TRIANGRAPHICS
Intelligent Terrain Solutions

Checks for QC4OpenX
for ASAM OpenX Standards

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ASAM QC4OpenX Proposal Workshop

Agenda

- **Introduction**
  - Company, Product
- **Validation**
  - Gaia X
  - Realization
  - Live Demo
  - Next Steps

About Us

Company

TrianGraphics GmbH

- Founded 2004 in Berlin
- Specialized in 3D content creation
  - Software development with flagship product Trian3DBuilder
  - Services: 3D scene map creation

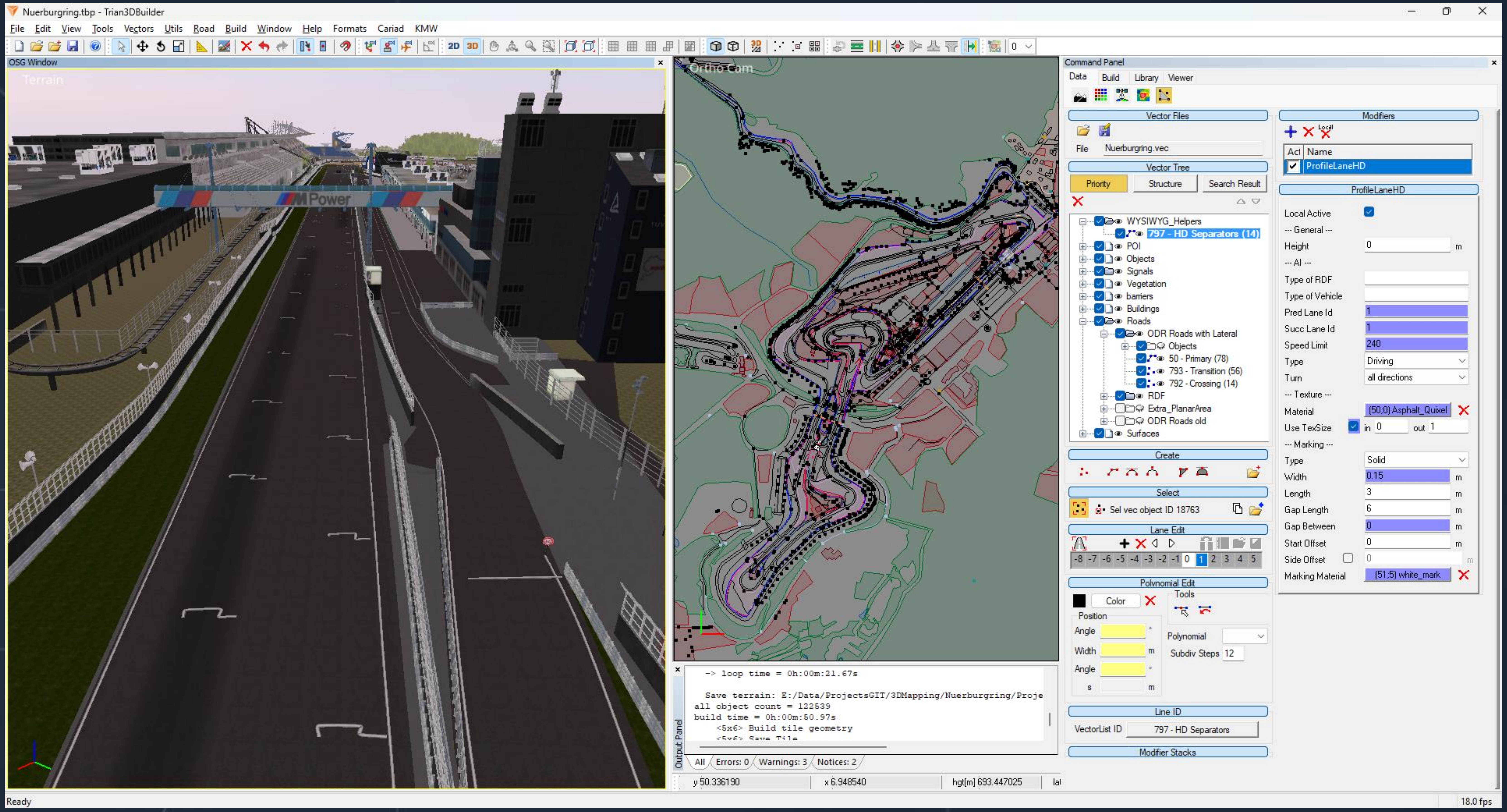
About Us

Product

TRIAN3DBUILDER
Database Generation System

DATABASE GENERATION SYSTEM

- Unique capabilities & flexibility
- Comprehensive support for input and output formats
  - Unreal, Unity, ..
  - VTD, Carmaker, ..
  - GLTF, FBX, …



File: Nuerburgring.vec

Sel vec object ID 18763

VectorList ID: 797 - HD Separators

Polynomial · Subdiv Steps: 12

☑ ProfileLaneHD

ProfileLaneHD

Local Active ☑

--- General ---

Height: 0 m

--- AI ---

Type of RDF:

Type of Vehicle:

Pred Lane Id: 1

Succ Lane Id: 1

Speed Limit: 240

Type: Driving

Turn: all directions

--- Texture ---

Material: (50;0) Asphalt_Quixel

Use TexSize ☑ in 0 out 1

--- Marking ---

Type: Solid

Width: 0.15 m

Length: 3 m

Gap Length: 6 m

Gap Between: 0 m

Start Offset: 0 m

Side Offset ☐ 0 m

Marking Material: (51;5) white_mark

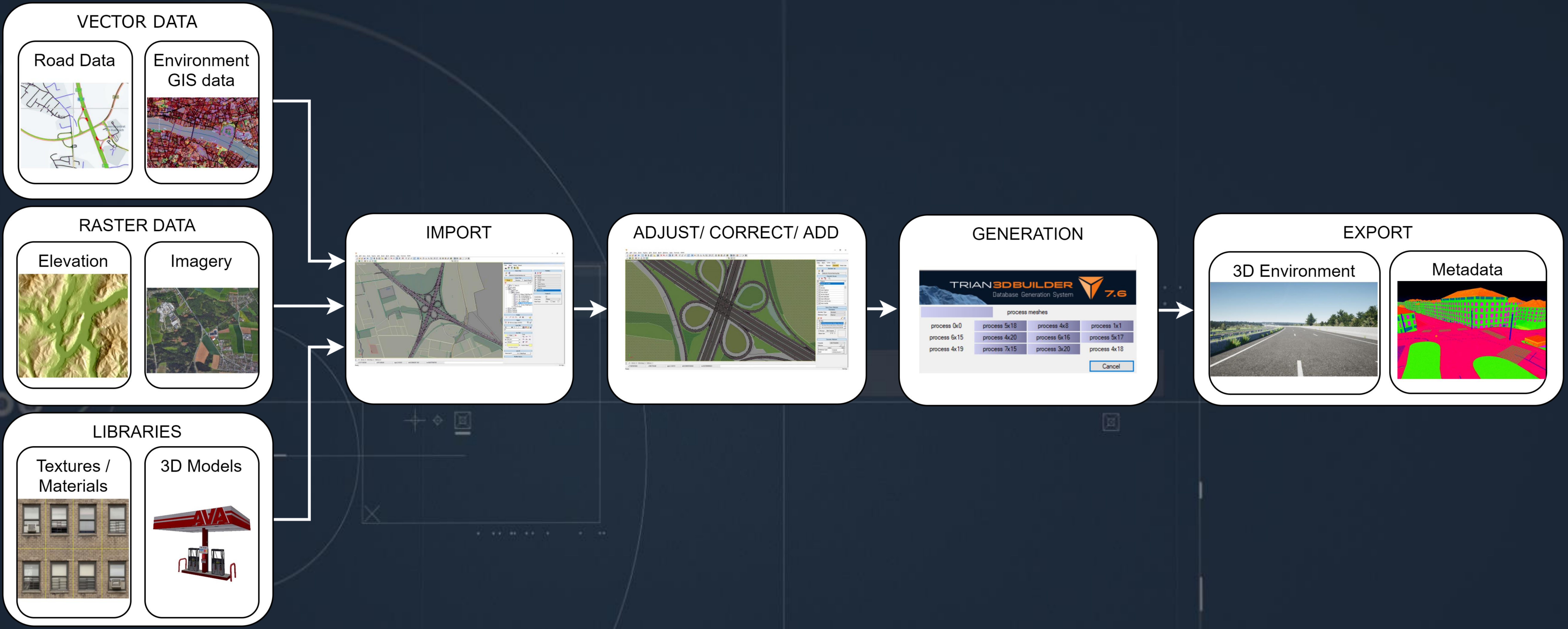
```
  -> loop time = 0h:00m:21.67s

  Save terrain: E:/Data/ProjectsGIT/3DMapping/Nuerburgring/Proje
all object count = 122539
build time = 0h:00m:50.97s
    <5x6> Build tile geometry
    <5x6> Save Tile
```

y 50.336190 | x 6.948540 | hgt[m] 693.447025

About Us

Workflow and components of the 3D environment model



VECTOR DATA

Road Data

Environment GIS data

RASTER DATA

Elevation

Imagery

LIBRARIES

Textures / Materials

3D Models

IMPORT

ADJUST/ CORRECT/ ADD

GENERATION

```
TRIAN3DBUILDER 7.6
Database Generation System
process meshes
process 0x0    process 5x18   process 4x8    process 1x1
process 6x15   process 4x20   process 6x16   process 5x17
process 4x19   process 7x15   process 3x20   process 4x18
Cancel
```

EXPORT

3D Environment

Metadata

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About Us

Examples

Rüdesheim
Wiesbaden
Mainz
Wallau
66
Mainz
Basel
Stuttgart
F. Kreuz
3
Köln
3
AMG
AMG

Validation

Research Project

gaia-x 4 PLC-AAD

- Research Project
  - www.gaia-x4plcaad.info
  - Goal: Setup of an open and distributed data ecosystem
  - Data Assets for driving simulation
    - HD map, 3D Model, Scenario, OSI, Sensor, ..
    - Based on https://envited.market/
  - Role
    - Data Provider for 3D models, HD maps
    - Service Provider for data analysis
  - Task
    - Validation of data assets

Validation

Motivation

- Many tool and data providers have their own test suites, but
  - checks from their point of view or application
  - Incomplete
  - Partly not accessible
- Data provider generate and Tools read formats differently
  - interpret elements slightly differently
  - do not support all features or characteristics
  - sometimes have certain constraints
- Standard description not always clear
  - offer room for interpretation
  - Implementation examples are missing
  - Schema does not cover everything or is incomplete

Validation

Criteria

- **Uniform**
  - Standardized framework with defined, documented test criteria
- **Comprehensible**
  - Publication as Opensource
  - Providing data examples
- **Extendable**
  - Flexible framework
    - For adding new checks
    - And adding new XML based formats
- **Complete**
  - **Try** to collect all checks
    - of available test suits
    - from our experience and customer feedback
  - need input from data and tool providers -> ASAM community

Validation

Categories

- Schema
  - Load the file (XML)
  - Test against schema file
- Semantic
  - Links
  - Order
  - Ranges
- Geometry
  - Values correct (e.g. lengths)
  - Values in range
  - Steadiness

- Tool Compatibility
  - loadable / usable in applications
  - Special requirements of applications
- Linkage
  - to other OpenStandards
    - e.g. ODR -> CRG, OSC -> ODR
  - Correct references / position
- Statistic
  - Node elements (e.g. roads / junctions)
  - Objects (e.g. signal type)

Validation

Implementation

- Language
  - Python
- Execution
  - Different platforms (Linux, Windows, Mac, Web?)
  - Local
  - Backend (Server)
  - Docker Container: OVAL-Platform of Perpettum Progress GmbH

- Data Structure
  - Each Format has
    - Bundles (categories) of
      - Checks with
        - Configuration (e.g. epsilon)
        - and report
          - Issues
            - Error level (Error, Warning, Info)
            - Locations (File, Xpath, Road)

- Input
  - XML based formats with schema
  - Currently OpenDRIVE, OpenSCENARIO
- Output
  - Write as TXT, JSON, **QChecker XQAR**
  - Console

Validation

Implementation

- Parameters
  - INPUT_FILES
    - can be a mix of different formats
  - -a addition-check-dirs
    - Reference to additional Checker Bundles
  - -c config
    - Path to config file. Specification of external variables for checks
  - -t output-type
    - Output format of result report: xqar, json, txt
  - -o output-directory
    - Path to validation report folder
- Features
  - Setup order for bundles and checks (e.g. schema check first)
  - Formats, bundles and checks scripts register themselves automatically

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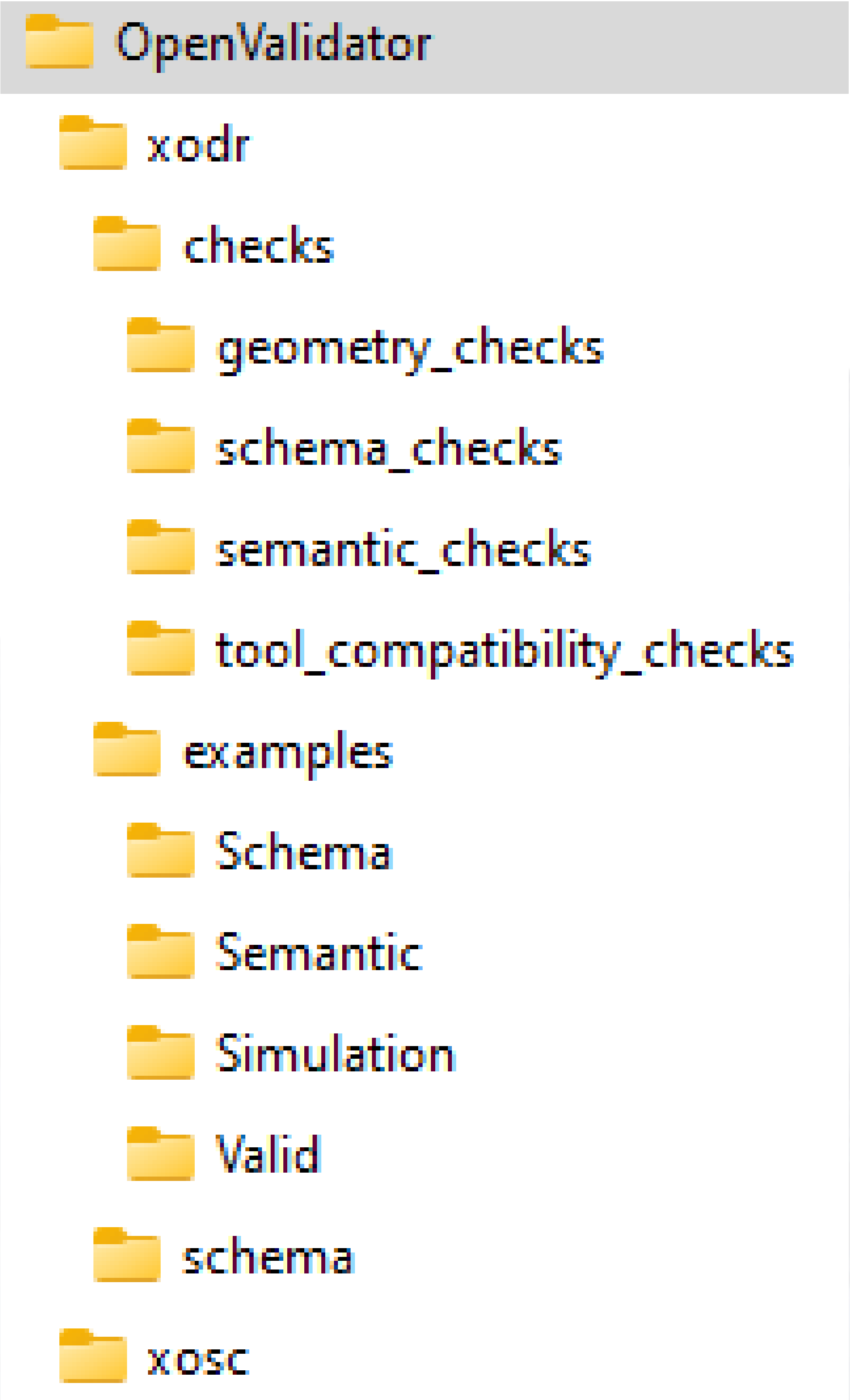
Validation

Implementation

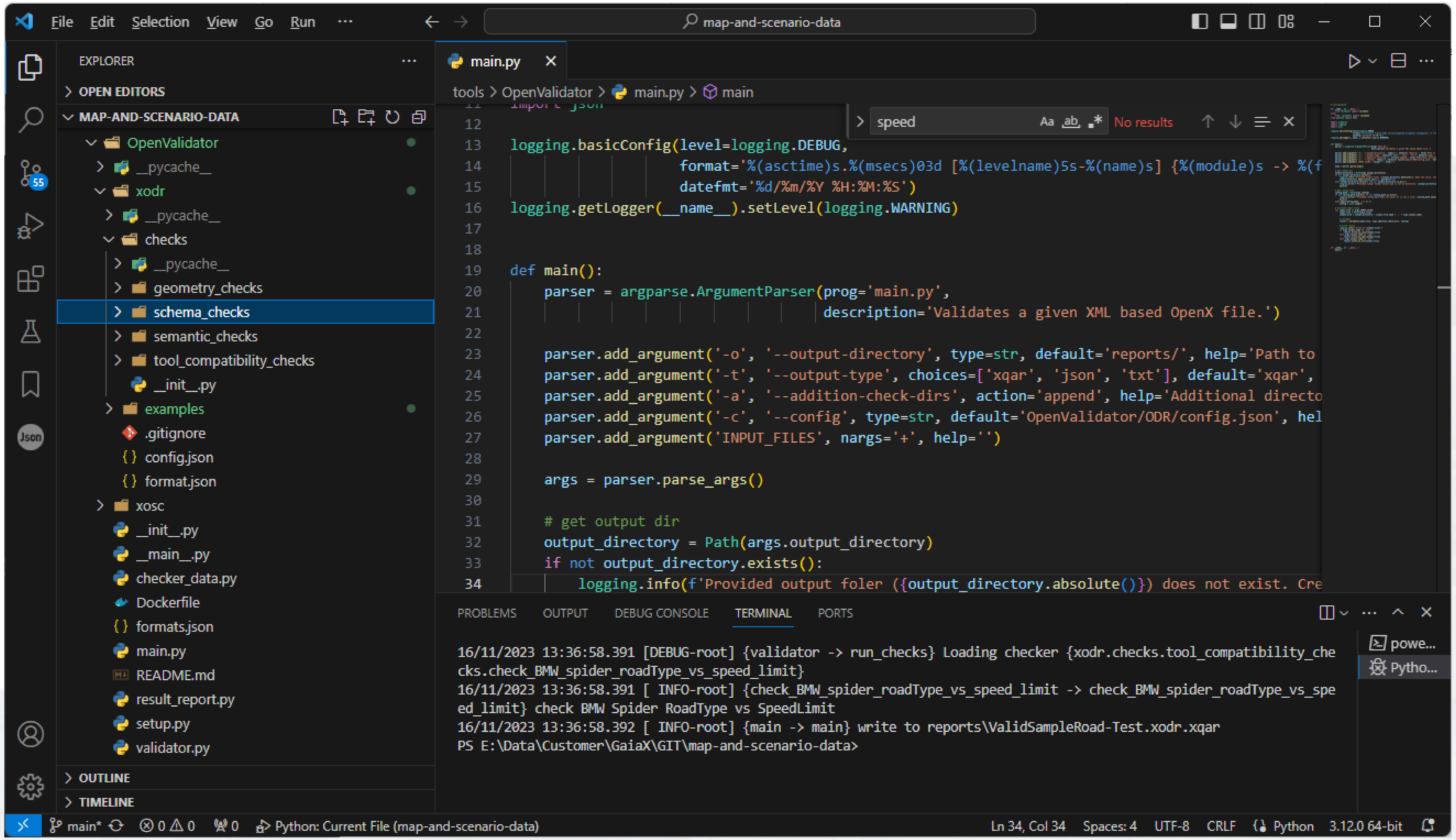
- Classes
  - Main.py
    - reads, checks parameters and for each file calls validation and writes output
  - validator.py
    - reads file as xml
    - loads registered bundles, loads and executes check
  - result_report.py
    - Data structure for report file and functions for registering
    - Writes Report Tree as different formats
  - Check scripts
    - Check interface function
    - get_checker_id and get_description for name and description



- OpenValidator
  - xodr
    - checks
      - geometry_checks
      - schema_checks
      - semantic_checks
      - tool_compatibility_checks
    - examples
      - Schema
      - Semantic
      - Simulation
      - Valid
    - schema
  - xosc

Validation

Live Demo

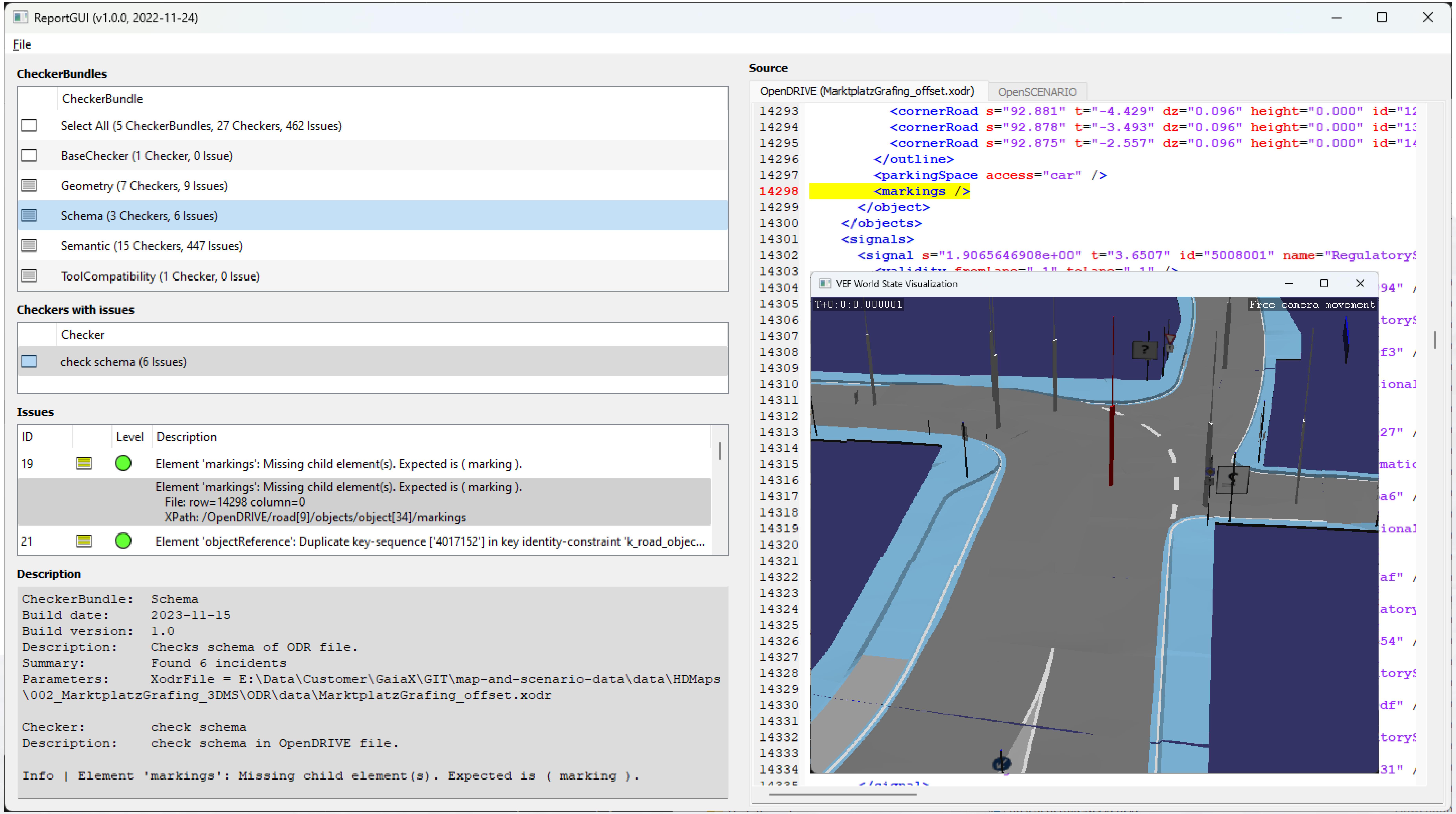


```python
import json

logging.basicConfig(level=logging.DEBUG,
                    format='%(asctime)s.%(msecs)03d [%(levelname)5s-%(name)s] {%(module)s -> %(f
                    datefmt='%d/%m/%Y %H:%M:%S')
logging.getLogger(__name__).setLevel(logging.WARNING)


def main():
    parser = argparse.ArgumentParser(prog='main.py',
                                     description='Validates a given XML based OpenX file.')

    parser.add_argument('-o', '--output-directory', type=str, default='reports/', help='Path to
    parser.add_argument('-t', '--output-type', choices=['xqar', 'json', 'txt'], default='xqar',
    parser.add_argument('-a', '--addition-check-dirs', action='append', help='Additional directo
    parser.add_argument('-c', '--config', type=str, default='OpenValidator/ODR/config.json', hel
    parser.add_argument('INPUT_FILES', nargs='+', help='')

    args = parser.parse_args()

    # get output dir
    output_directory = Path(args.output_directory)
    if not output_directory.exists():
        logging.info(f'Provided output foler ({output_directory.absolute()}) does not exist. Cre
```

```
16/11/2023 13:36:58.391 [DEBUG-root] {validator -> run_checks} Loading checker {xodr.checks.tool_compatibility_che
cks.check_BMW_spider_roadType_vs_speed_limit}
16/11/2023 13:36:58.391 [ INFO-root] {check_BMW_spider_roadType_vs_speed_limit -> check_BMW_spider_roadType_vs_spe
ed_limit} check BMW Spider RoadType vs SpeedLimit
16/11/2023 13:36:58.392 [ INFO-root] {main -> main} write to reports\ValidSampleRoad-Test.xodr.xqar
PS E:\Data\Customer\GaiaX\GIT\map-and-scenario-data>
```

Validation

QChecker



ReportGUI (v1.0.0, 2022-11-24)

CheckerBundles

	CheckerBundle
□	Select All (5 CheckerBundles, 27 Checkers, 462 Issues)
□	BaseChecker (1 Checker, 0 Issue)
▨	Geometry (7 Checkers, 9 Issues)
▨	Schema (3 Checkers, 6 Issues)
▨	Semantic (15 Checkers, 447 Issues)
▨	ToolCompatibility (1 Checker, 0 Issue)

Checkers with issues

	Checker
□	check schema (6 Issues)

Issues

ID		Level	Description
19	▤	●	Element 'markings': Missing child element(s). Expected is (marking).
			Element 'markings': Missing child element(s). Expected is (marking). File: row=14298 column=0 XPath: /OpenDRIVE/road[9]/objects/object[34]/markings
21	▤	●	Element 'objectReference': Duplicate key-sequence ['4017152'] in key identity-constraint 'k_road_objec...

Description

```
CheckerBundle:   Schema
Build date:      2023-11-15
Build version:   1.0
Description:     Checks schema of ODR file.
Summary:         Found 6 incidents
Parameters:      XodrFile = E:\Data\Customer\GaiaX\GIT\map-and-scenario-data\data\HDMaps
\002_MarktplatzGrafing_3DMS\ODR\data\MarktplatzGrafing_offset.xodr

Checker:         check schema
Description:     check schema in OpenDRIVE file.

Info | Element 'markings': Missing child element(s). Expected is ( marking ).
```

Source

```
          <cornerRoad s="92.881" t="-4.429" dz="0.096" height="0.000" id="1
          <cornerRoad s="92.878" t="-3.493" dz="0.096" height="0.000" id="1
          <cornerRoad s="92.875" t="-2.557" dz="0.096" height="0.000" id="1
        </outline>
        <parkingSpace access="car" />
        <markings />
      </object>
    </objects>
    <signals>
      <signal s="1.9065646908e+00" t="3.6507" id="5008001" name="Regulatory
```

Validation

Release

- Current State
  - GitHub repository at Gaia X
  - Around 30 checks with 70 issues
  - XML based checks for OpenDRIVE, OpenSCENARIO

- Beginning of 2024
  - as an Opensource project at
    - **ASAM**
      - Checks close to standards
    - **asc(s OpenMSL**
      - Application-oriented checks
      - Interaction with other models, processes, tools and marketplace processes
    - **Technology roadmap between ASAM and asc(s**

Validation

OpenMSL

- ENVITED **Opensource M**odel & **S**imulation **L**ibrary
  - Operator is asc(s e.V.
  - Hosting of Opensource simulation models, tools and documentations for R&D of automated driving functions
  - https://github.com/openMSL

  - SL1 - Perception Sensor Models
    - collection of OSI compliant sensor models
  - SL2 - Traffic Participant Models
    - set of OSI compliant traffic participant models, which include pedestrian models, SSP based ALKS systems, automated road users
  - SL3 - Scenario Data
    - example scenario data following the ASAM OpenSCENARIO standard
  - SL5 – Tooling
    - various tools to import, export, analyze and visualize co-simulation data (OSI, SRMD)

Validation

Next Steps

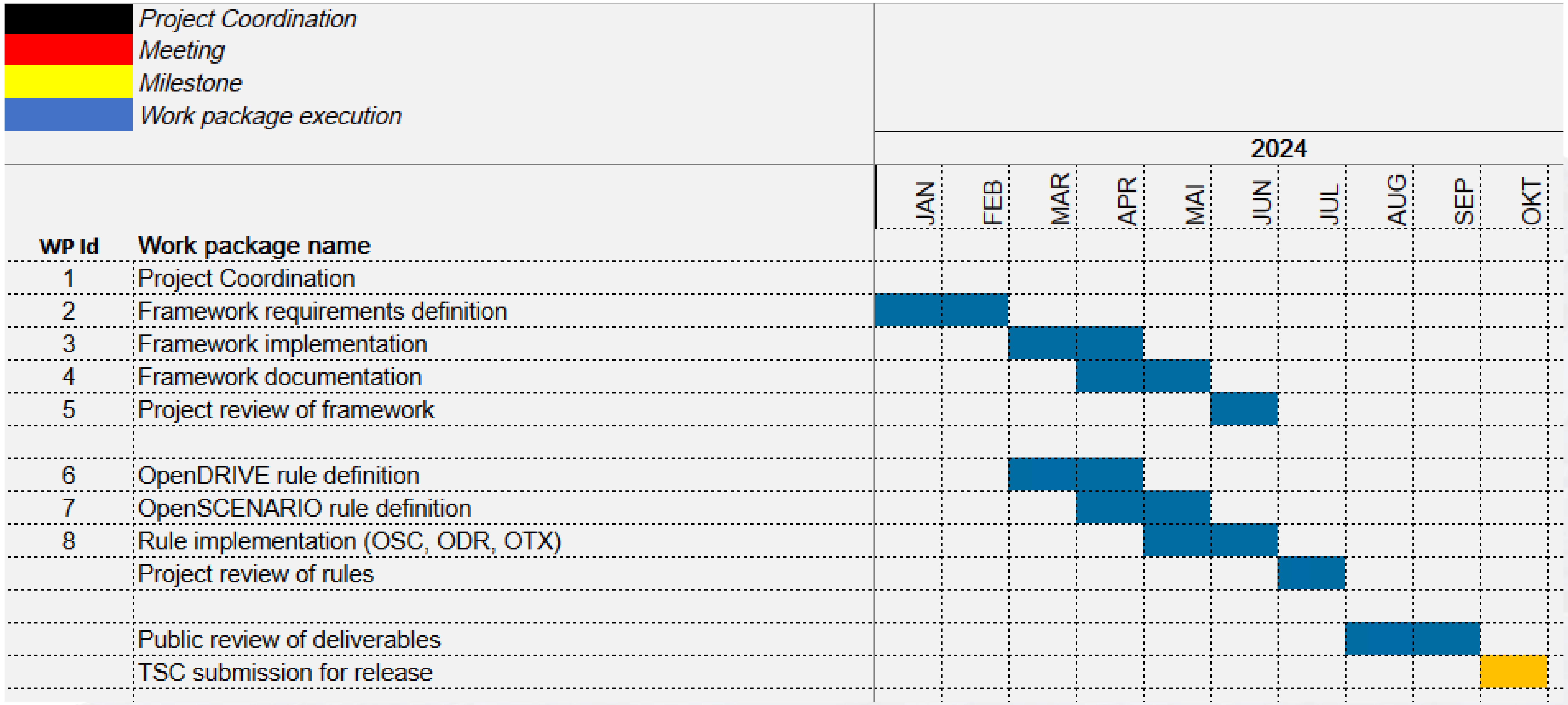
Todo's

Questions

- Code and Rights transfer
  - As Opensource
    - License MPL-2
    - used 3thParty libs
      - LXML, SCIPY, esmini
  - to ASAM
    - ➢ When and how?
    - Further development on the GaiaX, TrianGraphics side
      - ➢ How? As a fork/branch, which will then be merged back at the defined time?
  - to OpenMSL
    - ➢ When and how to split?
      - ASAM
        - General framework
        - Bundles Schema, Semantic, Geometry
      - OpenMSL
        - Bundles Tool Combability, Linkage, Statistic

Validation

Project plan



⬛ *Project Coordination*
🟥 *Meeting*
🟨 *Milestone*
🟦 *Work package execution*

		2024									
WP Id	**Work package name**	JAN	FEB	MAR	APR	MAI	JUN	JUL	AUG	SEP	OKT
1	Project Coordination										
2	Framework requirements definition	🟦	🟦								
3	Framework implementation			🟦	🟦						
4	Framework documentation				🟦	🟦					
5	Project review of framework						🟦				
6	OpenDRIVE rule definition			🟦	🟦						
7	OpenSCENARIO rule definition				🟦	🟦					
8	Rule implementation (OSC, ODR, OTX)					🟦	🟦				
	Project review of rules							🟦			
	Public review of deliverables								🟦	🟦	
	TSC submission for release										🟨

Validation

Next Steps

Todo's

Questions

Framework Todo’s

- Robustness
- More flexible configuration files
  - Format specific, enable bundles/checks
- Docker Container
- Checking complete folder contents
  - For Unit test to check all examples

Checks

- Current checks
  - should be reviewed
  - test for different format versions
- Further checks
  - Who coordinates this?
  - New checks could lead to errors at the data provider
    - Preparation time until publication so that data providers can correct this on their side

Schema

- ➢ Can all schema files be supplied? Rights?

- QChecker
  - Implementation of 3D visualization
    - Use from esmini or libOpenDRIVE
  - Support for displaying large files (5 MB limit)
  - Drag&Drop für Report GUI
  - Refresh after loading new result file
  - Bundle philosophy
    - ➢ Bundle executables vs. Check folder?
    - ➢ Result file per bundle or total?

- Documentation
  - Doxygen documentation in python scripts
    - Convert as HTML documentation
    - creation of general pages
  - ➢ What form and content?
    - Specification from ASAM

- Example
  - One data example per check
  - Only the specific issues of this check hits
  - Test all issue code paths

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Validation

Issues

- Schema
  - Incorrect key definition for Object References?
    - Object References can refer multiple times to Object with unique ID, and therefore Object Reference id is not unique!
    - OpenDrive 1.5 – 1.7
  - Old OpenDrive schema file not usable?
    - OpenDrive 1.1 – 1.2
    - Element 'OpenDRIVE': No matching global declaration available for the validation root.
  - Outline_cornerRoad and outline_cornerLocal should not have a key reference to outlineId
    - OpenDrive 1.5
    - Fixed already in 1.6-1.7
    - Element 'cornerLocal': No match found for key-sequence ['0'] of keyref 'r_road_objects_object_outline_cornerLocal'.

Validation

Issues

- Examples for OpenDrive 1.7
  - Ex_Railway-station
    - 2 xords – one (Ex_Railway_station.xodr) is in old OpenDrive 1.5
  - UC_Motorway-Exit-Entry
    - Lane validity for signals should not be “0”
    - E.g. UC_Motorway-Exit-Entry-DirectJunction.xord

THANKS FOR YOUR INTEREST

- **Contact**

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www.Trian3DBuilder.com

www.youtube.com/user/TrianGraphics

in www.linkedin.com/company/triangraphics-gmbh