Euro NCAP
For Safer Cars

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Safe Driving & Crash Avoidance Virtual Testing

Safe Driving & Crash Avoidance

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DEFINITIONS

Throughout this protocol the following terms are used (listed in alphabetical order):

Perfect perception - This means that all objects have a 100% existence probability and appear once they are classified as by the physical sensors in the idealised Field-of-View of relevant sensors.

CPC – all Car-to-Pedestrian Crossing scenarios

CBC – all Car-to-Bicyclist Crossing scenarios

1 VIRTUAL TESTING PROCEDURE

An OEM can use virtual testing to provide input to Safe Driving and Crash Avoidance performance predictions. Where virtual testing is (partly) used, the OEM shall use the following process.

1. Qualification of simulation model by OEM
    i. OEM dossier with simulation set-up, model details, sensor details, etc.
    ii. In-house qualification between virtual and physical testing for the applicable clusters where VTA is used using ISO score and defined KPIs calculated using the Euro NCAP scripts
2. Virtual testing by OEM to generate colour predictions for Safe Driving and Crash Avoidance, where applicable
3. Physical verification testing by Euro NCAP
    i. Randomly selected grid cells for verification testing by Euro NCAP
    ii. OEM provides virtual test data for selected grid cells
    iii. Physical testing of selected grid cells by Euro NCAP
4. Validation of virtual test data
    i. ISO score and KPIs are determined
    ii. Overall acceptance is calculated
5. Possible re-simulation by OEM in case the validation of the virtual test data does not meet the requirements.

It should be noted that text and/or values shown in square brackets […] need to be confirmed based on additional data.

2 REFERENCE SYSTEM

2.1Convention

Use the convention specified in ISO 8855:2011, with the origin at the most forward point on the centreline of the VUT for dynamic data measurements as shown in Figure 2-1. This reference system should be used for both left- and right-hand drive vehicles. In Figure 2-1 nearside and far-side are shown for a left-hand drive vehicle. For a right-hand drive vehicle, nearside and far-side are swapped.

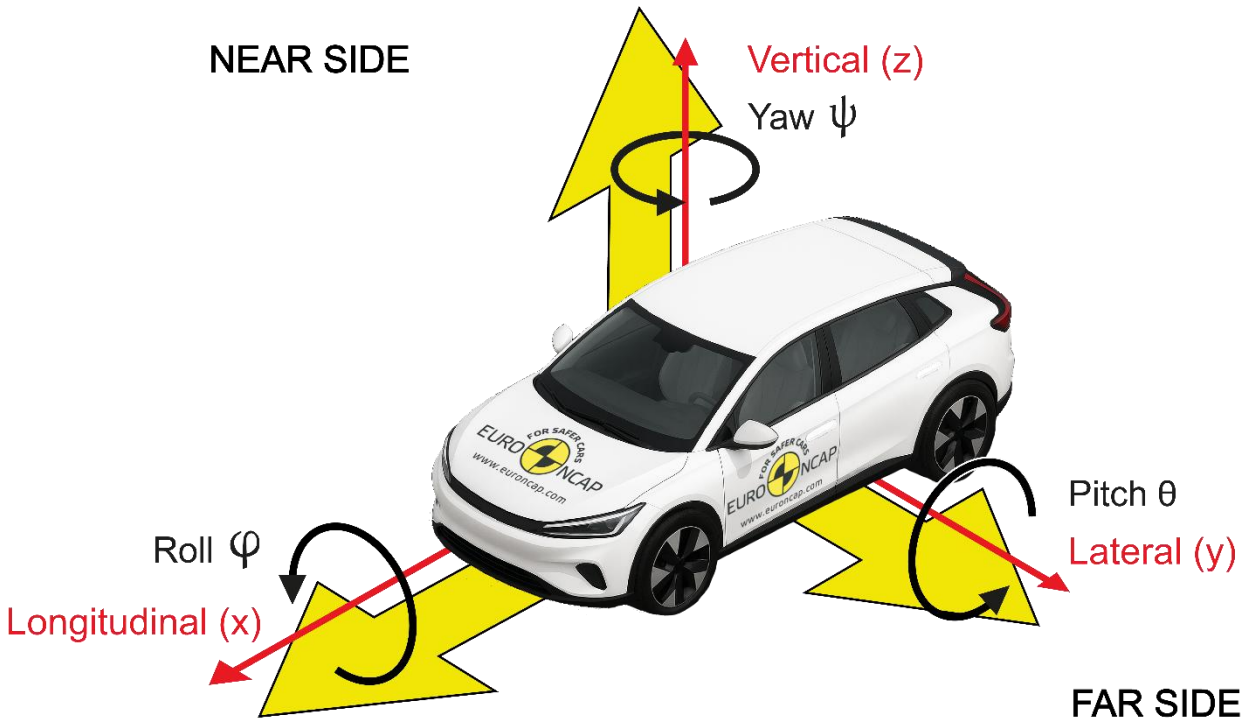

Figure 2-1 Coordinate system and notation

3 SIMULATION DATA

All simulation results must be uploaded in the prescribed format below to the Euro NCAP VTA server by the OEM. Euro NCAP will make parameterised OpenScenario files available for each scenario that may be used by the OEM. Data that are not provided in the correct format or outside of physical limits, e.g. acceleration levels that can never be seen in physical tests will be rejected.

3.1 Measurements and Variables

For all required channels data between T0 and Tend as specified in the specific protocols shall be provided.

All channels must be named according to the ISO MME channel codes listed in Technical Bulletin CA-004. The ISO MME codes have to be consistent between physical and virtual tests, where applicable.

3.2 Data Filtering

All time series data must be provided with an output frequency of 100 Hz and no additional filtering shall be applied on the output data.

4 SIMULATION MODEL

For all simulations, the vehicle simulation model, target simulation models and environmental model must be kept the same where applicable.

The exact parameters value for each grid cell (e.g. speed, impact location, etc) of a scenario should be used in the virtual tests and all boundary conditions as per physical test protocol should be met.

4.1 Vehicle simulation model

The relevant vehicle simulation model properties need to be representative of the vehicle under assessment, e.g. vehicle mass, width, etc.

Perfect perception can be assumed in the simulation models. All virtual sensors used should be positioned in the same location with the same opening angles, azimuth and range as the physical sensors.

The function algorithm used in the virtual model should be similar as the one present in the physical vehicle.

Vehicle dynamics models can be simplified, but should include relevant dynamic characteristics for the virtual test scenarios.

4.2 Target simulation models

Virtual targets shall have the same dimensions, and bounding box where relevant, as their physical counterparts.

4.3 Environmental simulation model

The toolchain and its components shall be capable of accurately representing the relevant aspects of the physical test that is being modelled. Environmental models that are used in the simulation models should have the nominal and relevant characteristics and elements as described in the test protocols and shall be kept the same throughout the whole process.

5 QUALIFICATION OF SIMULATION MODEL

The simulation models used by the OEM will need to meet the qualification criteria detailed below.

These criteria apply for both the initial OEM in-house qualification and the spot test qualification done by Euro NCAP. For each scenario cluster, different acceptance criteria might apply as detailed in this chapter. At least 75% of the Euro NCAP verification tests per cluster where VTA is used should meet the qualification criteria, otherwise the simulation dossier will not be accepted for that scenario cluster.

The qualification criteria are calculated automatically on the VT server as soon as the data is uploaded.

Physical data from test cases that are determined to be unrealistic, outside of physical limits will be excluded from the qualification.

5.1 Qualification and Validation scenarios

5.1.1 OEM in-house qualification

The OEM in-house qualification is performed on the following scenarios, per cluster where VTA is used by the vehicle manufacturer.

5.1.1.1 Frontal - Longitudinal

CCRs (standard matrix), at least the marked corner cases and [3-5] additional cases.

CCRs	GVT speed	Function	125%	100%	75%	50%	25%	0%	-25%
10 km/h	0 km/h	AEB							
20 km/h	0 km/h	AEB							
30 km/h	0 km/h	AEB							
40 km/h	0 km/h	AEB							
50 km/h	0 km/h	AEB							

5.1.1.2 Frontal - Turning

CCFtap (standard matrix), at least the marked corner cases.

CCFtap	GVT speed			
	30 km/h	45 km/h	60 km/h	80 km/h
10 km/h				
15 km/h				
20 km/h				
25 km/h				

5.1.1.3 Frontal - Crossing

CPNA (standard matrix), at least the marked corner cases and [3-5] additional cases.

CPNA	10%	25%	50%	75%	90%
10 km/h		X		X	
20 km/h					
30 km/h					
40 km/h					
50 km/h					
60 km/h		X		X	

CPNCO for monitoring purposes (standard matrix), at least the marked cases and [1] additional cases in between.

CPNCO	25%	50%	75%
10 km/h		X	
20 km/h			
30 km/h			
40 km/h			
50 km/h			
60 km/h		X	

5.1.1.4 Lane - ELK

Road Edge (standard matrix), at least the marked corner cases and [3-5] additional cases.

ELK-RE	0.2 m/s	0.3 m/s	0.4 m/s	0.5 m/s	0.6 m/s	0.7 m/s
50 km/h						
60 km/h						
70 km/h	X				X	
80 km/h						
90 km/h	X				X	
100 km/h						

5.1.2 Euro NCAP spot test qualification

The spot test cases will be selected by Euro NCAP after receiving the OEM predictions. [Reference to CA protocol].

5.2 Qualification Criteria

The qualification criteria used are the ISO Score and KPIs according the table below.

Qualification Criteria application	ISO Score	KPI
Standard Range	X	X
Extended Range	X	

The respective criteria must fulfil the acceptance criteria as defined in 5.3.1 and 5.3.2.

5.2.1 ISO score

The ISO score, according to ISO TS 18571, of the longitudinal vehicle acceleration channel (10VEHC000000ACXS) is calculated.
Before calculating the ISO score, the time channel for the virtual test is time-shifted so that Taeb is aligned between the physical test and the simulation.

The ISO score calculation will only take into account the time series data from Taeb-0.2s until Tend as defined in the physical test protocols. The Tend from physical or virtual test is to be used, whichever is the earliest.

5.2.2 Key Performance Indicator (KPI)

For each applicable KPI, the error between physical test and simulation are calculated:

KPI_error = KPI_physical - KPI_simulation

5.3 Acceptance Criteria

Different acceptance criteria exist for the scenarios within the scenario clusters:

- **Frontal – Longitudinal**: CCR, CMR, CPLA, CBLA, CCF
- **Frontal – Turning**: CCFtap, CMFtap, CPTA, CBTA
- **Frontal – Crossing**: CCC, CMC, CPC, CBC
- **Lane – ELK**: Road Edge, Oncoming, Overtaking

5.3.1 ISO score

Scenario cluster	Acceptance criteria Standard Range	Acceptance criteria Extended Range
Frontal – Longitudinal	[0.5]	[0.5]
Frontal – Turning	[0.5]	[0.5]
Frontal – Crossing	[0.5]	[0.5]

5.3.2 KPI

Scenario cluster	KPI_error	Accepted KPI_error
Frontal – Longitudinal	TTC_AEB [s]	[+-0.2]
	TTC_FCW [s]	[+-0.2]
	Remaining distance [m]	[+-1.0]
	Impact speed [m/s]	[+-1.0]
Frontal – Turning	TTT_AEB [s]	[+-0.2]
	TTT_FCW [s]	[+-0.2]
	Impact speed [m/s]	[+-1.0]
Frontal – Crossing	TTT_AEB [s]	[+-0.25]
	TTT_FCW [s]	[+-0.5]
	Impact speed [m/s]	[+-1.0]
Lane – ELK	DTLE_ELK [m]	[+-0.2]