Scenarios have to be described on multiple levels of abstraction.

Different applications of scenarios in each development phase of a V-model-based development process result in contradicting requirements for scenario representation.

- **Concept phase**: Human experts shall be able to formulate scenarios in the fields terminology in natural language.
- **System development phase**: Scenarios shall include the parameter ranges of the state values used for scenario representation.
- **Test phase**: Scenarios shall be modeled via a single representative for each state value to ensure reproducibility.

Multiple levels of abstraction for scenarios can help to support a structured scenario generation along a V-model-based development process.

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**Functional scenario “Follow”**
- **Base road network**: Road has layout two-lane motorway
  - Road has geometry curve
- **Moveable objects**: Car has position on right lane
  - Truck has position on right lane
  - Car follows truck

**Logical scenario “Follow”**
- **Base road network**: Right lane: width 2.5 m 3.75 m
  - Left lane: width 2.5 m 3.75 m
  - Curve: radius 300 m 900 m
- **Moveable objects**: Truck: long position 0 m 110 m
  - Car: long position 10 m 100 m
  - Truck: long position > Car: long position

**Concrete scenario “Follow”**
- **Base road network**: Right lane: width 2.5 m 3.75 m
  - Left lane: width 2.5 m 3.75 m
  - Curve: radius 300 m 900 m
- **Concrete scenario**: Concrete road network
- **Moveable objects**: Truck: long position 0 m 80 m
  - Truck: long position > Car: long position

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**Level of abstraction**

**Number of scenarios**
SCENARIO DESCRIPTION AND KNOWLEDGE-BASED SCENARIO GENERATION

Generation of functional scenarios:
A wide variety of functional scenarios can be generated with a knowledge-based approach in a traceable way.

Motivation:
- Development and systems safety can be supported by traceable scenario generation
- Creative processes by humans are unable to generate high variety of scenarios

Approach:
- Formalize knowledge with an ontology
- Knowledge is structured according to a 6-layer-model
- Scenario export to HTML-based visualization and scenario graph

Results:
- Generation of more than 10,000 functional scenarios
- Manual verification of 700 scenarios regarding correctness and completeness

6-layer-model to structure scenarios based on Schuld (2017), Bagschik et al. (2018) and Bock et al. (2018)
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SCENARIO DESCRIPTION AND KNOWLEDGE-BASED SCENARIO GENERATION

From functional to logical scenarios:
Functional scenarios can automatically be transformed into the formats for simulation and build the basis for test case generation.

Motivation:
- Conversion of functional scenarios into the data formats for simulation takes considerable manual effort
- A standardized interpretation of linguistically described scenarios is not guaranteed

Approach:
- Each keyword in the respective functional scenario is specified in detail through parameters
- Dependencies of the parameters as well as constraints for choosing parameter values are modeled and documented
- Parameter space representation is converted into OpenDRIVE and OpenSCENARIO

Results:
- Generation of more than 10,000 OpenDRIVE- and OpenSCENARIO-files
- Examination of selected OpenDRIVE-files through OpenDRIVE-Viewer
- Examination of selected OpenSCENARIO-files through execution in simulation

Augmentation of the parameter space with arrangement relations as well as object and parameter dependencies. The tangent length $T$ of a crest has to be calculated based on the radius $R$ as well as the initial tilt $s_1$ and the final tilt $s_2$. 

$T = \frac{R}{2} \cdot \frac{s_2 - s_1}{100}$