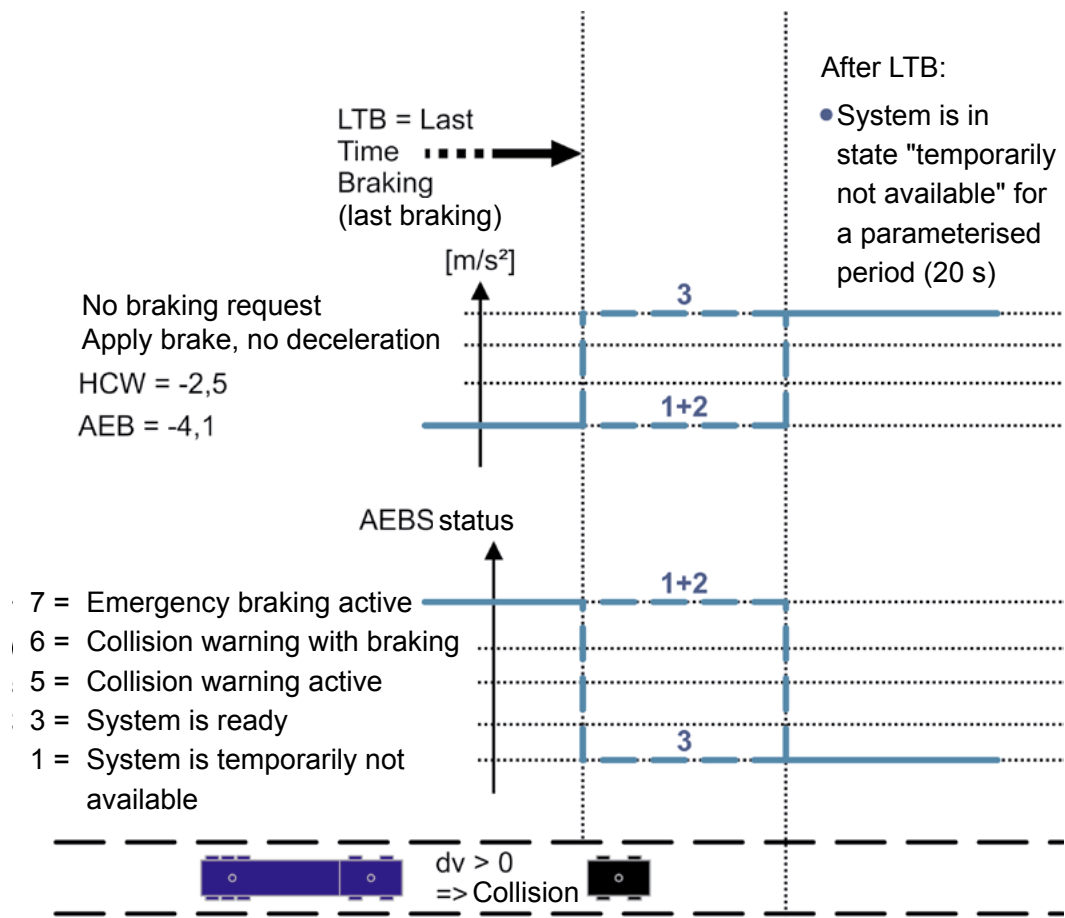
Figure 2   Example for a warning and braking cascade for stationary objects

3.7.3.3   Reaction to objects that enter the lane of the host vehicle

The emergency braking sequence may differ if the FCW cannot start early enough. This situation could occur if the criteria for issuing the warning are fulfilled too late – e.g. if an object enters the lane of the host vehicle at a very short distance. Figure 3 shows an example of such a cutting-in situation at a short distance. As a result, the warning is issued too late because the object was not relevant for the warning before it executed its cutting-in manoeuvre. After the FCW has been output, the situation is so critical that AEBS starts activating the brake shortly after the FCW. The HCW is skipped, but AEBS is limited in its deceleration while the minimum warning time (1.4 seconds) has not yet been reached. After the minimum warning time has elapsed, AEBS requests its full braking power. In this situation, collision avoidance is not possible due to the limited emergency braking at the beginning of the event.
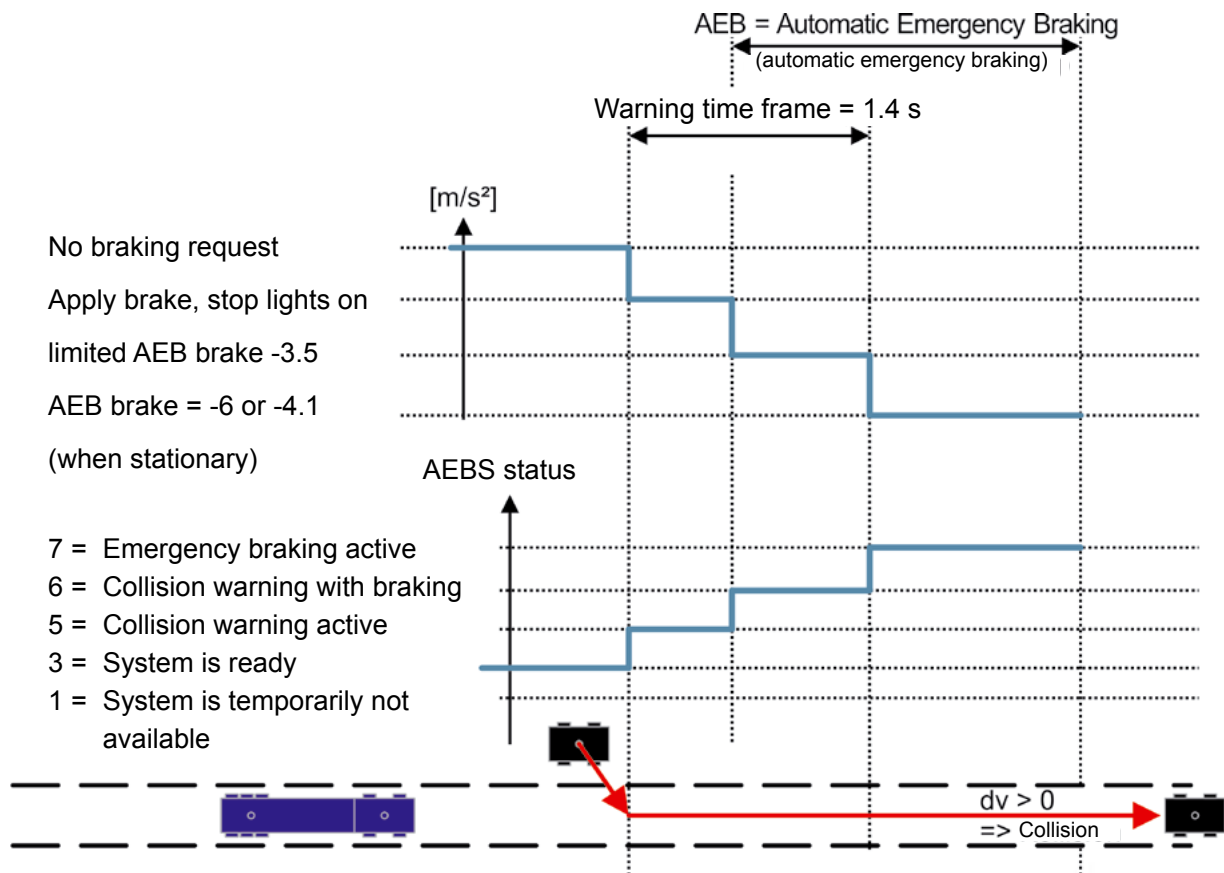
Figure 3   Example for limited AEBS due to the vehicle driving ahead moving into lane at close range.

3.7.4   Limitations of the AEBS

The following subchapters show various limitations of the AEBS, which can lead to an unexpected reaction and reduced system performance.

3.7.4.1   False and unwanted warnings

In the FCW there are objectives that can come into conflict. One objective is to react very early in critical situations so that even for a distracted driver it is possible to defuse a critical situation himself. On the other hand, unnecessary or false warnings should be avoided as far as possible.

An unnecessary warning is not the result of an incorrect object detection. Instead, it occurs in a situation where the driver is aware of the situation, has already planned his response to resolve the situation and has just initiated his countermeasures. In contrast to this, the FCW has to take the response time of the driver into account and does not know the current intention of the driver. The warning occurs shortly before the driver's reaction is executed and is therefore classified by the driver as an unnecessary warning. Unnecessary warnings, as described above, therefore do not constitute a system error, but are caused by conflicting objectives. Nevertheless, under normal conditions an "aggressive" driving style is necessary to generate such warnings.

Unnecessary warnings may also occur if the object driving ahead suddenly changes its movement status. Since the algorithms of the AEBS must predict the movement of the object driving ahead and they have no further information about the intention of the driver, they assume that the current dynamic status of the object (e. g. acceleration or transverse speed) is constant. Any sudden change in the dynamic status of the object would trigger a critical situation that has already been detected by the driver of the vehicle, which could also lead to a warning perceived as unnecessary by the driver.

An example of such behaviour is when the object in front slows down or drives at a lower speed and the direction indicators are activated. The driver of the host vehicle does not react because

he assumes that the target wants to leave the road. However, because there is no or only a slight transverse movement of the object, the system evaluates the situation as collision-critical and triggers a corresponding warning. Nevertheless, the assumption of the driver of the host vehicle does not have to be correct in this situation - for example, if the object unexpectedly does not turn or stops completely because the other road is blocked by a pedestrian.

In addition to unnecessary warnings, false warnings can also occur. False warnings are caused by incorrect measurement or classification of detected objects. Such restrictions currently represent the current state of technology for individual radar sensors.

3.7.4.2   General limitation of algorithms

AEBS must react before the accident occurs. For this reason, AEBS must monitor the current traffic situation. This prognosis is made by evaluating the longitudinal and lateral movements of the detected objects and the host vehicle. Since there is no further information about the intention of the driver of the vehicles driving ahead, any sudden change in their movement while the prognosis is made will affect the performance of the AEBS. In these situations, a delayed system response is possible because the system may detect an impending collision too late. This could mean that the collision can no longer be avoided.

A system response can also be delayed if the system detects that an impending collision is unavoidable even in the event of an evasive manoeuvre by the driver. This behaviour usually occurs when the object in front of the vehicle only partially overlaps with the lane of the host vehicle, or when the object has tendencies to leave its lane. Even in high speed situations, the system may not be able to prevent an accident because the time available to the driver for evading an object is much longer, but he would need to start braking immediately to avoid an accident.

3.7.4.3   Restrictions due to the environment

AEBS always assumes the best braking conditions for its calculations (road with a high coefficient of friction). In the standard setting, the system expects that a deceleration of at least -5.5 m/s² is possible. If this deceleration cannot be achieved by the vehicle due to weather conditions or road surface, collision avoidance by AEBS is not possible.

3.7.4.4   Limitation due to the detection performance of the sensor

The system uses a radar sensor for object detection. The current radar sensors are limited in particular with regard to the measuring accuracy of lateral acceleration and the velocity of objects. For this reason, the system uses tolerances to avoid incorrect warnings and braking. These tolerances could lead to a situation in which an accident can occur without the system having reacted beforehand. This problem mainly affects stationary objects.

In urban environments, many objects on the roadside are recognized as stationary (e. g. parked cars on the side of a curve or traffic signs on a traffic island), and the driver of the host vehicle has to perform a lot of steering manoeuvres in the vicinity of these targets. To compensate for this, AEBS uses

- an avoidance path for stationary objects with other parameters at low speeds, which leads to later responses.

- an avoidance path for stationary objects with other parameters when driving in curves, which leads to later responses.

In addition, there are the following restrictions for all object types:

- To initiate a brake activation, the centre of the object must be detected in the lane of the host vehicle. There is no system response for this object if this is not fulfilled.

- In narrow curves (R < 300 m) the object must be located almost in the middle of the host vehicle's lane, as the detection performance of the sensor is limited in such curves.

3.7.4.5 Further safety restrictions of the system

The risk and hazard analysis for this system evaluates an accident of the traffic following the host vehicle caused by emergency braking as critical. In addition, the risk of destabilising the host vehicle through emergency braking is also assessed as critical.

In order to minimise these risks, various safety functions are used to reduce the requested acceleration to a safe value. By default, the requested deceleration is limited to -3.5 m/s² if one of the following functions becomes active.

3.7.4.6 Restriction having to guarantee the advance warning period

To ensure that the following traffic has enough time to react to an emergency braking of the host vehicle, the brake lights are activated shortly before AEBS initiates an unlimited emergency braking. This duration is set to 1.4 s by default. As long as this time has not elapsed, the requested deceleration is limited to -3.5 m/s². The warning time is counted from the start of the FCW.

3.7.4.7 Restriction due to high lateral acceleration

When driving in curves with high lateral acceleration, the braking requests of the AEBS are restricted. Based on the lateral acceleration, the braking request is limited so that the resulting deceleration is below a critical level.

3.7.4.8 Restriction due to driving in a tunnel

If AEBS detects that the driving takes place in a tunnel, it restricts the maximum deceleration to -3.5 m/s² because radar detection may be impaired by tunnel wall reflections, leading to a higher risk of false detections.

3.7.4.9 Restriction due to active vehicle stability system events

The braking requests of the AEBS are reduced to -3.5 m/s² if the functions of the vehicle stability system were active before FCW was activated.

It can be expected that the dynamics of the host vehicle are already impaired if one of these vehicle stability system functions actively intervenes. This could lead to signals such as the host vehicle's speed being incorrect, namely due to excessive slip or similar effects.

3.7.4.10 AEBS – reduced sensitivity mode

After ignition, AEBS is in an operating mode with reduced sensitivity, which basically means that more conservative parameters must be used than in normal operation. This mode is necessary for the functional safety of the system because after start-up, various plausibility checks are carried out for the sensor, which take a certain amount of time before a result can be derived. The reduced sensitivity mode is active:

- at least during the first 10 km
- if the difference in alignment angles during operation is too large
- if the plausibility check for the yaw rate has not yet returned a successful result

When AEBS is in reduced sensitivity mode, only limited emergency braking is performed. The full performance of the AEBS is only available if all the following conditions are met:

- straight roads (|curve radius| > 1000 m)
- no city traffic and no high speed driving (the speed of the host vehicle is between 60 and 90 km/h)
- AEBS-relevant objects have no recognisable relative transverse speed

If these conditions are not met, AEBS only requests a reduced deceleration of -3.5 m/s². The conditions for a limited emergency deceleration are checked when the FCW is started - there is no adjustment of the deceleration in the warning cascade.

3.7.4.11   Speed range of AEBS

AEBS is specified for a speed range of 15 - 125km/h. It deactivates itself at lower and higher speeds, as described below.

- AEBS is switched to "temporarily unavailable" when the speed of the host vehicle exceeds 125 km/h
- AEBS reactivates itself when the speed of the host vehicle falls below 124 km/h
- AEBS is switched to "temporarily unavailable" when the speed of the host vehicle drops below 14 km/h
- AEBS reactivates itself when the speed of the host vehicle exceeds 15 km/h

If AEBS is in "temporarily unavailable" status, no warning is issued and no emergency braking is performed. During an active FCW or AEBS event, the speed is not checked until both functions have become passive again. If only the FCW was active at a host vehicle speed higher than the deactivation speed, AEBS is also activated if the FCW has not become passive before.

3.7.5   Event counter of the AEBS

The event counter of the AEBS counts the emergency braking events initiated by the AEBS. If this counter exceeds a predefined threshold value (currently 3 events), the system changes to an error status because this number is higher than expected over the life of the vehicle. This is necessary because such a high rate of emergency braking indicates that there are undetected faults in the AEBS. The event counter of the AEBS has a self-healing process depending on the distance driven by the vehicle. If the counter has not yet exceeded its maximum and a predefined maximum distance has been travelled without increasing the counter, it is reset.

3.7.6   Deactivation and override conditions

The following subchapters describe the deactivation and override conditions that can be used by the driver to cancel FCW and AEBS events.

3.7.6.1   Conditions for overriding by the driver

AEBS supports various criteria for the driver to override, which are set up separately for FCW and emergency braking. Such an override is only intended to suppress the current AEBS event and is only detected within a short time frame to ensure that it is really intended for the current driving situation ("clear positive driver action"). For example, a turn signal that is continuously active for 100 s will no longer override an EBA event.

An override by the driver can be triggered by the following criteria:

- Accelerator pedal position: This override condition is triggered when the pedal position exceeds a pre-defined threshold value of 80% and the speed of actuation exceeds a pre-defined threshold value of 100% per second.
- Pressing the accelerator pedal right through: This override condition is triggered when the kickdown switch signal becomes active.
- Hazard light switch: This override condition is triggered when the driver activates the hazard warning lights.
- Direction indicator switch (=> turn signal switch): This override condition is triggered when the left or right turn signal has been activated by the driver. If the signal is active for more than 5 s, it is ignored by the AEBS.

The override is always linked to a specific warning or braking event of the AEBS. If an FCW or AEBS event was overridden, it will not reactivate until the situation that triggered it has become uncritical again (i. e. the cancellation criterion for FCW and AEBS is met), regardless of whether the override is still active.

3.7.7 Output signals of the emergency brake assistant (AEBS)

3.7.7.1 AEBS1 message

AEBS provides its current status and warning level using the AEBS1 message. The following subchapters describe the signals contained in this message in detail.

3.7.7.2 Warning or brake status notification

In the AEBS1 message, there are two signals that are the main interface to the vehicle's instrument panel. The most important signal is the status of the AEBS.

The "FCW" function can be actively supported even if the AEBS is in error state, which has no effect on the "FCW" function. While AEBS is manually switched off or overridden by the driver, the "FCW" function remains active and provides warning signals as required.

3.7.7.3 External brake request

All deceleration requests of the HCW, AEBS or EBA functions are transmitted to the braking system by means of the XBR message. Such requests are made with the highest priority in the so-called maximum mode so that the driver can manually request further deceleration if physically possible. The braking system to be used must be approved by WABCO for use in combination with OnGuardACTIVE because it must meet the corresponding requirements.

3.8 Extended Brake Assist (EBA)

EBA supports the driver by increasing the manual braking request in a critical collision situation to prevent an imminent accident. In the case of an active FCW, EBA sends a request to the braking system. This is necessary for the required deceleration to prevent an accident if the driver has previously pressed the brake pedal slightly. This deceleration request is not a constant value as requested by the "AEBS" or "HCW" functions, but is constantly adapted to the current situation. EBA responds to moving, stopped and stationary objects. It does not react to oncoming objects.

EBA does not become active if there is no active FCW when the driver presses the brake pedal. After EBA has been activated, the FCW status is no longer relevant. The driver is supported until the host vehicle has come to a standstill or the driver releases the brake pedal. If the object is lost during an active EBA event, its last deceleration request is maintained as long as EBA is active.

3.8.1 Safety restriction of the EBA

For functional safety reasons, the max. stage of the deceleration request from the EBA is linked to the current brake pedal position in order to avoid excessive deceleration when the brake pedal is only touched. Resulting restriction ▶ Figure 4 on page 27. If the position of the brake pedal is less than 10%, EBA does not request deceleration. For 30 % or more, a maximum permissible request of the EBA of -6 m/s² is possible. Irrespective of this restriction, EBA always requests only the deceleration necessary to prevent an imminent accident.
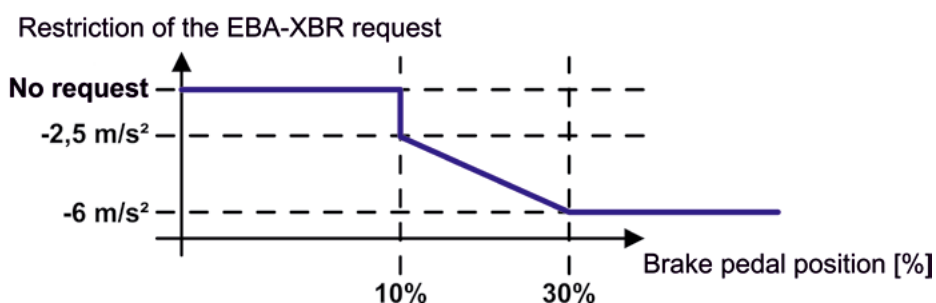

Figure 4   Restriction of the EBA request

3.9   Functions for the plausibility check

The radar sensor requires the current speed of the host vehicle as well as information about the current yaw rate for its operation. The source of the vehicle speed signal is the speed of the free-rolling front axle which is provided by the braking system. The yaw rate signal is provided by OnGuardACTIVE's internal yaw rate sensor. These signals are checked and monitored individually and continuously.

A correct vehicle speed is mandatory for OnGuardACTIVE because the classification of whether an object is moving or stationary depends mainly on the precision of the provided vehicle speed. The radar can only measure the relative speed of a detected object. If the source of the vehicle speed does not match the real speed, the provided object classification may be incorrect. For this reason, two mechanisms are implemented and ensure that the speed signal is correct.

3.9.1   Calibration function for the host vehicle speed

This function monitors and compares the speed signal received from the braking system with the reference speed of the vehicle. It can be activated by parameter and must be active during normal operation if the braking system does not compare the wheel speeds with the speedometer speed. When this function is activated, it calculates a correction factor between the vehicle speed and the wheel speeds from the braking system and ensures that internally the corrected speed is provided. The calculated correction factor is stored in the unit's EEPROM memory.

3.9.2   Calibration function of the internal sensor

In addition, the radar sensor monitors and adjusts the internally received vehicle speed by comparing it with the differential speed of the measured object, mainly with stationary objects at the roadside. The result of this comparison is an internal correction factor of the radar which is also stored in the unit's EEPROM memory. This calibration of the sensor speed is always active and cannot be deactivated. The learned value can be read out via the external diagnosis and, if necessary, reset using diagnostic commands. If the calculated correction factor exceeds a certain threshold value, a fault message is sent and the functionality of all applications is blocked.

3.9.3   Signal plausibility for the internal yaw rate sensor

The internal yaw rate signal is checked for plausibility by either comparing it with the yaw rate signal provided by the ESC module or by comparing it with the yaw rate that is calculated using wheel speeds. If the plausibility check fails, the AEBS function and the "EBA" application switch off and the system transmits the relevant fault message on the CAN interface.

4 System architecture

OnGuardACTIVE is a complete solution connected via a CAN interface of the vehicle. However, since the ACC function is a kind of extension to conventional cruise control, which is usually integrated in engine control or another control function for vehicle dynamics, it is only fully functional in combination with the cruise control's (CC) speed control function.

All other ADAS functions of OnGuardACTIVE are independent but require access to various vehicle systems such as ACC.

As shown below, the system architecture has a generic design that can differ between different OEs and vehicles, e. g. with regard to the CAN interfaces used there.
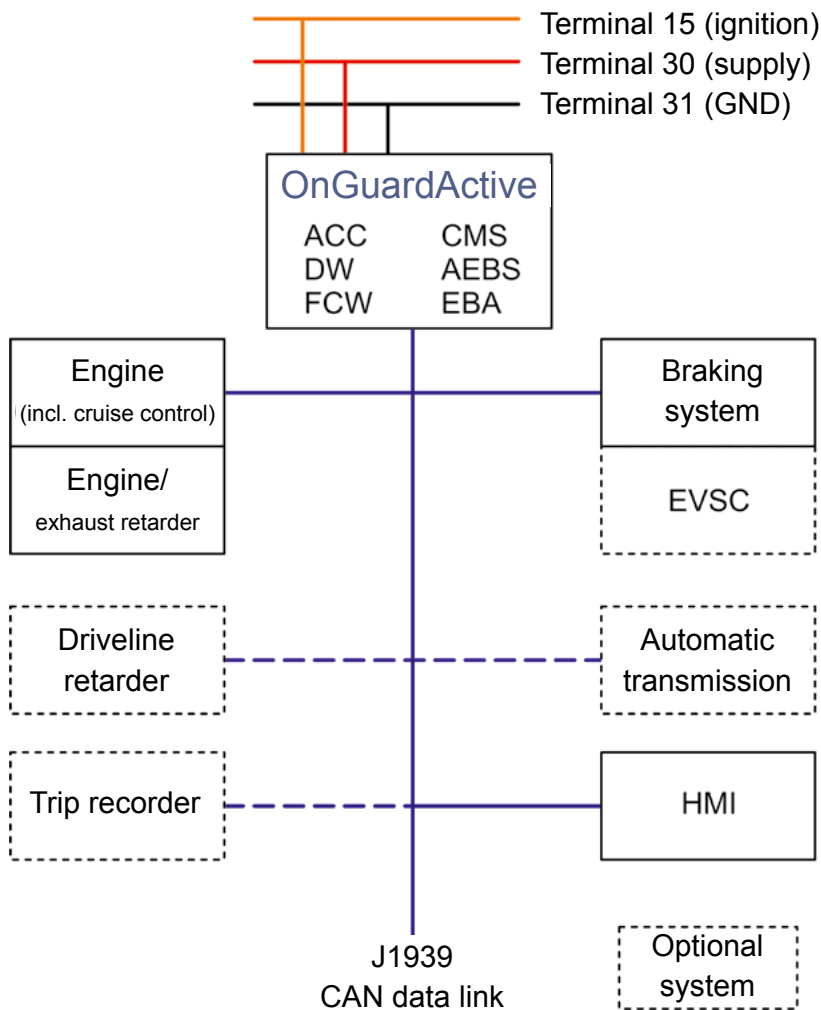

Figure 5   Generic electronics system architecture of OnGuardACTIVE

OnGuardACTIVE is equipped with an internal yaw rate sensor, the signals of which are required for predicting the direction of movement of the host vehicle in order to determine the relevance of objects driving ahead. In addition, the yaw rate signal of an existing ESC is used for plausibility checks. If no ESC is available, yaw rate plausibility is determined using wheel speeds.

4.1 Power supply

OnGuardACTIVE is designed for use with a 12 V or 24 V supply. The following table shows the voltage thresholds for both variants, i. e. above or below which voltage level the radar sets a DTC that deactivates the OnGuardACTIVE functions. The general voltage range within which the radar is operational is shown in Table 5.

POWER SUPPLY		12 V SUPPLY RATED VOLTAGE	24 V SUPPLY RATED VOLTAGE	EXPLANATION
Overvoltage	Activation of fault	> 16 V	> 32 V	Above this voltage threshold value OGA sets an "overvoltage fault". All functions (e.g. ACC, AEB) are deactivated.
	Deactivation of fault	> 15.5 V	< 30 V	An active "overvoltage fault" becomes passive when the supply voltage falls below this threshold value. All functions are reactivated.
Undervoltage	Activation of fault	< 7.5 V	< 8 V	Above this voltage threshold value OGA sets an "undervoltage fault". All functions (e.g. ACC, AEB) are deactivated.
	Deactivation of fault	> 8 V	> 9 V	An active "undervoltage fault" becomes passive when the supply voltage exceeds this threshold value. All functions are activated.
Undervoltage level	Activation of fault	> 9.5 V	< 19.5 V	Below this voltage threshold value OGP sets an "undervoltage level" fault without a yellow warning lamp if no signals of other systems are affected. In case of additional communication errors the system switches all affected functions (e. g. ACC, AEBS) off and the corresponding yellow warning lamps are activated. Communication errors are not stored as separate DTCs.
	Deactivation of fault	> 10.5 V	> 20.5 V	If the supply voltage exceeds this threshold value, an active "undervoltage level" fault becomes passive.

Table 5   Voltage threshold values, depending on the external mains voltage

The system offers various options for implementing the power supply:

- Connection only to terminal 15 (ignition) and terminal 31 (ground) so that it is completely de-energised when the ignition is switched off
- Connection to terminal 15 (ignition) and 31 (ground), with terminal 30 providing supply power, while terminal 15 is used as a wake-up for the system
- Connection to terminal 30 (battery) and 31 (ground), with terminal 30 providing supply power, while the activity on the vehicle's CAN interface is used to activate and shut down the system.

5 Installation

5.1 Safety information

Before starting with the installation, read and comply with the following safety instructions.

> ⚠ **Danger of injury by electricity, heat**

- To avoid short circuits, pull out the fuse for the respective power circuit.
- Disconnect the battery if necessary.
  However, the downstream theft-protection systems may have to be reprogrammed.

> ⚠ **Traffic safety, functionality of the safety equipment / operating elements**

- Installing the components in an unsuitable location can cause injury in the event of an accident or hinder the efficacy of safety devices (e.g. airbags).
- Observe the instructions of the vehicle manufacturer relating to installation.
- Install the system so that the driver's view is not obstructed and access to all important controls is not hindered.
- During installation, ensure that the function of the airbag is not constrained, or that it is not accidentally triggered.
- Secure the components so that these cannot break loose in the event of a collision or sudden braking.

> ⚠ **Damage to the cable**

- Ensure that the cable does not become trapped or damaged.
- Plan your installation position so that the cables cannot become kinked, trapped or damaged.
- Fasten the cables and connectors so that the plug connections are not subjected to any tensile stress or lateral forces.

5.2 Vehicle installation

5.2.1 Installation position

The specified installation position is located at the centre of the vehicle front. The mounting height can be selected between 330 and 1000 mm above the road surface level (reference point is the centre of the sensor). At higher mounting positions the detection performance of the sensor can be impaired and must therefore be checked by WABCO in each case.

The tolerance for a position towards the side outside the centre is ±600 mm. The selected lateral offset position must be communicated to the sensor via parameter setting.

The best overall performance is achieved in the middle of the installation tolerances described above.

The sensor must be mounted so that its antenna points in the driving direction. The sensor can be mounted in the position "connector left" or "connector right". The selected alignment must be communicated to the sensor via parameter setting.

The sensor module can be attached to the rear using its mounting bolts. There are two different bolt lengths. An additional mounting bracket can be used as an adapter for the frame of the host vehicle.

Installation

In any case the breather hole on the back of the sensor housing must be covered by the bracket or frame to ensure proper resistance to high-pressure cleaning. The area to be covered is the breather hole itself covered by a diameter of at least 4 mm, as shown in Figure 6. The air gap between the bracket or frame and the breather hole must be 2 mm.
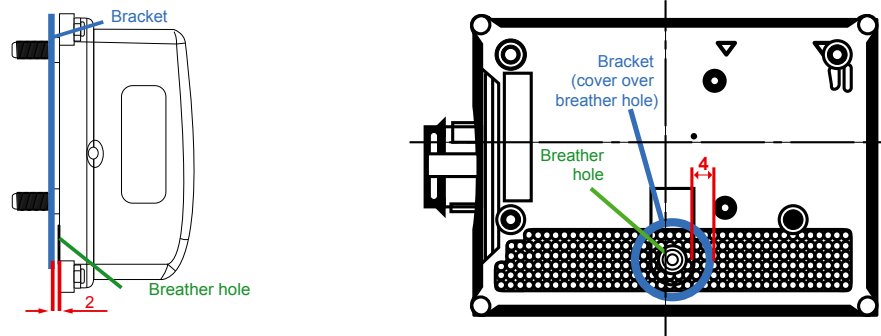

Figure 6   Installation of bracket and venting window

The accuracy of the mounting position must ensure an alignment tolerance in azimuth and elevation of ±3° with respect to the driving position of the vehicle. Additional mechanical alignment is not required. The final alignment within these limits can be carried out by the sensor itself, either by EOL alignment or self-learning during operation.

The back of the sensor must be able to dissipate heat in a suitable way. For this reason the temperature difference between ambient air and the back of the sensor should be higher than 0.5 K.

5.2.2 Automatic alignment

The sensor can align itself in both directions – azimuth and elevation. The automatic alignment function can compensate for a mechanical misalignment within the tolerances given above. There are three options for automatic alignment:

- End-of-line alignment
- Alignment in service stations
- Monitoring of a misalignment and correction while driving

After a successful alignment procedure and after each successful alignment correction, the radar stores the correction angles in azimuth and elevation, which can be read out via the external diagnostic software. If the mechanical misalignment exceeds tolerances that can be corrected, the radar sets an active fault code and all OnGuardACTIVE functions are deactivated. In this case, no correction angles are stored. The fault code contains information about which alignment procedure has failed (i. e. either EOL, service or monitoring during operation), and also in which direction the alignment has failed, e. g. the sensor is looking too far up or too far to the left.

The end-of-line alignment is started via a diagnostic command after the reference object has been positioned in front of the vehicle with appropriate accuracy and can take up to 30 seconds.

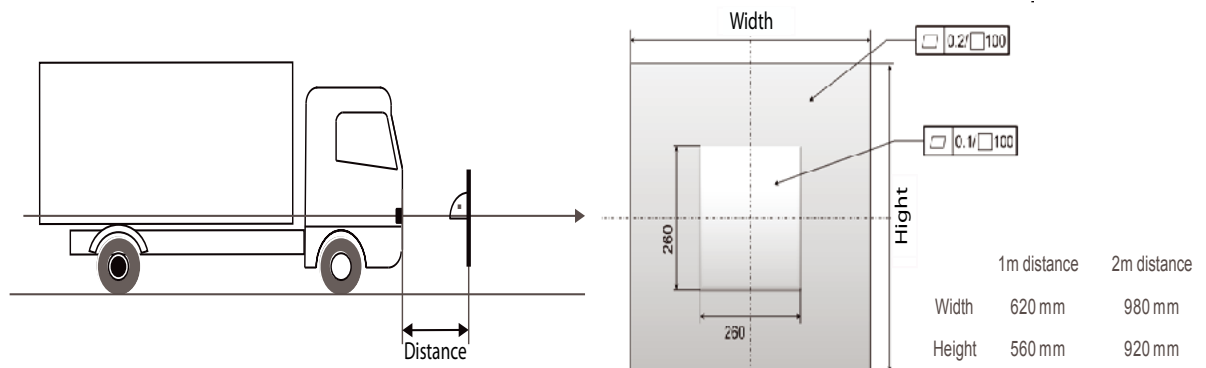Below is an example of an EOL alignment.

	1m distance	2m distance
Width	620 mm	980 mm
Height	560 mm	920 mm

Figure 7   Example EOL alignment

5.2.2.1 Alignment in service stations (workshops)

This alignment method does not require any special tools or knowledge of alignment. The radar sensor must always be aligned when the sensor has been removed from the vehicle or a new sensor is installed.

If a sensor was already aligned for operation and is then removed from the vehicle, it also requires an alignment which must be started via a diagnostic command in the workshop.

The new radar sensor automatically starts the sensor alignment procedure after the start of driving.

The vehicle must be driven for several minutes. After this drive the sensor is either aligned or outputs a fault message that it cannot compensate the mechanical misalignment. In the latter case, the sensor installation must be corrected to comply with the general mounting tolerances.

The azimuth alignment is based on the measurement of reflections of stationary objects on both sides of the road. The number of these stationary objects determines the duration of the alignment process. For this reason, situations with many stationary objects are better suited for alignment than situations with a few stationary objects. In addition, the host speed has a significant influence. Higher vehicle speeds are weighted more heavily than lower speeds.

The alignment in elevation is based on moving objects in front of the host vehicle while driving. The radar sensor moves its radar beam up and down to detect the position of the height alignment by searching for the maximum reflection power for most of the detected objects. The number of these moving objects determines the duration of the alignment process. For this reason, situations with many moving objects are better suited for alignment than situations with only a few moving objects.

The typical duration for the sensor alignment procedure is approx. 10 minutes, depending on the traffic situation and other conditions. The duration may be extended if the required conditions are not met at any time. Below are the conditions that must be fulfilled for a sensor alignment.

PARAMETERS	REQUIRED CONDITION
Speed of the vehicle	> 25 km/h < 125 km/h
Acceleration of the vehicle	< 1.5 m/s^2 (absolute value)
Road curvature	> 250 m
Environmental conditions	no heavy rain or snowfall
Tunnel detection	no tunnel detected

Table 6   Conditions for service alignment

The fastest result is achieved when the sensor alignment is carried out on country roads or motorways. On these roads the necessary environmental and traffic conditions can be found more easily than in urban areas.

6 Hardware radar sensor module

6.1 Sensor overview

OnGuardACTIVE uses a 77 GHz radar sensor with a mechanical scan antenna that contains two independent radar beams: a long-range beam of ±9° with a range from 0.25 to 200 m, and a short-range beam of ±28° with a range from 0.25 to 60 m. The system operates simultaneously in transmission and reception mode, with both operating modes using the same antenna.

The radar beams are adapted in their shape to the azimuth plane of the sensor (parallel to the road surface). A tiltable reflector plate is used to implement beam shaping and beam direction adjustment in the elevation plane (vertical to the road surface).

6.1.1 Detailed sensor properties

The radar has a maximum target detection range of 200 m. In order to reduce incorrect responses for distant objects, OnGuardACTIVE uses a reduced range depending on the speed of the host vehicle. The vehicle speed is divided into 3 areas to represent city traffic, country roads and motorways. The range and vehicle speed threshold values have been selected to achieve the best compromise between ACC and AEBS performance and incorrect object responses. Increasing the detection range would increase the risk of false responses for distant objects, such as incorrect lane assignments. After the object has been detected, OnGuardACTIVE retains it even if it moves out of the range threshold value. Figure 8 shows the characteristic values of the range that depends on the vehicle speed.
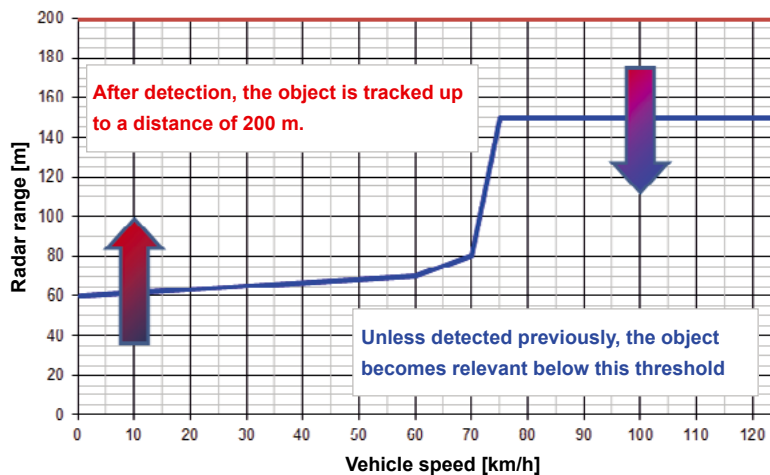

Figure 8   Range that depends on the vehicle speed

6.1.2 Blockage detection

The sensor can detect whether it is blocked based on the number of objects present. This can be caused by snow, ice, heavy rain or even a bull bar in front of the vehicle. If a blockage is detected, the radar will output a corresponding fault code. This fault code remains active until the radar successfully detects a clear field of view again. Switching the ignition off and on does not delete this fault code.

Blocking detection only works while the vehicle is in motion, i. e. during a standstill a blockage is not identified and a corresponding activation fault is not reset. There are two different types of blockage:

- complete blockage, i. e. the radar sensor does not detect any object at all

- a reduced detection range, i.e. the radar loses almost all objects in short distances (this can be caused by heavy rain or snowfall, for example)

Detection of a complete blockage takes 2 minutes while driving at speeds above 20 km/h. A blockage caused by a range reduction due to bad weather conditions (snow, rain) can take longer depending on the conditions.

Driving in areas without traffic ahead and almost without objects at the roadside (e. g. desert-like regions) can also lead to a blocking error, because the radar does not detect any objects.

6.1.3   Electrical connector

Type: Tyco/AMP MQS (Micro Quadlak System), 8-pin; associated connector on cable harness:

Housing: AMP 1-1534229-1

Contacts: AMP 962885 (0.2 – 0.5 mm²) or AMP 965906 (0.75 mm²)

(matching single wire seals are required)

The seal between the connector and the housing as well as each individual wire in the plug connection is sealed against the environment. An additional sealing (e. g. lubrication) by the customer is not permitted.
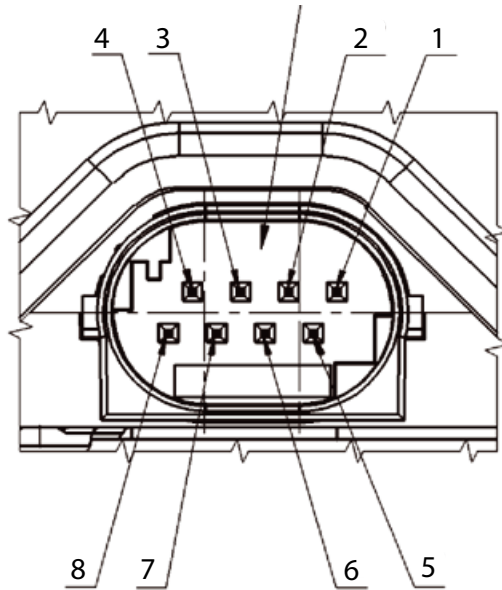
Figure 9   Plug connection contacts

The pin assignment is shown below:

PIN	NAME	CONNECTION
1	UBAT	Terminal 15 or 30
2	WAKE_UP	Terminal 15 or open
3	CAN1_HI	J1939 CAN high
4	CAN0_LO	Optional
5	SW_OUT	Optional
6	CAN1_LO	J1939 CAN low
7	CAN0_HI	Optional
8	GND	Ground

Table 7   Pin assignment

7 Installation

7.1 Requirements

This chapter describes the installation requirements to be met by the vehicle.

Vehicle equipment

In order to install OnGuardACTIVE, the vehicle must meet the following requirements:

- Equipped with ABS or EBS (which supports an XBR interface for external braking processes with -10m/s²)

7.1.1 Installation position of the sensor

The installation height of the radar sensor can be between 330 mm and 1000 mm above road level.

The specified installation position is the centre of the vehicle front where the sensor can be installed within a tolerance of +/- 600 mm relative to the centre of the vehicle. (The parameters for installation height and deviation from the centre of the vehicle must be set to the actual value during the start-up procedure).

7.2 Installation of the sensor

A radar mount should be mounted on the front of the vehicle.

The sensor can be fastened to the radar mount using the fastening bolts on its rear side. The connector of the sensor should be on the driver's side.

The sensor antenna must point in the driving direction. If an installation accuracy of +/- 3° in horizontal and vertical direction is given, the sensor can align itself. (The parameter for the alignment of the connector must be set during the start-up procedure).

7.2.1 Sensor cover

The sensor cover is required to protect the sensor. The following explains the factors that may impair the function of the sensor.

Material of the cover

The cover should consist of a plastic material with low attenuation and a low dielectric constant (εr). These plastics are particularly suitable:

NAME	CONNECTION
ABS	3.12
PP	2.35
PA	2.75
PC	2.8
PC-PBT	2.9

Table 8   Plastics suitable for the cover

These are only guide values, as the values may vary from manufacturer to manufacturer.

Coating of the cover

A painted cover or a manufacturer's logo can also be mounted in front of the sensor. However, the following points must be taken into account:

- Manufacturer's logos must be checked for the material used
- How many coats of paint are applied

For metal finishes, the following points must also be taken into account:

- The alloy content of the coating
- The size and shape of the alloy particles in the coating
- Number and thickness of different layers of primer and paint coat

Sloping position of the cover

To prevent the sensor from being negatively affected, the cover must not be installed parallel to or at an angle of >30° to the sensor.

For optimum efficiency of the sensor, the cover must be mounted at an angle of <30° relative to the sensor.

7.3 Maintenance

The OnGuardACTIVE system is maintenance-free.

8 Diagnosis

8.1 Training

Certain functions are protected in the diagnosis. These functions can be activated with a PIN2. You obtain the PIN2 after you have successfully worked through an E-Tutorial.

E-Tutorial / PIN2

For further information please visit out digital learning platform:
wbt.wabco.info

Please contact your WABCO partner if you have any questions.

8.2 Hardware

– Connect the Diagnostic Interface (WABCO part number: 446 301 030 0) to the central diagnostic port on the vehicle and the diagnostic PC.

8.3   Software

Ordering OnGuardPlus™ diagnostic software

– Open the myWABCO website:
http://www.wabco-auto.com/en/aftermarket-services/mywabco/

Help on logging in can be obtained by pressing the *Step-by-step instructions* button. After you have successfully logged in, you can order the OnGuardPlus™ diagnostic software via myWABCO.

Please contact your WABCO partner if you have any questions.

! OnGuardPlus™ corresponds to OnGuardACTIVE

Open the WABCO diagnostic software for the OnGuardACTIVE™ system.

⇨ The start window is opened.

The following functions are concealed behind the buttons:

■ (**1**) Exit the diagnostic program

■ (**2**) Initialise ECU and switch to diagnostic mode

■ (**3**) Exit ECU diagnostic mode

■ (**4**) Display content of diagnostic memory

■ (**5**) Display of current measured values

■ (**6**) ECU parameter setting

■ (**7**) Help function for using the program

– Check the connection of the diagnostic tool:

⇨ LED symbol lights up green (**8**): Connection is established

⇨ LED symbol lights up red (**8**): No connection available

8.4 Display content of diagnostic memory

– Click on the button *Display content of diagnostic memory* (1).

⇨ The *Diagnostic memory* window is opened.
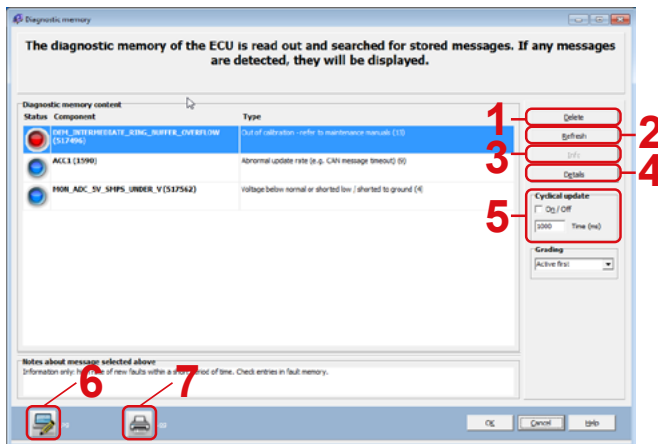
The following functions are available for selection:

- (**1**) Clear diagnostic memory
- (**2**) Update diagnostic memory
- (**3**) Info / Not available
- (**4**) Display additional information for a highlighted note
- (**5**) Update diagnostic memory automatically in cycles
- (**6**) Output diagnostic memory log to a file
- (**7**) Print diagnostic memory log

8.5 Display of current measured values

– Click on the button *Display current measured values* (1).
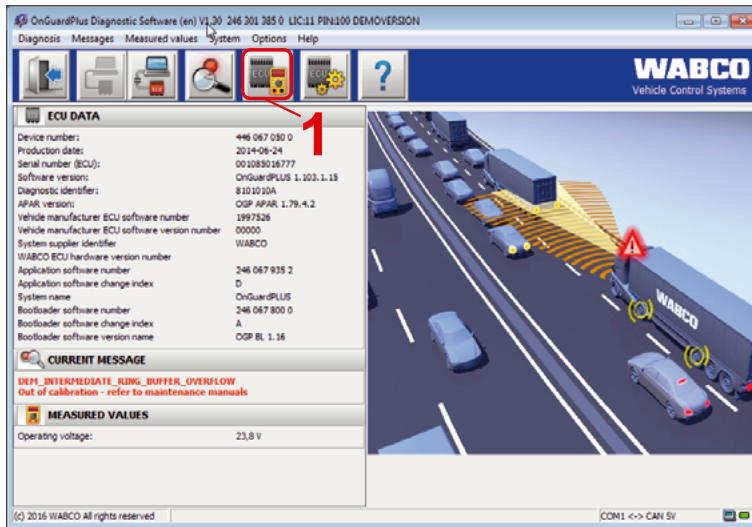
⇨ The *Measured values* window is opened.
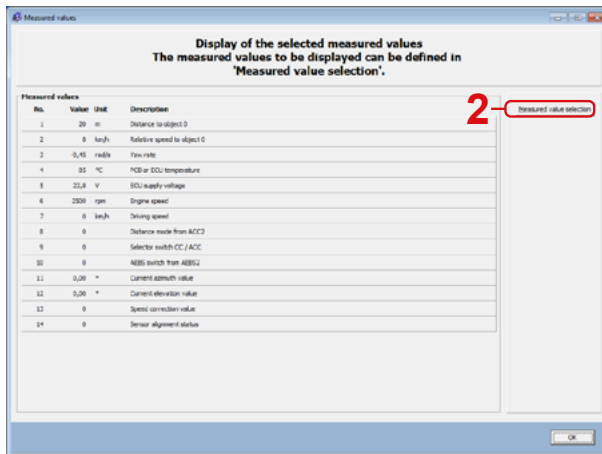
– Click on *Measured values selection* (2) to select the measured values to be displayed.
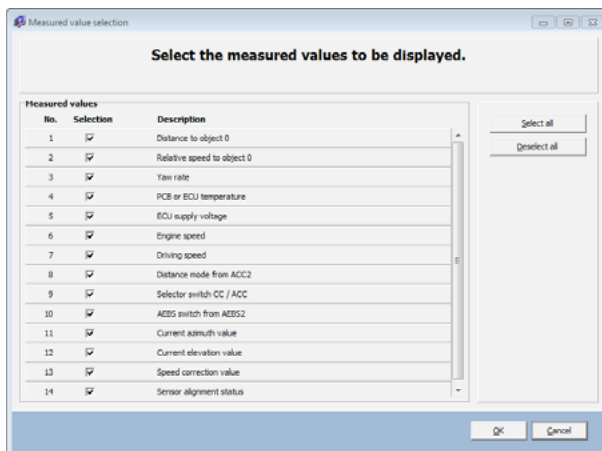
8.6 ECU parameter setting

– Click on the button *ECU parameter setting* (**1**).
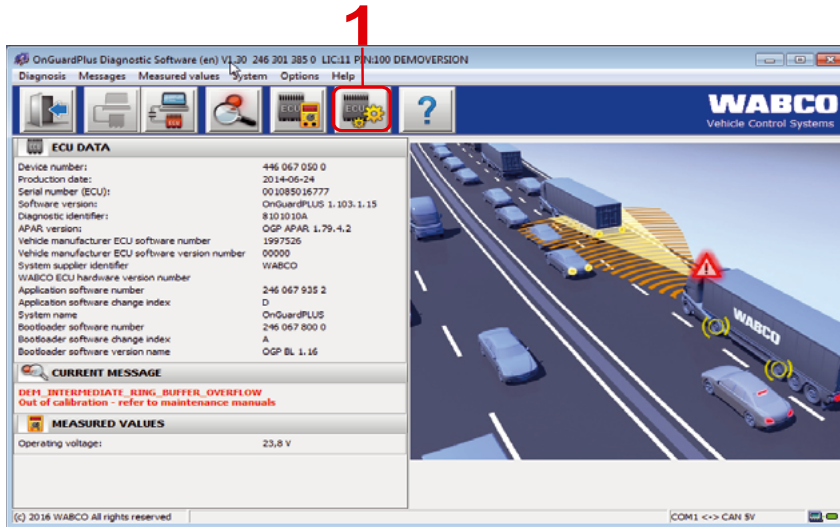
⇨ The *Parameters* window is opened.
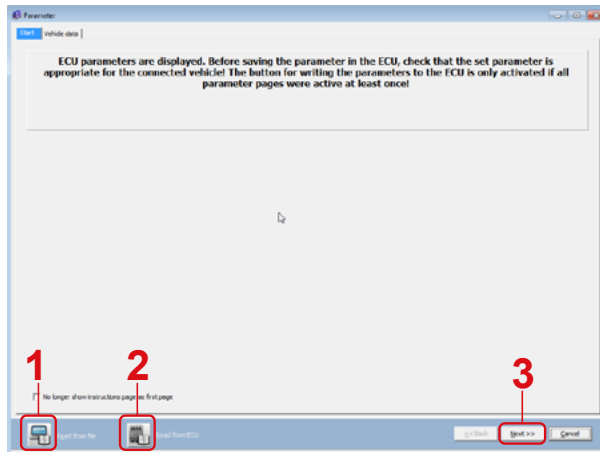
The following functions are available for selection:

- (**1**) Read parameters from a file
- (**2**) Read parameters from the ECU
- Once you have read the parameters from a file or the ECU, click *Next* (**3**).

⇨ The *Vehicle data* tab is opened.
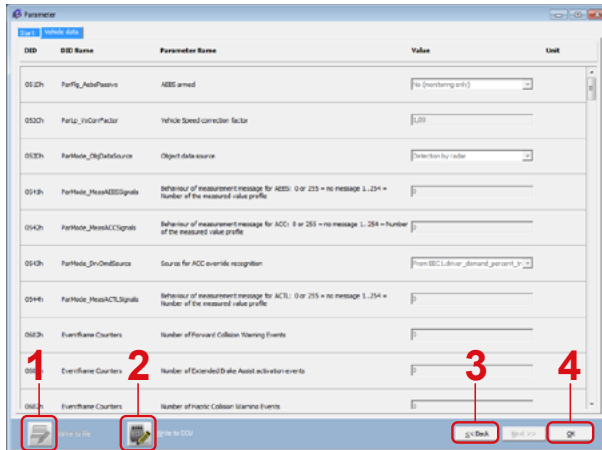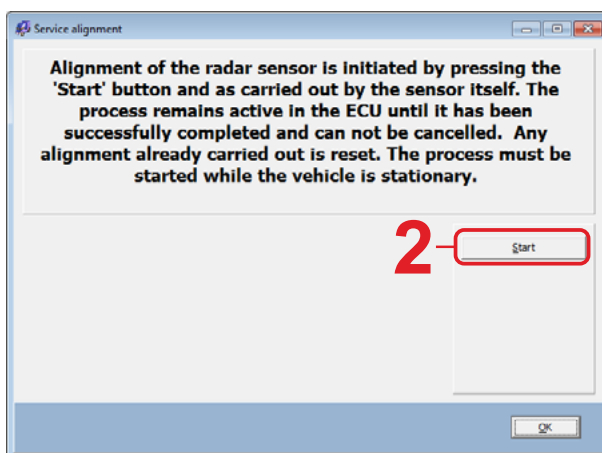

The following functions are available for selection:

- ▪ (**1**) Store parameters in a file
- ▪ (**2**) Write parameters to an ECU (e.g. when replacing)
- ▪ (**3**) Back to selection of the parameter source
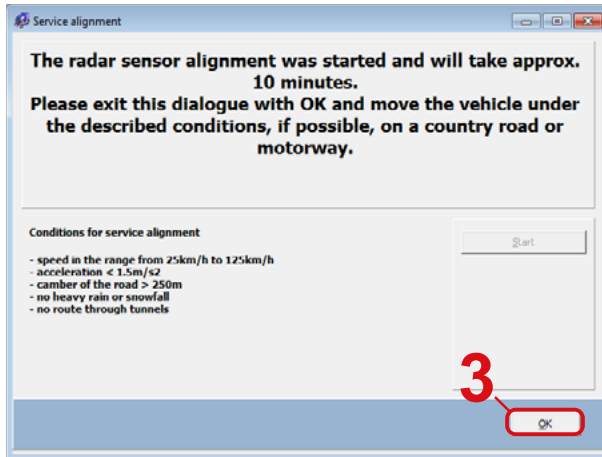- – Once the procedure has been completed, click *OK* (**4**).

8.7 Service alignment

– Under the *System* menu item, click on *Service alignment* (**1**).
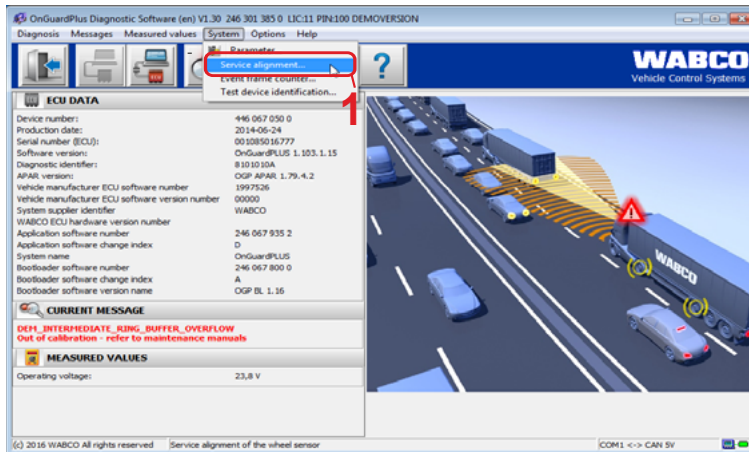
⇨ The window *Service alignment* is opened.

    – Click on *Start* (**2**).

       ⇨ In the *Service alignment* window, a dialogue box appears which indicates the conditions under which you must carry out the alignment of the radar sensor.

    – Carefully read through the conditions for the service alignment.

    – Drive in accordance with the conditions described above until the red light on the instrument panel goes out.

! The service alignment starts automatically as soon as the vehicle starts moving. In case of deviations from the conditions, the service alignment is interrupted. If the conditions are met again, the service alignment is continued.
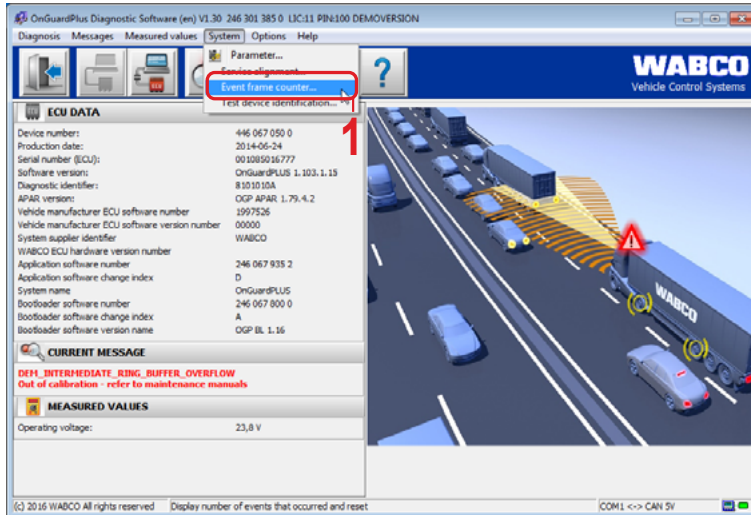

    – End the drive and click *OK* (**3**).

       ⇨ The service alignment is completed.

! While the service alignment is in progress, the diagnostic PC does not need to be on board the vehicle.
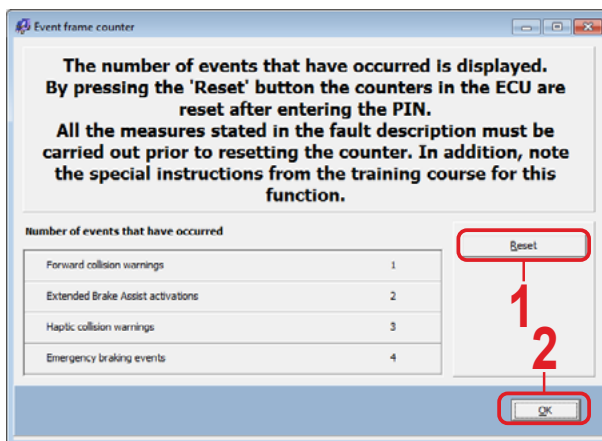

8.8   Event frame counter

The event frame counter displays the type and frequency of events that have occurred.

– Under the *System* menu item, click on *Event frame counter* (**1**).

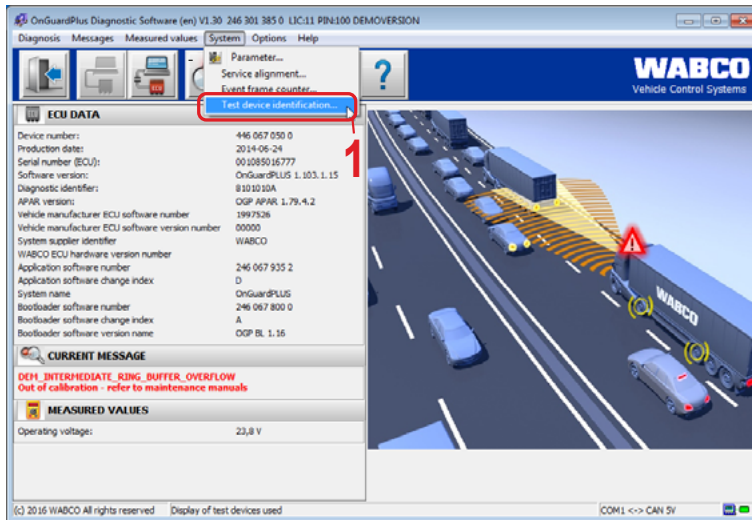⇨ The *Event frame counter* window is opened.

– Click on *reset* (**1**) to reset the event frame counter for all events to 0.
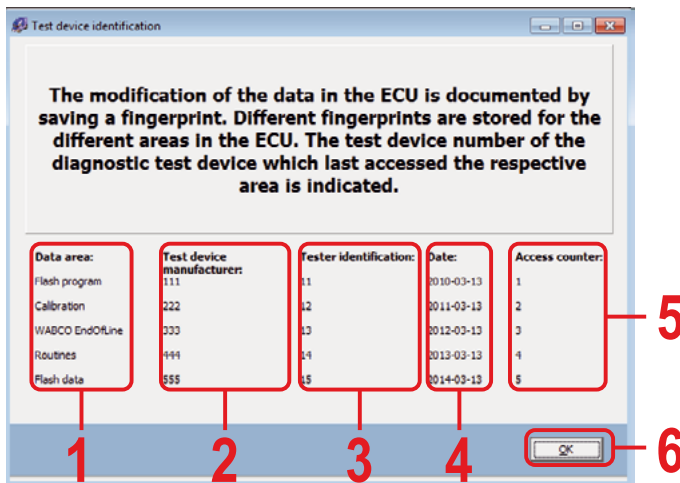
– Click on *OK* (**2**) to close the window.

! You need the PIN to reset the event frame counter.

8.9 Test device identification

– Under the *System* menu item, click on *Test device identification* (**1**).

⇨ The *Test device identification* window is opened.

The following data is displayed:

- ◼ (**1**) Data area: Data area that was accessed
- ◼ (**2**) Test device manufacturer: Manufacturer of the device used for access
- ◼ (**3**) Tester identification: Person through whom the access occurred
- ◼ (**4**) Date: Date on which access occurred
- ◼ (**5**) Access counter: Access number / Number of access events
- – Click on *OK* (**6**) to close the window.

8.10 Options and Help

Under the *Options* menu item (1) the following functions can be selected:

- Settings...
  - Display/change serial port
  - Manage file storage (read and writing directory)
  - Program options (change display and diagnostic connections)
  - Enter user data
- Enter PIN...
  - Enter user ID
  - Enter/change PIN/PIN2

Under the *Help* menu item (2) the following functions can be selected:

- Supported ECUs...
  - Display list of supported ECUs
- Content...
  - Help function for using the program (see chapter 7.3)
- Version history...
  - Display version history and installed software updates
- About...
  - Display information about the Diagnostic Software.

Notes

WABCO (NYSE: WBC) is a leading global supplier of technologies and services that improve the safety, efficiency and connectivity of commercial vehicles. Founded nearly 150 years ago, WABCO continues to pioneer breakthrough innovations for advanced driver assistance, braking, stability control, suspension, transmission automation and aerodynamics. Partnering with the transportation industry as it maps a route toward autonomous driving, WABCO also uniquely connects trucks, trailers, cargo, drivers, business partners and fleet operators through advanced fleet management systems and mobile solutions. WABCO reported sales of $2.8 billion in 2016. Headquartered in Brussels, Belgium, WABCO has 13,000 employees in 40 countries. For more information, visit

www.wabco-auto.com

WABCO