SCIENCE
PASSION
TECHNOLOGY

Workshop on Virtual Crash Testing

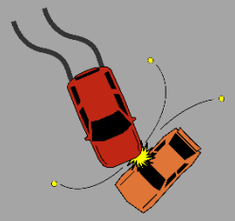
Informal Working Group on Equitable Occupant Protection

EqOP IWG

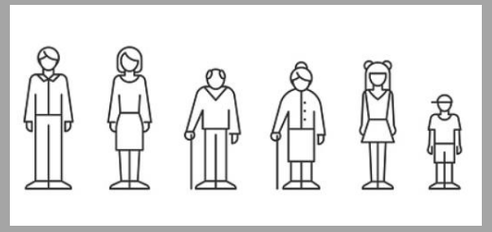
22.11.2023

EqOP Approach

0.) Field data study



Identify which loading scenarios in the field cause <u>significant differences in injury risks for different groups of the population</u> and review how those are currently assessed in regulations



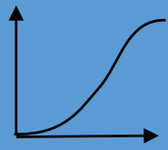
- gender
- age
- body height
- BMI

1.) Use available tools (already currently used in regulations) to address problems identified in 0.)

Change wordings in regulations

Change requirements in regulation with available tools:

a) Change what is required / voluntary?

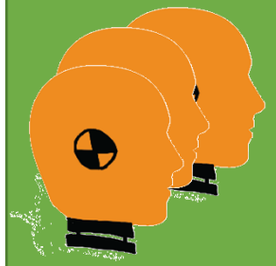


b) Change injury criteria

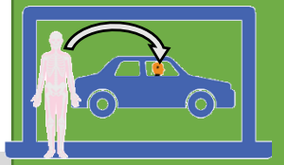
c) Change test conditions (speed, barrier, angle...)

2.) Use alternative test tools to address problems identified in 0.)

Which injury mechanisms can be predicted additionally compared to currently available tools, where problem in the field are observed?



Which alternative physical test tools are suitable for this?



What can be simulated what currently can‘t be tested?

Aim of the workshop

- Which benefits of virtual crash testing can be used to overcome equity issues?
- How could we implement it?
  - Which barriers do we have to overcome to enable virtual crash testing in regulations?
  - How can we address them?
  - What can we learn from other disciplines?
  - What would be required to make it happen?

Not in the scope:

- Discussion of tools and related specific requirements

Expected results

- Definition of next steps (how can do what and who else should we approach; plan for further workshops)

- Conclusions
  - Report to the rest of EqOP (22nd of November) & GRSP (4th – 8th December)

Around the table presentations on the current activites

- What can you contribute to the workshop?
  - Motivation for virtual testing from BASt
  - Presentation of Euro NCAP on Virtual testing in consumer information testing at Euro NCAP
  - Presentation of IIHS on their plans for Virtual testing
  - Presentation on current status of Virtual Testing in regulations by TÜV-SGS
  - Presentation on current procedure on validation of vehicle models for regulations by Spain
  - Presentation of secretary of IWG DPPS on VT
  - Presentation on validation requirements for vehicle models from BASt
  - Presentation on validation of vehicle models from Autoliv

What is the motivation for virtual testing? Which benefits of virtual testing can be used to overcome equity issues?

- More robust evaluation considering human diversity & different loadcases
- Possibility to use HBMs instead of ATDs (diversity, biofidelity)
  - Applicability in new load cases (e.g. reclined, integrated systems (before t0))
- Cost Benefit ratio (needs to be evaluated)
- Sustainability (needs to be evaluated)

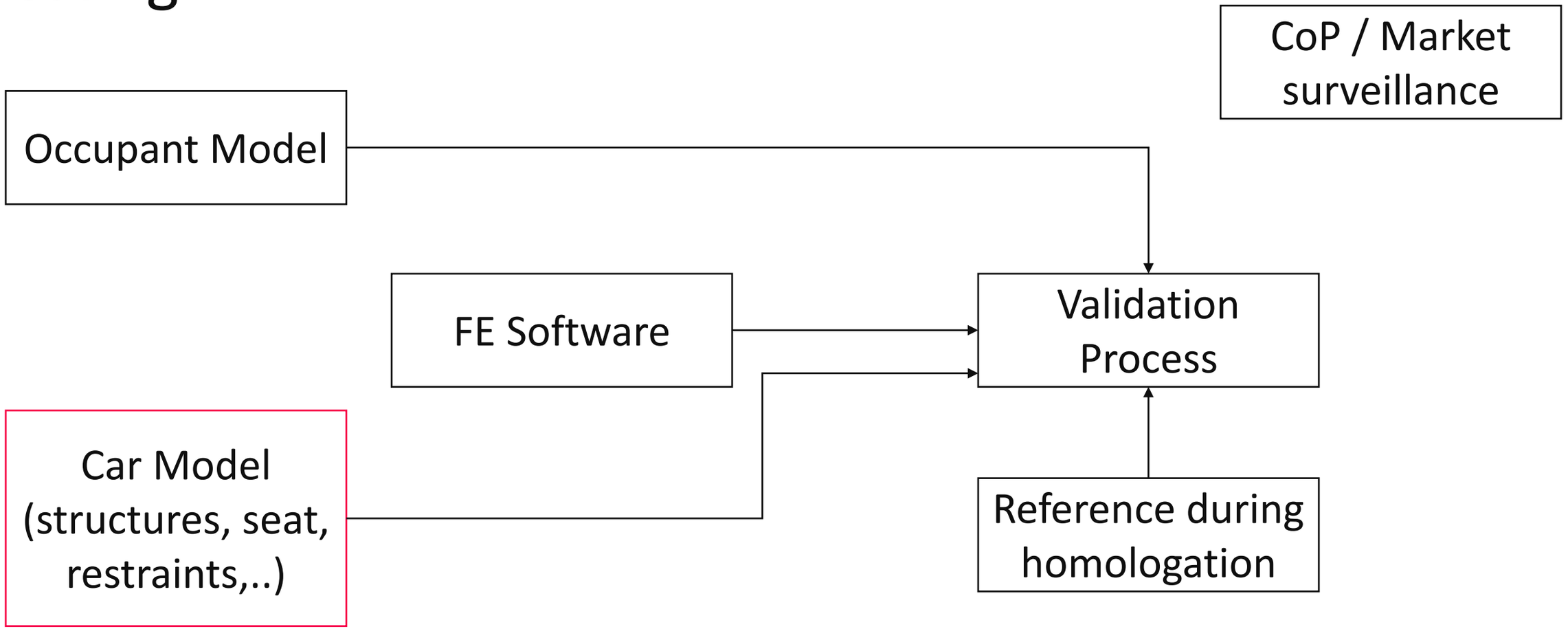
In which areas can we find barriers for the introduction of virtual crash testing into regulations?

- In consumer information currently very interactive process
- Traceability - same results in 5 years
- access to the models: IP protection vs. transparent evaluation

What can we learn from other disciplines?

- Virtual testing for worst cases
- Virtual testing for approval
- Reference physical tests to compare with (and for market surveillance)
  - Full-scale vs. component tests
- References simulations / “gold standards” to compare with

Building blocks for Virtual Crash (Occupant Protection) Testing



Breakout Sessions

1. In which areas can we find barriers and opportunities for the introduction of virtual crash testing into regulations?
2. What are possible solutions to overcome the barriers?
3. How can we develop **trust** in virtual testing for regulations?
4. How could virtual testing fit in regulatory frameworks and processes for type approval?

Joint discussion: What is needed as next steps to reach our EqOP goals when it comes to virtual crash testing?

Opportunities:

- Cover more scenarios (autnomous driving, diversity, position, posture)
- Potential speedup (after initial investment)
- More robustness
- Reduce physical tests
- New opportunities
  - Substitute design requirement with performance requirement (e.g. for seatbelt)

Barriers

- Not everyone has the same resources
- New standards / references needed
- New standardised procedure (e.g. positioning for currently not considered statures)
- Software updates (needs to be controlled)→ how does this affect CoP?
- Complexity of design / load cases
- Variability / scatter if outputs
- Intellectual Property
- Bounds for extrapolation
- Knowledge in FE outside of industry
- Storage of Data
- Missing validation tools / standardised process

How can we gain trust in simulation based assessments?

- Hierarchical validation (standardised procedures)
- Quality management frameworks (methods remain comparable to each other; even 5-10 years after initial validation process)
  - → for software, models and persons running simulations
- Physical testing (randomly selected)
- Design of experiments
  - large number of simulations cost time and money; should be chosen wisely
  - What makes a difference in the real world?
  - Be smart what is simulated and what is tested? (tests during validation / homologation and within conformity of production)
- Define what are the limits of the model
- Virtual tests with dummies
- Standardised processes (ISO Group?)
- HBM – qualification requirements are needed
- Multi-step approach
- Traceability tools
- Use common language
- Quality checks
- Technical service runs simulations with encrypted model (with specific tool to configure VT loadcases)

How can we overome barriers?

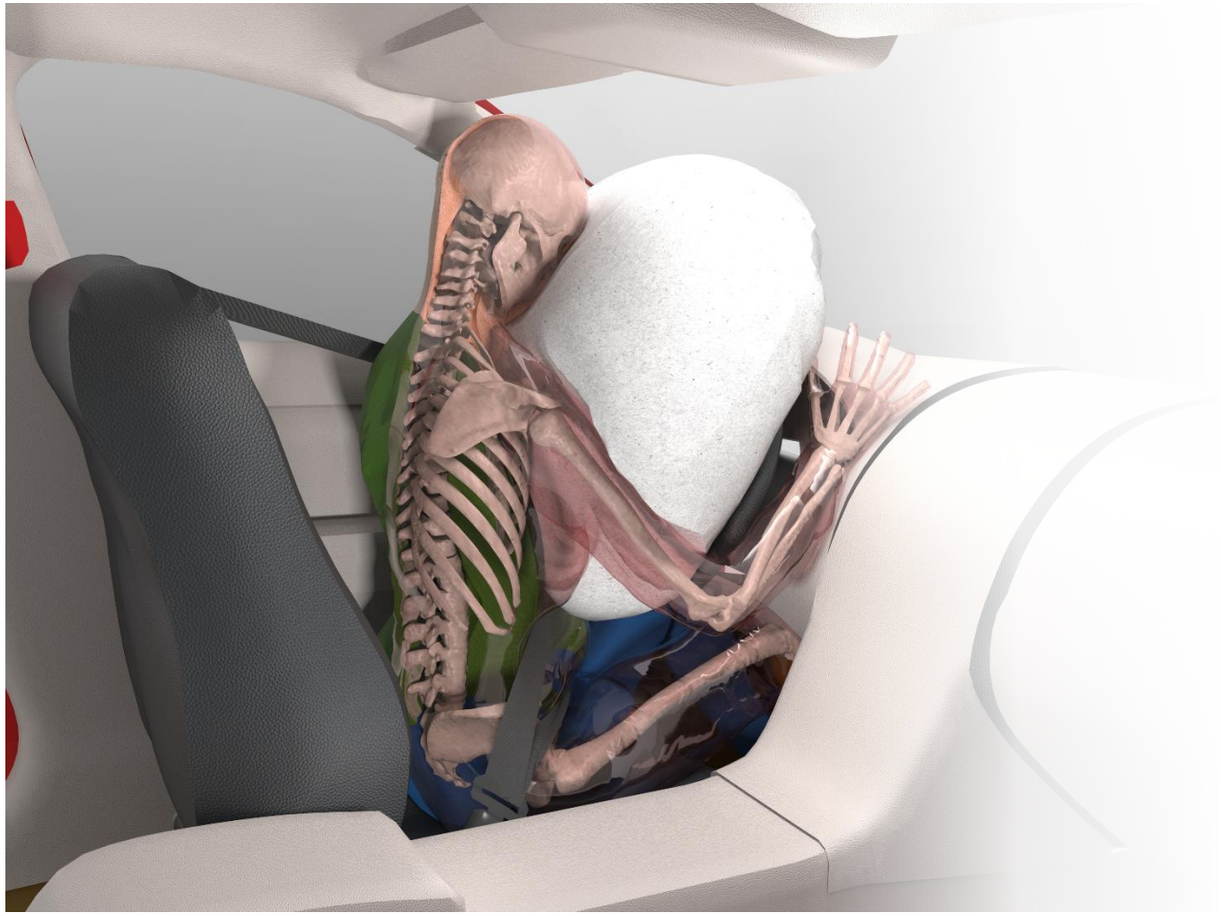
- Small and smart steps
- Get feedback during the development work
- Use of virtual twins (occupant) for new requirements
- For HBM- either open source (traceability?) or „locked“ reference model
- COP – only physical test might be necessary, clear requirements for data and results necessary, quality checks necessary
- Growing trust from existing VT
- Leveraging existing component testing
- Open Source assessment tools (accessible for free for everyone)
- Prioritise and limit components that need validation
- Define hardware scatter and realistic accuracy targets (consider test scatter)
- Develop validation tools for a range of occupant sizes

How could process work?

- Clear requirements for occupant models (reference model made available by UNECE?)
- Clear requirements on validation of vehicle (component & full scale)
- Clear requirements on outputs which need to be provided
- Check of validation tests (randomly selected from matrix) → CoP
- Begin with small variation on existing occupant tests
- Extension of type approval variants on the same vehicle
- Begin with simple regulatory tests

Next steps?

1. Define wording / glossary
2. Sketch General Process
3. Definition of loadcases
4. Requirements for occupant simulation models (ATDs & HBM)
5. Requirements for vehicle model validation (Standards)
6. Processes to combine occupant and vehicle model to a simulation loadcase/scenario
7. Requirements for FE Software
   a. Process for traceability of model changes and linked results
   b. Process for running models at technical service
8. Requirements for outputs / documentation
9. Collaborations with other groups / experts?
   - Forum i.e. as policy lab
   - Cyber security
   - GRVA (e.g. R157)
   - SAR (specific absorption rate)
   - WP6 (Standardisation…)
   - Ask SAE to organise a workshop to better link with other disciplines?



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UN R 13 Uniform provisions concerning the approval of vehicles of categories M, N and O with regard to braking

2.1.3. The vehicle stability function shall be demonstrated to the Technical Service by dynamic manoeuvres on one vehicle which has the same vehicle stability function as the vehicle type to be approved. This may be realised by a comparison of results obtained with the vehicle stability function enabled and disabled for a given load condition. As an alternative to carrying-out dynamic manoeuvres for other vehicles and other load conditions, fitted with the same vehicle stability system, **the results from actual vehicle tests or computer simulations may be submitted. The use of the simulator is defined in Appendix 1 to this annex. The specification and validation of the simulator is defined in Appendix 2 to this annex.**

Appendix 1:

1. USE OF THE SIMULATION

1.1. The vehicle stability function shall be demonstrated by the vehicle manufacturer to the Type Approval Authority or Technical Service with the same dynamic manoeuvre(s) as for the practical demonstration in paragraph 2.1.3 or 2.2.3 of this annex.

1.2. The simulation shall be a means whereby the vehicle stability performance may be demonstrated with the vehicle stability function enabled or disabled, and in the laden and unladen conditions.

1.3. The simulations shall be carried out with a validated modelling and simulation tool. The simulation tool shall only be used when each relevant parameter of the vehicle to be type-approved, as listed in paragraph 1.1 of Appendix 2 to this annex, is included in the simulation tool and when the value of each parameter falls within its respective validated range. The verification shall be carried out using the same manoeuvre(s) as defined in paragraph 1.1 of this appendix this annex.

The method by which the simulation tool is validated is given in Appendix 2 to this annex.

1.3.1. A vehicle manufacturer using a validated simulation tool that was not directly validated by themselves for a vehicle type-approval shall carry out at least one confirmation test.

This confirmation test shall be conducted in conjunction with a Technical Service and shall be a comparison between an actual vehicle test and a simulation using one of the manoeuvres as defined in paragraph 1.1 of this appendix.

The confirmation test shall be repeated in the event of any change to the simulation tool (1).

The results of the confirmation test shall be attached to the type-approval documentation.

1.4. **The availability of the simulation tool software, to the software version used, shall be maintained for a period of not less than 10 years following the date of the approval of the vehicle.**

(1) The necessity of a confirmation test shall be subject to a discussion between the vehicle manufacturer, the Technical Service and the Type Approval Authority.

Appendix 2:

1. SPECIFICATION OF THE SIMULATION TOOL

1.1. The simulation tool shall take into account the main factors which influence the directional and roll motion of the vehicle.

1.1.1. The simulation tool shall take into account the following vehicle parameters as applicable (1):

1.1.2. The simulation model shall include at least the following parameters as applicable (1):

2. VALIDATION OF THE SIMULATION TOOL

2.1. The validity of the applied modelling and simulation tool shall be verified by means of comparisons with a practical vehicle test(s). The test(s) utilised for the validation shall be those which, without control action, would result in loss of directional control (under-steer and over-steer) and/or roll-over control as appropriate to the functionality of the stability control function installed on a vehicle.

During the test(s) the following motion variables, as appropriate, shall be recorded …

2.2. The objective is to show that the simulated vehicle behaviour and operation of the vehicle stability function is comparable with that seen in practical vehicle tests.

The ability of the simulation tool to be used with parameters that have not been validated by a practical vehicle test shall be shown by conducting simulations with varied parameter values. The results of these simulations shall be checked to be logical and similar in comparison to the results of known practical vehicle tests.

2.3. The simulation tool shall be deemed to be validated when its output is comparable to the practical test results produced by the same vehicle(s) during the manoeuvre(s) selected from those defined with paragraph 2.1.3 or 2.2.3 of this annex, as appropriate.

The simulation tool shall only be used with regard to features for which a comparison has been made between real vehicle tests and simulation tool results. The comparisons shall be carried-out in the laden and unladen condition to show the different conditions of load can be adapted to and to confirm the extreme parameters to be simulated, e.g.: […]

2.4. The physical parameters that are different between the reference vehicle and simulated vehicle configurations shall be modified accordingly in the simulation.

2.5. A simulation tool test report shall be produced, a model of which is defined in Appendix 3 to this annex, and a copy attached to the vehicle approval report.

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Vehicle stability function simulation tool test report

Appendix 3

Vehicle stability function simulation tool test report

Test report number: …

1. Identification
1.1. Name and address of the simulation tool manufacturer
1.2. Simulation tool identification: name/model/number (hardware and software)

2. Simulation tool
2.1. Simulation method (general description, taking into account the requirements of paragraph 1.1 of Appendix 2 to this annex)
2.2. Hardware/software in the loop (see paragraph 1.2 of Appendix 2 to this annex)
2.3. Vehicle loading conditions (see paragraph 1.4 of Appendix 2 to this annex)
2.4. Validation (see paragraph 2 of Appendix 2 to this annex)
2.5. Motion variables (see paragraph 2.1 of Appendix 2 to this annex)

3. Scope of application:
3.1. Vehicle category:
[…]
3.24. Loading:
3.25. Limiting factors:
3.26. Manoeuvre(s) for which the simulation tool has been validated:

4. Verifying vehicle test(s)
4.1. Description of vehicle(s) including the towing vehicle in case of trailer testing:
[…]
4.2. Description of test(s) including location(s), road/test area surface conditions, temperature and date(s):
4.3. Results laden and unladen with the vehicle stability function switched on and off, including the motion variables referred to in paragraph 2.1 of Appendix 2 to this annex, as appropriate:

5. Simulation results

5.1. Vehicle parameters and the values used in the simulation that are not taken from the actual test vehicle (implicit):
5.2. Results laden and unladen with the vehicle stability function switched on and off for each test conducted under paragraph 4.2 of this appendix, including the motion variables referred to in paragraph 2.1 of Appendix 2 to this annex, as appropriate:

6. Concluding statement
The simulated vehicle behaviour and operation of the vehicle stability function is comparable with that of practical vehicle tests.
Yes/No

7. Limiting factors
This test has been carried out and the results reported in accordance with Appendix 2 to Annex 21 to Regulation No 13 as last amended by the …series of Amendments.

Technical Service conducting the test (1)

Signed: …Date: …

Type Approval Authority (1)

(1) To be signed by different persons if the Technical Service and the Type Approval Authority are the same organisation.

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A42016X0218%2801%29&qid=1700472162492

EU Regulations - Emissions

4.6. For RDE tests performed during type approval the TAA may verify if the test setup and the equipment used fulfills the requirements of Appendices 1 and 2, through a direct inspection or an analysis of the supporting evidence (e.g. photographs, records).

4.7. **Compliance of the software tool used to verify the trip validity and calculate emissions in accordance with the provisions laid down in Appendices 4, 5, 6, 7a, and 7b shall be validated by the tool provider or a type approval authority.** Where such software tool is incorporated in the PEMS instrument, **proof of the validation shall be provided along with the instrument**.';

Commission Regulation (EU) 2018/1832 of 5 November 2018 amending Directive 2007/46/EC of the European Parliament and of the Council, Commission Regulation (EC) No 692/2008 and Commission Regulation (EU) 2017/1151 for the purpose of improving the emission type approval tests and procedures for light passenger and commercial vehicles, including those for in-service conformity and real-driving emissions and introducing devices for monitoring the consumption of fuel and electric energy (Text with EEA relevance.) C/2018/6984