Validation Method: Virtual Testing

IWG AEBS - UTAC
Agenda

- Virtual testing activities already in progress
- Discussions on going for validation methods
- Automated Driving applications
- Next steps
Virtual testing activities already in progress

Discussions on going for validation methods

Automated Driving applications

Next steps
Virtual testing activities already in progress

Virtual testing already in use for alternative testing solutions according to regulations or to European approval framework for motor vehicles

- 2007/46 annex XVI or 2018/858 annex VIII defining the specific conditions required from virtual testing methods and regulatory acts for which virtual testing methods may be used by a manufacturer or a technical service
  - UNECE n° 46 on indirect vision
  - UNECE n° 125 on forward field of vision
  - UNECE n° 21 on interior fittings
  - UNECE n° 66 on strength of superstructure of large passenger vehicles
Virtual testing activities already in progress

Virtual testing already in use for alternative testing solutions according to regulations or to European approval framework for motor vehicles

- UTAC protocol defined for virtual testing application: validation methodology of virtual testing method focusing on objective evaluation of a correlation level.

- Objective evaluation based on different evaluations between physical and numerical results under a validity area depending on the application:
  - Kinematics
  - Scalar Values
  - Curves using IAPE method (peak time, peak value, curve shape, error evaluation)
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Discussions on going for validation methods

Dedicated Informal Working Group of GRVA for validation methods (VMAD)

Virtual testing considered as part of the audit/assessment of vehicles with automated mode
- Safety principles evaluation & validation
- Critical situations to be evaluated
- High number of situations to be covered
Discussions on going for validation methods

Dedicated Informal Working Group of GRVA for validation methods (VMAD)

- New regulation on Automated Lane Keeping Systems (ALKS) annex 4 (functional and operational safety) § 4.2.:
  - Simulation tool and mathematical models for verification of the safety concept may be used in accordance with 1958 Agreement, in particular for scenarios that are difficult on a test track or in real driving conditions.
  - Manufacturers shall demonstrate the scope of the simulation tool, its validity for the scenario concerned as well as the validation performed for the simulation tool chain (correlation of the outcome with physical tests).

- Similar approach and application for larger AD functions implementation.
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Context: virtual testing tools

- **Software In the Loop** (SIL)
  - 100% numérique
  - Utilisation de modèles

- **Hardware In the Loop** (HIL)
  - Essai composants
  - Environnement émulé

- **Vehicle In the Loop** (VIL)
  - Essai sur véhicule complet
  - Environnement émulé indoor/outdoor

- **Reality**
  - Essai sur véhicule complet
  - Environnement réel (piste/route ouverte)

- UTAC involved in Working Group Euro NCAP Virtual testing
- UTAC involved in WMAD traffic scenarios
- **Member of P.E.A.R.S initiative**: Prospective safety performance assessment of pre-crash technology by virtual simulation
  - ISO assessment method of active safety simulation
Context: tools become necessary for ADAS-AD validation

2019 Official Physical tests

2020-2022 = Physical+VIL+digital tests + audits

Driving Simulator & requirements

MIL digital tests

SIL tests

VIL tests

Physical tests

HIL tests
A good input means a good correlation rate.

Diagram:
- **Input**
  - Data quality
- **Simulation model**
- **Output**
  - Correlation rate
Injecting real test data into scenarios...
... provides results very close to reality

Simulation model

Distance to stop (m)

\[ \Delta = 0.62 \text{ m} \]

Speed (km/h)

Real

\[ X = 58.12 \text{ m} \]

Basic control

\[ X = 57.5 \text{ m} \]

UTAC CERAM Advanced control

\[ X = 58.11 \text{ m} \]

Gap : 0.01 m

Gap : 0.01 m

Distance to stop (m)
UTAC CERAM expertise in target control & proving ground

UTAC CERAM Trajectories
Event timeline

Dynamic vehicle model
ADAS control
ADAS sensors

Ego Vehicle

SCANeR™ studio

Proving ground
Targets control
Example of correlation: Pedestrian turning scenario

VUT Speed: 20.16 km/h
TTC: 14.89 s

Pedestrian Speed: 0.00 km/h
Example of correlation: Pedestrian turning scenario

UTAC CERAM driving robot model control Vehicle Under Test

Ego vehicle pedestrian turning scenario trajectory

- Trajectory definition in test protocols
  - Design to be use by robot control software on track
- Difficult to design without real input
- Theoretical scenarios haven’t real trajectories
  - UTAC CERAM have real trajectories
Methodology use availability: is the vehicle reproductible?

Find physical mean value to compare

Output correlation rate of each variables

Output final correlation rate: process validated or not validated

4 Steps methodology

- Step 1:
  - 10 tests / scenario
  - Mean value of impact speed or remaining distance
  - 10 values have to be in corridor

- Step 2

- Step 3

- Step 4
UTAC CERAM have tested 2 vehicles, with different scenarios

**same vehicle**

2 different scenarios

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**Car-to-Car Rear Stationary (CCRs)**

- 100% overlap

**Test vehicle speed:** 30 kph

**Target vehicle speed:** 0 kph

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**Car-to-Pedestrian Nearside Adult 25% (CPAN25)**

**Test vehicle speed:** 55 kph
Methodology use availability: is the vehicle reproducible?
- Find physical mean value to compare
- Output correlation rate of each variables
- Output final correlation rate: process validated or not validated

10 tests / scenario

Mean value of impact speed or remaining distance

10 values have to be in corridor

Step 1

Step 2

10% of real tests can be taken away (an absurd point)

Step 3

Mean value to compare to simulation

Step 4
UTAC CERAM step 1 apply → Vehicle tested in UTAC CERAM: 10 tests repeated each scenario

- Car to car validity domain: **NOK**
- Pedestrian validity domain: **Ok → Full methodology can be apply**

Virtual validation can be applied in a validity domain

**Can be taken away (10%)**

**Test out of boundaries**
The UTAC numerical procedure applied on AEB

TTC: Time to collision
FCW: Forward Collision Warning

IAPE Method
- Vehicle Speed
- Acceleration
- TTC AEB
- TTC FCW

Double thresholds method
- Remaining distance
- Impact Speed

Interval Method
- Lateral distance
- Relative distance

If \( A < X < B \rightarrow 100\% \)
Else \( \rightarrow 0\% \)
4 Steps methodology

- Methodology use availability: is the vehicle reproducible?
- Find physical mean value to compare
- Output correlation rate of each variables
- Output final correlation rate: process **validated** or **not validated**

**Step 1**
- 10 tests / scenario
- Mean value of impact speed or remaining distance
- 10% of real tests can be taken away (an absurd point)
- 10 values have to be in corridor

**Step 2**
- Mean value to compare to simulation

**Step 3**
- 13 variables (speed, accel, remaining distance, lateral deviation, stop distance, impact speed, TTC AEB, TTC FCW)
- 3 methods to compare:
  - IAPE method: peaks, times, amplitudes, curves
  - Double thresholds method
  - Interval method

**Step 4**
- Final correlation rate
  - Compare to requirement
IAPE example

 Curve to curve comparison shows good correlation
 IAPE method to quantify correlation rate

<table>
<thead>
<tr>
<th>Ponderation</th>
<th>I</th>
<th>A</th>
<th>P</th>
<th>E</th>
<th>G</th>
<th>C</th>
<th>Correlation Rate</th>
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</thead>
<tbody>
<tr>
<td>Critere</td>
<td>95,93%</td>
<td>97,45%</td>
<td>99,57%</td>
<td>86,22%</td>
<td>94,79%</td>
<td>92,70%</td>
<td>94%</td>
</tr>
</tbody>
</table>
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Action Plan: AEBS & ALKS virtual test validation & type approval

- **2018**
  - Test reference despite dispersions for test/simu gaps

- **2019, Oct. 31st**
  - Draft procedure UTAC for AEB virtual test validation

- **2019, Dec. 31st**
  - Test procedure with OEMs AEB tests
  - Convergence with OEMs

- **2020, May 4th**
  - UTAC repetability AEB tests with OEMs vehicles
  - Work with OEMs: Target = 3 OEM x 2 véh

- **2020, May 15th**
  - UTAC meetings with
    - French simu OEM experts
    - French TAA
    - Euro NCAP & PEARs WGs

- **2020, Sept. 10th / 11st**
  - Presentation to French automotive industry

- **Middle 2021**
  - GRVA IWG AEBS M1-N1 (R152) views sharing and first amendment draft proposal to allow virtual testing as alternative solution to physical tests
  - GRVA IWG VMAD, ALKS regulation annex 4 amendment proposal to detail conditions for virtual testing acceptability to be provided by OEM
  - VMAD experts discussion including SG2a activities

UTAC meeting with European Commission
Action Plan: AEBS & ALKS virtual test validation & type approval

FR proposal for presentation to GRVA IWGs VMAD

- Virtual test validation method presentation (based on the current slides)
  - Information sharing, experts discussions and contracting parties feedbacks
  - Proposal for next steps to introduce such approach as virtual testing alternative for AEBS M1-N1 with longitudinal application only
  - Proposal for next steps to detail such approach for virtual testing in ALKS audit/assessment annex with longitudinal application only

Cut in

Cut out

Stationary obstacle/car/VRU

Following & Braking car/PTW

Lane keeping