VECTOR

Automated NCAP tests with ASAM OpenSCENARIO

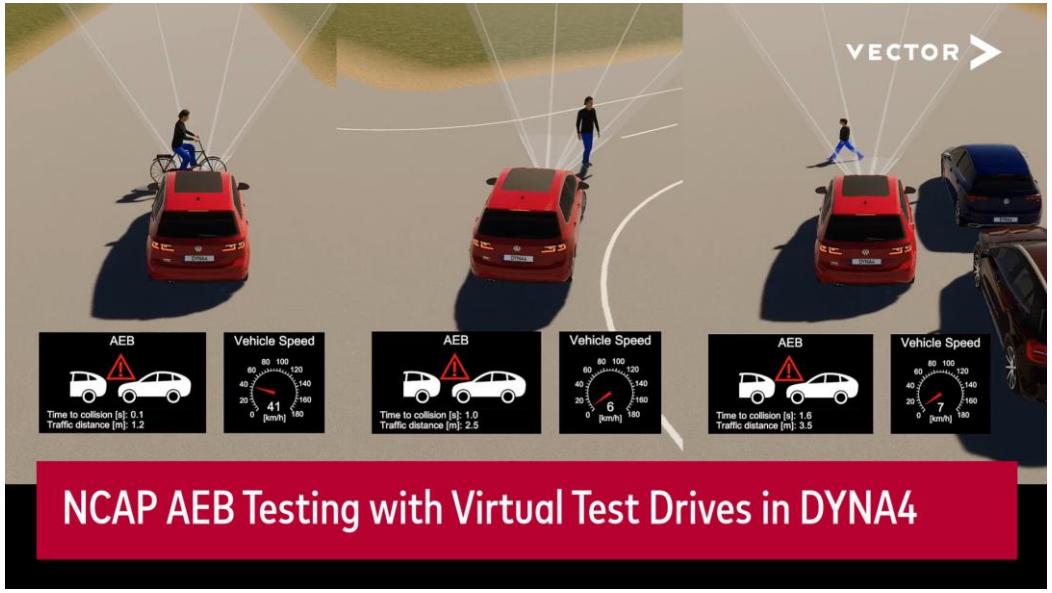
OpenSCENARIO as a Basis for Full Re-Usability

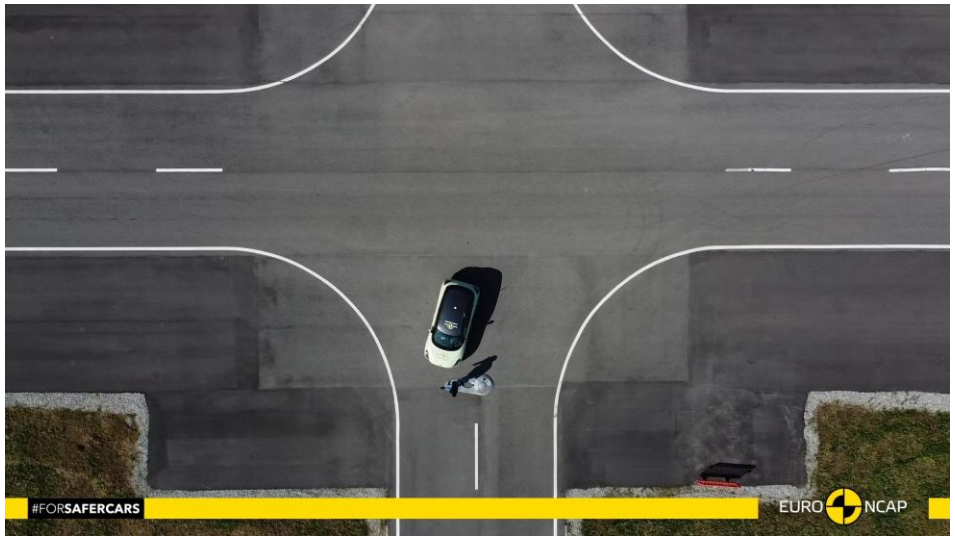
V1.1 | 2023-07-01

Shift-left Testing with Virtual Test Drives

NCAP AEB Tests

- Synchronized collision scenarios with Vulnerable Road User (VRU) or Cars (C2C)
- Based on expert knowledge
- Well-defined and well-accepted
- Probably available in a multitude of proprietary implementations





source: https://euroncap.newsmarket.com/

How suitable are the ASAM OpenX Standards for NCAP Tests?

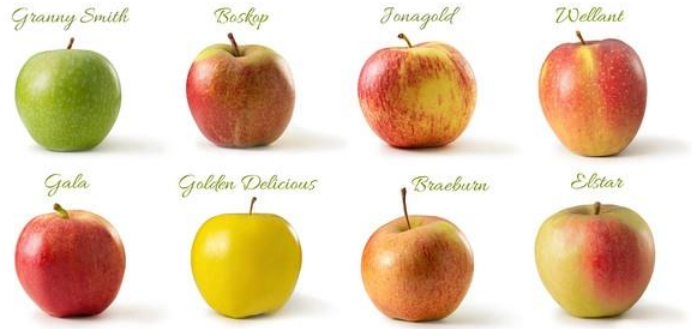
Or more specifically, can we…

? … avoid proprietary **pre-processing** of simulation input data?

? … use OpenSCENARIO XML logical scenario features for the NCAP **parameter variations**?

? … re-use the scenario descriptions and the post-processing of the simulation results from **MIL over SIL to HIL?**

source: https://www.gefu.com/



source: https://www.br.de/

source: https://www.possmann-shop.de/

What is a Scenario?

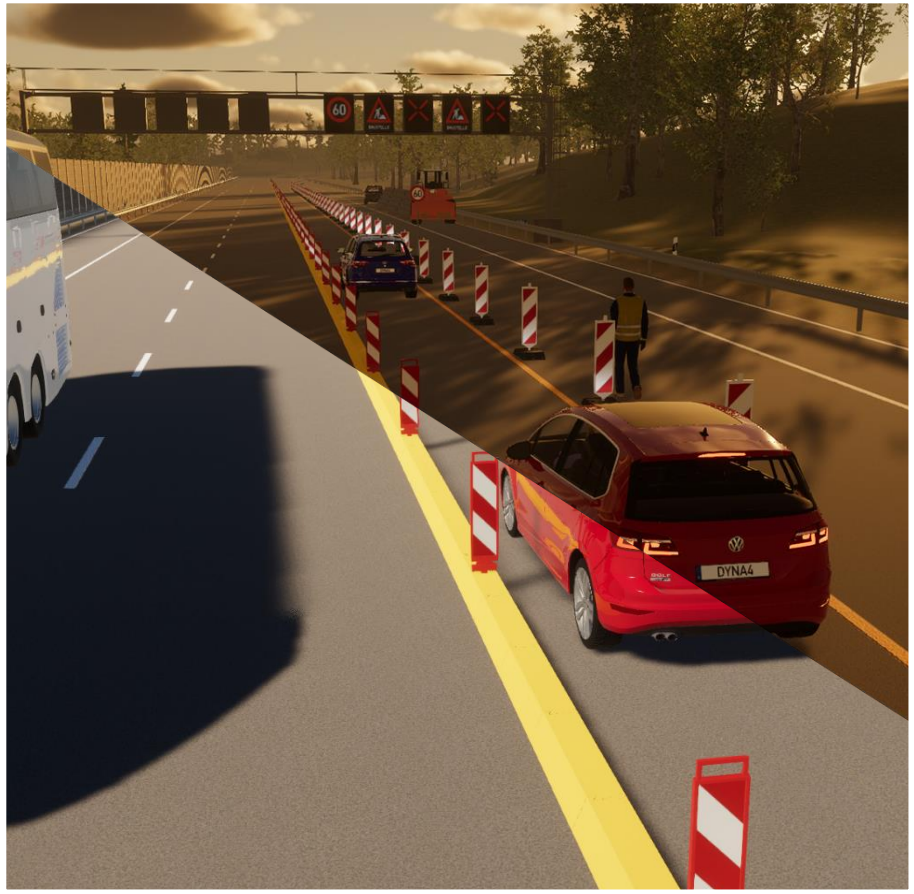
„ A scenario is a description of how the view of the world changes with time, [...] this encompasses [...] both

- **world-fixed (static)** elements such as the road layout and road furniture

  OpenDRIVE

- **world-changing (dynamic)** elements such as weather and lighting , vehicles, objects, people, and traffic light states. "

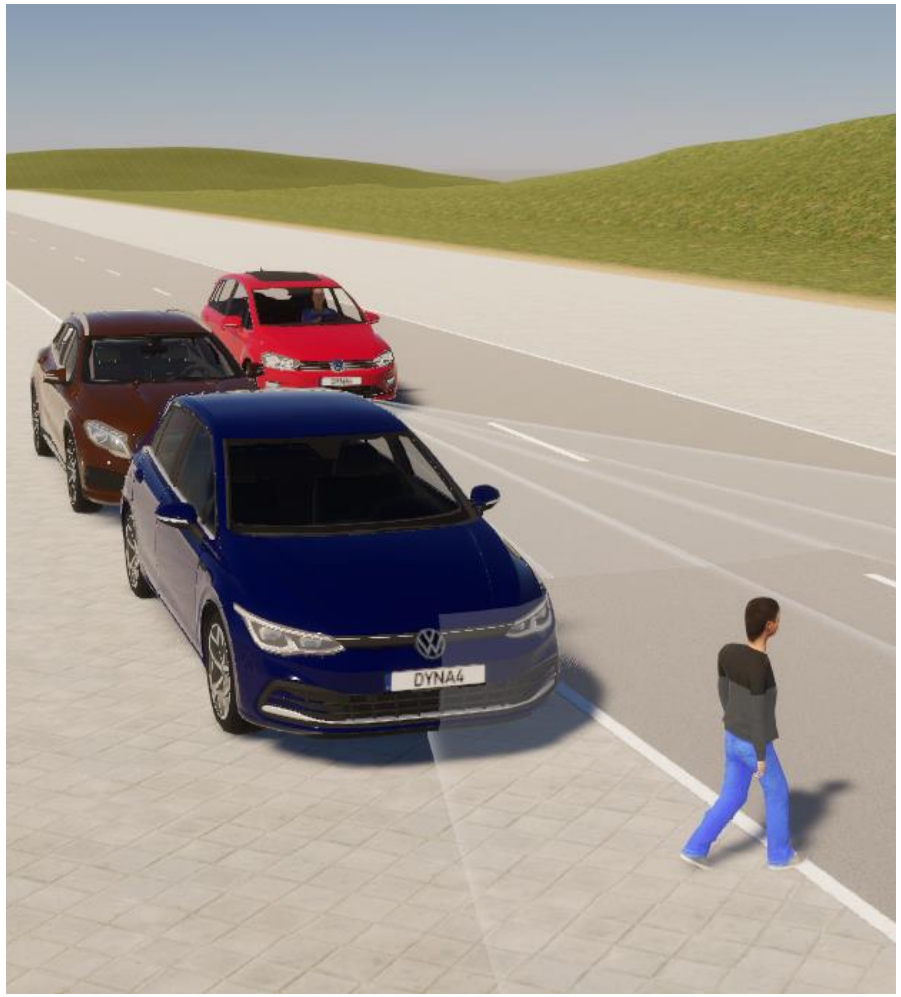
  OpenSCENARIO



source: ASAM OpenSCENARIO XML 1.3 User Guide

What is OpenSCENARIO XML?

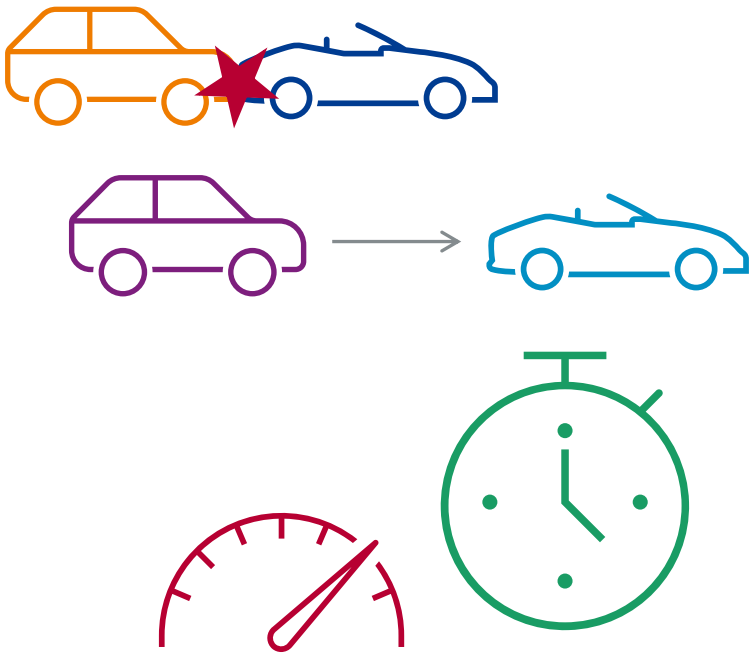
- Standard by ASAM e.V. capable of describing **complex maneuvers** that involve multiple entities using XML
- Hierarchical **Storyboard**
  - **Actions** to describe the desired behavior of Entities
    - **driver-related** Actions like lane or speed changes, or
    - **prescribed behavior** such as recorded trajectories, and
    - **environment- and infrastructure-related** Actions such as traffic light states, precipitation or cloudiness

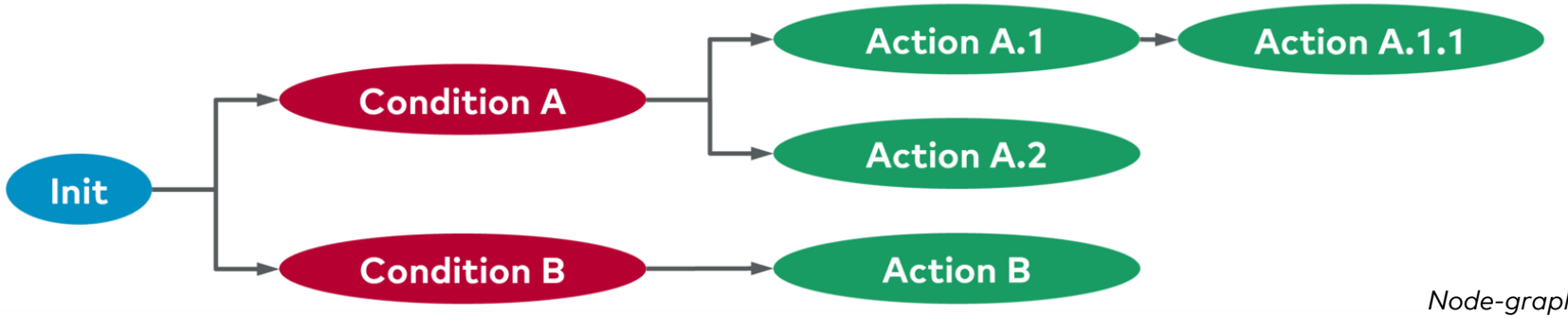


Synchronize Action for reproducible collision in NCAP CPNCO Scenario

What is OpenSCENARIO XML?

- Standard by ASAM e.V. capable of describing **complex maneuvers** that involve multiple vehicles using XML
- Hierarchical **Storyboard**
  - **Actions** to describe the desired behavior of Entities
  - **Conditions** trigger the Actions and together form an **Event**
    - **entity-related** Conditions, e.g. to react on a certain position of an Entity
    - **value-related** Conditions, e.g. to react based on the simulation time or the state of a Storyboard element like the end of an Action





Node-graph representation of Scenario definition

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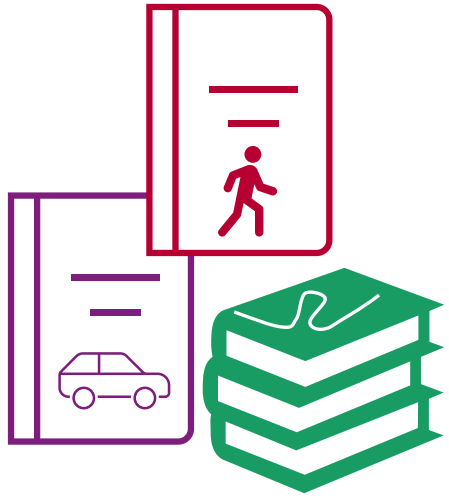
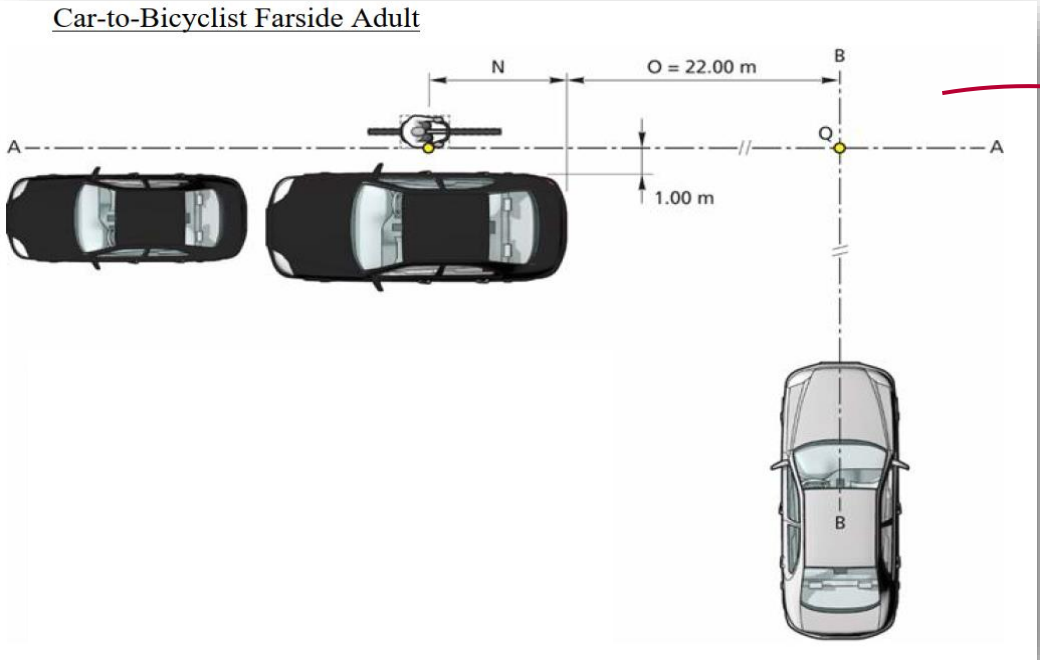
- Hierarchical **Storyboard**
  - **Actions** to describe the desired behavior of Entities
  - **Conditions** trigger the Actions and together form an **Event**
- **Catalogs, Parameters and Variables** for higher flexibility and re-usability



Highlight: OpenSCENARIO XML Synchronize Action

„Synchronizes an entity's arrival at a destination with a master entity. Both entities are provided with their own reference position which shall be reached at the same time. Final speed can be specified. “

source: ASAM OpenSCENARIO XML 1.3 User Guide



source: Euro NCAP Test Protocol – AEB/LSS VRU systems, Implementation 2023, Version 4.5.1

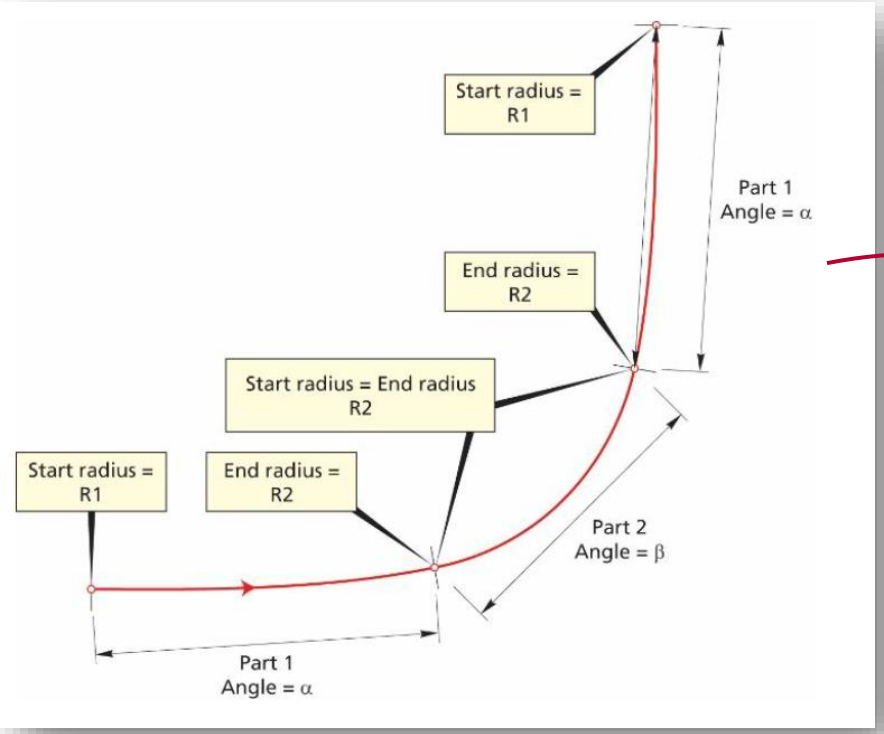
Implementation in DYNA4
OpenSCENARIO XML Editor

Action *(name: VRU_SynchronizeAction)*	
abc name	VRU_SynchronizeAction
PrivateAction	
SynchronizeAction	
masterEntityRef	Ego
TargetPositionMaster	
RoutePosition	
RouteRef	
InRoutePosition	
FromRoadCoordinates	
123 t	0
123 pathS	${$_Road_collisionPointBQ-$_Ego_frontBumperLon}
TargetPosition	
RoutePosition	
RouteRef	
InRoutePosition	
FromRoadCoordinates	
123 t	0
123 pathS	${$_Road_collisionPointAQ-$VRU_collisionPointOffset}
FinalSpeed	

- **Synchronize Action and parameterization** with mathematical expressions in OpenSCENARIO XML make pre-processing needless

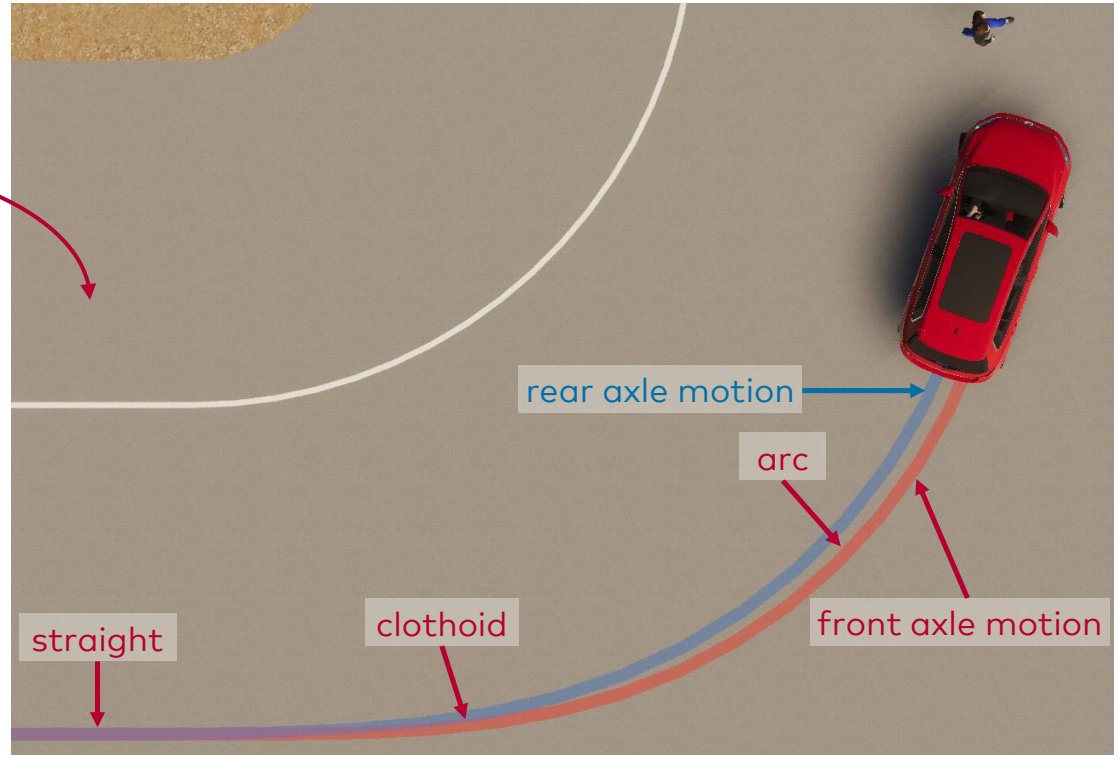
Highlight: OpenSCENARIO XML Clothoid Spline Trajectories

- **Clothoid Spline Trajectories (new in OpenSCENARIO XML 1.3)**
  - ✔ Trajectory definition with multiple concatenated clothoids
  - ! But: OpenSCENARIO uses rear axle while NCAP requires front axle
  - ✔ DYNA4 solution is a standard-compliant but proprietary key-value pair within a Controller



source: Euro NCAP Test Protocol – AEB/LSS VRU systems, Implementation 2023, Version 4.5.1

Trajectory and motion visualization in DYNA4

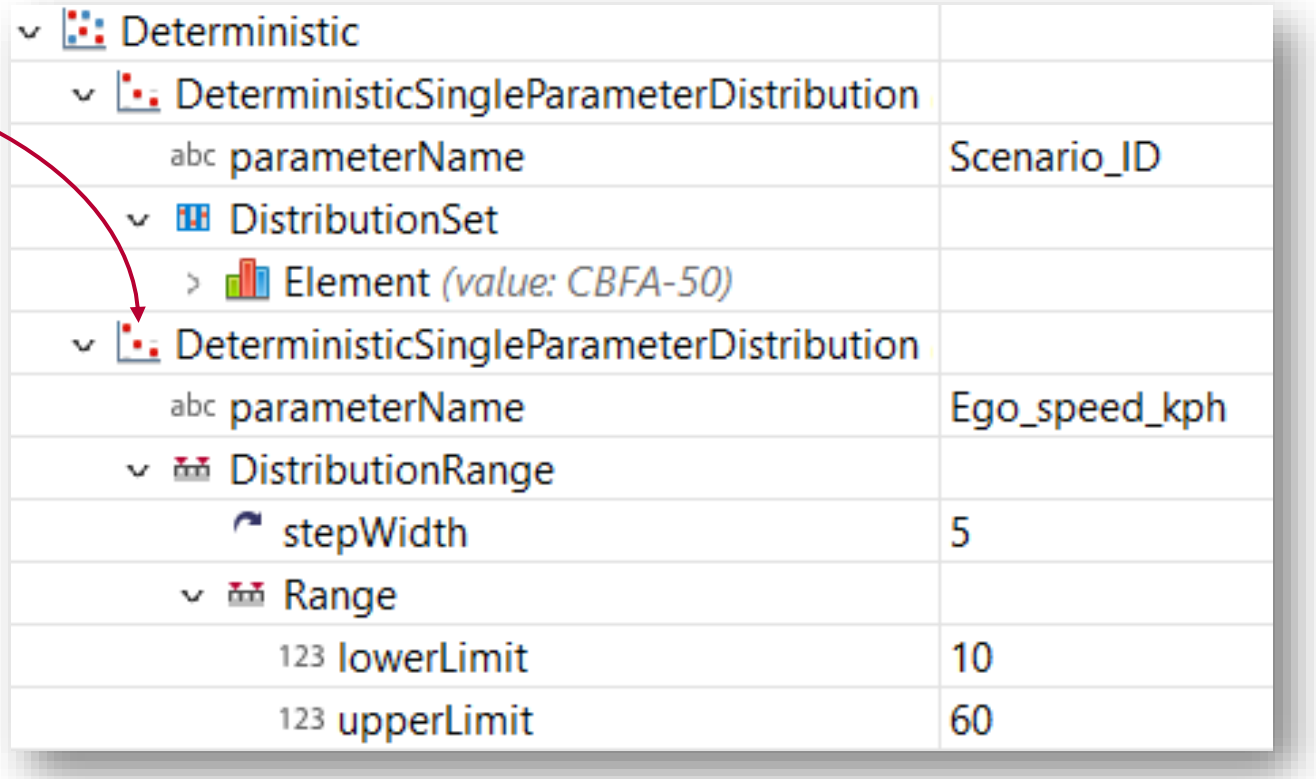


Highlight: OpenSCENARIO XML Parameter Variations

	CBFA
Paragraph	7.3.1
Type of test	AEB
VUT speed [km/h]	10-60
VUT direction	Forward
Obstruction	No
Target speed [km/h]	20
Target direction	Farside
Impact location [%]	50
Lighting condition	Day

source: Euro NCAP Test Protocol – AEB/LSS VRU systems, Implementation 2023, Version 4.5.1

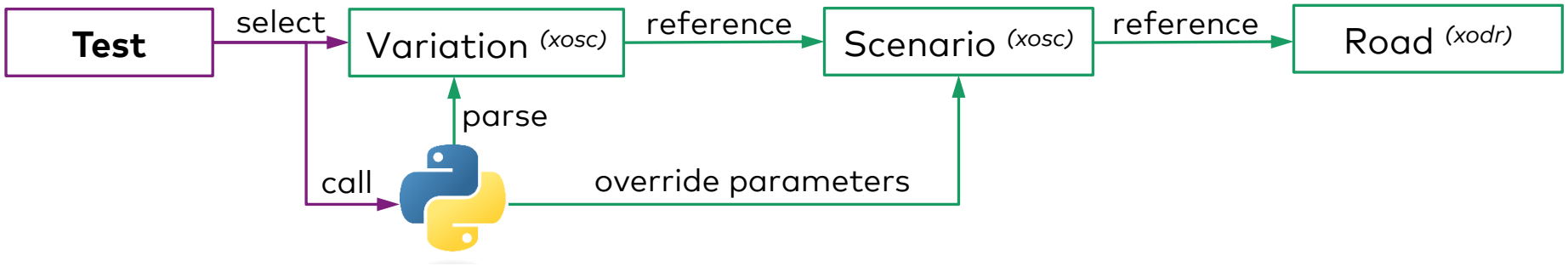
Implementation in DYNA4 OpenSCENARIO XML Editor



- ✔ **Parameter variations** according to NCAP Test Protocols representable with OpenSCENARIO XML logical scenario features

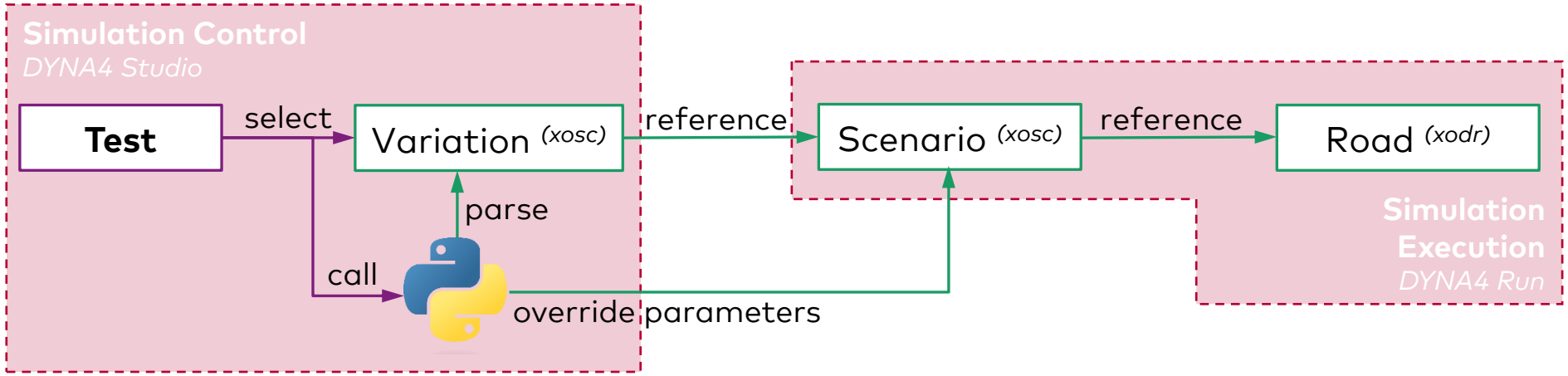
Declaration of Parameters and Variation in OpenSCENARIO

- **Native support** of parametrization and variation in OpenSCENARIO XML 1.3
  - Declaration of **parameters** in base scenario with default values → concrete scenario
  - Definition of **variation** of these parameters in separate variation xosc file → logical scenario
- Tool-agnostic Python implementation for parameter variation
  - **Callable** from external automation or within DYNA4 Studio



Unchanged Input for Different Execution Platforms

- Simulink Model can be **compiled and exported to** lightweight **DYNA4 Run Applications**
  - Windows / Linux Executables, Windows / Linux FMUs, CANoe node-layer DLL, ...
- **Variation and automation** from within DYNA4 or with external tools



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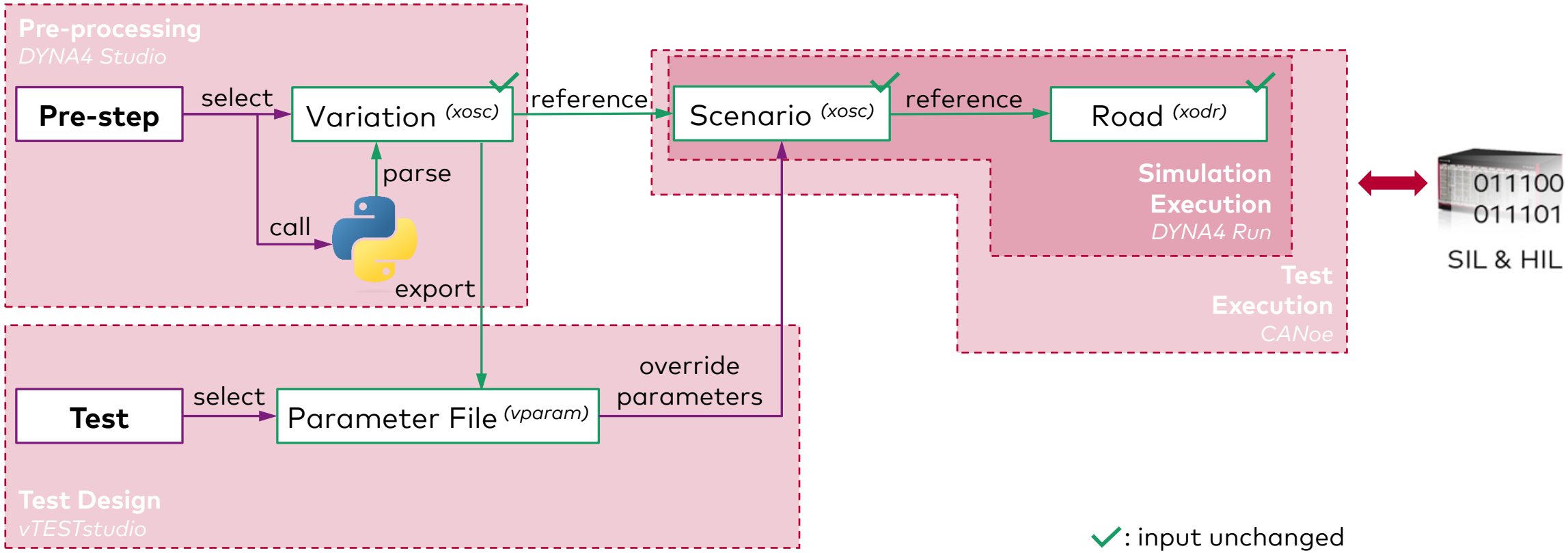

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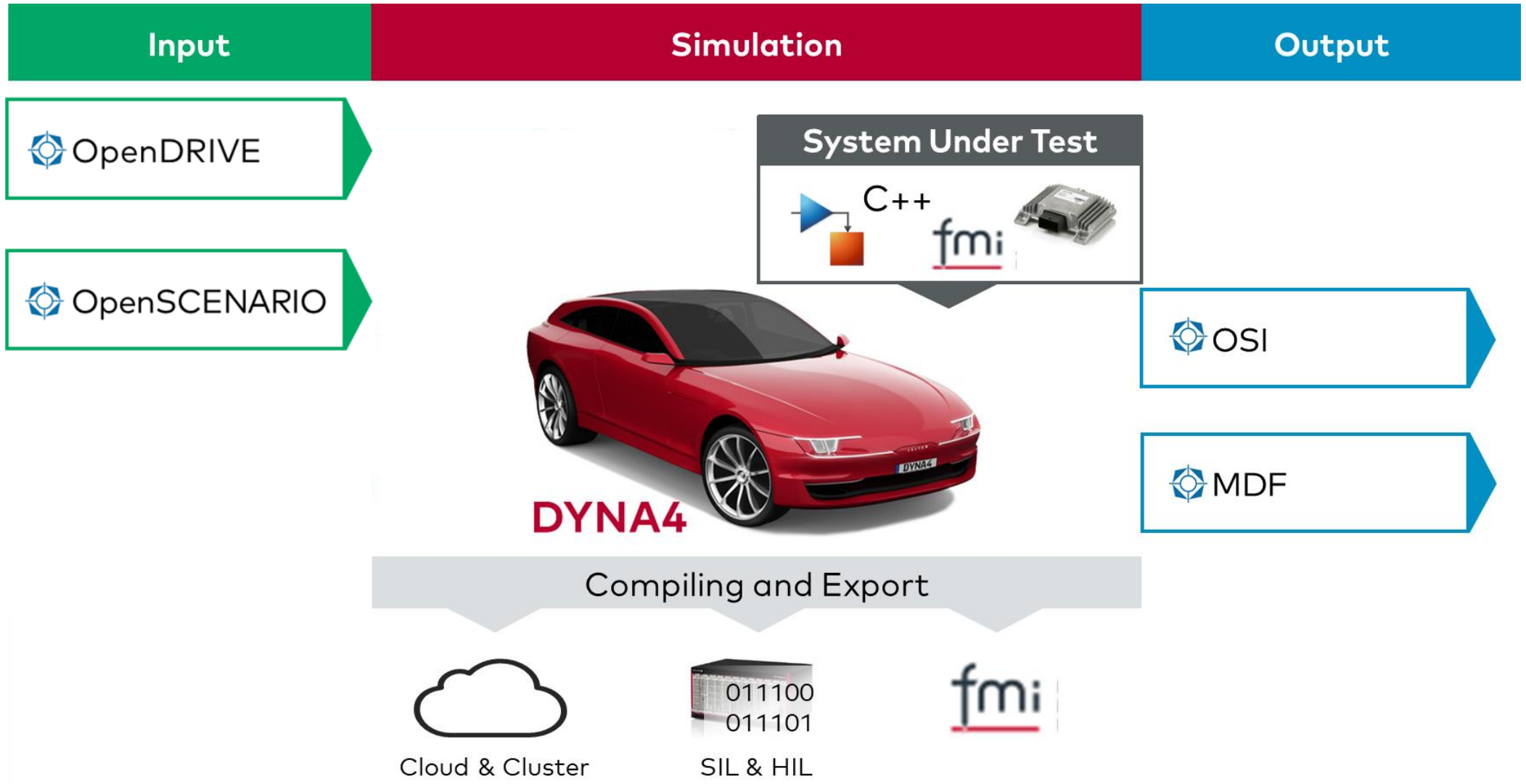
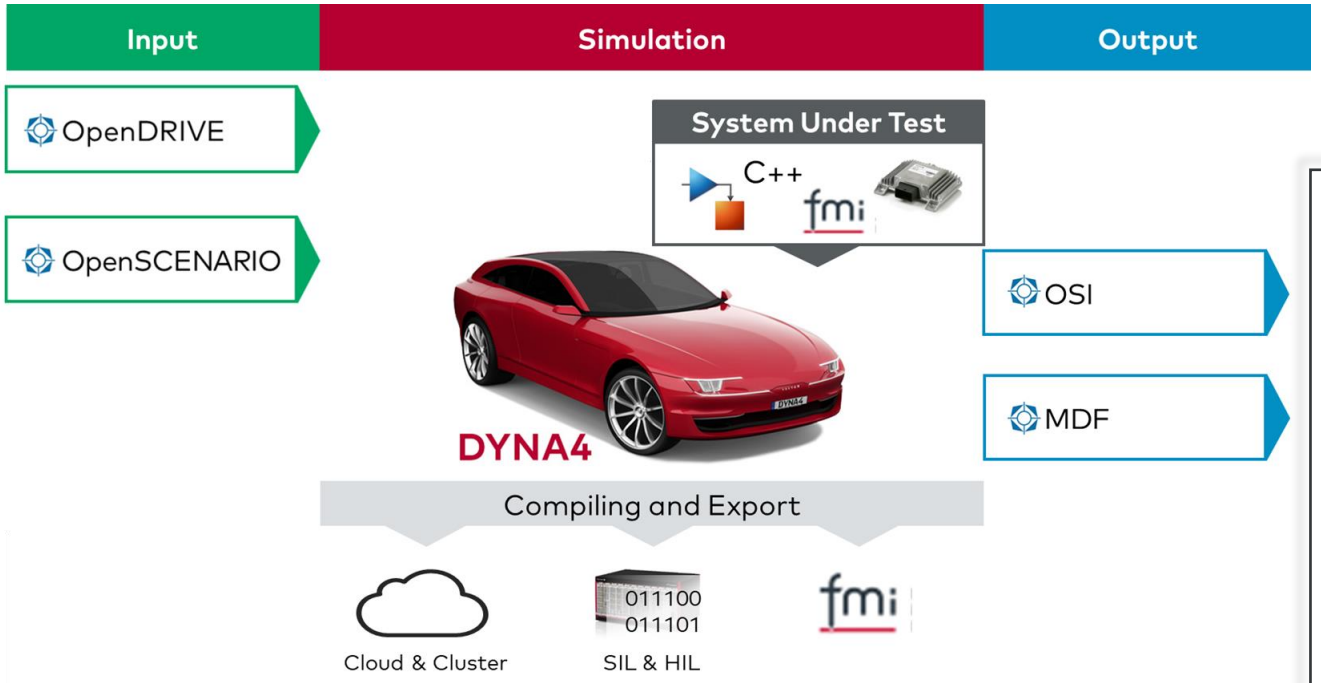
Standards for Scenario-Based Testing





Reporting in DYNA4

Scoring Table:

Test Parameters	Impact Speed	Achieved Score	Verdict
Ego speed: 60 kph	11.43 kph	0.50 / 1.00	
Ego speed: 55 kph	0.00 kph	3.00 / 3.00	
Ego speed: 50 kph	0.00 kph	3.00 / 3.00	
Ego speed: 45 kph	0.00 kph	3.00 / 3.00	
Ego speed: 40 kph	0.00 kph	2.00 / 2.00	
Ego speed: 35 kph	0.00 kph	2.00 / 2.00	
Ego speed: 30 kph	0.00 kph	1.00 / 1.00	
Ego speed: 25 kph	0.00 kph	1.00 / 1.00	
total		**15.50 / 16.00**	

- **Automatic reporting** according to NCAP Assessment Protocols based on MDF input with embedded OSI messages
- Input to report generation **unchanged from MIL to HIL**

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Summary

- Fully **standard-compliant OpenSCENARIO XML** implementation of NCAP Scenarios
- **No pre-processing** required
- Automatic **parameter variation** according to NCAP Test Protocols
- Automatic HTML **report generation** according to NCAP Assessment Protocols
- **Direct execution** of OpenSCENARIO XML in DYNA4 without conversion…
- … in many environments like Simulink, as Windows/Linux Executable, FMU, in Vector CANoe …
- … leading to **full re-usability** of scenario definition from MiL over SiL to HiL
- OpenSCENARIO XML and OpenDRIVE files published **open-source on github**

"I am pleased to hear Vector publishes the Euro NCAP scenarios in the OpenSCENARIO XML format free of charge. Such activities foster the community trend for shift left testing with virtual test drives, which ultimately contributes to safer roads."
Richard Schram, Technical Director Euro NCAP

vector.com/ncap