

stiEF Presentation

Motivation, overview and publication

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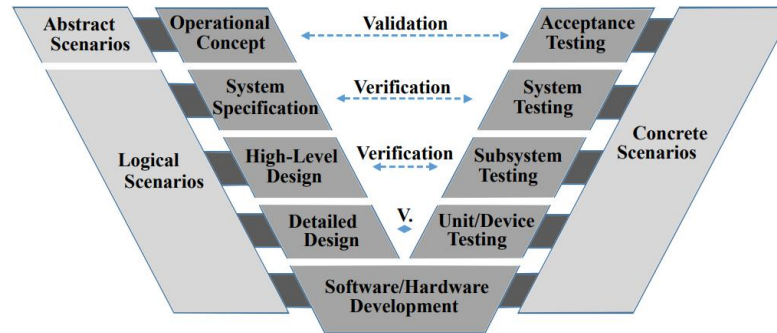
Goals and Key Features

- **stiEF** („scenario-accompanied, textbased, iterative Evaluation of automated driving Functions“) is a textual domain-specific language for traffic scenario descriptions
- **stiEF** is based on
 - already existing manually created scenarios to provide a natural language style description format
 - the PEGASUS abstraction levels (functional, logical, concrete) and the content layers (1: road level, 2: traffic infrastructure, 3: temporary modifications, 4: objects & maneuvers, 5: environment conditions) to structure scenarios
 - the open-source framework JetBrains Meta Programming System (MPS)
 - Note: „Abstract scenario“ ⇔ „Functional scenario“
- stiEF is currently limited to freeway/highway descriptions
- stiEF provides the scenario descriptions in English and German
- stiEF provides generators/exporters for Word, Excel, JSON, PNG and animated GIF

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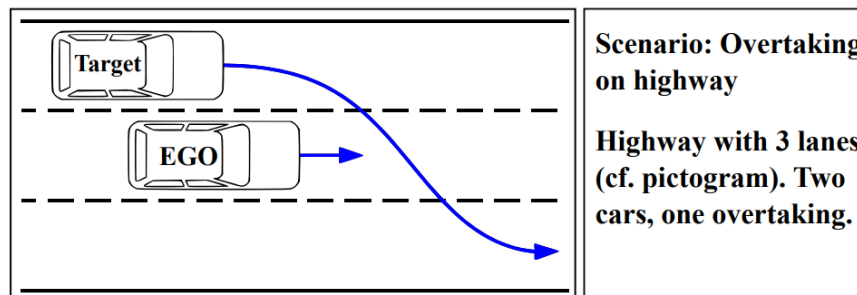
Problem definition

- › Scenarios are used throughout the development process



From: F.Bock, C.Sipl, A.Heinz, C.Lauer, R.German –
 “Advantageous Usage of Textual Domain-Specific Languages for Scenario-Driven Development of Automated Driving Functions”,
 SysCon 2019, Orlando

- › Scenario creations is done mainly by hand
- › Scenario descriptions are often inconsistent or incomplete (also visualization)
- › Support for multiple languages by manual translations





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DSLs in JetBrains MPS¹

- A DSL in JetBrains MPS includes three different aspects:
 - Structure: The data model of the language with all entities and their attributes
 - Editor: The visualization of the data model for the user based on rules
 - Generator: Rules to generate target artifacts out of the data model

Specification Document: Braking Assistant

Configuration:

Create ML/SL-Artefact? true
Create UML-Artefact? true

1. General

General information and definitions.

Requirement DEF1

ABS : Antilock Braking System

2. System Behavior

Description of the system behavior.

Requirement REQ1

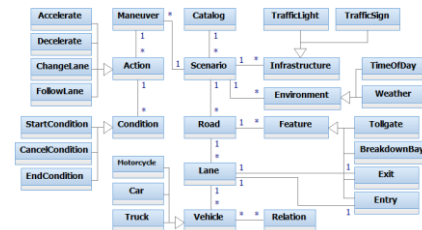
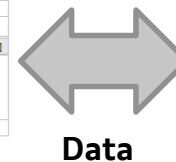
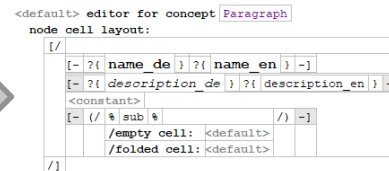
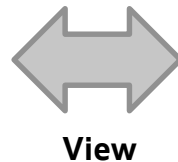
The driver assistance function aggregates the data from sensor A and sensor B and validates the data and calculates the braking recommendation.

3. Constraints

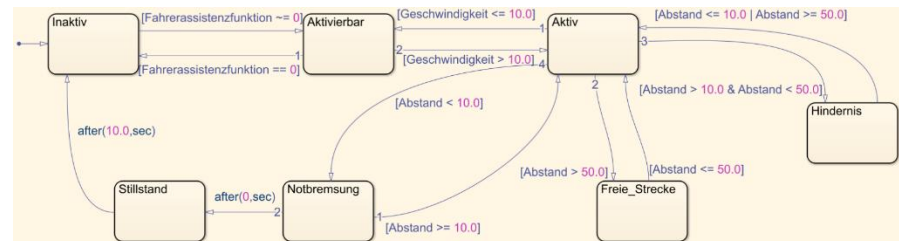
Technical and legal constraints/limitations.

Requirement LIM1

The value of sensor A shall not fall below 0.



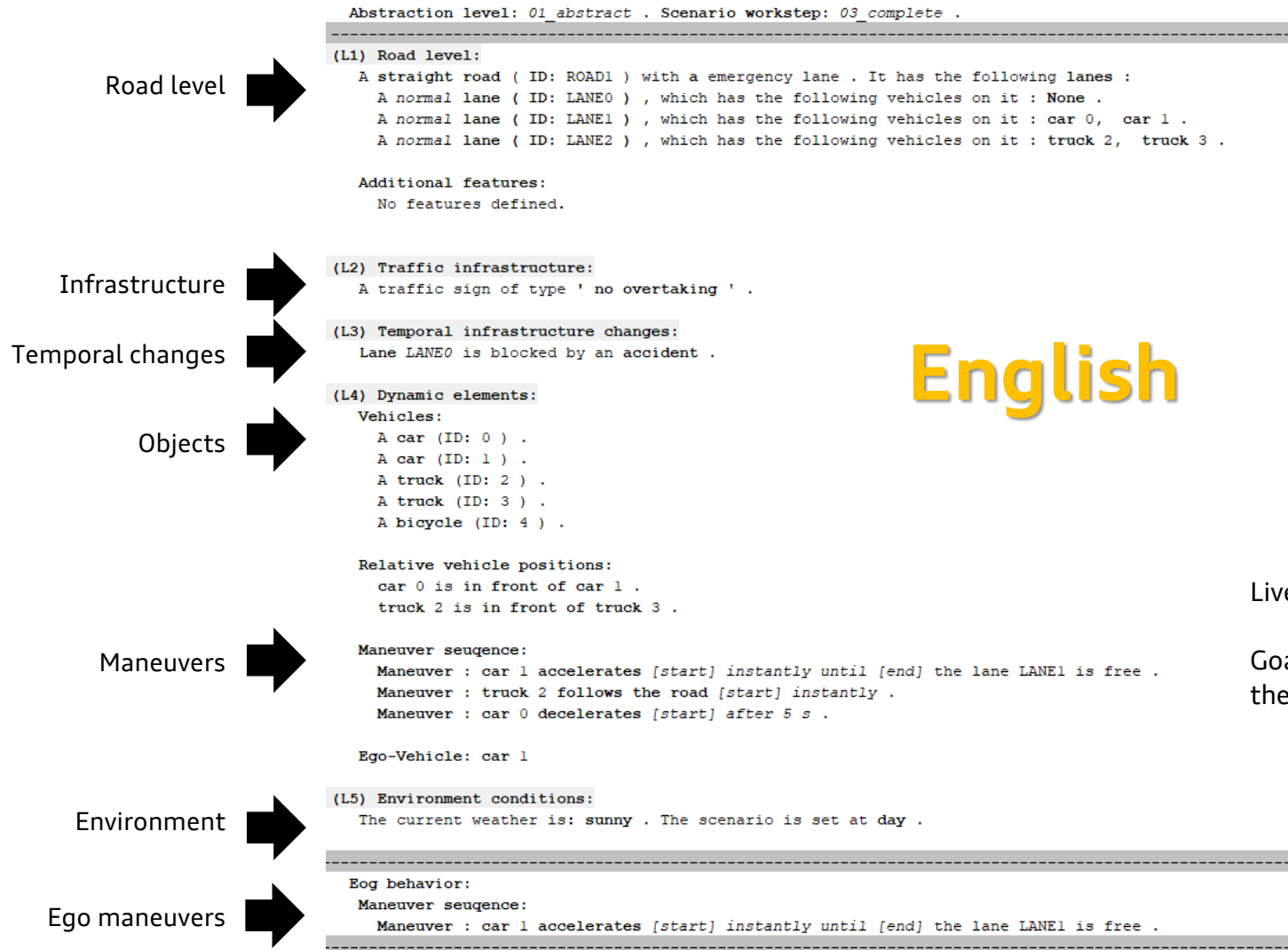
Generation



¹ JetBrains „Meta Programming System“ (MPS)
<https://www.jetbrains.com/de-de/mps/>

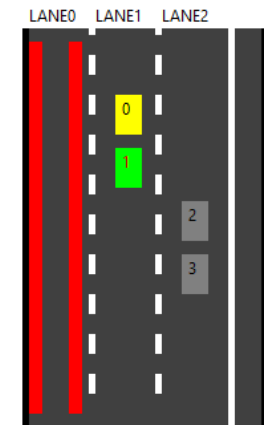
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Initial prototype – English representation



English

Preview:



Live visualization of the scenario

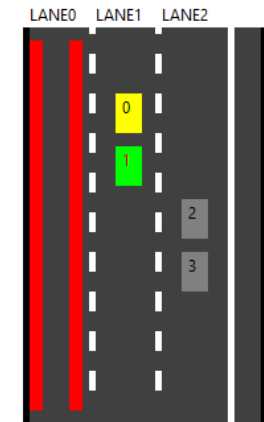
Goal: Review and discussion with the stakeholders

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Initial prototype – German representation



Vorschau:



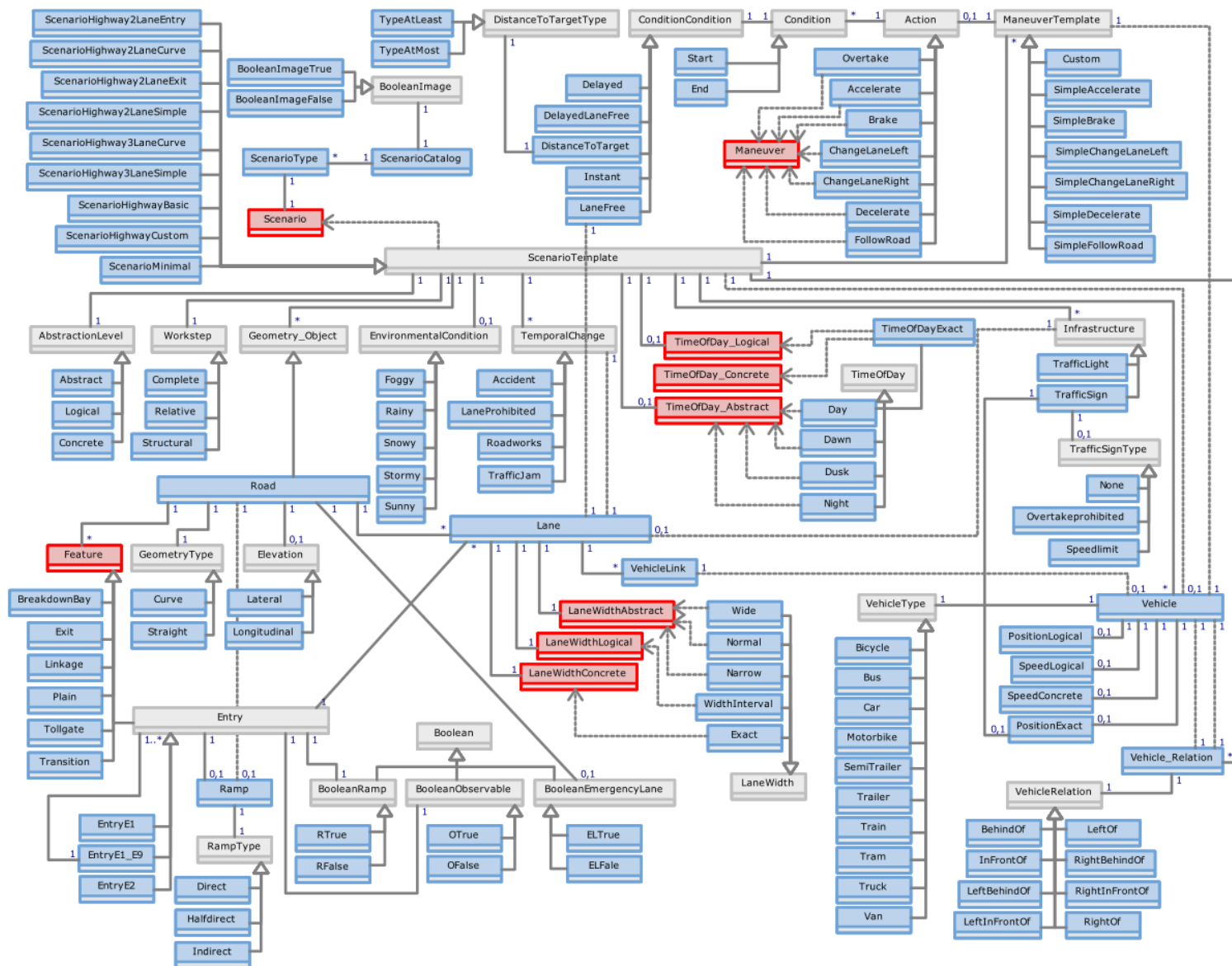
Live visualization of the scenario

Goal: Review and discussion with the stakeholders

German

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Initial prototype – data model



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Final implementation – English representation

- Scenario description in English with the corresponding generated visualization:

The screenshot displays the stiEF software interface, which is used for scenario description and visualization. The interface is divided into several panels:

- Project Panel (Left):** Shows the project structure with 'Project1' and 'Katalog1'.
- Scenario Catalog (Top Right):** Displays 'Scenario Catalog: Katalog1', 'Scenario Count: 1', 'Current Scenario: Stau auf einer zweispurigen Autobahn', 'Display Language: English', 'Show Visualization: Yes', and 'Editor: Text View'.
- Scenario Overview (Main Text Area):**
 - Scenario:** Stau auf einer zweispurigen Autobahn
 - Description:** " Stau auf einer zweispurigen Autobahn " scenario is located in Germany on the Freeway . Please add meta description of scenario.
 - Base Scenario:** traffic jam on 2-lane freeway (A)
 - State:** Draft
 - Version:** 1
 - Abstraction level:** concrete
 - Layer 1 (Road Model):**
 - Segment #1 has a main roadway (A) and an entry.
 - The main roadway has a straight geometry, 2 driving lane(s) and a stop lane.
 - Driving lane #2 has a 3.60 m width.
 - Stop lane #3 has a 3.20 m width.
 - The entry has a straight geometry and 1 driving lane(s).
 - Layer 2 (Infrastructure):**
 - Segment #1 contains following elements:
 - There is a sign group #1 with a regulation sign of type overtaking Forbidden for Trucks.
 - The road has guideposts and guardrails on the median and the right shoulder.
 - The lateral vegetation consists of bushes on the median of 50 cm height with 30 % density.
 - Layer 3 (Temporary Modifications):** No Temporary Modifications
 - Layer 4 (Positioning and Velocity):**
 - Following Column #1 drives on Segment #1:
 - Medium truck #1 with Trailer drives on driving lane #1.
 - Medium truck #2 drives behind of the Medium truck #1.
 - Medium truck #3 drives behind of the Medium truck #2.
 - Following Vehicle group #2 drives on Segment #1:
 - Station wagon #4 drives with 105 km/h left of the Medium truck #1, 1 cm left road mark.
 - Ego Station wagon #5 drives with 119 km/h behind of the Station wagon #4.
 - No obstacles are defined.
- Preview Panel (Right):** Shows a top-down visualization of the scenario. It includes a sun icon, a compass, and a road layout with four lanes. Vehicles are represented by icons: a blue car (5), a white truck (1), a white truck (2), a white truck (3), and a white car (4). The road is labeled with numbers 1, 2, 3, and 4. The preview also shows a 'Phase #1' dropdown, 'Popout', 'Fit Content', 'Zoom In', 'Zoom Out', and 'PNG Export' buttons.

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Final implementation – German representation

- Scenario description in German with the corresponding generated visualization:

The screenshot displays the stiEF software interface, which is used for scenario description and visualization. The interface is divided into several panels:

- Left Panel (Project Structure):** Shows a tree view with 'Project1' containing 'NewSolution', 'Model', and 'Katalog1'. Below it is the 'Modules Pool'.
- Top Panel (Menu and Settings):** Includes a menu bar (File, Edit, View, Navigate, Code, Analyze, Build, Run, Tools, VCS, Window, Help) and a settings area with 'Anzeigesprache: Deutsch', 'Zeige Visualisierung: Ja', and 'Editor: Textansicht'.
- Main Text Area (Scenario Description):** Contains the following text:

Szenarienkatalog: Katalog1
Szenarienzahl: 1
Aktuelles Szenario: Stau auf einer zweispurigen Autobahn + -

Szenario: Stau auf einer zweispurigen Autobahn ▲ ▴ ▾ ▿

Szenarioübersicht ▲
Das Szenario " Stau auf einer zweispurigen Autobahn " befindet sich in Deutschland auf der Autobahn .
Beschreibung: Bitte fügen sie eine Metabeschreibung des Szenarios hinzu.

Ursprungsszenario: traffic jam on 2-lane freeway (♻) .
Status: Entwurf
Version: 1
Abstraktionsebene: konkret .

Schicht 1 (Straßenebene): ▲
Segment #1 hat eine Hauptfahrbahn (♻) und eine Auffahrt .
Die Hauptfahrbahn hat eine gerade Geometrie , 2 Fahrstreifen und einen Standstreifen .
Fahrstreifen #2 hat eine 3.60 m Breite .
Standstreifen #3 hat eine 3.20 m Breite .
Die Auffahrt hat eine gerade Geometrie und 1 Fahrstreifen .

Optionaler Kommentar

Schicht 2 (Straßenausstattung): ▲
Segment #1 enthält folgende Elemente:
Es steht eine Schildergruppe #1 mit einem Verkehrszeichen des Typs Überholverbot für LKWs .
Die Straße hat Leitpfosten und Leitplanken auf dem Mittelstreifen und dem rechten Bankett .
Die seitliche Vegetation besteht aus Büschen auf dem Mittelstreifen von 50 cm Höhe mit 30 % Dichte .

Optionaler Kommentar

Schicht 3 (Temporäre Beeinflussung): ▲
Keine temporären Änderungen

Optionaler Kommentar

Schicht 4 (Positionierung und Geschwindigkeit): ▲
Folgende Fahrzeugkolonne #1 fährt auf Segment #1 :
Kleinlaster #1 mit Anhänger fährt auf dem Fahrstreifen #1 .
Kleinlaster #2 fährt hinter dem Kleinlaster #1 .
Kleinlaster #3 fährt hinter dem Kleinlaster #2 .
Folgende Fahrzeuggruppe #2 fährt auf Segment #1 :
Kombi #4 fährt mit 105 km/h links von dem Kleinlaster #1 , 1 cm zur linken Straßenmarkierung .
Ego Kombi #5 fährt mit 119 km/h hinter dem Kombi #4 .
Keine Hindernisse definiert

Optionaler Kommentar
- Right Panel (Visualization):** Shows a top-down view of the road layout. It includes a compass rose, a sun icon, and a road with four lanes. The lanes are numbered 1, 2, 3, and 4. Lane 1 is the leftmost lane, and lane 4 is the rightmost lane. The road is flanked by green areas representing vegetation. A legend at the bottom right shows a blue circle with a white '1'.

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Final implementation – Table view

- Scenario description viewed as table:

The screenshot displays the stiEF software interface with a table view of a scenario description. The interface includes a menu bar (File, Edit, View, Navigate, Code, Analyze, Build, Run, Tools, VCS, Window, Help), a toolbar, and a sidebar with a project tree. The main area is divided into three columns: Scenario Overview, Layer 1 (Road Model), and Layer 2 (I).

Scenario Overview	Layer 1 (Road Model):	Layer 2 (I)
<p>Scenario Catalog: Katalog1</p> <p>Scenario Count: 1</p> <p>Current Scenario: Stau auf einer zweispurigen Autobahn + -</p> <p>Display Language: English</p> <p>Show Visualization: Yes</p> <p>Editor: Table View</p> <p>" Stau auf einer zweispurigen Autobahn " scenario is located in Germany on the Freeway .</p> <p>Description: Please add meta description of scenario.</p> <p>Base Scenario: traffic jam on 2-lane freeway (A) .</p> <p>State: Draft</p> <p>Version: 1</p> <p>Abstraction level: concrete .</p>	<p>Segment #1 has a main roadway (A) and an entry .</p> <p>The main roadway has a straight geometry , 2 driving lane(s) and a stop lane .</p> <p>Driving lane #2 has a 3.60 m width .</p> <p>Stop lane #3 has a 3.20 m width .</p> <p>The entry has a straight geometry and 1 driving lane(s) .</p> <p>Optional Comment</p>	<p>Segment #1</p> <p>There is</p> <p>The road</p> <p>The lane</p> <p>Optional C</p>

The bottom status bar shows "stiEF Export", "Messages", "Inspector", "Event Log", and "OFF".

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Final implementation – Generated artifacts

➤ Generated Work and Excel exports:

Katalog1.docx - Word

Datei Start Einfügen Entwurf Layout Verweise Sendungen Überprüfen Ansicht Sie wüns Bock, Flor... Freigegeben

Scenario Catalog: Katalog1

Scenario: Stau auf einer zweispurigen Autobahn



Scenario Overview

"Stau auf einer zweispurigen Autobahn" scenario is located in Germany on the Freeway .
Description: Please add meta description of scenario.

Base Scenario: traffic jam on 2-lane freeway (□) .
State: Draft
Version: 1
Abstraction level: concrete .

Layer 1(Road Model):
Segment #1 has a main roadway (□) and an entry .
The main roadway has a straight geometry , 2 driving lane(s) and a stop lane .
Driving lane #2 has a 3.60 m width .
Stop lane #3 has a 3.20 m width .
The entry has a straight geometry and 1 driving lane(s) .

Layer 2(Infrastructure):
Segment #1 contains following elements:
There is a sign group #1 with a regulation sign of type overtaking Forbidden for Trucks .
The road has guideposts and guardrails on the median and the right shoulder .
The lateral vegetation consists of bushes on the median of 50 cm height with 30 % density .

Layer 3(Temporary Modifications):
No Temporary Modifications

Layer 4(Positioning and Velocity):
Following Column #1 drives on Segment #1 :
Medium truck #1 with Trailer drives behind of the Medium truck #1 .
Medium truck #2 drives behind of the Medium truck #1 .

Seite 1 von 2 322 Wörter Deutsch (Deutschland) 80 %

Katalog1.xlsx - Excel

Datei Start Einfügen Seitenlayout Formeln Daten Überprüfen Ansicht Sie wüns Bock, Flor... Freigegeben

siID	Name	Layer 1 - Road Model	Layer 2 - Infrastruc
1	Stau auf einer zweispurigen Autobahn	<p>Segment #1 has a main roadway (□) and an entry .</p> <p>The main roadway has a straight geometry , 2 driving lane(s) and a stop lane .</p> <p>Driving lane #2 has a 3.60 m width .</p> <p>Stop lane #3 has a 3.20 m width .</p> <p>The entry has a straight geometry and 1 driving lane(s) .</p>	<p>Segment #1 contains</p> <p>There is a sign group</p> <p>The road has guideposts</p> <p>The lateral vegetation density .</p>
2			
3			
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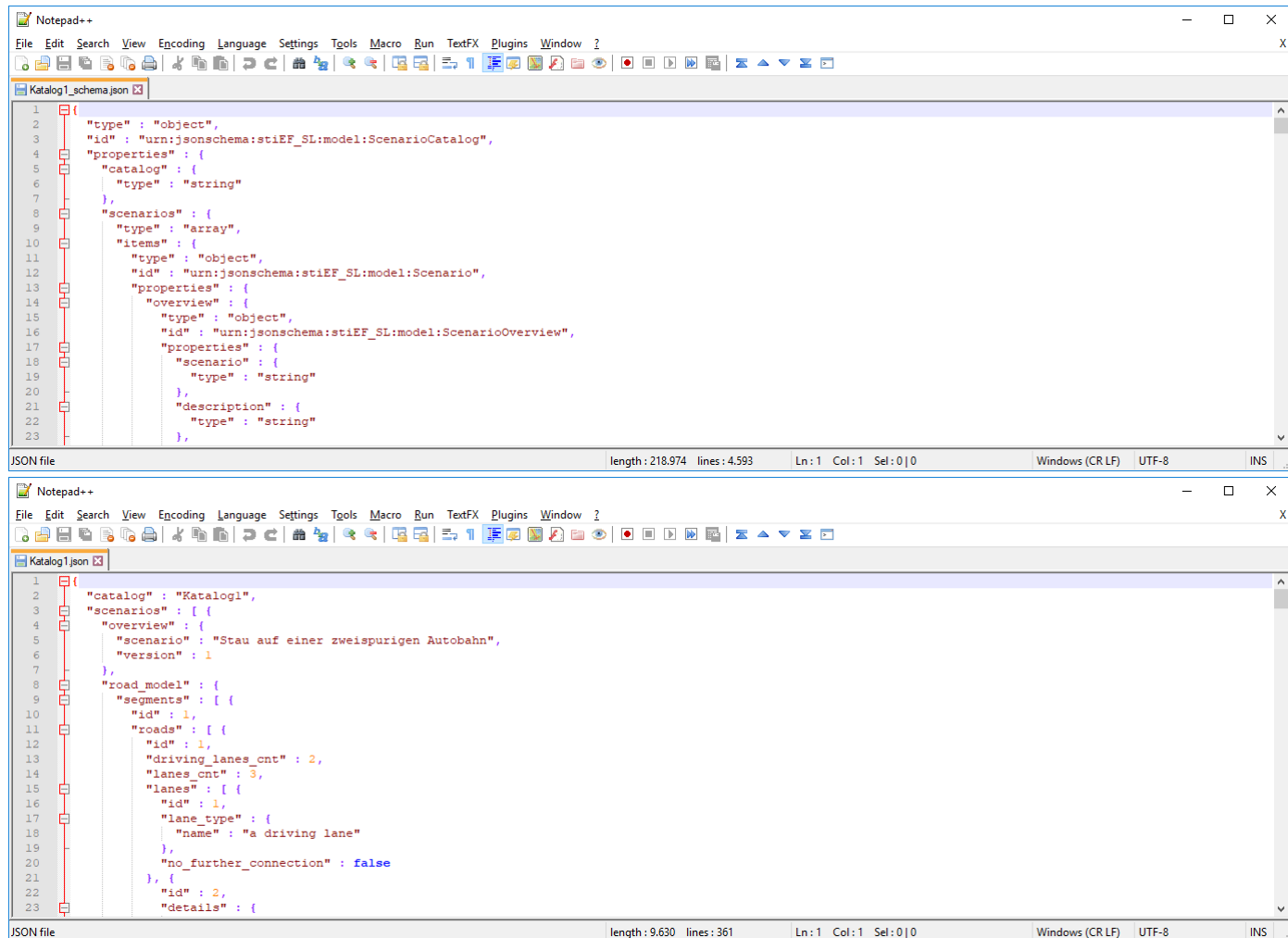
Katalog1

Bereit 70 %

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Final implementation – Generated artifacts

- › Generated JSON schema and JSON export for the scenario:



The image displays two Notepad++ windows side-by-side, showing generated JSON artifacts for the stiEF scenario.

The top window, titled "Katalog1_schema.json", displays a JSON schema. The schema defines a "ScenarioCatalog" object with properties: "catalog" (string), "scenarios" (array of "Scenario" objects), and "overview" (ScenarioOverview object). The "Scenario" object has properties: "id", "properties" (containing "overview" and "description"), and "type". The "ScenarioOverview" object has properties: "id", "scenario" (string), and "description" (string).

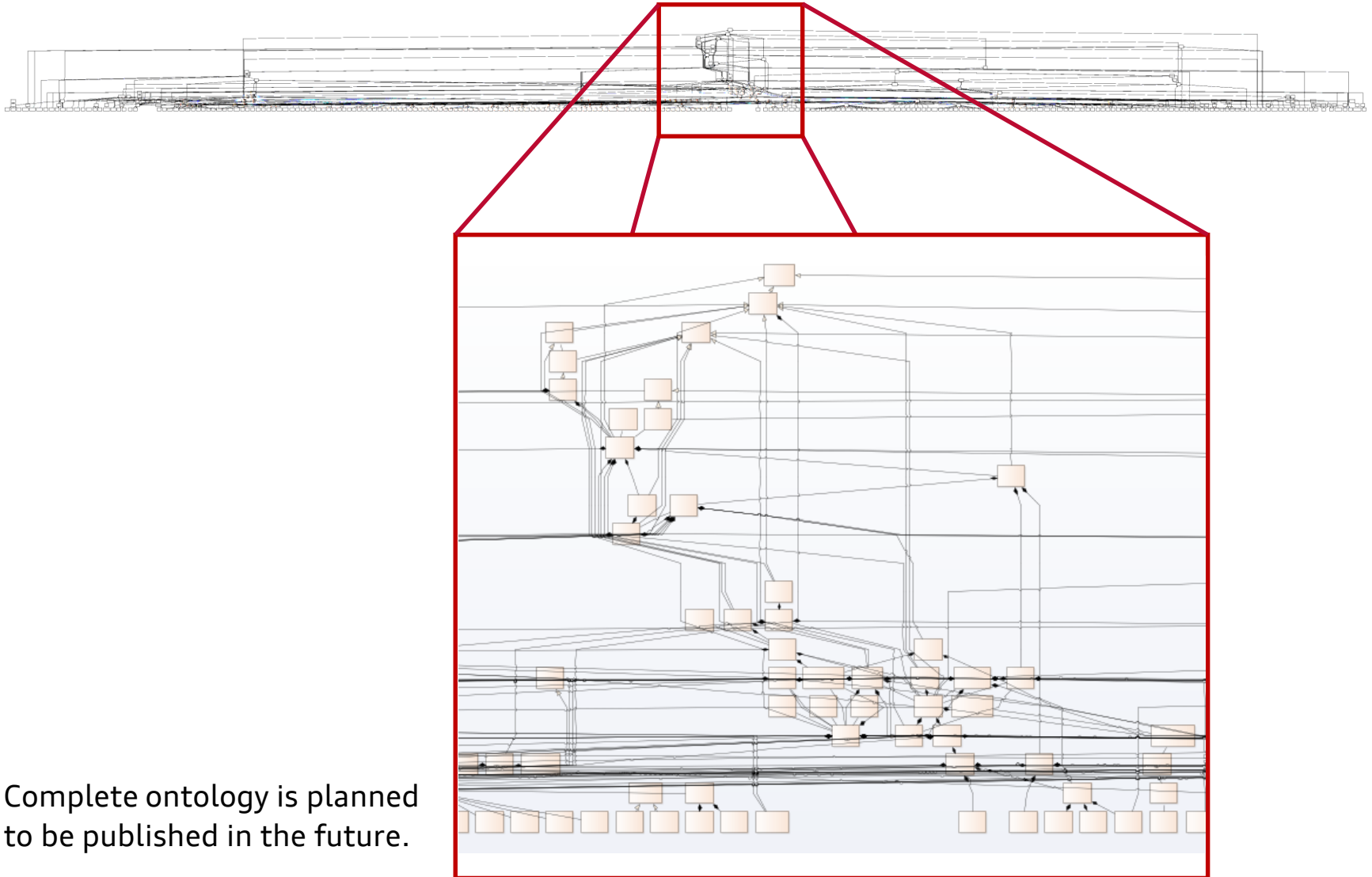
```
1 {
2   "type" : "object",
3   "id" : "urn:jsonschema:stiEF_SL:model:ScenarioCatalog",
4   "properties" : {
5     "catalog" : {
6       "type" : "string"
7     },
8     "scenarios" : {
9       "type" : "array",
10      "items" : {
11        "type" : "object",
12        "id" : "urn:jsonschema:stiEF_SL:model:Scenario",
13        "properties" : {
14          "overview" : {
15            "type" : "object",
16            "id" : "urn:jsonschema:stiEF_SL:model:ScenarioOverview",
17            "properties" : {
18              "scenario" : {
19                "type" : "string"
20              },
21              "description" : {
22                "type" : "string"
23              }
24            }
25          }
26        }
27      }
28    }
29  }
30 }
```

The bottom window, titled "Katalog1.json", displays a JSON export. It contains a "catalog" named "Katalog1" and a "scenarios" array. The first scenario is "Stau auf einer zweispurigen Autobahn" with version 1. It includes a "road_model" with segments, roads, and lane details. The "road_model" has segments, roads, and lane details. The "road_model" has segments, roads, and lane details.

```
1 {
2   "catalog" : "Katalog1",
3   "scenarios" : [ {
4     "overview" : {
5       "scenario" : "Stau auf einer zweispurigen Autobahn",
6       "version" : 1
7     },
8     "road_model" : {
9       "segments" : [ {
10        "id" : 1,
11        "roads" : [ {
12          "id" : 1,
13          "driving_lanes_cnt" : 2,
14          "lanes_cnt" : 3,
15          "lanes" : [ {
16            "id" : 1,
17            "lane_type" : {
18              "name" : "a driving lane"
19            },
20            "no_further_connection" : false
21          }, {
22            "id" : 2,
23            "details" : {
24              "type" : "object",
25              "id" : "urn:jsonschema:stiEF_SL:model:ScenarioCatalog",
26              "properties" : {
27                "catalog" : {
28                  "type" : "string"
29                },
30                "scenarios" : {
31                  "type" : "array",
32                  "items" : {
33                    "type" : "object",
34                    "id" : "urn:jsonschema:stiEF_SL:model:Scenario",
35                    "properties" : {
36                      "overview" : {
37                        "type" : "object",
38                        "id" : "urn:jsonschema:stiEF_SL:model:ScenarioOverview",
39                        "properties" : {
40                          "scenario" : {
41                            "type" : "string"
42                          },
43                          "description" : {
44                            "type" : "string"
45                          }
46                        }
47                      }
48                    }
49                  }
50                }
51              }
52            }
53          }
54        }
55      }
56    }
57  } ]
58 }
```

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Final implementation – data model



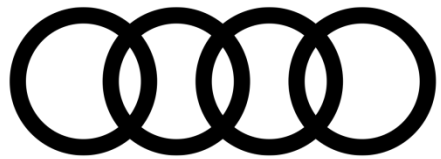
stiEF

File location, documentation and installation steps

- Tool „stiEF“:
 - Currently AUDI IP, so only available internally at VW
 - Publication is currently discussed – no decision yet

- Language „stiEF“:
 - Publication of the language as a document is approved
 - Publication is currently prepared and will be available soon™

- Publications:
 - 2019 – “Advantageous Usage of Textual Domain-Specific Languages for Scenario-Driven Development of Automated Driving Functions”, SysCon 2019, Orlando
 - 2019 – “Scenario-Based Systems Engineering: An Approach Towards Automated Driving Function Development”, SysCon 2019, Orlando
 - 2020 – “Efficient usage of abstract scenarios for the development of highly-automated driving functions”, FKFS Symposium 2020, Stuttgart



Thank you!

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