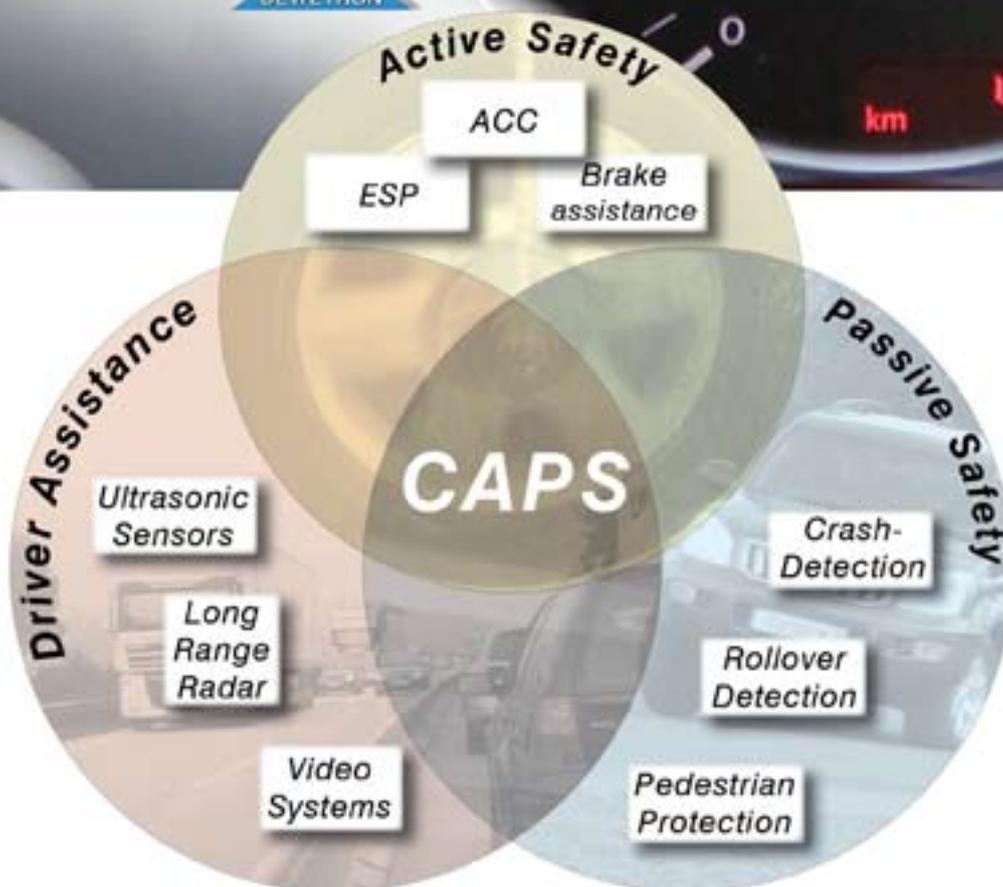


CAPS-ACC



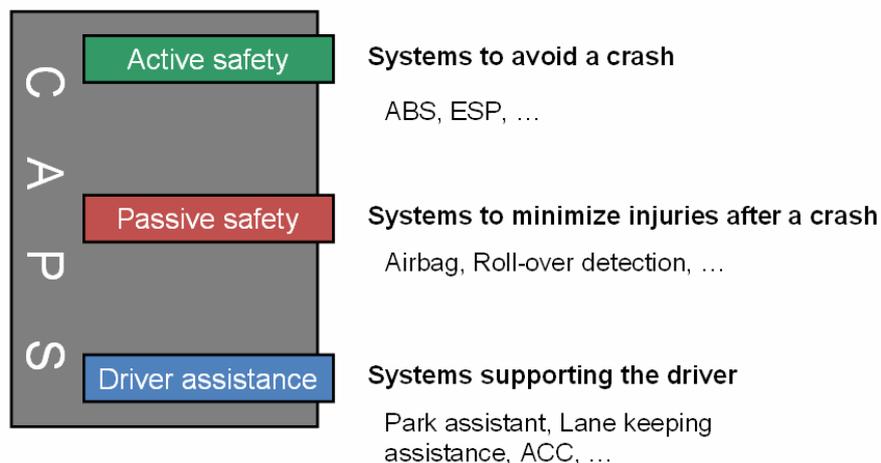
Technical Reference Guide



1. Introduction

Driver assistance systems in modern vehicles become more and more complex. Until now, systems like ABS or ESP only had to communicate with the vehicles internal sensors, but advanced driver assistance systems such as Adaptive Cruise Control (ACC) or Lane Departure Warning (LDW) also have to communicate with the environment. This makes not only the development of these systems much more complex but also requires far more complex evaluation methods. For this reason we developed the DEWETRON-CAPS system.

Combined Active Passive Safety



The DEWETRON-CAPS system is a complete package consisting of measurement system, sensors and software that allows:

- ✓ online calculation of relative position, speed and heading between multiple vehicles simultaneously
- ✓ online visualization of the vehicles relative position
- ✓ fully synchronized measurement data without the need for post-processing
- ✓ wireless transmission of measurement data between the test vehicles
- ✓ immediate results
- ✓ fast and easy installation and therefore short rigging times
- ✓ expansion of existing DEWETRON systems to full fledged CAPS systems
- ✓ connection of additional sensors (analogue inputs, digital inputs, counters, video, CAN)
- ✓ interfacing with ABD steering robots

And since the measurement unit itself is a fully fledged computer with the A/D hardware, the signal conditioning and the software all included, it is not limited to be used solely for CAPS measurements but can be used for other measurement tasks too.

2. System overview

The following picture should give you an overview on the components that make a complete DEWETRON-CAPS system for a single vehicle.



The DEWETRON-CAPS system comprises:

- Measurement system – data acquisition, synchronization, calculation and storage
- Gyroscope – sensor for high precise position and motion information
- WLAN interface – communication link to other measurement units in the measurement compound.

In addition to that, other sensors can be connected, such as video camera for capturing video data of the measurement, or the vehicle CAN to acquire information from the vehicles internal sensors.

CAPS measurements are typically performed with two or more vehicles. In this case each vehicle is equipped with a DEWETRON-CAPS system as shown above. The communication link between each vehicle is WLAN.



2.1. Measurement system

The measurement system is the heart of the DEWETRON-CAPS system. It is the central node where all measurement data from each connected sensor is merged, synchronized, calculated and stored.

Basically there are two types of DEWETRON-CAPS systems: Standard and Professional.

CAPS-STANDARD



The CAPS-STD system (DEWE-211-CAPS-16) shown in the picture is typically equipped with 16 analogue input channels, 16 digital input channels, 2 counter channels and two CAN interfaces. It also offers external channel expansion via the integrated EPAD2 connector. Thanks to its integrated solid state hard drive it ensures data safety even in rough environments.

The great advantage of the DEWE-211 is for sure its small form factor which makes it very easy to install in every vehicle and even on motorcycles. It has a wide input range from 8-24VDC which makes it ideal for automotive applications.

CAPS-PROFESSIONAL



The CAPS-PRO system (DEWE-501-CAPS-32 or DEWE-510-CAPS-16) has up to four times the channel count of a CAPS-STD system. The DEWE-510-CAPS-16 is even more flexible because its single channel DAQP amplifiers can be exchanged to have a matching amplifier for whatever sensor you would like to connect. Another great feature of the CAPS-PRO systems is the possibility to run up to 3 hours without external power supply by using the internal battery packs. The uptime can even be expanded by hot-swapping the internal battery packs.

The DEWETRON-CAPS system is an industrial grade PC with internal mass storage and A/D hardware. It can be equipped with single- or multichannel amplifiers for almost any sensor type. As a standard, DEWETRON-CAPS systems are equipped with typically 16 analogue input channels, 16 digital input channels, two counter inputs and two CAN interfaces. If greater channel count is required, these systems can easily be expanded.

The data acquisition software DEWESoft takes care of the synchronization of all input signals.

2.2. Gyroscopic sensor



The ADMA gyro system was especially developed for dynamic testing of vehicles. The ADMA-G continuously measures both the acceleration and position in all three axes and the pitch, roll and heading angle of a moving vehicle. The system can also be used for the dynamic calculation of speed. The ADMA-G is the sophisticated ADMA version with an integrated GPS receiver for highly accurate measurements.

The system comprises:

- three fibre-optic gyros (unaffected by acceleration) for detecting rotational motion
- three servo accelerometers for determining acceleration
- an internal GPS receiver for accurate position update with WAAS- or RTK-DGPS corrections
- a 32-bit processor unit that continuously calculates the angular orientation and position from internal sensor signals and external information (e.g. velocity sensors)

The calculation algorithms are optimised for dynamic vehicle tests such as slalom and circular movement and take account of the gravitational acceleration and rotation of the earth. In addition to the integrated DGPS receiver, an external speed signal (odometer or Correvit) can be connected in order to improve the accuracy of positional data and heading angle stability. The extended Kalman filter merges the internal with the external sensor data to achieve high-frequency output as well as great accuracy. In this way, positional accuracy in the centimetre range can be obtained while the vehicle is in motion. Data output is transmitted via the CAN bus and can therefore be directly connected to the DEWETRON measurement system. Additionally, the ADMA provides an interface to ABD steering robots.

In order to synchronize the CAN data with other data, the ADMA also outputs the sample clock to the measurement system. The output frequencies are configured from within DEWESoft and can be set between 1Hz and 8kHz. This also allows measuring acoustic signals in the vehicle such as the ACC gong with the measurement systems analogue inputs.

The bidirectional communication between the measurement system and the ADMA is done via RS232 interface.

2.2.1. RTK base station

For optimal position accuracy with accuracies down to 2 cm it is highly recommended to use DGPS-RTK correction data from local base stations or GSM services transmitting correction data. If neither is available, it is also possible to install a local base station on your own.

2.3. Wireless data transmission

If you perform measurements with multiple vehicles, the measurement data is collected in a central point where it is combined to calculate the relative positions, distances, speeds, headings etc. between the vehicles. This central point is referred to as the Master Measurement Unit (MMU) and is typically installed in the main vehicle under test. The units in the other vehicles are called Slave Measurement Units (SMU).



There is a bidirectional communication between the MMU and the SMU(s):

- Measurement data is being sent from the SMU(s) to the MMU
- Configuration data is being sent from the MMU to the SMU(s)

Measurement data transmission: The SMU(s) send the relevant measurement data to the MMU where it is being combined to calculate the relative position and motion parameters. The result of this calculation is shown and stored on the MMU.

Configuration data transmission: The configuration of each measurement unit in the measurement compound is being done from one single measurement unit – the MMU. The configuration includes the channel setup, the display setup, the configuration and initialization of the ADMA and the start/stop of storage. Theoretically, the SMU(s) do not even need a display or keyboard, though it can provide helpful information for the driver during the measurement.

3. Installation

3.1. Installation of the GPS base station

Before preparing the vehicle, you can set up the GPS base station so it can average its position in the meanwhile. Detailed information on the setup and calibration of the GPS base station can be found in the GeneSys manual. Here are a few tips to start with:

- Be aware of the surroundings. Tall objects (buildings, trees, walls etc.) as well as interference sources (transmitting stations and the like) will reduce the coverage or even block the correction data transmission.
- Double check cables and connectors. A bad connection may result in loss of signal quality and operating range.
- Before powering the FM modems, make sure the antenna is connected, otherwise they might get damaged!
- Mark the exact position of the GPS antenna on the ground with a piece of chalk or a stick and store the corresponding GPS coordinates. This will allow the base station to be easily removed and reinstalled at the same spot, if necessary.
- Absolute accuracy vs. relative accuracy: Absolute position accuracy requires the GPS base station to average its position for a long time – the *accuracy mode* is ideal for that because you can enter the desired accuracy. For measurements of relative positioning (e.g. between two cars), use the *duration mode* and set it to 15-30 minutes, which is usually sufficient.

3.2. Installation of the gyroscope

The mounting of the GeneSys ADMA has a great influence on the measurement accuracy and should therefore be done with care. Again, you can find detailed information in the GeneSys manual but here are some hints to start with:

- Make sure the ADMA is aligned correctly. The sticker with the coordinate frame should be on the back side (facing the vehicles rear bumper).
- If you can not screw down the ADMA directly onto the vehicles frame, screw it on a wooden plate and strap it down to ensure a stable connection between vehicle and ADMA.
You can also use a telescopic beam to fix the position of the ADMA.
- Mounting the ADMA in the middle of the vehicles lateral axis (e.g. on the transmission tunnel or in the middle of the trunk) minimizes the Y-offset to the cars CoG (center of gravity) and therefore makes determining the virtual measurement point offsets easier.
- Also, positioning the GPS antenna right above the ADMA (so X- and Y-offsets are zero), minimizes the error probability when measuring the mounting offsets.
- Before powering the FM modems, make sure the antenna is connected, otherwise they might get damaged!
- Document the setup by making pictures and taking notes!

3.3. Installation of the measurement system

3.4. Installation of the antennas

A full setup requires antennas for the GPS receiver, for the reception of DGPS correction data from a local base station or GSM service and for the wireless transfer of measurement data via WLAN. The antennas should not be placed too close to each other to avoid interferences between the antennas.

Some special WLAN cards (e.g. 802.11n) have up to three antennas to extend the network range

4. System configuration

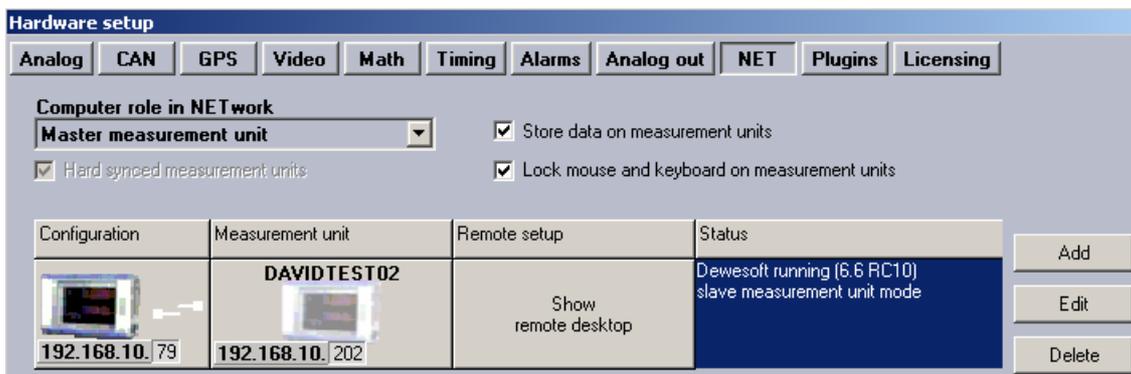
4.1. Configuration of the measurement units as MMU or SMU(s)

On the slave measurement unit (SMU), go to [System → Hardware setup → NET] and set the computer role to Slave measurement unit. Click OK to apply the settings and exit from Hardware setup.

NOTE: When the two units are connected, the SMU will be operated by the master measurement unit (MMU) and can not be operated locally until disconnected. Further, since channels are only transferred from SMU to MMU, the SMU will only see local data on the display.



On the master measurement unit (MMU), go to [System → Hardware setup → NET] and set the computer role to *Master measurement unit*.



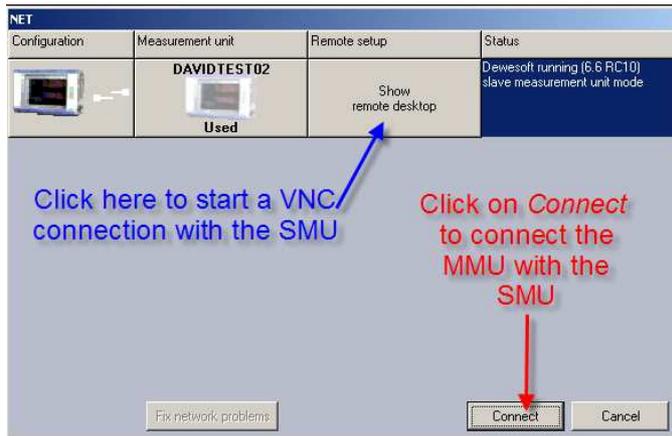
Add the SMU, which was configured before, to the NETWORK by pressing the *Add* button. Click *OK* to apply the settings and exit from Hardware setup.

NOTE: The MMU has full control over the SMU. Therefore, the MMU should be installed in the car which controls the measurements.

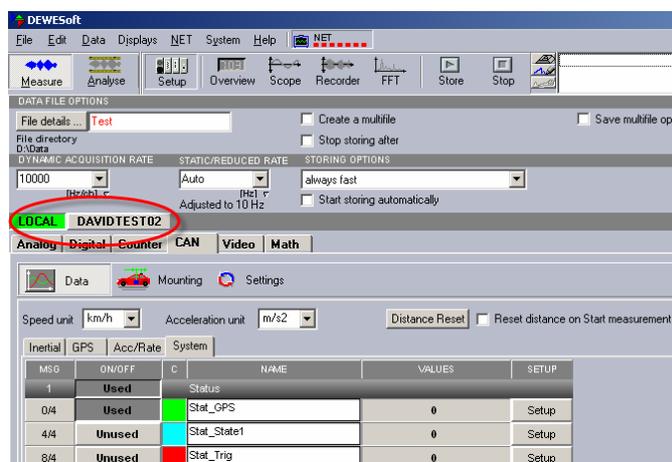
Now the two measurement units have to be connected to each other in order to be configured and to transfer the measurement data.



On the MMU, you will note a new *NET* icon on the menu bar.



Click on *Connect* to connect the MMU to the SMU.



You should now see the Setup screen from the MMU with two new buttons: LOCAL and [NameOfSMU] (here DAVIDTEST01)

When the two measurement units are connected, the MMU has full control over the SMU. All further configurations of both units can be done from the master measurement unit.

4.2. Configuration of the gyroscope



In the Data section you can rename, recolor and select/deselect the ADMA CAN channels. When activated, you will see the ADMA channel list divided in tabs (Inertial, GPS, Acc/Rate and System) below. In addition to that, you can rescale the speed (m/s, km/h, mph) and acceleration channels (mg, g, m/s²) and perform a distance reset.

The channels are divided into 4 categories:

- Inertial: data from the Kalman filter
- GPS: data from the GPS receiver
- Acc/Rate: data from the internal fibre optic sensors
- System: system status information

MSG	ON/OFF	C	NAME	VALUES	SETUP
24	Used		Inertial absolute position		
0/32	Used	Blue	IN_Latitude_abs	0°0,0'	Setup
32/32	Used	Teal	IN_Longitude_abs	0°0,0'	Setup
25	Used		Inertial relative position		
0/32	Used	Yellow	IN_Latitude_rel	0 m	Setup
32/32	Used	Green	IN_Longitude_rel	0 m	Setup
26	Used		Inertial velocity (horizontal)		
0/16	Used	Blue	IN_VXH	0 km/h	Setup
16/16	Used	Pink	IN_VYH	0 km/h	Setup
32/16	Used	Cyan	IN_VZH	0 km/h	Setup
27	Unused		Inertial velocity (north/east/up)		
21	Unused		Tilt/Heading		
22	Unused		Height		
11	Unused		Misc		
28	Unused		Inertial positional error		
29	Unused		Inertial velocity/angular error		
23	Used		Inertial time		
0/32	Used	Pink	IN_Time	23:59:46	Setup



Mounting

In the Mounting section you can enter the values for mounting offset angle, GPS antenna offset and virtual measurement point offset. These values for each axis (X,Y,Z) are entered in centimetres.

E.g. the GPS antenna is 41 cm behind the ADMA (in respect of the driving direction indicated by the green arrow), so you have to enter a negative sign.

Mounting offset angle of ADMA sensor

X 0 deg Y 0 deg Z 0 deg

Mounting offset position of GPS antenna

X -41 cm Y 0 cm Z 102 cm

Virtual measurement point

X -107 cm Y 0 cm Z 0 cm

The offset values for the GPS antenna and the virtual measurement point are essential for accurate measurement results and should be entered as precise as possible (accuracy ± 1 cm).

Settings

In the Settings section you can define ADMA specific settings such as threshold data, DGPS settings, RTK settings, CAN baudrate etc.

Transfer options

CAN baud rate: 1000 CAN base address: 100 Message update frequency: 200 Setup COM port: COM1

GPS options

Radio/GSM based augmentation: SAPOS Satellite based augmentation: EGNOS

Threshold data

Min. velocity for GPS - course: 1 m/s Spin rate: 90 deg/s Max. side spin angle: 25 deg

Standstill detection

Max rate at standstill: 0,2 deg/s Max velocity at standstill: 0,2 m/s Prealignment duration: 10 (for cars) sec

Position quality

Threshold - yellow to red: 5 m Threshold - green to yellow: 1 m

Tilt quality

Threshold - yellow to red: 0,3 deg Threshold - green to yellow: 0,1 deg

Output clock options

Use ADMA as clock provider:

Transfer options

CAN baud rate: This defines the baud rate (in kBaud) at which the ADMA outputs data via the CAN bus. The CAN interface on the measurement unit will be automatically set to the same baud rate. It is recommended to set the baud rate to 1000 kBaud/s to ensure maximum throughput.

CAN base address: This defines the address offset that is added to each message ID from the ADMA's CAN channels.

Message update frequency: This is the internal sample rate of the ADMA (the internal GPS receiver samples at 20Hz independent of this setting).

Setup COM port: The serial port where the ADMA is connected. You can check the serial communication by clicking on "Get version". This requests the SN from the ADMA via the COM port and will only work if the correct COM port is selected (and the ADMA is powered on).

GPS options

Radio/GSM based augmentation: This enables the high accurate RTK (real time kinematics) mode by incorporating correction data from local base stations.

Satellite based augmentation: This enables the reception of correction data from geostationary satellites.

Threshold data

Min. velocity for GPS-course: This threshold is used to switch off the GPS course over ground calculation, if the vehicle speed drops below this threshold.

Data coordinate output format

Choose between the SAE or DIN70000 coordinate system.

Standstill detection

The parameters for the Standstill detection are very important, as standstill allows a special form of augmentation for use within the Kalman filter, the so called Zero-Velocity-Update. This increases the stability of the measurement mode in case of standstill.

Prealignment

Here you can define how long the prealignment period endures. Further you can choose whether to calculate the heading from the GPS heading or from a predefined angle.

Position and tilt quality

Use these thresholds to set indicators for the position and tilt quality. They are represented in the CAN channels Stat_Pos and Stat_Tilt (red=0,yellow=1,green=2).

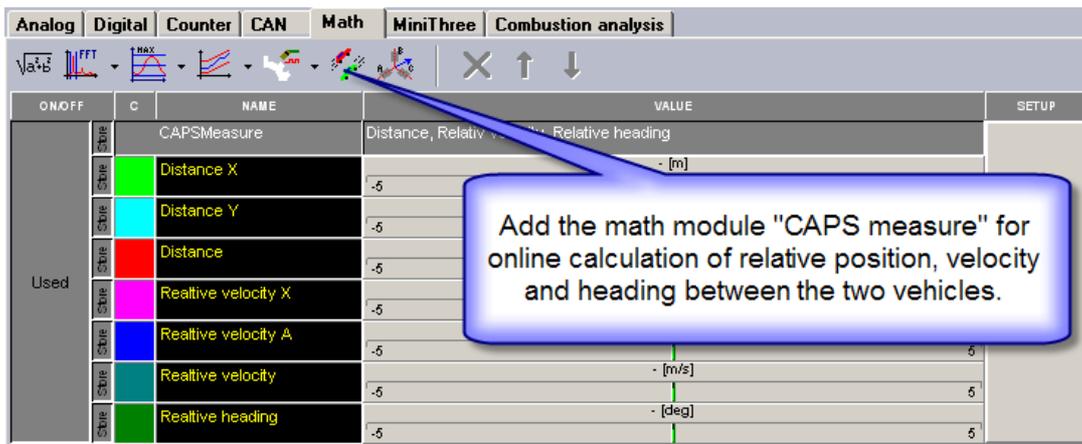
Output clock options

Check the option "Use ADMA as clock provider" to use the clock and trigger output from the ADMA SyncOut connector to clock the measurement system. This is mandatory for synchronized measurements between multiple units (e.g. two cars). However, the analogue

sample rate of the measurement system is then limited to the maximum output clock rate of the ADMA, which can be selected in the following ranges: 1Hz, 10Hz, 50Hz, 100Hz, 200Hz, 250Hz, 400Hz, 500Hz, 1kHz, 2kHz, 4kHz and 8kHz. The maximum sample frequency of 8kHz allows even the acquisition and identification of acoustic signals such as the ACC gong of a vehicle (indicating that another vehicle has been spotted) for example.

4.3. Configuration of the CAPS math channel

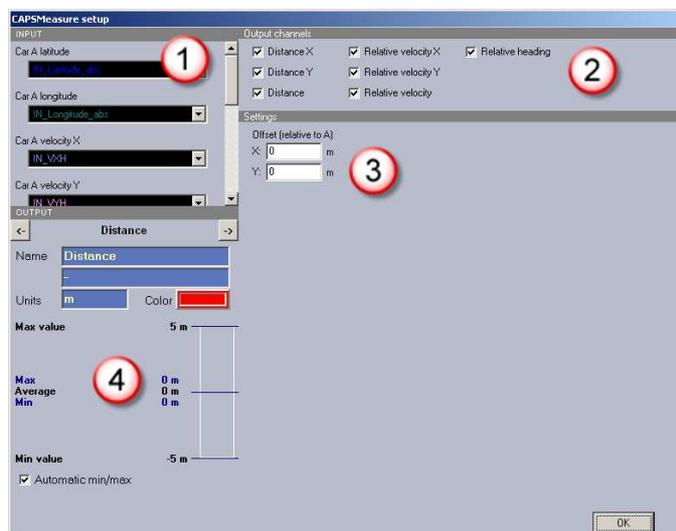
DEWESoft contains an additional math module “CAPS measure” that automatically calculates relative position, velocity and heading from the local and remote ADMA channels.



The math module requires the following channels to be entered in the input menu (1) from both, the local (Car A) and the remote (Car B) measurement unit:

- Latitude (IN_Latitude_abs)
- Longitude (IN_Longitude_abs)
- Longitudinal velocity (IN_VXH)
- Lateral velocity (IN_VYH)
- Heading (IN_True_Heading)

You can identify the slave channels (from the remote car) by their prefix: <NameOfSMU>:ChannelName. For example: Slave:IN_Latitude_abs



You can select which channels the math plugin should calculate by selecting these in the output channels menu (2).

Optionally, you can enter an offset between car A and car B in the settings section (3).

Section (4) shows the channel settings of each output channel.

4.4. Initializing the ADMAs from MMU and SMU(s)

Each ADMA has to be initialized to feed the Kalman filter with data before they deliver correct results. The initialization procedure consists of three phases:

- (1) Standstill phase (10s): In this phase the internal acceleration sensors are being zeroed. Make sure the car is not moved and nobody enters or leaves the vehicle during this phase.
- (2) Drive straight phase (>3m/s): This phase is to get the vehicles heading from the GPS course referenced to true north. Drive straight for at least 30 meters.
- (3) Dynamic phase (120s): This phase is very important for the dynamic behaviour of the Kalman filter. Try to drive some eights, slaloms, bigger turns etc. Since there is no need for high dynamic maneuvers, avoid over- or understeering (e.g. drifting) during this phase in order to teach the Kalman filter with proper data.

Since the MMU has full control over the SMU, the initialization procedure for both cars is started by the MMU. Follow this procedure to initialize both ADMAs (both vehicles) at the same time:

- (1) The master starts the initialization procedure on the slave by starting the ADMA from the slave (the standstill phase begins for the slave).
- (2) The master starts its own initialization procedure (the standstill phase begins for the master).
- (3) When the standstill phase (10s) on the master is over, both vehicles enter the next phase and drive straight with more than 3 m/s for at least 30 meters.
- (4) Both cars drive the dynamic phase (120s).
- (5) By the time the master has finished the dynamic phase, also the dynamic phase of the slave will be finished and the initialization of the ADMAs is finished. You can now enter the measurement mode (e.g switch to Overview) and start the data acquisition.

5. Measurement

The start and stop of the measurement is initiated from the MMU. When the measurement is started, the SMU(s) transfer the channels selected for transfer to the MMU. The driver in the MMU can see all the transferred data in real time and fully synchronized, directly on the screen. This may include analogue data, CAN data, video data, GPS data, ... from any of the SMU(s) in the measurement compound. The numerous analogue, digital or visual controls can be arranged as needed to give the driver an overview of the whole measurement.



5.1. Analysis

The software can detect when the test run has reached a steady state (e.g. constant distance between hunter and target vehicle) and automatically stop the measurement and display the result screen for this measurement maneuver. Just like the measure screen, the result screen with its visual controls can be configured as needed.

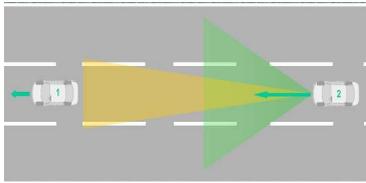


6. Evaluation of Combined Active Passive Safety Systems (CAPS)

TÜV Süd Automotive has defined maneuvers for evaluating ACC systems as now built in modern vehicles. These maneuvers each have a defined set of parameters on which the performance of the systems is being measured. This also allows direct comparison between different ACC systems from different vehicles or manufacturers. The definition of these result parameters is described in 6.1.2.

6.1. Manoeuvres

6.1.1. Approaching traffic queue



Target vehicle drives with constant speed while the hunter vehicle approaches the target vehicle with a higher speed.

In this manoeuvre the leading vehicle (target) drives with a constant speed. The hunter vehicle approaches the target vehicle with a higher speed than the target vehicle. The test starts when the ACC system has recognized the target vehicle and stops when the distance between target and hunter is constant for a defined period of time. I.e. there are no noticeable changes in the acceleration or the speed of the hunter vehicle.

The speed difference between target and hunter vehicle will be varied in different steps.

Test Track Requirements

Test track: High Speed Track

Target: Driving with constant speed 80 km/h

Hunter: Driving with constant speed 80 km/h

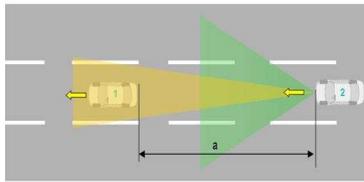
Measured Signals

Distance between the Target and Hunter

Acceleration of the Test Vehicle, focusing on comfort/drivability behaviour

ACC Signals: Acceleration and Break Pedal (Intervention of ACC)

6.1.2. Stationary distance



Constant Distance between Target and Hunter at a average speed from 80 km/h by a distance from 20 m (minimum Distance by law up to max ACC Range)

After approaching the column, as described before, the next manoeuvres for ACC will be keeping a stationary distance (a) to the vehicle in front (Target) of the Test Vehicle (Hunter). In this case we will assume that the column is driving at a constant or nearly constant speed (74 to 86 km/h which means a tolerance +/- 5%), so no noticeable acceleration or deceleration will occur. The test vehicle will start the manoeuvre by using the maximum detection range of ACC and will while the Lead Vehicle drives a constant speed. Subsequently the Test Vehicle will decrease the distance of the ACC setup so that it will reduce the distance to the Lead Vehicle. Hence the aim of the task stationary distance will be to keep the distance between both vehicles constant.

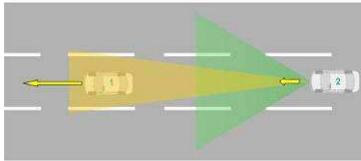
Test Track Requirements

Test track: High Speed Track
Target: Driving with constant speed 80 km/h
Hunter: Driving with constant speed 80 km/h

Measured Signals

Distance between the Target and Hunter
Acceleration of the Test Vehicle, focusing on comfort/drivability behaviour
ACC Signals: Acceleration and Break Pedal (Intervention of ACC)

6.1.3. Column driving acceleration



Target and Hunter are driving in a queue where Target accelerates with various acceleration levels, and the Hunter follows via ACC.

Driving in a Queue won't always be a stationary process with a constant level of speed, caused by several influences, e.g. of the other traffic such as heavy traffic. Influences also will be the weather like fog, rain or snow. And for sure the road itself, positive or negative incline of the road, its surface (dry, wet, snowy). All these just mentioned listings will lead to the situation that the whole queue could accelerate as well as decelerate which should be covered by the ACC system

Test Track Requirement

Test track: High Speed Track

Target: Driving / Accelerate with various speeds 80 - 180 km/h during one testrun/measurement. It is necessary that the vehicle will reach the end of the speed area by using several speed levels, no constant acceleration from 80 to 180 at once.

Hunter: Following with a constant distance

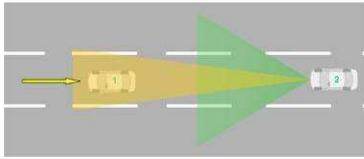
Measured Signals

Distance between the Target and Hunter

Acceleration of the Test Vehicle, focusing on comfort/drivability behaviour

ACC Signals: Acceleration and Break Pedal (Intervention of ACC)

6.1.4. Column driving deceleration



Target and Hunter are driving in a queue where Target decelerates with various decelerating levels, and the Hunter follows via ACC.

Driving in a Queue won't always be a stationary process with a constant level of speed, caused by several influences, e.g. of the other traffic such as heavy traffic. Influences also will be the weather like fog, rain or snow. And for sure the road itself, positive or negative incline of the road, its surface (dry, wet, snowy). All these just mentioned listings will lead to the situation that the whole queue could accelerate as well as decelerate which should be covered by the ACC system

Test Track Requirement

Test track: High Speed Track

Target: Driving / decelerates with various speeds 180 - 80 km/h during one testrun / measurement. It is necessary that the vehicle will reach the end of the speed area by using several speed levels, no constant deceleration from 180 to 80 at once. This scenery has also to include sudden braking of the Target.

Hunter: Following with a constant distance

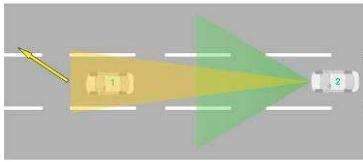
Measured Signals

Distance between the Target and Hunter

Decelerating of the Test Vehicle, focusing on comfort/drivability behaviour

ACC Signals: Acceleration and Break Pedal (Intervention of ACC)

6.1.5. Column driving shear out



Lane Change by Target out of Hunter's lane with various lateral accelerations and initial speeds.

Not all of the participants of the traffic will use the same speed, or face the same destination, so the scenery of a car veering out of the queue is a further one which has to be tested. Due to the fact that the vehicles will be driven by humans, various behaviour occurs. That means that Driver A will leave the queue at a other distance to the vehicle in front of him as Driver B, which could be caused by the current traffic intensity or just on the Drivers behaviour. Also the time for the change of the lane is different from driver to driver, some will either do a smooth lane change or have to (e.g. Passenger car with a trailer). So this slight change has also be correct detected as well as a fast lane change.

Test Track Requirement

Test track: High Speed Track

Target: Leaves the lane at several speed and several lateral accelerations

Hunter: Driving at the lane

Measured Signals

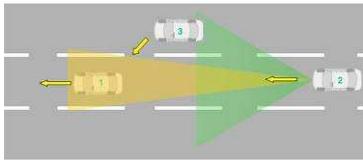
Distance between the Target and Hunter

Decelerating of the Hunter, focusing on comfort/drivability behaviour

Position of the Target

ACC Signals: Acceleration and Break Pedal (Intervention of ACC)

6.1.6. Column driving shear in



Lane change by the Vehicle 3 into the Hunter's lane (Lane gap Between Target and Hunter).

Driving in a queue does not mean, that the Vehicle in front will always stay the same. The Vehicle could leave the queue or another one could veer in because it is entering the road, finished an overtaking, or starts an overtaking process. Hopefully rarely it will change the lane in cause of avoiding an accident.

Test Track Requirement

Test track: High Speed Track

Target: Driving at the lane with a constant speed

Hunter: Veering In the lane

Vehicle 3: Driving at the Target's lane with activated ACC

Measured Signals

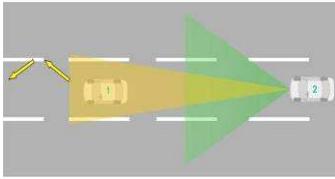
Distance between the Target and Hunter

Decelerating of the Hunter, focusing on comfort/drivability behaviour

Position of the Target and Vehicle 3

ACC Signals: Acceleration and Break Pedal (Intervention of ACC)

6.1.7. Column driving shear out/in



Double lane change by Target at various lateral accelerations and initial speeds.

While driving in a queue a Vehicle could veer out by the idea of starting an overtaking. The overtaking could be stopped by oncoming traffic or by to less speed to overtake in an appropriate time slot. Following the Vehicle will veer in, this manoeuvre is the so called weaving in an out.

Test Track Requirement

Test track: High Speed Track

Target: Weaving In and Out at several speed and several lateral accelerations

Hunter: Driving at the Target's start lane with activated ACC

Measured Signals

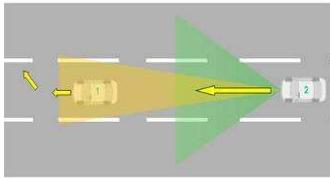
Distance between the Target and Hunter

Accelerating / Decelerating of the Hunter, focusing on comfort/drivability behaviour

Position of the Target and Hunter

ACC Signals: Acceleration and Break Pedal (Intervention of ACC)

6.1.8. Overtaking



After changing lanes of the Target, Hunter passes the Target.

Driving with activated ACC at a higher speed than the Target, drive against the Target. The Target will change the lane, and the Hunter could pass by. This will be a quite normal Situation at the highways. Although this manoeuvre contains several variables, like distance, speed, and lateral acceleration, which can have a big influence on the whole situation. Just mention that the lane change takes a very long time, and the Hunter arrives at high speed.

Test Track Requirement

Test track: High Speed Track

Target: Veering Out at several speed and several lateral accelerations

Hunter: Driving at the Target's start lane with activated ACC

Measured Signals

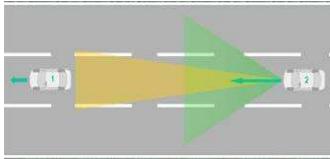
Distance between the Target and Hunter

Accelerating / Decelerating of the Hunter, focusing on comfort/drivability behaviour

Position of the Target and Hunter

ACC Signals: Acceleration and Break Pedal (Intervention of ACC)

6.1.9. Stop & go



Decelerating until stopping and subsequent acceleration with various decelerations and idling times

Driving with activated ACC needs not to drive in a queue like the previous manoeuvres, a realistic scenario is that the vehicle reaches the end of a queue which is stopped. In case of heavy traffic or a traffic light. In this case the Vehicle has to stop and move on again, including various idling times.

Test Track Requirement

Test track: Standard Track

Target: Stop & Go

Hunter: Reaching Target with the ACC Range, decelerating and entering the Stop and Go Mode.

Measured Signals

Distance between the Target and Hunter

Accelerating / Decelerating of the Hunter, focusing on comfort/drivability behaviour

ACC Signals: Acceleration and Break Pedal (Intervention of ACC)

6.2. Result parameters (characteristics)

The table below shows the typical result parameters of the ACC manoeuvres. These characteristics allow the direct comparison of multiple ACC systems from different vehicles and manufacturers. Please note that some manoeuvres may only use a subset of these characteristics because not all of them are applicable to every manoeuvre.

Pos	Abbreviation	Description	Unit
1	$\Delta s_{x,static}$	Adjusted distance	[m]
2	$\Delta s_{x,min}$	min distance	[m]
10	$\Delta s_x(t_{react})$	Distance of reaction	[m]
15	$\Delta t(a_{min})$	Time period of max deceleration	[s]
16	$\Delta t(a < 0)$	Time period of deceleration	[s]
21	Δt_{Risk}	Risk time	[s]
22	$\Delta v(t(a < 0))$	Velocity alteration during deceleration time	[km/h]
23	$\Delta v(t(a < 0)/2)$	Velocity alteration during half deceleration time	[km/h]
24	v_{min}	min velocity	[km/h]
30	a_{mean}	Average deceleration	[m/s ²]
31	a_{min}	max deceleration	[m/s ²]
33	$ j_{max} $	Absolute value of the max hitch	[m/s ³]
34	Risk	Accident risk	[ms]
35	$\Delta s_{x,US-rel}$	Relative distance undershoot due to adjusted distance	[%]
37	$\Delta s_{x,S-US-rel}$	Relative distance undershoot due to min safety distance *)	[%]

Adjusted distance

Adjusted distance at the end of the manoeuvre

Parameter:

- The distance going to be adjusted has to be known from manoeuvre 10 as a target value.
- The user has to define a bandwidth for the adjusted distance
- The time period for keeping the distance inside this bandwidth is at least 5 seconds.

Min. distance

Minimum distance during the manoeuvre

Distance of reaction

Distance at reaction of the test vehicle

Parameter:

- Threshold for reaction: -0.2 m/s^2

Time period of max. deceleration

Time period for which the deceleration of the test vehicle is inside a defined bandwidth.

Parameter:

- Bandwidth: 0.1 m/s^2

Time period of deceleration

Time for the whole period of deceleration of the test vehicle.

Parameter:

- Threshold for start of deceleration: -0.2 m/s^2
- Threshold for end of deceleration: $AXH > 0 \text{ m/s}^2$

Risk time

Time period for which the actual distance is below the safety distance (Tacho/4 related to test vehicle speed).

Parameter:

- Safety distance Tacho/4 (free definable because of differences in the law)
- Threshold begin: actual distance < safety distance
- Threshold end: actual distance > safety distance

Velocity alteration during deceleration time

Parameter:

- Time for deceleration
- Threshold for start of deceleration: -0.2 m/s^2
- Threshold for end of deceleration: $AXH > 0 \text{ m/s}^2$

Velocity alteration during half deceleration time

Parameter:

- Time for deceleration/2
- Threshold for start of deceleration: -0.2 m/s^2
- Threshold for end of deceleration time: time for deceleration/2

Minimum velocity

Parameter:

- Minimum test vehicle speed during the manoeuvre

Average deceleration

Mean deceleration for the whole period of deceleration.

Parameter:

- Threshold for start of deceleration: -0.2 m/s^2
- Threshold for end of deceleration: minimum speed

Max. deceleration

Maximum deceleration during the manoeuvre.

Absolute value of the max. hitch

Hitch is the derivative of the longitudinal acceleration of the test vehicle.

Parameter:

- Minimum hitch while the start of the test vehicle action
- Threshold begin: one second before deceleration
- Threshold end: maximum deceleration

Accident risk

Parameter:

- Threshold begin: actual distance < safety distance
- Threshold end: actual distance > safety distance
- $\text{Integral}(\text{safety distance}) - \text{Integral}(\text{actual distance})$

Relative distance undershoot due to adjusted distance

Parameter:

- $(1 - (\text{minimum distance} / \text{adjusted distance})) * 100$

Relative distance undershoot due to min. safety distance

Parameter:

- $(1 - (\text{minimum distance} / \text{safety distance})) * 100$

7. Specifications

Parameter	Accuracy
Position	0.02 m (using RTK-DGPS)
Angle	0.1°
System accuracies are dependent on the ADMA hardware. Please refer to the ADMA technical specifications for further system specifications.	

Note that the specifications for the distance calculations above are only valid if the DEWETRON synchronization feature, which offers full synchronization for all input channels is activated! If these kind of measurements are being performed without synchronization, the error in the distance calculation grows with higher speeds!

Error estimation of measurements without the DEWETRON Sync-Feature:

$$V = 100 \text{ km/h} = 27.7 \text{ m/s}$$

Typical delay of unsynchronized measurements: 40 ms

$$\rightarrow 27.7 \text{ m/s} * 0.04 \text{ s} = 1 \text{ m error !}$$