PROSPECTIVE EFFECTIVENESS ASSESSMENT FOR ROAD SAFETY (P.E.A.R.S.)

Overview

P.E.A.R.S. Consortium

UNECE VMAD Sub Group 2 Virtual Testing, 24th Feb. 2021

Structure

1. The P.E.A.R.S. Consortium
2. Content of Working Groups
3. Round Robin Simulation
4. Lessons Learned from P.E.A.R.S.

The P.E.A.R.S. Consortium

Prospective
Effectiveness
Assessment of
Road
Safety

Who we are:

- Open consortium of automotive industry, research institutes and academia
- Established in 2012

Our overall goals are:

- Harmonise the prospective effectiveness assessment of active safety systems by simulation.
- Encourage discussions on the safety performance assessment approaches by means of simulation.

The P.E.A.R.S. Initiative - Partners

BMW GROUP, TOYOTA, VOLKSWAGEN AKTIENGESELLSCHAFT, VOLVO

Continental, DENSO Crafting the Core, ZF, ASTech Automotive Safety Technologies, bast

VUFO GmbH, TÜV SÜD Auto Service, UTAC CERAM, TNO innovation for life, LAB

Allianz Center for Technology, GENERALI jenIOT, Swiss Re, virtual vehicle, TU Graz

ika Institut für Kraftfahrzeuge RWTH Aachen University, Technische Universität Berlin, University of Leeds, Technische Hochschule Ingolstadt, Fraunhofer IPK Institute Production Systems and Design Technology

Fraunhofer IVI, Technische Universität Dresden

Working Groups

	Theoretic Layer	Practical Layer
Effectiveness Calculation oriented	WG A “Methods, models and effectiveness calculation”	WG B “Round-robin simulation & hand-on experiences”
Supporting Processes oriented	WG C “Input Data and Validation & Verification”	WG D “ISO & external communication”

P.E.A.R.S. deals with the virtual assessment of technology’s safety performance prior to its market introduction.

Standardization Efforts

- Input of P.E.A.R.S. is used in ISO TC 22/SC 36/WG 7 to prepare related documents:

- ISO/TR 21934-1:2021: Road vehicles — Prospective safety performance assessment of pre-crash technology by virtual simulation — Part 1: State-of-the-art and general method overview
  - In publication process.
- ISO/TS 21934-2:20XX: Road vehicles — Prospective safety performance assessment of pre-crash technology by virtual simulation — Part 2: Guidelines for application
  - First draft under preparation.

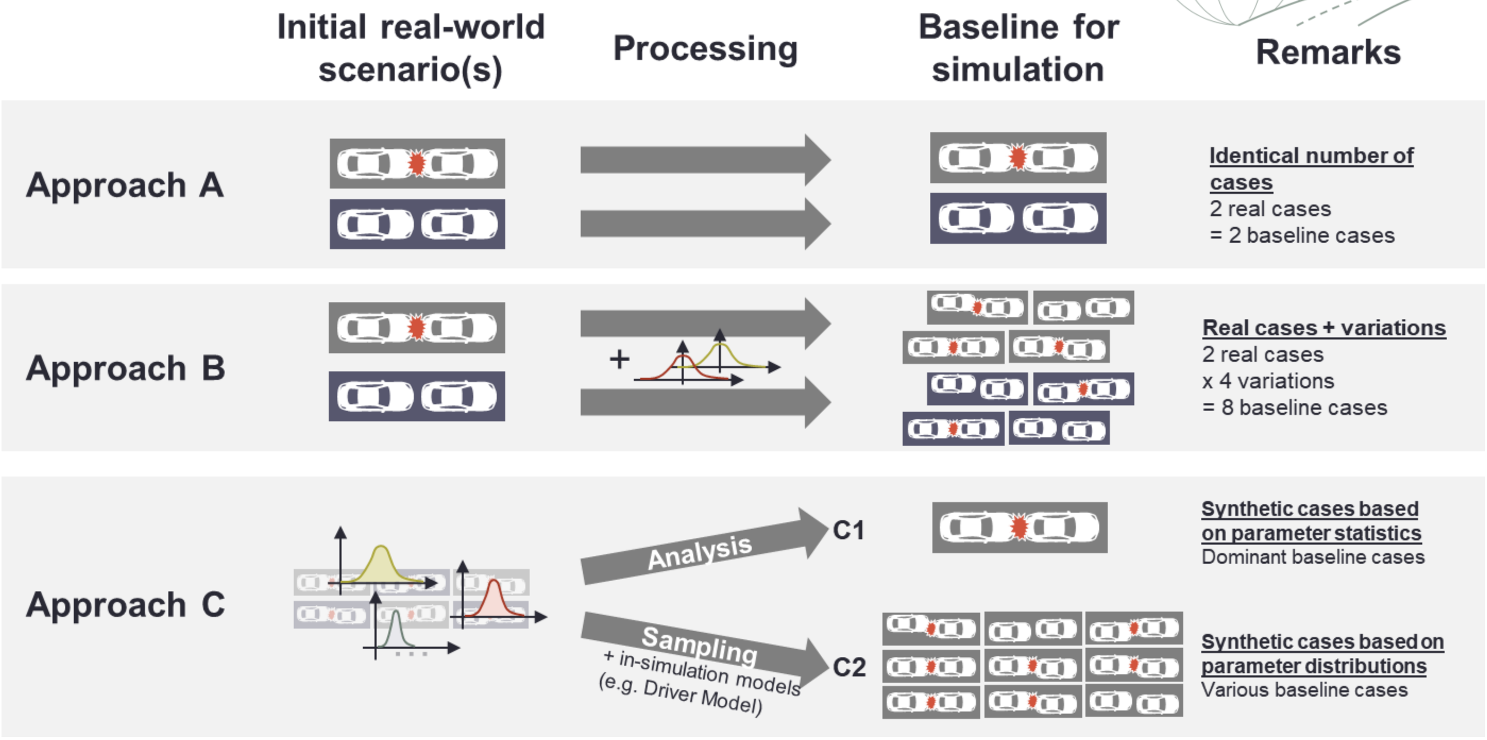
Outcome of P.E.A.R.S. fed into the ISO standardization process.

Evaluation Scope

- An evaluation objective for a study of a prospective safety performance assessment consists of three elements:
  - 1. Definition of a precise research question and the target of the study
    - technology, (incl. penetration rate), scenario and metric;
    - considered (environmental, infrastructure etc.) limitations;
    - considered region and time horizon of the projection;
    - envisioned level of confidence in relation to the objective of the research question.
  - 2. Identification of relevant scenario categories
  - 3. Definition of evaluation metrics to be applied, e.g. % crashes avoided or occupant fatal injury reduction

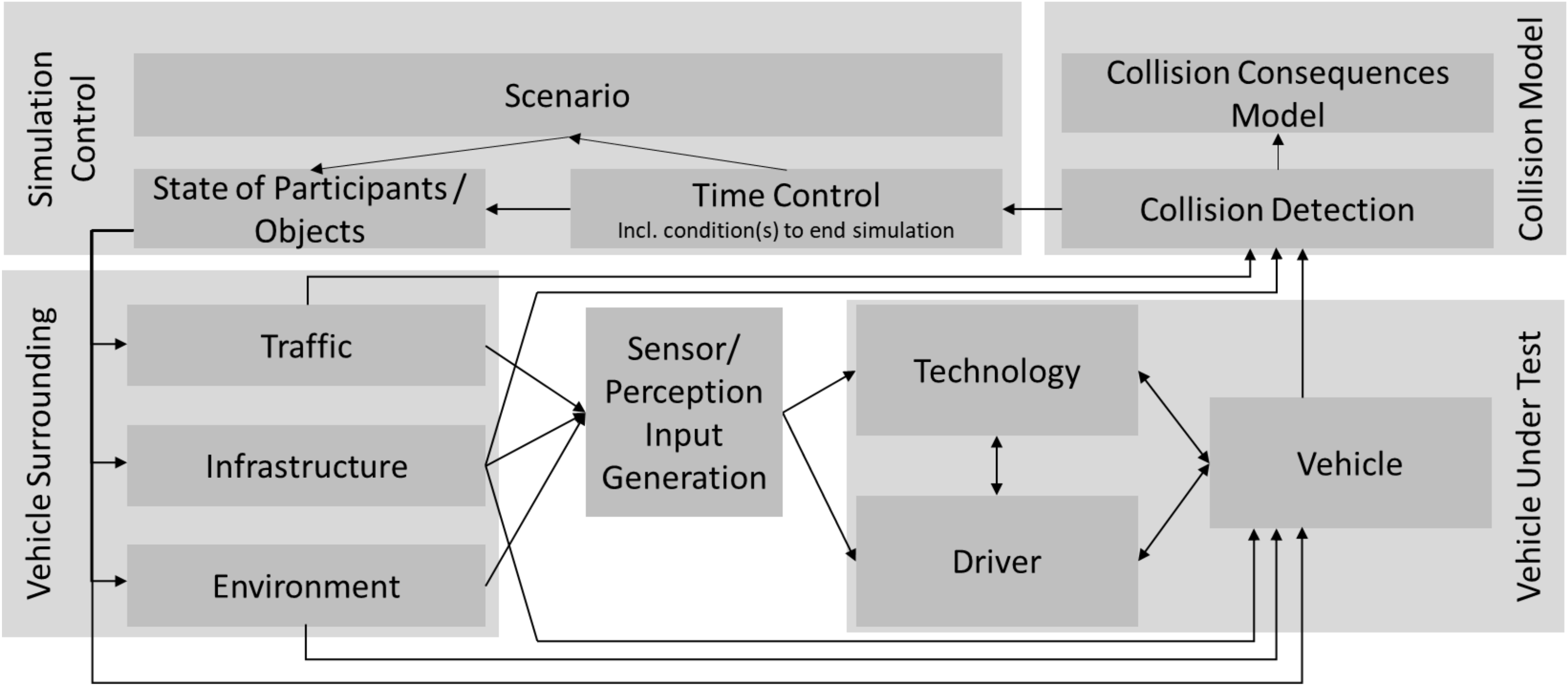
The evaluation scope defines all following steps of the virtual assessment.

Baseline Approaches



P.E.A.R.S. defined four baseline approaches for the safety performance assessment.

Virtual Simulation Framework



The generic simulation framework contains all possibly required models.

Validation and Verification

- Focus is on V&V of the method and the applied models.
- V&V must cover the entire method as well as relevant (sub-)modules.
- Independent of the reason, change(s) in the simulation tool, method or models shall be evaluated with respect to its implications on the outcome. Depending on this V&V needs to be repeated.
- V&V approach is defined per model (see →).

Simulation Model (see clause Fehler! Verweisquelle konnte nicht gefunden werden.**)**	**Validation and Verification Approach**	**Example (VRU AEB – same example as clause in clause** Fehler! Verweisquelle konnte nicht gefunden werden.**)**
Vehicle under Test - Vehicle Model	• Comparison of real-world test on a test track with output of simulation. Tested maneuvers on the track should be open loop (not considering the driver; e.g. using a driving robot) maneuvers. In this context rating approach as described in ISO/TR 16250:2013 and ISO/TS 18571:2014 can be applied. • Sensitivity analysis to ensure a stable model. Depending on the scenario different vehicle models can be applied. This need also be considered in the V & V. In general, vehicle model verification should follow a step by step process, starting from slow, longitudinal maneuvers and increasing vehicle speed and maneuver complexity (especially involving high speed lateral maneuvers, such as evasive steering). Comment: In case a validated model is updated for a different vehicle model spot testing might be sufficient.	Comparison of deceleration behavior of simulation model vs. real vehicle. For this test with the real on test track. In the simulation apply the same brake pedal position and check for the braking distance in both conditions.
Vehicle under Test - Technology Model (incl. sensor, logic & control and actuator)	• Review of implemented code versus specification; • Test of simulation output against the expectation based on the specification; • Black-box test, where tests on a test track are performed and the same tests are conducted in the simulation considering the same input data. Comment 1: Combination of the different approaches is also feasible. Comment 2: The described approaches apply also to the sub-models of the technology.	Compare the TTC of the warning and the TTC at the start of braking as well as the requested deceleration over time of the system for the simulated model as well as for the real function based on test on a test track.

V&V at different levels shall be an essential element of virtual assessment.

Round Robin

"Which aspects in simulation cause differences in simulation results (due to the used tool) and need further harmonization?"

- Identify and evaluate sources of variation in virtual pre-crash simulations
- Suggest topics for harmonization.
- Increase comparability (when using different tools) and trustworthiness of virtual simulation based prospective effectiveness assessment.
- Round Robin study considers only SIL-simulation.

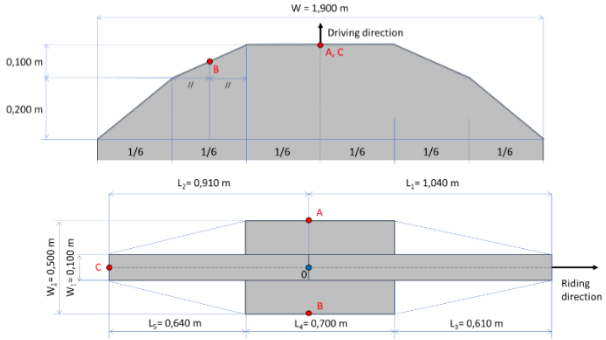
Aim of Round Robin study is to enable a comparison of tools.

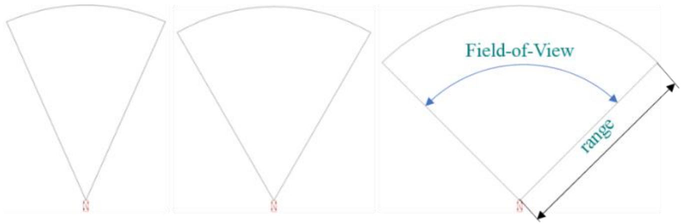
Round Robin – Setup & Specification

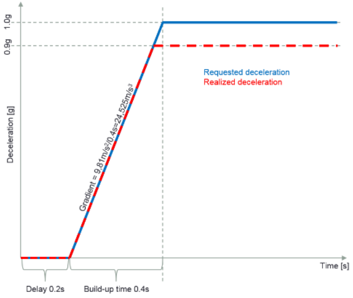
- 34 test cases from the CATS project
- Geometries of car and cyclist
- 3 safety system configurations (ideal sensor, generic algorithm, actuator)

→102 simulation configurations

	CVNB	CVNBO	CVFB	CVLB
Vehicle speed	20 – 60 km/h	10 – 40 km/h	20 – 60 km/h	20 – 60 km/h
Cyclist speed	15 km/h	10 km/h	20 km/h	15 km/h
Obstruction	Without	With D1=3.55m, D2=4.80m	Without	Without
Hitpoint	50 %	50 %	25 %	50%
Layout sketch				

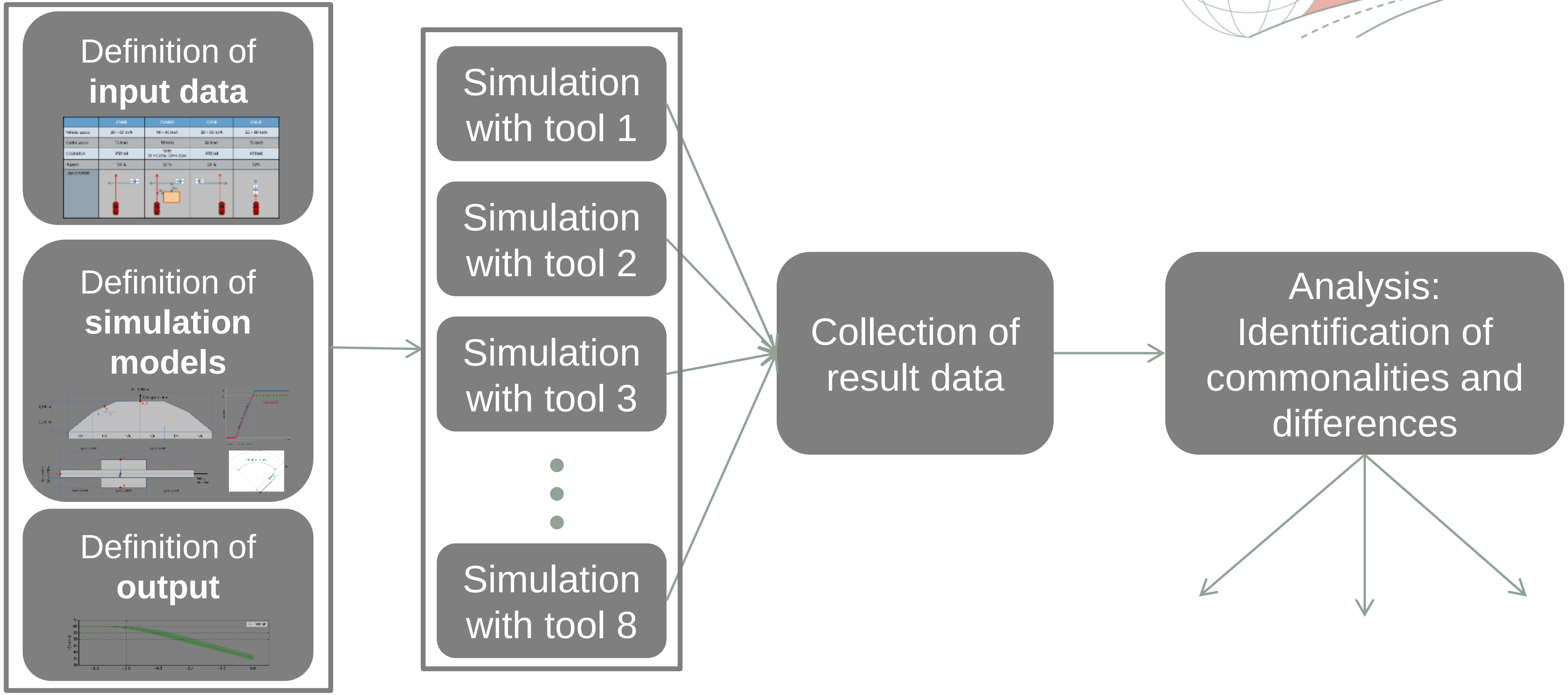






For a comparison in defined test cases, a precise definition of the setting is required.

Round Robin – Approach



Assessment by different simulation tools in the same conditions (e. g. CATS scenarios).

Round Robin – Analysis

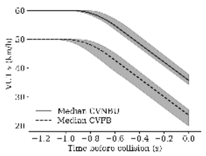
Analysis: Identification of commonalities and differences

Discrete Values Analysis (all 102 simulation configurations)

- Detection rate
- Firing rate
- Avoidance rate
- Average speed reduction

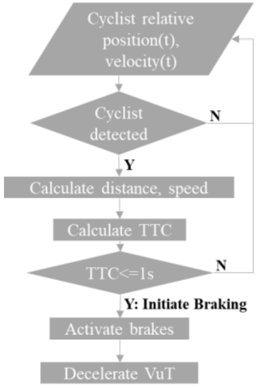
Time-Evolution Based Analysis (two simulation configurations)

- Positions
- Speeds
- Acceleration
- Distance
- TTC



Flow-of-Actions-Based Analysis (two simulation configurations)

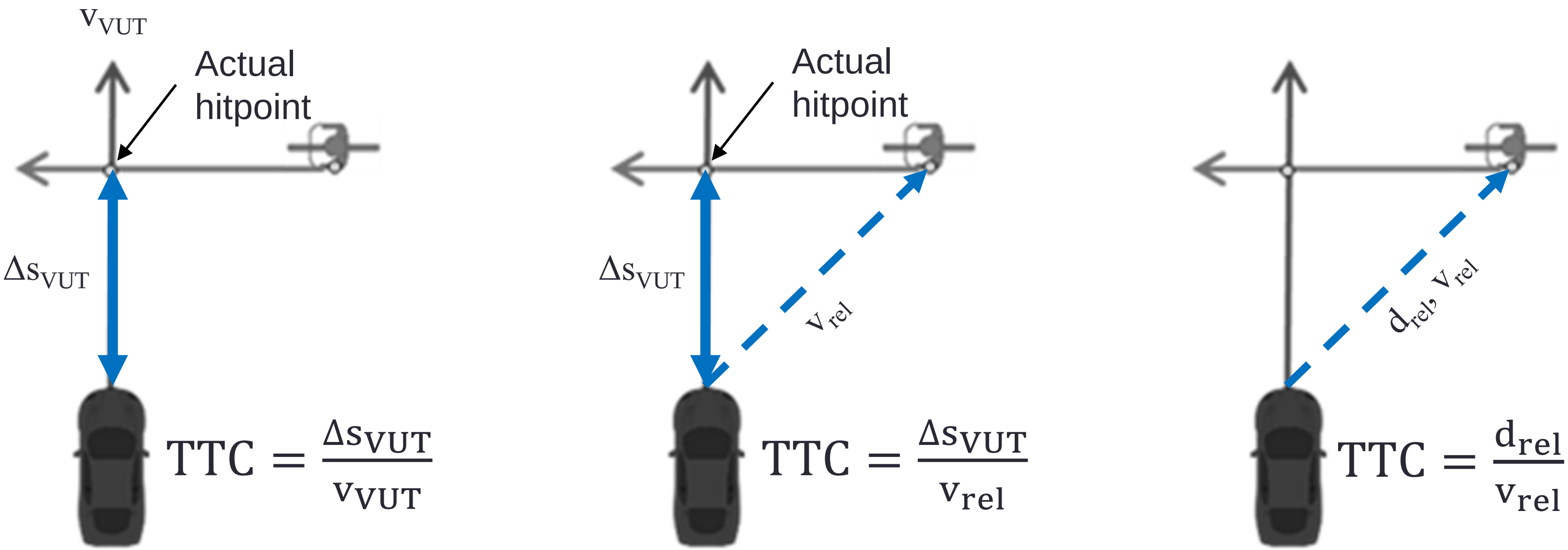
- Distance, speed calculation
- TTC calculation
- Brake initiation and activation
- Deceleration behaviour



Define reasonable metrics for the assessment. Here, the purpose is comparison.

Results – Which issues can occur?

→TTC influences braking initiation and thus avoidance / collision speed



Further examples: a) collision detection b) complex shapes c) hit location

Even aspects that might appear clear and obvious need to be clearly defined.

Lessons Learned from P.E.A.R.S.

- The evaluation scope (research question) needs to be carefully and precisely defined, since every further step depends on it (requirements for models, baseline approach etc.).
- For the safety assessment P.E.A.R.S. defines 4 baseline approaches.
- There is no unique way for the safety performance assessment / SIL-simulation, there are always different solutions.
- For the comparison of simulation tools, “the rules of the game” (i.e. metrics, minimum simulation tool requirements and evaluation procedures) need to be defined (Full paper: https://www.tandfonline.com/doi/full/10.1080/15389588.2019.1616086?scroll=top&needAccess=true).
- A comprehensive validation and verification (incl. quality of input data) approach is important.

Many thanks for your attention!

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