

Criticality Analysis – Method

8.2 | Criticality Analysis for the Verification and Validation of Automated Driving Systems (II)

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The Method Branch

How to turn *associations* (criticality phenomena, **CP**) into *plausible causalities* (causal relations, **CR**)?

Assumptions

- set of relevant CP is limited and manageable
→ finiteness of artefacts
- relevant CP leave traces in growing data basis
→ saturation of artefacts

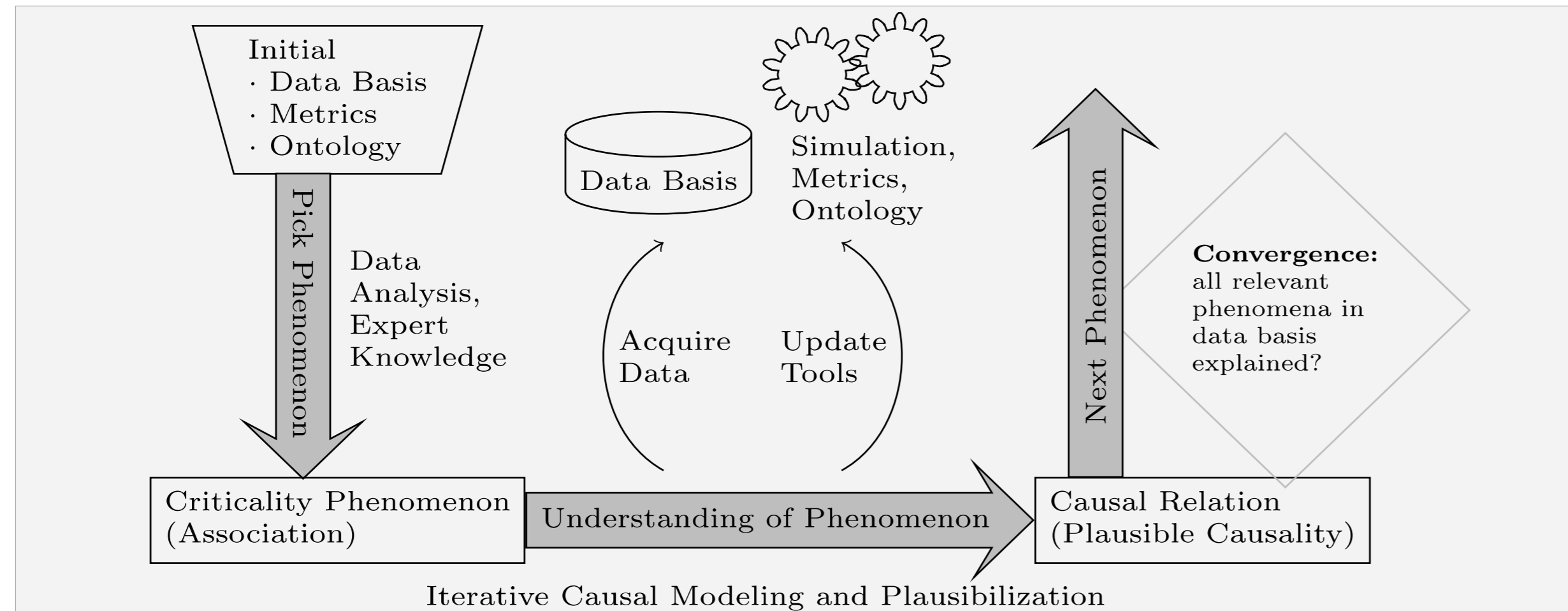


Figure 3: Method branch - from association to causality (© Neurohr et al. [1])

Associational Part [3, 4, 5]

- identification and formalization of **CP**,
- criticality metrics for relevance estimation of **CP**
- abstraction and refinement cycle based on strength of association

Causal Part [2, 3]

- modeling of **CR** as directed causal graphs
- plausibilization of **CR** using real-world data
- abstraction and refinement cycle based on causal indicator functions

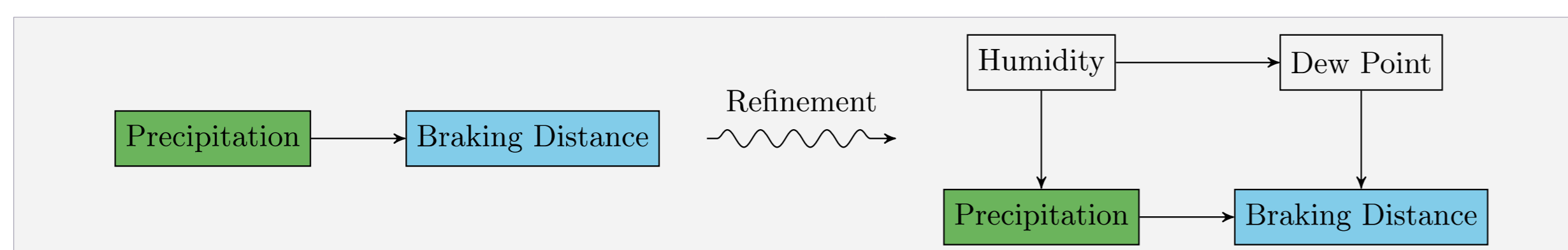


Figure 4: Refinement step in causal modeling (© Koopmann et al. [2])

Criticality metrics are mathematical functions which quantify certain aspects of criticality [3].

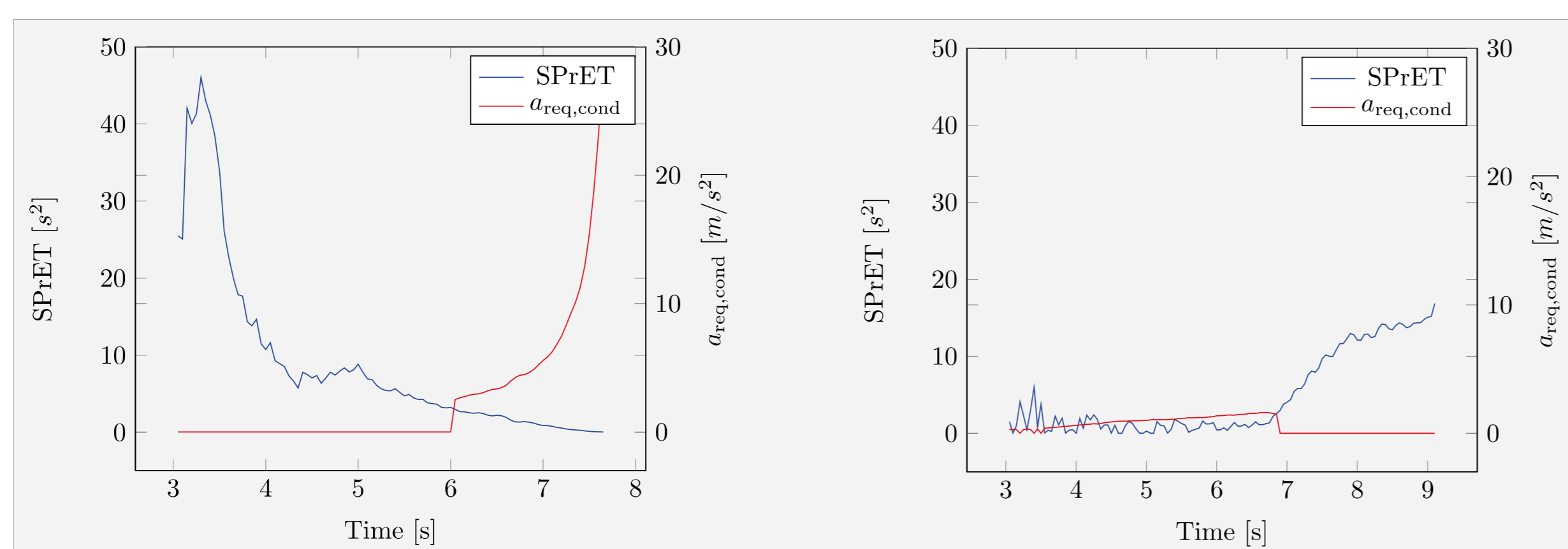


Figure 5: Criticality metrics over time in a critical occlusion resp. uncritical non-occlusion scenario (© Neurohr et al. [1])

The Information Branch

How is the method branch supplied with information?

Ontology

- formalization and reasoning via ontologies
- in VVM, the Automotive Urban Traffic Ontology (**A.U.T.O.**), was created as a suitable domain ontology for urban traffic
- **A.U.T.O** builds on the 6-Layer Model, and
- focuses on the formalization of CP and their recognition in data [4]

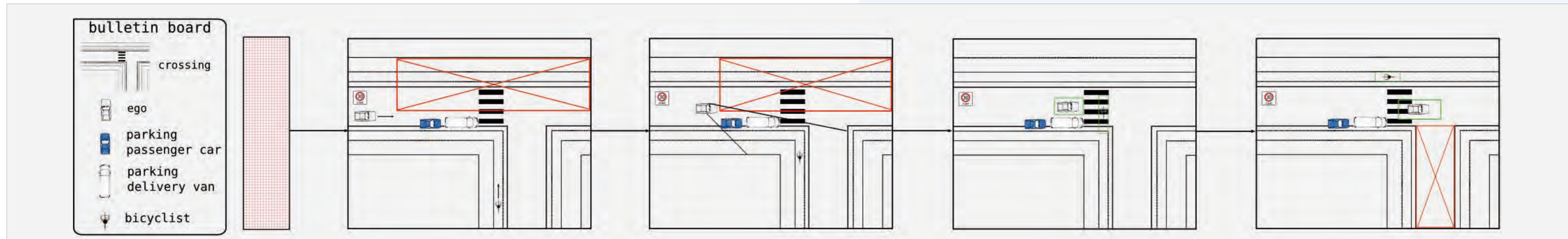


Figure 8: A traffic sequence chart specifying an abstract scenario in which a bicyclist is occluded at a pedestrian crossing by parking cars (© Neurohr et al. 2021 [1])

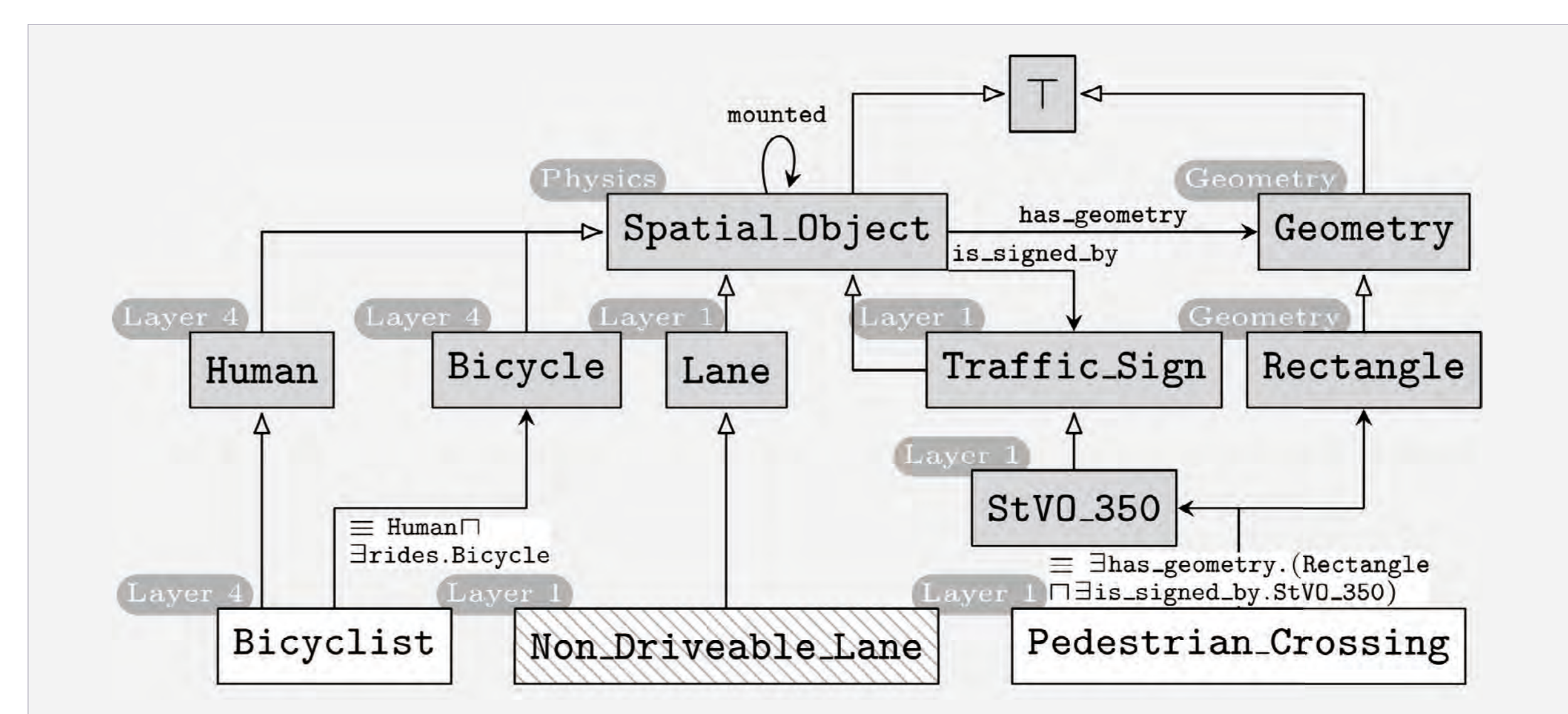
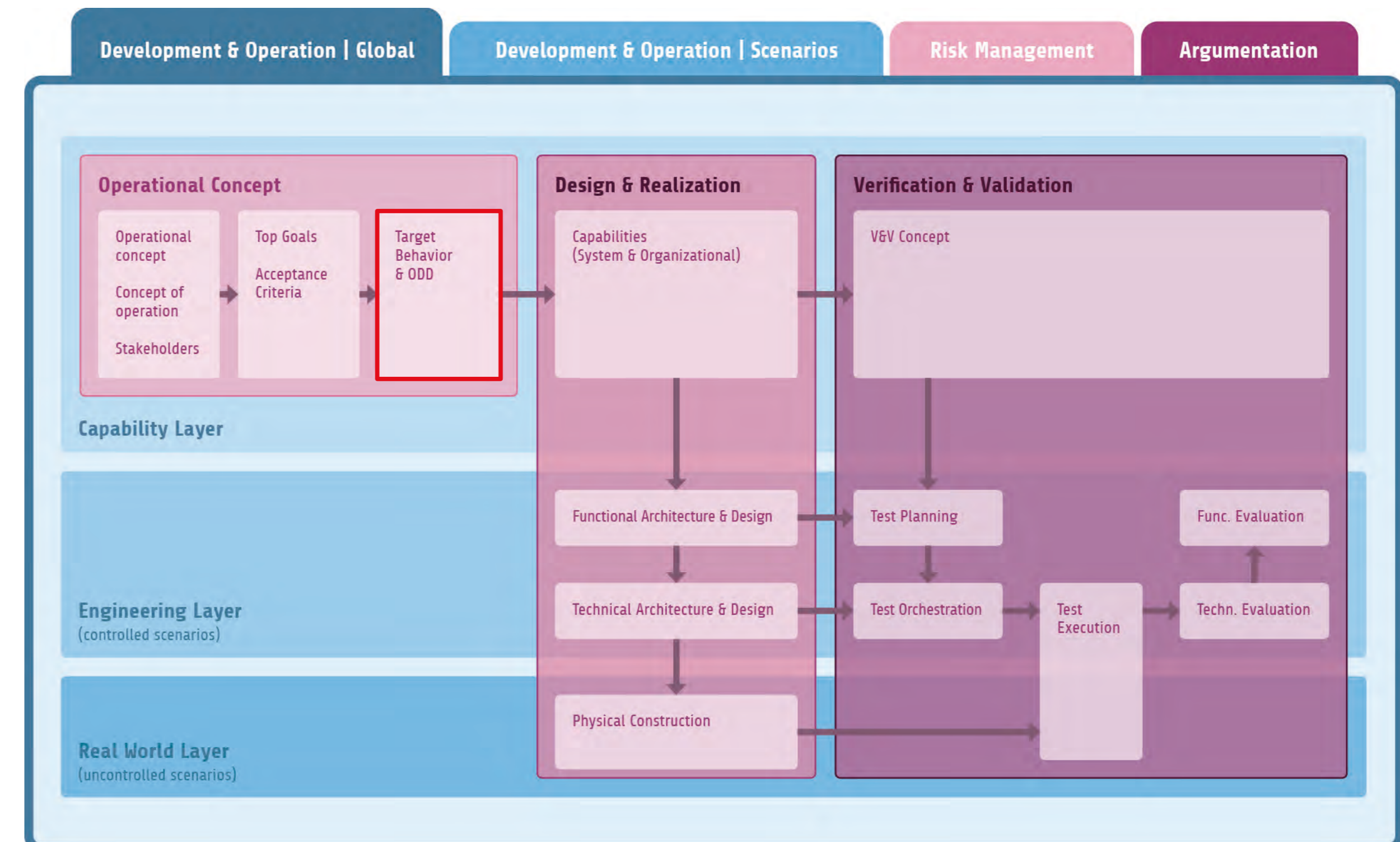


Figure 6: Excerpt from the VVM A.U.T.O. ontology (© DLR e.V.)

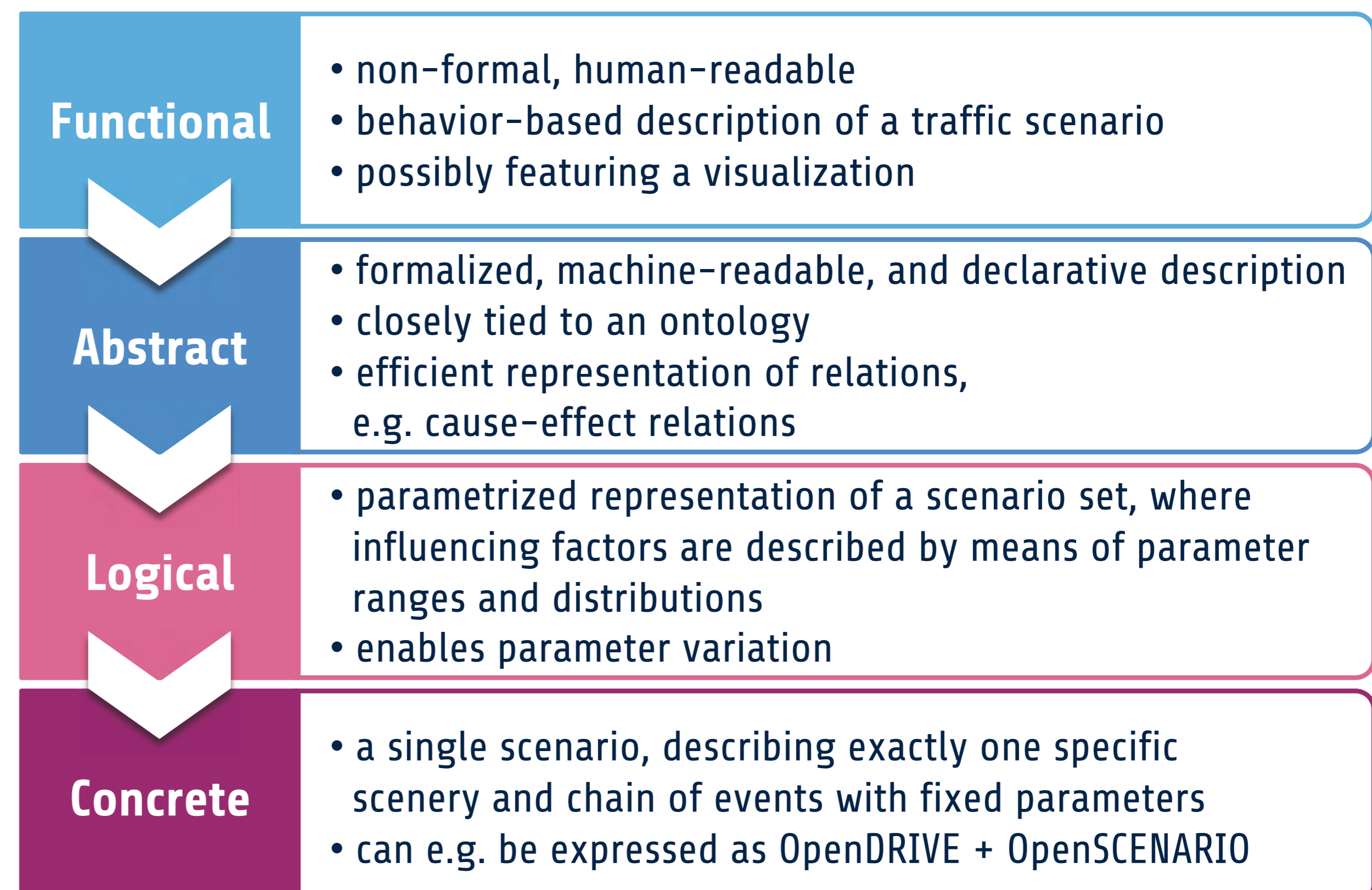


Figure 7: Abstraction levels of scenario description (© Neurohr et al. [1])

The Scenario Branch

How are scenarios used within a criticality analysis?

Scenarios

- various abstraction levels of scenario description in the development process, cf. Figure 7
- a criticality analysis specifies abstract scenarios that contain **CP** and **CR** [1,6]
- logical & concrete scenarios become necessary when real-world or synthetic data are integrated
- for quantification of criticality, concrete scenarios are evaluated using criticality metrics [3]

References:

- [4] Westhofen et al., Using Ontologies for the Formalization and Recognition of Criticality for Automated Driving, IEEE Open Journal of Intelligent Transportation Systems, 2022
- [5] Babisch et al., Leveraging the GIDAS Database for the Criticality Analysis of Automated Driving Systems, Journal of Advanced Transportation, 2023
- [6] Becker et al., Simulation of Abstract Scenarios: Towards Automated Tooling in Criticality Analysis, Autonomes Fahren. Ein Treiber zukünftiger Mobilität, 2022

Partners



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