PROJECT of the PEGASUS FAMILY

VERIFICATION VALIDATION METHODS

Mid-Term Presentation 15 / 16 March 2022

The OMEGA Format – A Comprehensive Open-Source Measurement Data Format

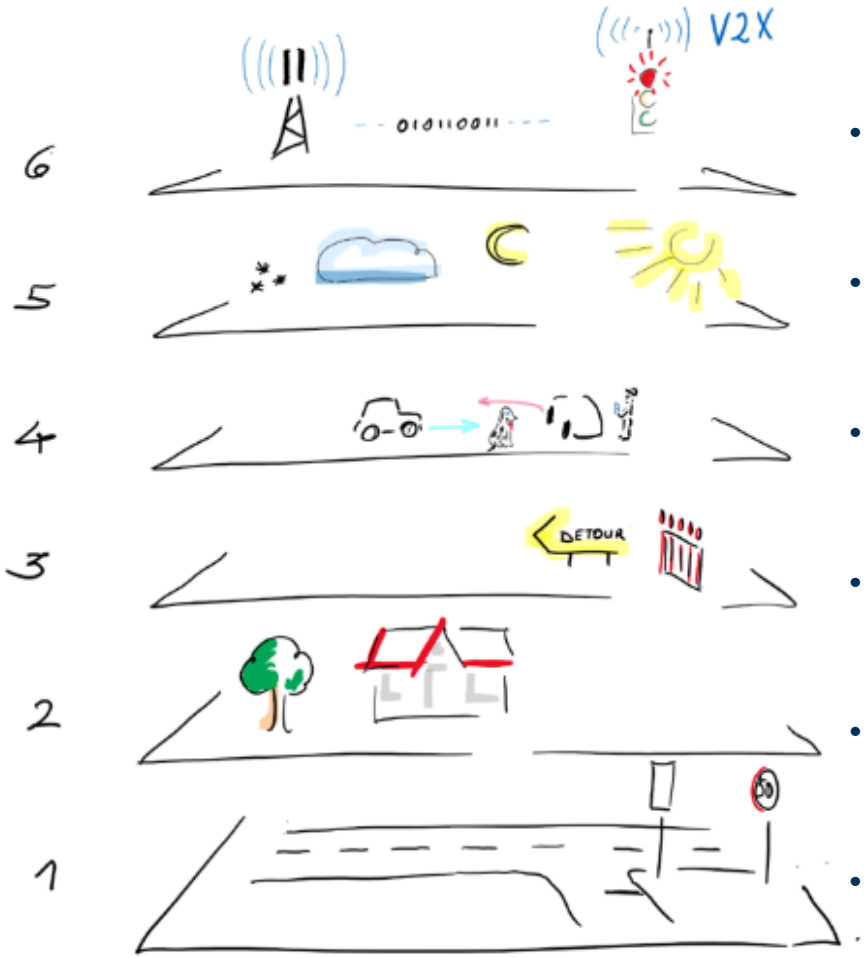
Michael Schuldes, RWTH Aachen University

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

6-Layer Model as Basis for Structured Traffic Environments



- Layer 6 – Digital Information
- Layer 5 – Environmental Conditions
- Layer 4 – Dynamic Objects
- Layer 3 – Temporary Modifications of L1 and L2
- Layer 2 – Roadside Structures
- Layer 1 – Road Network and Traffic Guidance Objects

Structuring the traffic environment

Requirements

- Capture Reference Data and Perception Data
  - != Simulation Instructions like OpenScenario
- Object-list based Data
- Single file
- Include data on
  - Dynamic Objects
  - Infrastructure
  - Weather
- ! Object Classes must match Labelling abilities
- Translation to other standards
- Early Verification of Format Conformance and plausible Data
  - Lesson learned of L3Pilot

Evolving Data Formats

VERIFICATION VALIDATION METHODS

Pegasus	OMEGA-Format	L3Pilot Common Data Format
• CSV • Relative Map • Not Designed for Urban • Concept for Perception	• HDF5 Container • Absolute Map • Designed for Urban • Concept for Perception	• HDF5 Container • Relative Map • Basic Support for Urban • No Concept for Perception

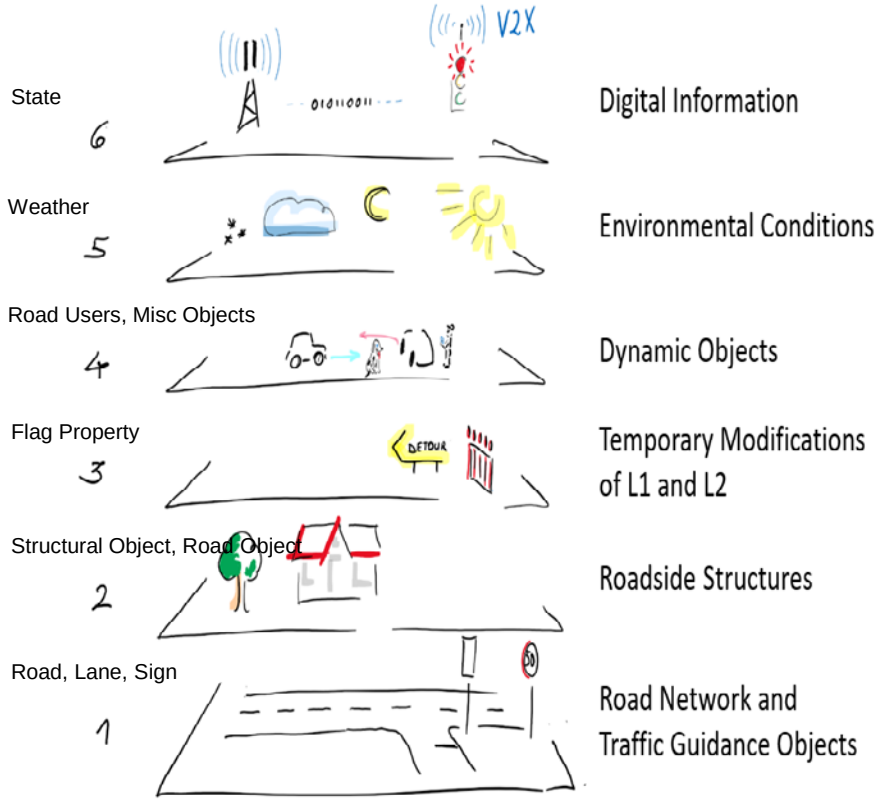
- Enabling automated algorithms for VVM Argumentation

Alternatives

Format	Map	Objects	Weather
OMEGA-Format	✓	✓	✓
OpenDrive	✓ (not polyline based)	✗	✗
Lanelet2	✓	✗	✗
OpenScenario	✗	✓ (not for concrete trajectories)	✗
OSI	✓ (not polyline based)	✓	✓ (not sufficiently detailed)
Pegasus	- (only relative)	✓	✗
L3Pilot-CDF	- (only relative)	✓	✓ (not sufficiently detailed)

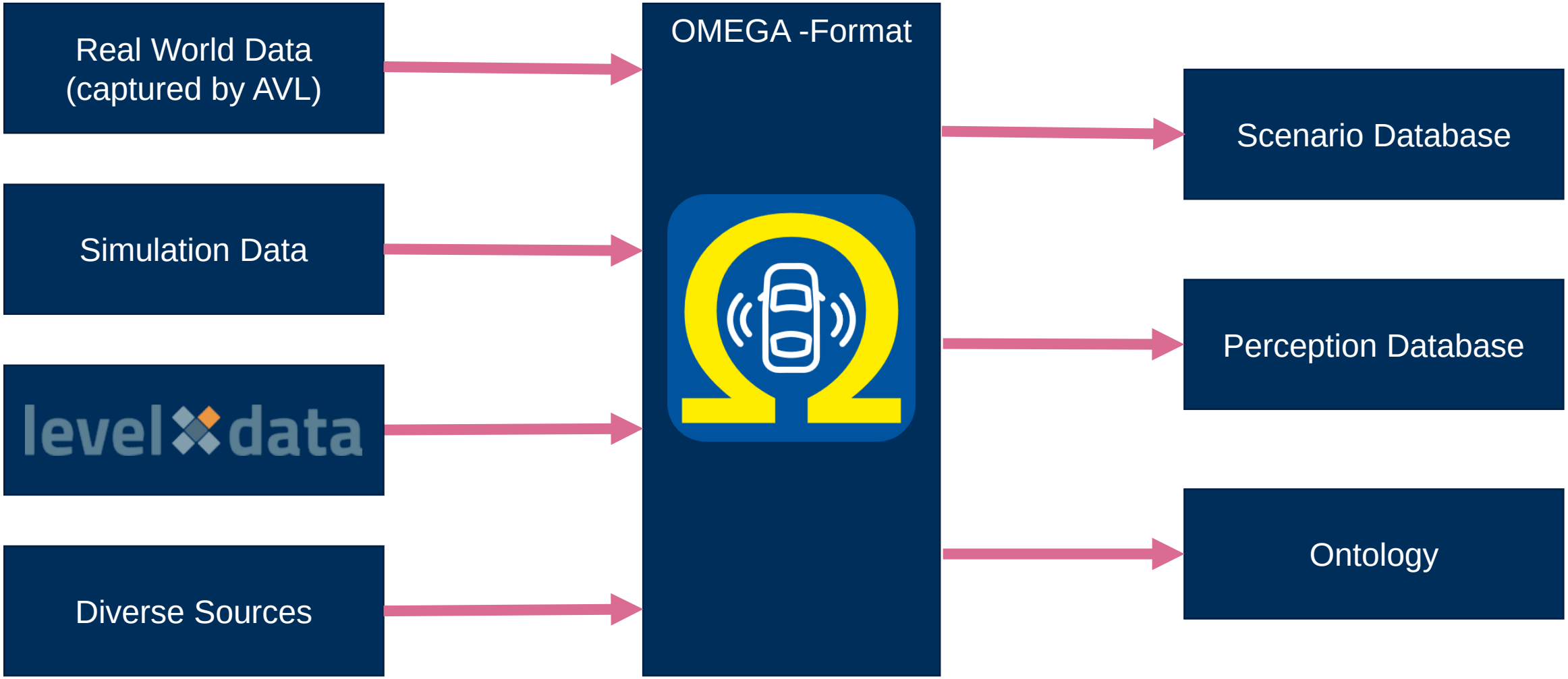
OMEGA Format

- Based on HDF5 file format
  - Proven in L3Pilot Project
- Object-list based representation
- Lanes defined through polylines
  - Directly annotatable on real world data
- Direct support for L3 (Temporary Modifications) in format
  - Increased reusability
- Closely tied to Perception-Format (Perception-Analysis)
- All Objects have synchronized timestamps

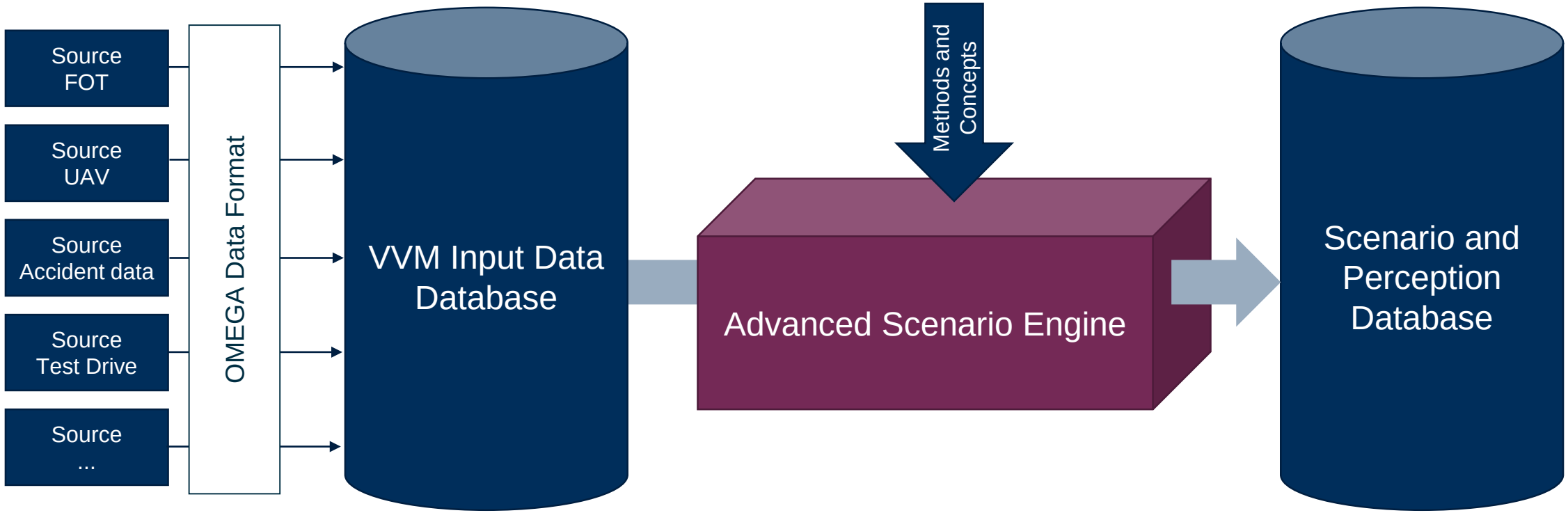


- Interoperability within and beyond VVM Project
- Complete 6LM covered
- Evolution over Pegasus and L3Pilot formats incorporating urban setting

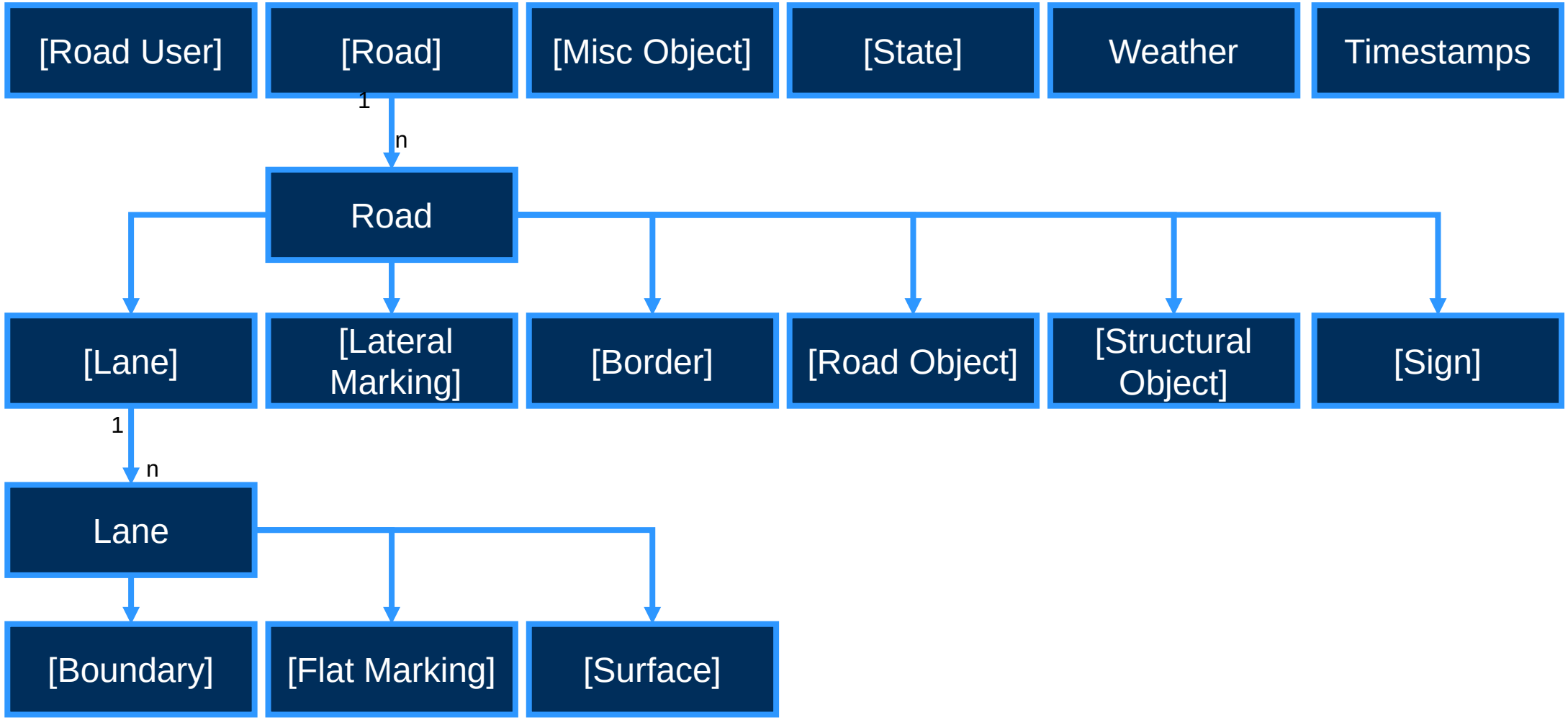
Omega Format as an Interface



Advanced Scenario Engine - From OMEGA to Scenarios

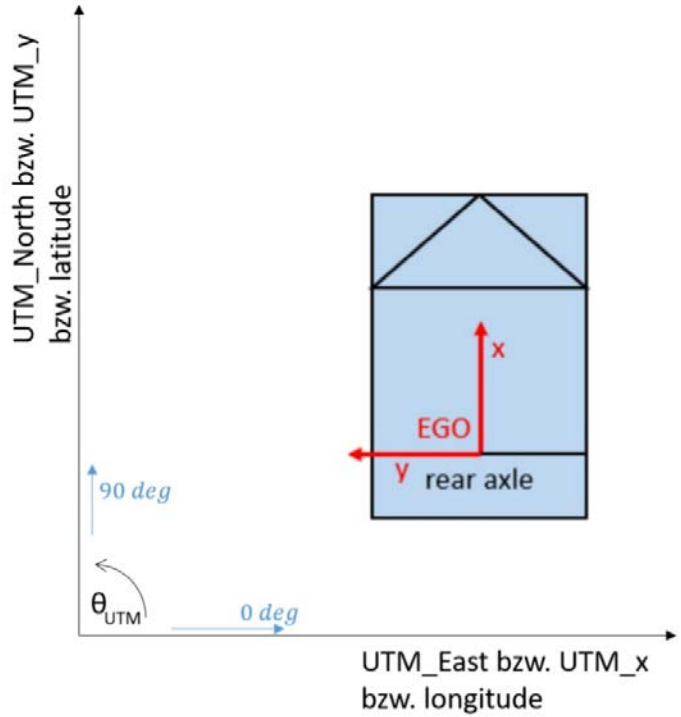


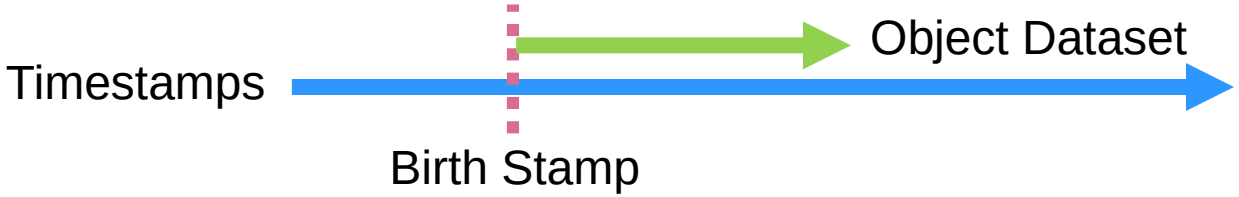
Structure


[Road User]
[Road]
[Misc Object]
[State]
Weather
Timestamps
1
n
Road
[Lane]
[Lateral Marking]
[Border]
[Road Object]
[Structural Object]
[Sign]
1
n
Lane
[Boundary]
[Flat Marking]
[Surface]

Road User (Misc Object is analogous)

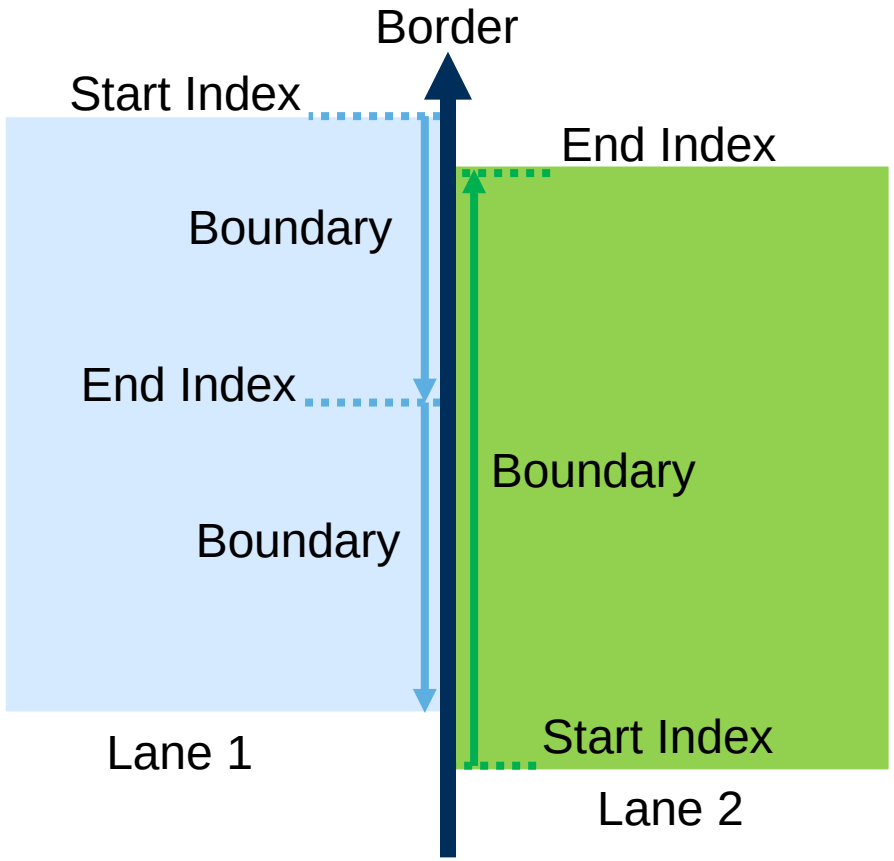
- Attributes
  - Birth Stamp, connected To, is Data Recorder, Type, Subtype
- Datasets (Arrays connected to timestamp array)
  - Bounding Box
    - Height, Length, Width
  - Trajectory
    - {Acceleration, Velocity} x {Lateral, Longitudinal, Vertical}
    - {Pitch, Heading, Roll} x {_, Derivation}
    - {Position} x {X, Y, Z}– (in local UTM rel. to WGS84 Ref Point)
  - Vehicle Lights
    - Blue Lights, Brake Lights, Headlights, Indicator Left, Indicator Right, Reversing Lights





Road

- Borders
  - Border defined through Polyline
  - Are referenced by multiple lanes
- Lane
  - Left and Right Border
  - List of Boundaries
    - Color, Condition, Height, Start/EndIndexOfBorder, Type, Subtype
    - Further specifies border
  - List of Flat Markings
    - Color, Condition, (Polyline/Position)
    - E.g., Keep out Area, Zigzag, Arrows, …
  - Predecessors, Successors
  - List of Surfaces



Signs and Road Objects

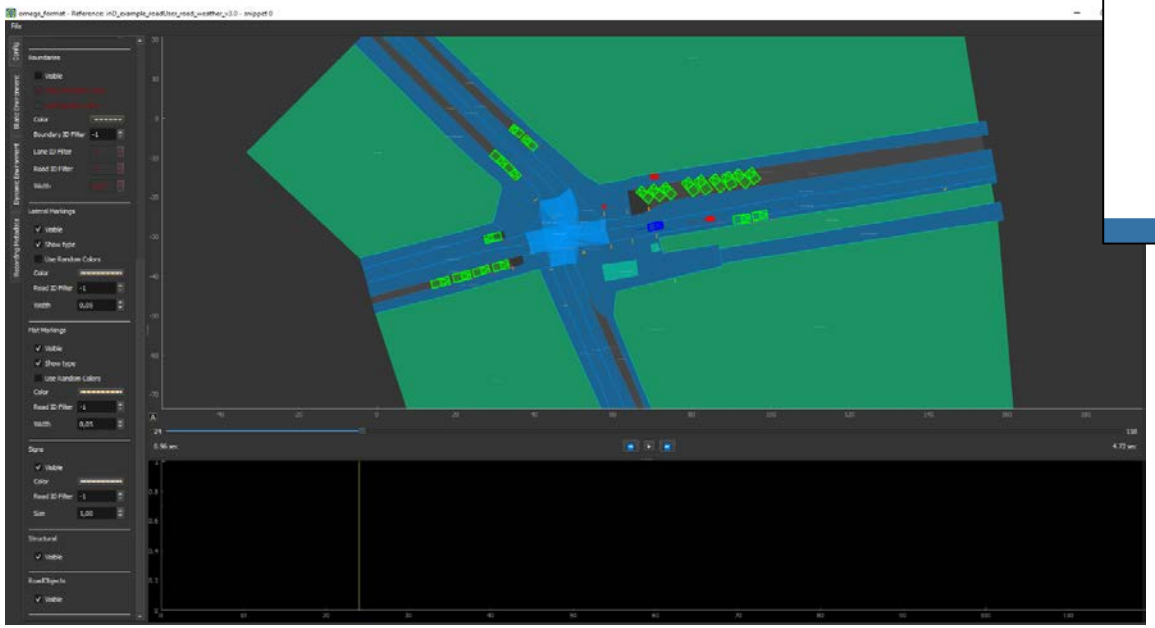
- Signs
  - Classification based on StVO and Wiener Convention
  - Size Class, Time dependent, Weather dependent
  - Applicable Lanes, Connected To, Fallback
  - Polyline/Position, Heading
- Lateral Marking
  - Crosswalk, Stop Line, Hold Line, …
  - Applicable Lanes, Long Size, Polyline, Color
- Road Objects
  - Streetlamps, Roundabout Center, Parking, Crossing aid, speed bump, …
  - Polyline, Height, Drivable, Walkable

Weather

- Air Pressure
- Cloudiness
  - In 8th of sky coverage (DWD)
- Gust of Wind
- Humidity
- Precipitation
  - Amount, snow depth, type
- Road Condition
  - Maintenance Status, Spray, Surface Condition
- Solar
- Temperature
- Visibility
- Wind
  - Direction, Speed

Tooling Features

- Python API
- C API
- Data Verification
- Visualization
- → Detailed Documentation on github.com



ika-rwth-aachen/
omega_format

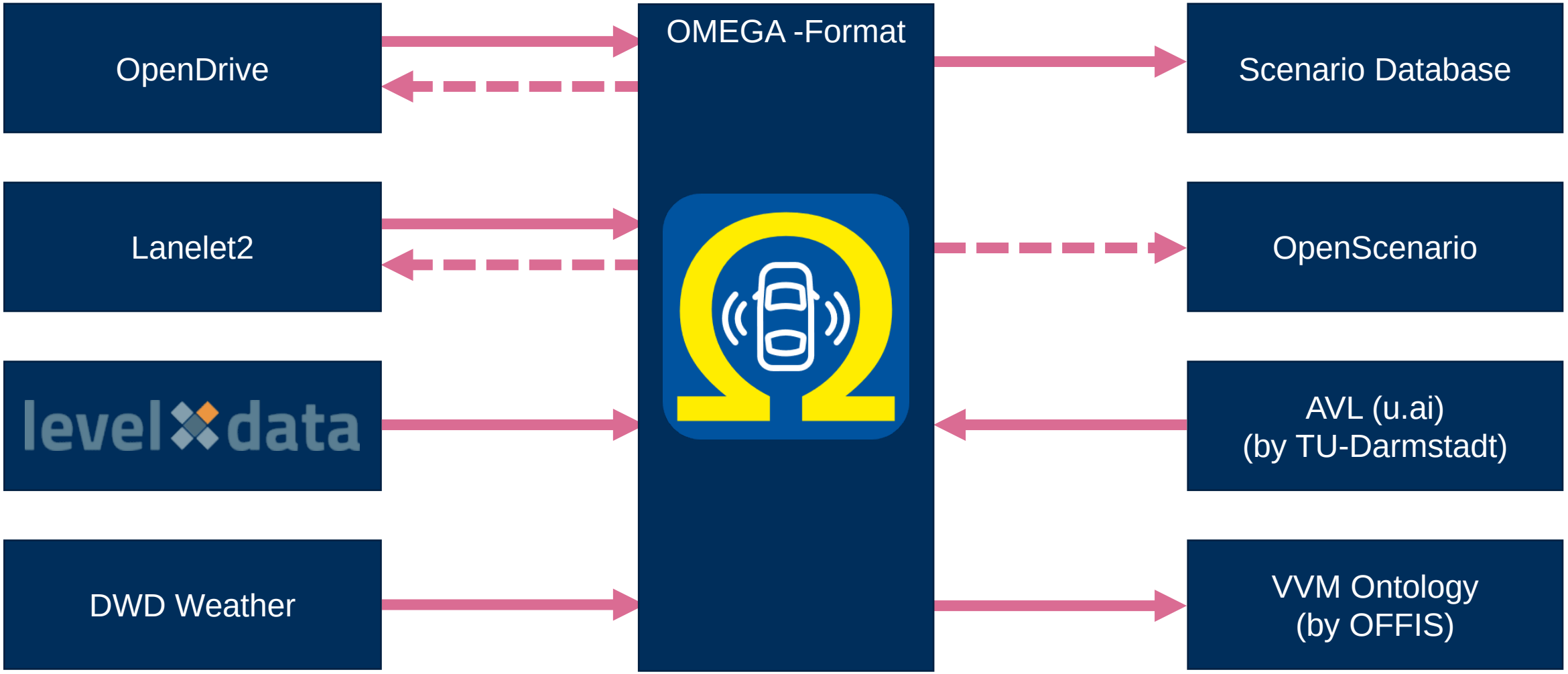
A Python library for reading, writing and visualizing the OMEGA Format, targeted towards storing reference and perception data in the...

2 Contributors | 1 Issue | 7 Stars | 0 Forks

Tooling Features - Data Verification

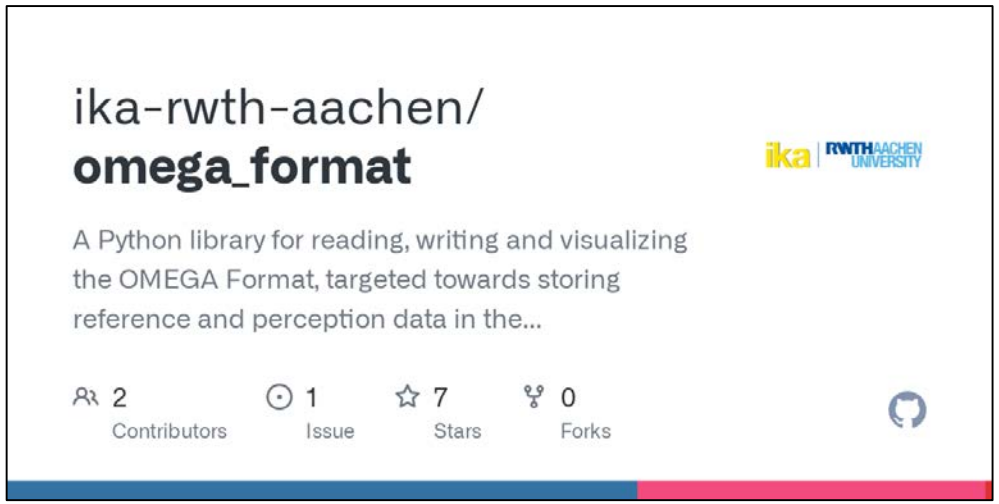
- Check if file is format compliant
  - Minimum requirement
- Plausibility Checks
  - Important early in the processing pipeline
  - Catch errors in data creation ASAP
  - Mitigates silent errors
- Examples of Plausibility Checks
  - Upper Limits for speed and acceleration
  - GPS differences close to speed
  - Well formed geometry for road network
- Performed on Advanced Scenario Engine Upload
  - Immediate Feedback

Format Converters



The Omega-Format

- Key Interface for Data Exchange in VVM
  - Captured Data, Databases, Ontology
- Features
  - Object-List-Based Data structure for Reference Data
    - Includes Map Information
    - Includes detailed Weather Information
    - Includes L3
  - Large Tooling
    - Converters for most popular Formats (OpenDrive, Lanelet2, LevelXData)
    - Visualization, Verification, APIs



- Evolution of Pegasus and L3Pilot formats
- Enabling automated algorithms for VVM Argumentation

VERIFICATION
VALIDATION
METHODS

Thank you!

Michael Schulder, RWTH Aachen University

PROJECT of the PEGASUS FAMILY

A project developed by the
VDA Leitinitiative
autonomous and connected driving

Supported by:

Federal Ministry
for Economic Affairs
and Climate Action

on the basis of a decision
by the German Bundestag