Euro NCAP
For Safer Cars

Version 1.3
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Data Acquisition And Assessment Criteria Calculation

Safe Driving & Crash Avoidance

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PREFACE

DISCLAIMER: Euro NCAP has taken all reasonable care to ensure that the information published in this protocol is accurate and reflects the technical decisions taken by the organisation. In the unlikely event that this protocol contains a typographical error or any other inaccuracy, Euro NCAP reserves the right to make corrections and determine the assessment and subsequent result of the affected requirement(s).

CONTENTS

1 TEST DATA

To ensure consistency in the general folder structure, this chapter details the required folder structure. For each (sub)test where measurements are performed with vehicles and/or other test equipment, all test data shall be provided in ISO-MME 1.6 format and shall be fully compliant with the ISO/TS 13499 standard. It should be noted that some file names are also prescribed in this document. All data shall be provided using SI units unless specified otherwise.

1.1 Safe Driving and Crash Avoidance

The following folder structure, generated automatically in the Euro NCAP sharing platform, is to be used for all test series where the name of the main folder containing all tests consists of:

- The year of test
- OEM abbreviation
- Euro NCAP internal number (4 digits)
- Make and Model

The next paragraph details the folder structure. On the highest level, the folder structure is as follows with on the right an example using the Volvo ES90 that is assumed to be tested in 2026 with a Euro NCAP internal number of 9999.

- Main Folder Name
  - Safe Driving
    - Occupant Monitoring_Seatbelt Usage
    - Occupant Monitoring_Occupant Classification
    - Occupant Monitoring_Occupant Presence
    - Driver Engagement_Driver Monitoring
    - Driver Engagement_Driving Controls
    - Vehicle Assistance_Speed Assistance
    - Vehicle Assistance_ACC Performance
    - Vehicle Assistance_Steering Assistance
    - Assisted Driving _Driver Monitoring
    - Assisted Driving _Driving Collaboration
  - Collision Avoidance
    - Frontal Collisions_Car_Motorcyclist
    - Frontal Collisions_Pedestrian_Bicyclist
    - Lane Departure_Collisions_Single Vehicle
    - Lane Departure_Collisions_Car_Motorcyclist
    - Low Speed_Collisions_Car_Motorcyclist
    - Low Speed_Collisions_Pedestrian_Bicyclist

- 26-VOL-9999-Volvo ES90
  - 26-VOL-9999-SD
    - 26-VOL-9999-OM_SU
    - 26-VOL-9999-OM_OC
    - 26-VOL-9999-OM_OP
    - 26-VOL-9999-DE_DM
    - 26-VOL-9999-DE_DC
    - 26-VOL-9999-VA_SAS
    - 26-VOL-9999-VA_ACC
    - 26-VOL-9999-VA_STA
    - 26-VOL-9999-AD_DM
    - 26-VOL-9999-AD_DCOL
  - 26-VOL-9999-CA
    - 26-VOL-9999-FC_C_M
    - 26-VOL-9999-FC_P_B
    - 26-VOL-9999-LDC_SV
    - 26-VOL-9999-LDC_C_M
    - 26-VOL-9999-LSC_C_M
    - 26-VOL-9999-LSC_P_B

1.1.1 Test folders

The number of test folders in each of the following main folders depends on the performance of the vehicle under test. For each of the test combinations, there shall be a separate test folder. It should be noted that the test laboratory may use the naming convention of their choice for each of the test folders.

1.1.2 Test reports

Each of the stage element folder (e.g., Occupant Monitoring_Seatbelt Usage) shall contain a test report provided by the laboratory. This document shall be detailed enough to understand the test execution, the system reaction and the laboratory judgment.

1.2 ISO MME folder structure

The ISO MME folder structure is to be applied to all applicable tests and the files contained in these folders follow the ISO/TS 13499 standard. The main directory contains two folders and one file. The following folders and files (comment files when needed in .txt format) need to be provided for every test performed, where the test number is the one as specified in the previous section.

For each file and folder (where necessary) the required contents are specified in detail in the paragraphs below.

- Test folder
  - Channel
  - Movie
  - <test number>.mme
  - <test number>.txt

1.2.1 Channel folder

The channel folder contains all channels from the vehicle and targets used in the test as defined in Section 2.

- Test folder
  - **Channel**
    - <test number>.xxx
    - <test number>.chn
  - Movie
  - <test number>.mme
  - <test number>.txt

1.2.2 Movie folder

The movie folder contains the films, using the exact names as specified in the Euro NCAP Film and Photo protocol.

- Test folder
  - Channel
  - **Movie**
    - < test number _ name of movie file 1>
    - < test number _ name of movie file m>
  - <test number>.mme
  - <test number>.txt

1.2.3 MME-file

The mme-file contains the information of the test.

- Test folder
  - Channel
  - Movie
  - **<test number>.mme**
  - <test number>.txt

The mme-file shall contain the following headers:

Item	Header	Unit	Remarks
Data format edition number	:1.6		
Laboratory name	:<Lab name>		
Customer name	:Euro NCAP		
Customer project ref. number	:<Test series number>		4 digits number, e.g. 9999
Title	:Euro NCAP <year of test>		
Timestamp	:<Date Time>		Date of the test using YYYY/MM/DD HH:MM:SS format
Scenario	:<Scenario>		See table
Type of the test	:<Type of the test>		See table
Subtype of the test	:<Subtype of the test>		See table
Run repetition	:<Run repetition>		Integer
Test completion	:<Test completion>		<Completed/Aborted>
Region	:<Region>		<EU/UK>
Robustness Layer	:<Type Code, Robustness Layer Code, Parameter Code>		See table
Name TOB 1	:<Make, Model>		
Driver position TOB 1	:<Driver position>		<1/3>, LHD=1 and RHD=3
Ref. number TOB 1	:<VIN >		
S/W version TOB 1	:<SW version>		As given by OEM
Dimensions TOB 1	:<Length, Width>	mm	Dimensions as defined in protocol
Shape Front TOB 1	:<(x1;y1),(x2;y2),(x3;y3),(x4;y4),(x5;y5),(x6;y6),(x7;y7)>	mm	Origin (x4,y4) at the most forward point on the centreline of test object 1. Integer expected.
Shape Left Side TOB 1	:<(x8;y8),(x9;y9),(x10;y10),(x11;y11),(x12;y12)>	mm	All coordinates relative to the most forward point on the

Shape Rear TOB 1	:<(x13;y13),(x14;y14),(x15;y15),(x16;y16),(x17;y17),(x18;y18),(x19;y19)>	mm	centreline of test object 1 (x4,y4) as illustrated below. Integer expected.
Shape Right Side TOB 1	:<(x20;y20),(x21;y21),(x22;y22),(x23;y23),(x24;y24)>	mm	
Front overhang TOB 1	:<Front overhang>	mm	Positive integer expected
Velocity longitudinal TOB 1	:<VUT longitudinal velocity>	km/h	Desired (scenario) velocity. Fill with 0 for start from stop scenarios
Lane Departure Velocity TOB 1	:<VUT lateral velocity>	m/s	Desired (scenario) velocity
Lane Departure Side TOB 1	:<Side of the lane departure>		<Driver/Passenger/ NOVALUE>
Impact side TOB 1	:<Impact side>		<NOVALUE/FR/LE/RE/RI>
Impact location TOB 1	:<Impact location>	%	Desired (scenario) impact location
Driver State TOB 1	:<Driver state>		<NOVALUE/Attentive/ Inattentive>
Name TOB 2	:<Name TOB 2>		See table
Velocity TOB 2	:<Target velocity>	km/h	Desired (scenario) velocity
Acceleration TOB 2	:<Target acceleration>	m/s^2	Desired (scenario) acceleration for braking test cases
Heading TOB 2	:<Target heading>	°	Desired (scenario) heading. See dedicated section for the convention.
Type of data source	:<Type>		<Virtual Test/Physical Test>

Notes:

- Test Object (TOB) 1 corresponds to the vehicle under test
- When a field is not relevant for a particular test, the corresponding header should be field with “NOVALUE”
- “Desired scenario” parameter corresponds to the parameter without the robustness layer applied

1.2.3.1 Scenario, type of test and subtype of test

Scenario	Type of the test	Subtype of the test
CCRs	:<AEB/FCW/AES/ESS/ACC>	:<st/cu>
CCRm	:<AEB/AES/ACC>	:NOVALUE
CCRb	:<AEB/AES/ACC>	:NOVALUE
CCRcut-in	:<ACC>	:NOVALUE
CCRcut-out	:<ACC>	:NOVALUE

CCFhos	:<AEB/AES>	:NOVALUE
CCFhol	:<AEB/AES>	:NOVALUE
CMRs	:<AEB/AES/ESS/ACC>	:<st/cu>
CMRm	:<ACC>	:NOVALUE
CMRb	:<AEB/AES/ACC>	:NOVALUE
CMR cut-in	:<ACC>	:NOVALUE
CMR cut-out	:<ACC>	:NOVALUE
CPLA	:<AEB/FCW/ESS/ACC>	:<D/N>
CBLA	:<AEB/FCW/ESS/ACC>	:NOVALUE
CCFtap	:<AEB>	:NOVALUE
CMFtap	:<AEB>	:NOVALUE
CPTA	:<AEB>	:<fs/ns/fo/no>
CBTA	:<AEB>	:<fs/ns/fo/no>
CCCscp	:<AEB>	:NOVALUE
CMCscp	:<AEB>	:NOVALUE
CPNA	:<AEB >	:<D/N>
CPFA	:<AEB>	:<D/N>
CPNCO	:<AEB/AES>	:<D/N>
CBNA	:<AEB>	:NOVALUE
CBFA	:<AEB>	:NOVALUE
CBNAO	:<AEB>	:<NOVALUE/Li>
ELK RE	:<RE>	:NOVALUE
ELK On	:<DL>	:NOVALUE
ELK Ov	:<DL>	:<U/I>
CPMRCs	:NOVALUE	:NOVALUE
CPMRCm	:NOVALUE	:<Li>
CPMFC	:NOVALUE	:<D1/D2>
CBDA	:<i/w/r>	:<Li>
DA	:<OT>	:NOVALUE
LDW	:<RE/SL/DL>	:NOVALUE

For the parameter Li, the index “i” should be reported into the subtype of test header according to the following table:

Header	Corresponding rear gap
L1	0.5 m
L2	1 m
L3	1.5 m
L4	2 m
L5	2.5 m

1.2.3.2 Robustness layers

Type	Robustness Layer		Parameter	
Code	Code	Name	Code	Unit
NOVALUE	NOVALUE	Not applicable	NOVALUE	
VUT	DI	Driver input pre-crash		
	IL	Impact location	<adjusted* impact location>	%
Target	S	Speed	<adjusted* target velocity>	km/h
	A	Acceleration	<adjusted* target acceleration>	m/s^ 2
	IP	Initial position offset	<adjusted* target position offset>	m
	H	Trajectory/Heading	<adjusted* target heading>	°
Environment	N	Illumination (Nighttime)		
	HG	Illumination (Headlamp Glare)	TBD (from CA 002)	
	I	Infrastructure/Clutter	TBD (from CA 002)	
	O	Obscuration/Obstruction	TBD (from CA 002)	

* Relative to the scenario parameter without the robustness layer applied (e.g., Robustness Layer: Target, S, -5).

1.2.3.3 Shape of test object 1

The shape of the VUT, as defined in the test protocols, is characterized by 24 distinct points. They shall be defined in the coordinate system whose origin is the most forward point on the centreline of the VUT corresponding to the point (x4, y4).

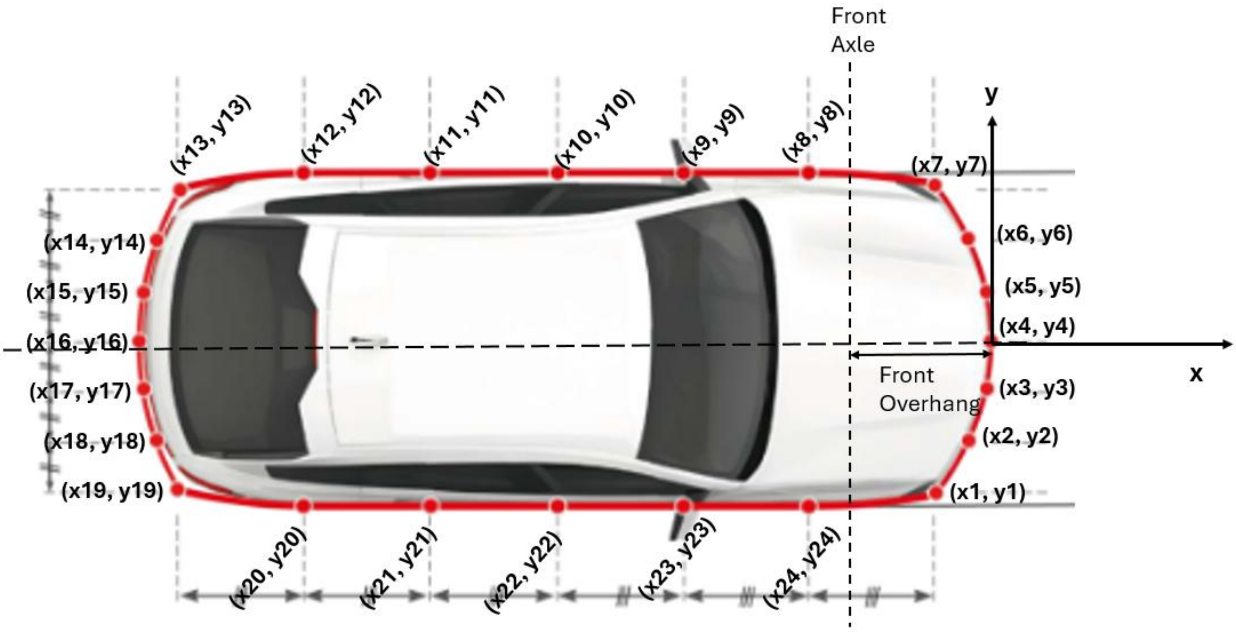

Figure 1 - Shape of test object 1

1.2.3.4 Name of test object 2

Name TOB 2	Description
GVT	: Global Vehicle Target
RVT	: Real Vehicle Target
EPTa	: Euro NCAP Pedestrian Target adult
EPTc	: Euro NCAP Pedestrian Target child
EBTa	: Euro NCAP Bicyclist Target adult
EMT	: Euro NCAP Motorcyclist Target
RMT	: Real Motorcyclist Target
NOVALUE	: Not applicable

1.2.3.5 Heading of test object 2

The heading of the test object depends on the object trajectory in the global coordinate system as defined in the dedicated protocols. The figure below shows an example of the different heading positions of the GVT for the different categories of test (longitudinal same direction, longitudinal oncoming and crossing). This also applies to all candidates for test object 2.

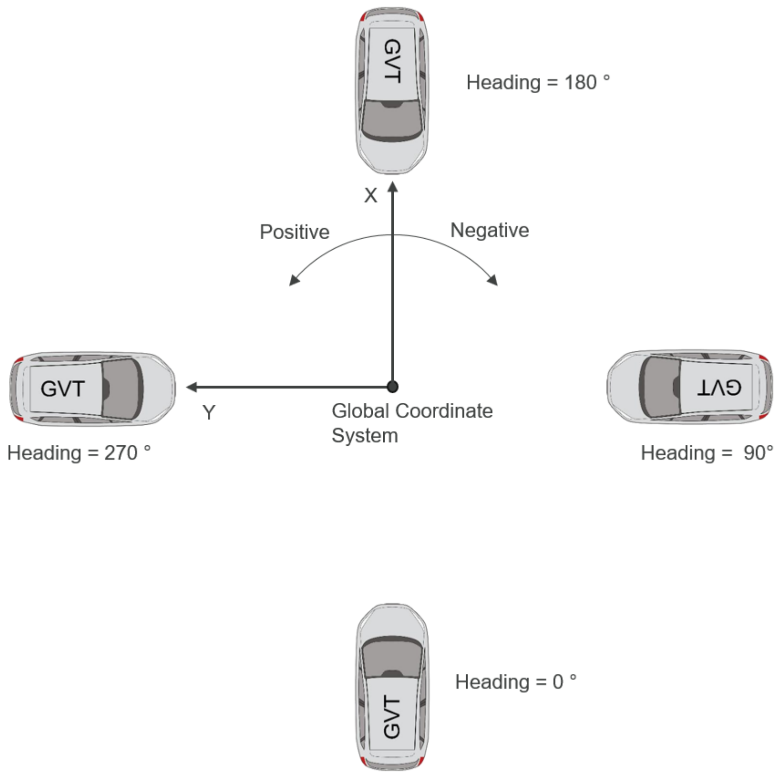

Figure 2. Illustration of the GVT heading position for the different tests

When a heading variation is applied as a robustness layer, the following convention shall be used: if the heading variation is positive, the target shall be rotated clockwise around the impact point whereas, if the variation is negative, it shall be rotated counter-clockwise.

2 CHANNEL DEFINITION AND FILTERING

For test objects used in the different Euro NCAP tests, both physical and virtual, the following channel names shall be used. All channels shall be supplied either unfiltered or prefiltered.

All the channels shall be recorded from 0.5 seconds before T0 until 0.5 seconds after Tend as defined in the corresponding protocol except for bicyclist and pedestrian turning and crossing scenarios. For these scenarios, all the channels shall be recorded from 0.5 seconds before the start of the target acceleration until 0.5 seconds after Tend.

2.1 Channel file

The channel file shall contain the headers as defined in the ISO.

2.2 Channel names

2.2.1 Vehicle Under Test

Location	Parameter	ISO code	Unit	RefSys	Assessment Calculation
Time (LSS & AEB)	Time series for FCW activation	10TFCW000000EV00	1	-	FCW Time-to-Collision
	Time series for LDW activation	10TLDW000000EV00	1	-	Distance to Line Crossing for LDW
	Time series where VUT enters in curve segment	10TECS000000EV00	1	-	T_{steer}
Time (Dooring)	Time series where VUT driver door opening interface	10TDOP000000EV00	1	-	Contact sensor / door operation channel / video [optional]
	Time series of Visual Information signal	10TINF000000EV00	1	-	
	Time series of Warning signal	10TWRN000000EV00	1	-	

	Time series when the door opens	10TDOP010000EV00	1	-	Contact sensor / door operation channel / video [optional]
Vehicle Front	Position X_{VUT}, Y_{VUT}	10VEHC000000DS[X,Y]P	m	TST	
	Speed V_{VUT_x}, V_{VUT_y}	10VEHC000000VE[X,Y]P	m/s	1DY	Relative impact speed, Speed reduction
	Acceleration A_{VUT_x}, A_{VUT_y}	10VEHC000000AC[X,Y]P	m/s^2	1DY	
	Yaw velocity $\dot{\psi}_{VUT}$	10VEHC000000AVZP	rad/s	1DY	
	Yaw angle ψ_{VUT}	10VEHC000000ANZP	rad	TST	
Vehicle front wheel (outer edge)	Position $X_{VUT_{wheel}}$, $Y_{VUT_{wheel}}$	1[1,3]WHEL000000DS[X,Y]P	m	TST**	DTLE for LKA DTLE for LDW
Steering wheel	Steering wheel angle velocity	10STWL000000AV1P	rad/s	LOC	
	Steering wheel angle	10STWL000000AN1P	rad	LOC	
	Steering wheel torque	10STWL000000MO1P	Nm	LOC	Estimated torque from steering wheel
Accelerator pedal	Pedal position (robot)	10PEAC000000DS0P	m	LOC	
Brake pedal	Pedal position (robot)	10PEBR000000DS0P	m	LOC	
	Pedal Force	10PEBR000000FO0P	N	LOC	
Turning Indicator	Turning indicator	10TURN000000EV00	1	-	

***Origin on the lane marking (before the bend)*

In case of data generated using virtual testing to predict the performance in Frontal Collision and/or Lane Departure Collision, the following channels are not requested for the vehicle under test:

- Steering wheel related channels
- Accelerator and brake pedal related channels
- Turning indicator channel

2.2.2 Euro NCAP Global Vehicle Target

Location	Parameter	ISO code	Unit	RefSys	Assessment Calculation
GVT	Position X_{GVT}, Y_{GVT}	20VEHC000000DS[X,Y]P	m	TST	
	Speed V_{GVT_x}, V_{GVT_y}	20VEHC000000VE[X,Y]P	m/s	2DY	Relative impact speed
	Acceleration A_{GVT_x}	20VEHC000000ACXP	m/s^2	2DY	
	Yaw velocity $\dot{\psi}_{GVT}$	20VEHC000000AVZP	rad/s	2DY	
	Yaw angle ψ_{GVT}	20VEHC000000ANZP	rad	TST	

2.2.3 Euro NCAP Pedestrian Target

Location	Parameter	ISO code	Unit	RefSys	Assessment Calculation
EPT adult & child	Position X_{EPT}, Y_{EPT}	20PED[A,C]000000DS[X,Y]P	m	TST	
	Speed V_{EPT_x}, V_{EPT_y}	20PED[A,C]000000VE[X,Y]P	m/s	2DY	
	Acceleration A_{EPT_x}	20PED[A,C]000000ACXP	m/s^2	2DY	
	Yaw angle ψ_{EPT}	20PED[A,C]000000ANZP	rad	TST	
	Yaw velocity $\dot{\psi}_{EPT}$	20PED[A,C]000000AVZP	rad/s	2DY	

2.2.4 Euro NCAP Bicyclist Target

Location	Parameter	ISO code	Unit	RefSys	Assessment Calculation
EBT adult	Position X_{EBT}, Y_{EBT}	20CYCL000000DS[X,Y]P	m	TST	
	Speed V_{EBT_x}, V_{EBT_y}	20CYCL000000VE[X,Y]P	m/s	2DY	
	Acceleration A_{EBT_x}	20CYCL000000ACXP	m/s²	2DY	
	Yaw angle ψ_{EBT}	20CYCL000000ANZP	rad	TST	
	Yaw velocity $\dot{\psi}_{EBT}$	20CYCL000000AVZP	rad/s	2DY	

2.2.5 Euro NCAP Motorcycle Target

Location	Parameter	ISO code	Unit	RefSys	Assessment Calculation
EMT	Position X_{EMT}, Y_{EMT}	20TWMB000000DS[X,Y]P	m	TST	
	Speed V_{EMT_x}, V_{EMT_y}	20TWMB000000VE[X,Y]P	m/s	2DY	
	Acceleration A_{EMT_x}	20TWMB000000ACXP	m/s²	2DY	
	Yaw angle ψ_{EMT}	20TWMB000000ANZP	rad	TST	
	Yaw velocity $\dot{\psi}_{EMT}$	20TWMB000000AVZP	rad/s	2DY	

2.3 Filtering

Before processing the data, Euro NCAP will apply the following filtering rules:

- Position and speed will not be filtered and shall be used in their raw state.

- Acceleration, yaw rate, steering wheel velocity, and force will be filtered using a 12-pole phase-less Butterworth filter with a cut-off frequency of 10 Hz.

3 ASSESSMENT CRITERIA CALCULATION

This chapter describes the calculation for the parameters used for the assessment criteria used within Euro NCAP active safety tests. The test laboratory shall supply Euro NCAP with the channels outlined in chapter 2, and the calculation of parameters will be done by Euro NCAP as described in this chapter.

3.1 Autonomous Emergency Braking and Active Cruise Control

3.1.1 Relative impact speed

The (relative) impact speed is calculated with the following formula:

$$V_{rel,impact} = V_{VUT_x}(t_{impact}) - V_{target_x}(t_{impact})$$

With:

V_{VUT_x}	Speed of the VUT along the X axis	10VEHC000000VEXP
V_{target_x}	Speed of the target along the X axis	20[VEHC,CYCL,PED[A,C],TWMB]000000VEXP
t_{impact}	Time of impact	

3.1.2 Speed reduction

The speed reduction is calculated with the following formula:

$$V_{reduction} = V_{VUT_x}(t_0) - V_{VUT_x}(t_{impact})$$

With:

V_{VUT_x}	Speed of the VUT along the X axis	10VEHC000000VEXP
t_0	Time of start of test	
t_{impact}	Time of impact	

3.1.3 Closest distance

The distance between the target and the VUT (D_{VUT_Target}) is defined, as the closest distance between the target bounding box and the VUT profiled line (i.e., closest polygon-to-polygon distance).

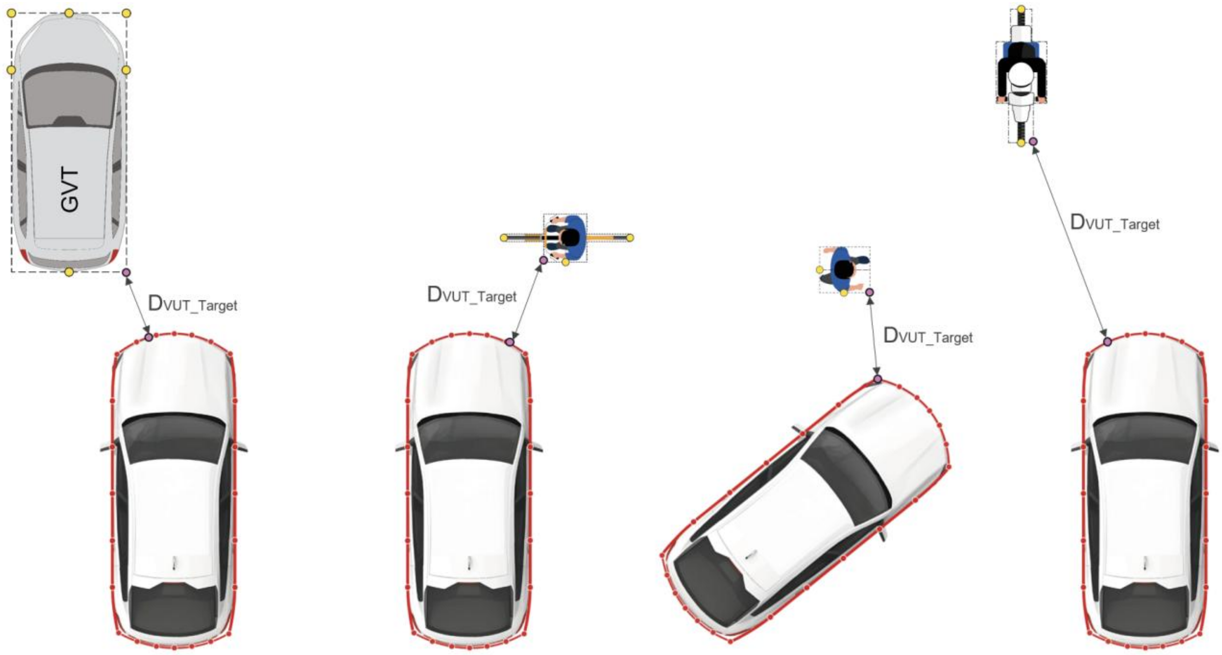

Figure 3 – Illustration of D_{VUT_Target} in different scenarios

It is calculated with the following formula:

$$D_{VUT_{Target}}(t) = f(\,X_{VUT}(t),\ Y_{VUT}(t),\ X_{Target}(t), Y_{Target}(t), Poly_{VUT}, Poly_{Target})$$

With:

X_{VUT}	Position of the VUT along the X axis	10VEHC000000DSXP
Y_{VUT}	Position of the VUT along the Y axis	10VEHC000000DSYP
X_{Target}	Position of the target along the X axis	20[VEHC,CYCL,PED[A,C],TWMB]000000DSXP
Y_{Target}	Position of the target along the Y axis	20[VEHC,CYCL,PED[A,C],TWMB]000000DSYP
$Poly_{VUT}$	VUT polygon VUT defined with the profiled lines	MME file (Shape Front TOB 1, Shape Left TOB 1, Shape Rear TOB 1, Shape Right TOB 1)
$Poly_{Target}$	Target polygon (target bounding box as defined in the Frontal Collision protocol)	

3.1.4 Time Headway

The Time Headway (THW) is defined for the longitudinal scenarios, at an instant t, as the time it takes the VUT to travel the closest distance between the front of the VUT and the rear of the preceding target. It is calculated with the following formula:

$$THW(t) = \frac{D_{VUT\_Target}(t)}{V_{VUT_x}(t)}$$

With:

D_{VUT_Target}	Closest distance between the target bounding box and the VUT profiled line as described in 3.1.3	
V_{VUT_x}	Speed of the VUT along the X axis	10VEHC000000VEXP

3.1.5 Time-to-Collision

The Time-to-collision (TTC) is defined for the longitudinal scenarios, at an instant t, as the time remaining before a collision would occur if the relative speed between the VUT and the target remains constant. It is calculated with the following formula:

$$TTC(t) = \frac{D_{VUT\_Target}(t)}{V_{VUT_x}(t) - V_{target_x}(t)}$$

With:

D_{VUT_Target}	Closest distance between the target bounding box and the VUT profiled line as described in 3.1.3	
V_{VUT_x}	Speed of the VUT along the X axis	10VEHC000000VEXP
V_{target_x}	Speed of the target along the X axis	20[VEHC,CYCL,PED[A,C],TWMB]000000VEXP

3.1.6 FCW Time-to-Collision

The Time-to-Collision (TTC) of FCW for the longitudinal scenarios is calculated with the following formula:

$$TTC_{FCW} = TTC(t_{FCW})$$

With:

TTC	Time-to-Collision	
t_{FCW}	Time of FCW initiation	10TFCW000000EV00

3.1.7 Time-to-Target

3.1.7.1 Crossing scenarios

The Time-to-Target (TTT) is defined for the crossing scenarios, at an instant t, as the time remaining before the VUT would travel the projection of D_{VUT_Target} along the X axis if the longitudinal speed of the VUT remains constant.

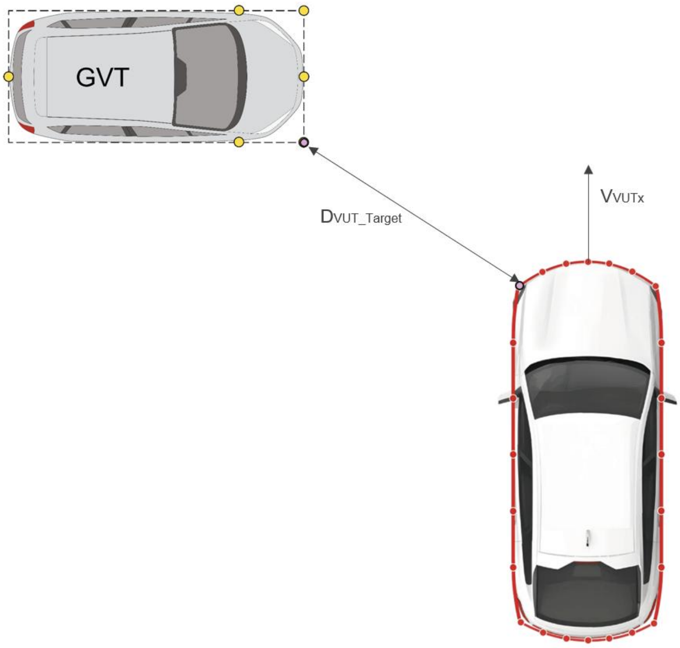

Figure 4. Illustration of the TTT calculation for a crossing scenario

It is calculated with the following formula:

$$TTT(t) = \frac{D_{VUT\_Target}(t)}{V_{VUT_x}(t)}$$

With:

D_{VUT_Target}	Closest distance between the target bounding box and the VUT profiled line as described in 3.1.3	
V_{VUT_x}	Speed of the VUT along the X axis	10VEHC000000VEXP

3.1.7.2 Turning scenarios

The Time-to-Target (TTT) is defined for the turning scenarios, at an instant t, as the time remaining before the VUT would travel the projection of D_{VUT_Target} along the Y axis if the projection of the longitudinal speed of the VUT remains constant.

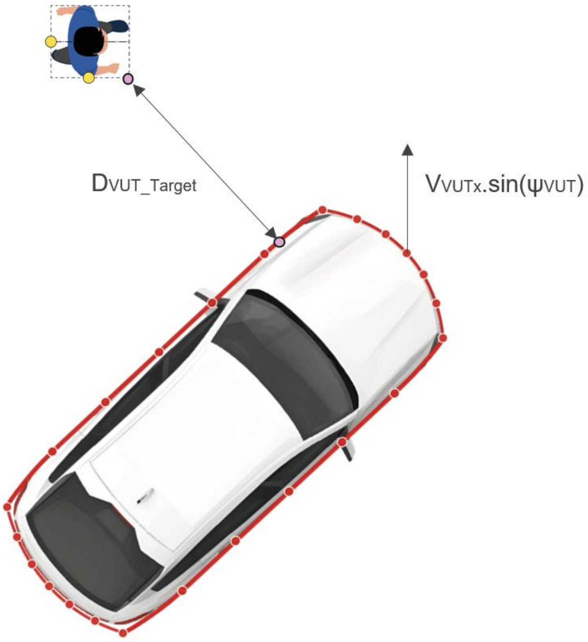

Figure 5. Illustration of the TTT calculation for a turning scenario

is calculated with the following formula:

$$TTT(t) = \frac{D_{VUT\_Target}(t)}{V_{VUT_x}(t).\sin(\psi_{VUT}(t))}$$

With:

D_{VUT_Target}	Closest distance between the target bounding box and the VUT profiled line as described in 3.1.3	
V_{VUT_x}	Speed of the VUT along the X axis	10VEHC000000VEXP
ψ_{VUT}	Yaw angle of the VUT	10VEHC000000ANZP

3.1.8 Time of AEB intervention

To be updated

3.1.9 Time of ACC intervention

To be updated

3.1.10 SCP time error

The SCP (Straight Crossing Path) Time Error is determined, at an instant t, as the difference between the actual time of the VUT to the intended collision point and the actual time of the target to the intended collision point. It is calculated with the following formula:

$$VUT\ Time\ Error(t) = \frac{Y_{Target}(t)}{V_{Target_y}(t)} - \frac{X_{VUT}(t)}{V_{VUT_x}(t)}$$

With:

X_{VUT}	Position of the VUT along the X axis	10VEHC000000DSXP
V_{VUT_x}	Speed of the VUT along the X axis	10VEHC000000VEXP
Y_{Target}	Position of the target along the Y axis	20[VEHC,TWMB]000000DSYP
V_{Target_y}	Speed of the target along the Y axis	20[VEHC,TWMB]000000VEYP

3.1.11 Longitudinal path error

The VUT longitudinal path error is determined as the difference between the desired position and the actual position of the front of the VUT when measured at a single defined “stable” position of the target during the test. It is calculated with the following formula:

$$VUT\ Longitudinal\ Path\ Error = X_{VUT_{Desired}} - X_{VUT}\ (@X_{Ref_{Target}})$$

With:

$X_{Ref_{Target}}$	Reference position of the target along the X axis as defined into Frontal Collision protocol	
$X_{VUT_{Desired}}$	Desired position of the VUT along the X axis as defined into Frontal Collision protocol	
X_{VUT}	Actual position of the VUT along the X axis	10VEHC000000DSXP

3.1.12 Lateral path error

The VUT lateral path error is determined as the lateral distance between the centre of the front axle of the VUT when measured in parallel to the intended path as illustrated in the figure below.

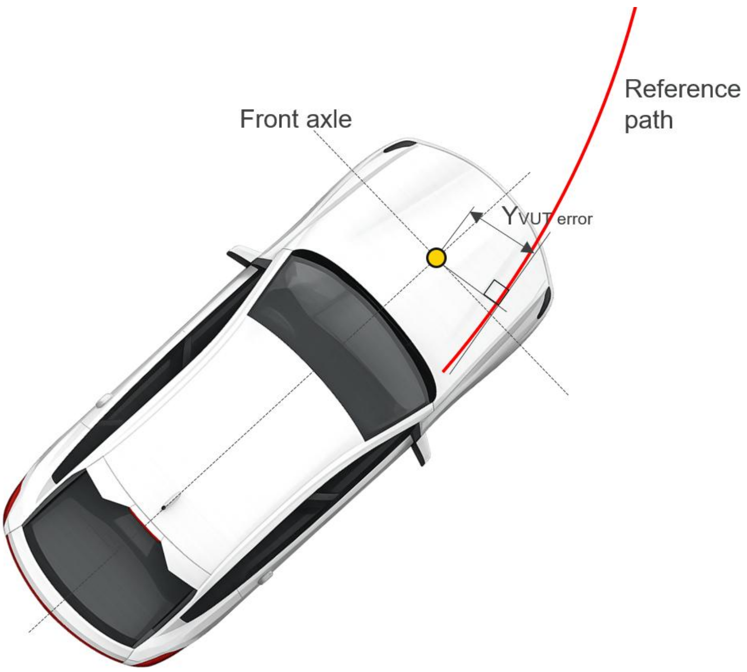

Figure 6. Illustration of the lateral path error during a turning manoeuvre

It is calculated with the following formula:

$$VUT\ Lateral\ Path\ Error = f(X_{VUT}(t), Y_{VUT}(t), \psi_{VUT}(t), Font\ overhang, Reference\ path)$$

With:

X_{VUT}	Position of the VUT along the X axis	10VEHC000000DSXP
Y_{VUT}	Position of the VUT along the Y axis	10VEHC000000DSYP
$Font\ overhang$	Front overhang of the VUT	MME file (Front overhang TOB 1)
$Reference\ path$	Reference path as defined in the Frontal Collision protocol	

3.2 Lane Support Systems

3.2.1 Distance to Lane Edge

The Distance-to-Lane Edge is calculated with the following formula:

$$DTLE(t) = y_{VUT,wheel}(t)$$

With:

$y_{VUT,wheel}$	Lateral position of the outer edge of wheel	1[1,3]WHEL000000DSYP

By convention, DTLE is positive before the VUT crosses the lane edge.

3.2.1.1 Distance to Lane Edge for LKA

The Distance-to-Lane Edge for LKA is calculated with the following formula:

$$DTLE_{LKA} = max(\, y_{VUT,wheel})$$

With:

$y_{VUT,wheel}$	Lateral position of the outer edge of wheel	1[1,3]WHEL000000DSYP

3.2.1.2 Distance to Lane Edge for LDW

The Distance-to-Lane Edge for LDW is calculated with the following formula:

$$DTLE_{LDW} = y_{VUT,wheel}(t_{LDW})$$

With:

$y_{VUT,wheel}$	Lateral position of the outer edge of wheel	1[1,3]WHEL000000DSYP
t_{LDW}	Time of LDW initiation	10TLDW000000EV00

3.2.2 Lane approach velocity

The Lane Approach Velocity (LAV) for LSS is calculated, at an instant t, with the following formula:

$$LAV(t) = D\dot{T}LE(t)$$

With:

$DTLE$	The time derivative of $DTLE$

3.2.3 Separation between the VUT and the target

3.2.3.1 Car-to-Car scenarios

The separation for oncoming and overtaking Car-to-Car scenarios corresponds to the closest distance as presented in 3.1.3.

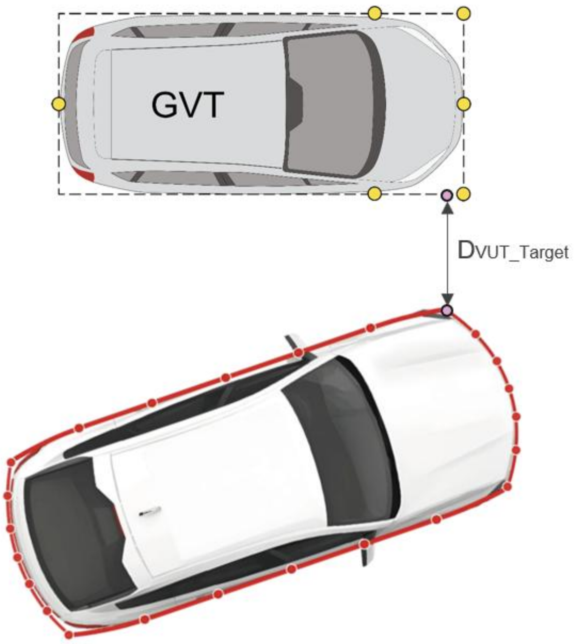

Figure 7. Closest distance illustrated in a Car-to-Car overtaking scenario

3.2.3.2 Car-to-Motorcyclist scenarios

The separation for oncoming and overtaking Car-to-Motorcyclist scenarios corresponds to the closest distance as presented in 3.1.3. Note that for these scenarios, the bounding box of the motorcycle is extended by 0.3 m.

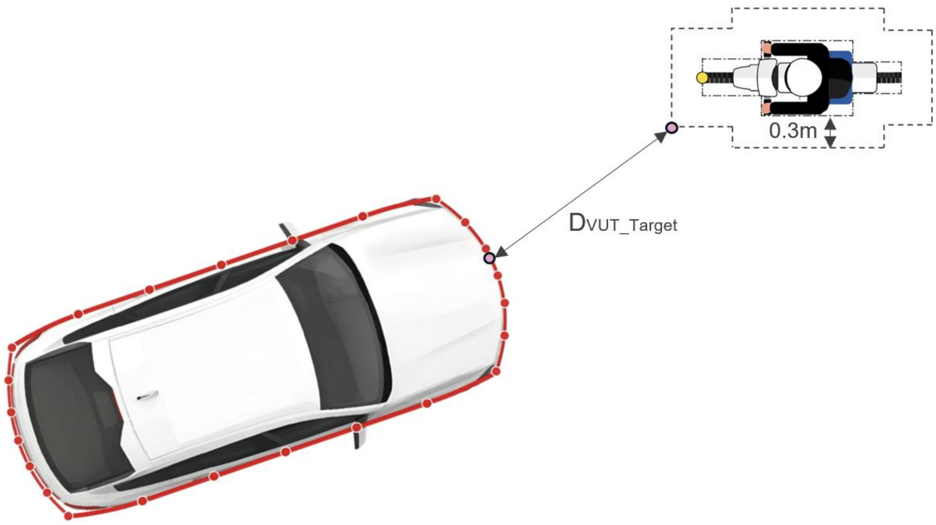

Figure 8. Closest distance illustrated in a Car-to-Motorcycle oncoming scenario

3.2.4 Time of LKA intervention

T_{LKA} means the time where the LKA system of the vehicle intervenes. Activation time is determined by the following sequence, based on Yaw velocity $(\dot{\psi}_{VUT})$ during the LSS manoeuvre:

1. Steering robot release is triggered by X position of VUT (green vertical line)
2. Identify when $\dot{\psi}_{VUT}$ > 0,4°/s
3. From point 2., start searching backwards until $\dot{\psi}_{VUT} < 0.1\ °/s$ to identify T_{LKA} (red vertical line)

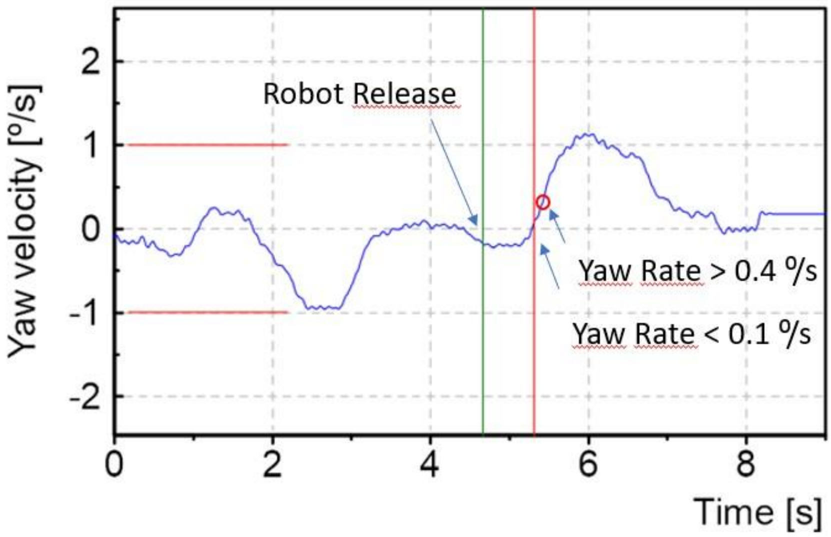

Figure 9 - Identification of T_{LKA}

With:

$\dot{\psi}_{VUT}$	Yaw velocity of the VUT	20VEHC000000AVZP
T_{LKA}	Time where the LKA system intervenes	

3.3 Acceleration application

3.3.1 Time of accelerator pedal input

The time of accelerator pedal input (T_{ACC}) means the time where the accelerator pedal input is applied in CPMFC scenario (Low Speed Collisions protocol), which is as soon as the accelerator pedal position has reached 90% of the total position.

With:

APP	Accelerator pedal position	10PEAC000000DS0P

3.4 Steering application

3.4.1 Time when entering the curve segment

T_{steer} means the time where the VUT enters in curve segment determined by the following sequence, based on the lateral position and the lateral speed during the curving manoeuvre:

1. Look for first time (t_1) when $\left|Y_{VUT_0} - Y_{VUT}(t)\right| > 0.05$ m
2. From t_1, go back in time to when $\left|V_{VUT_y}\right| < 0.05$ m/s to identify T_{steer}

With:

Y_{VUT_0}	Initial position of the VUT along the Y axis	
Y_{VUT}	Position of the VUT along the Y axis	10VEHC000000DSYP
V_{VUT_y}	Speed of the VUT along the Y axis	10VEHC000000VEYP
T_{steer}	Time where the VUT enters in curve segment	