# Standards for Collaborative Simulation of Autonomous Driving

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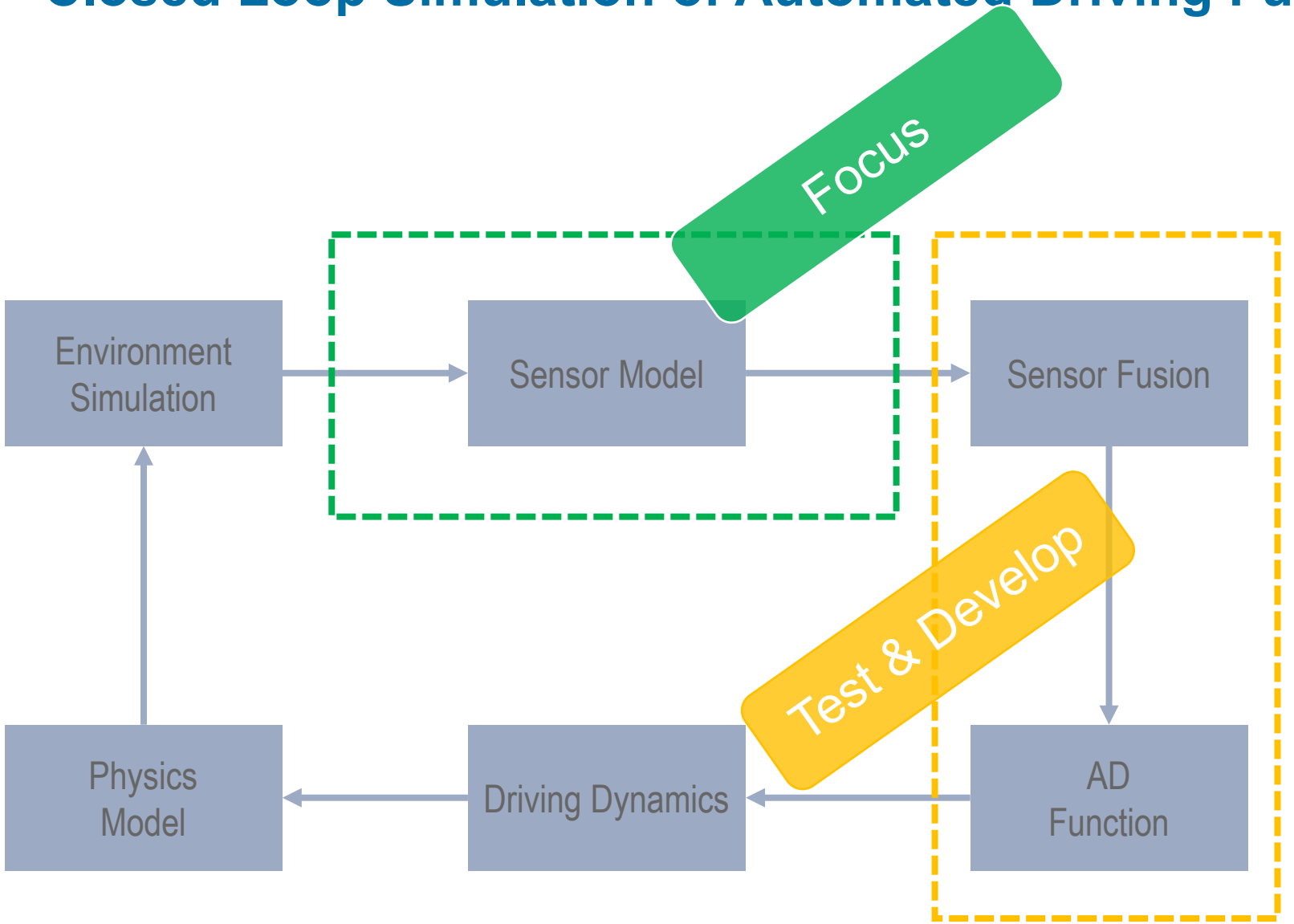
Böblingen, Germany

ASAM
Association for Standardization of Automation and Measuring Systems

# Closed Loop Simulation of Automated Driving Function



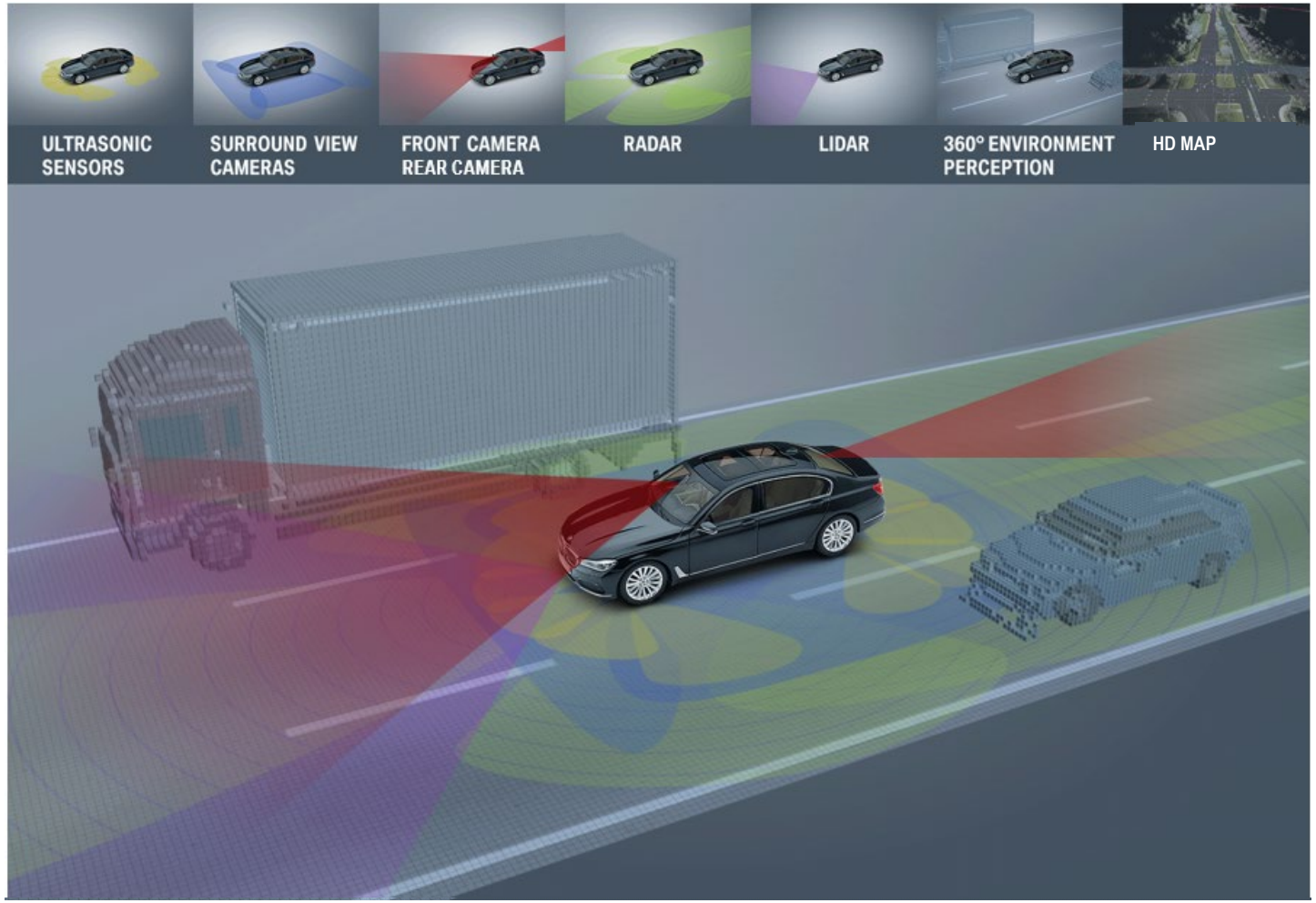

Vehicle tests

Vehicle in the loop

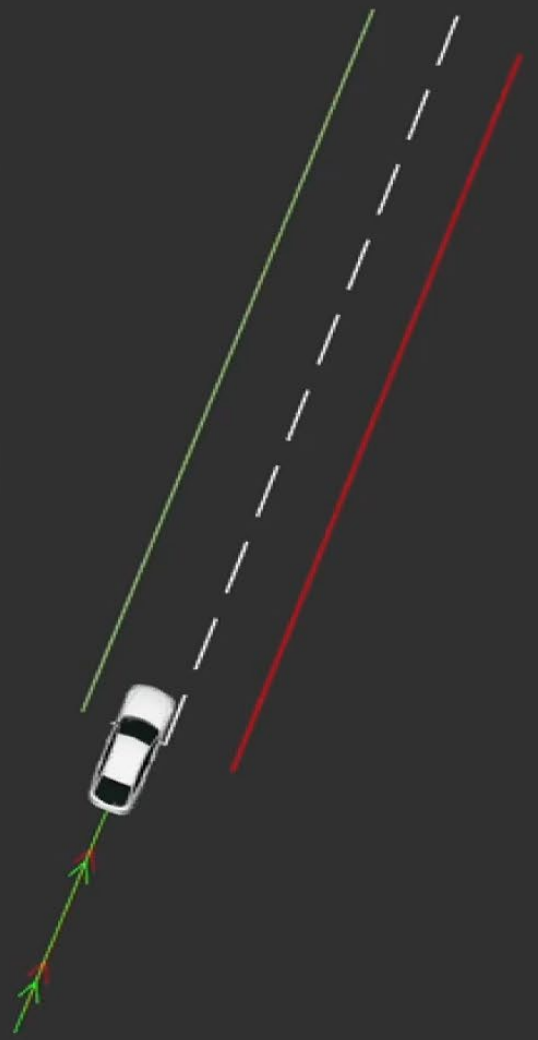
Software in the loop

Hardware in the loop

# Automated Driving Requires Numerous Sensors and Technologies

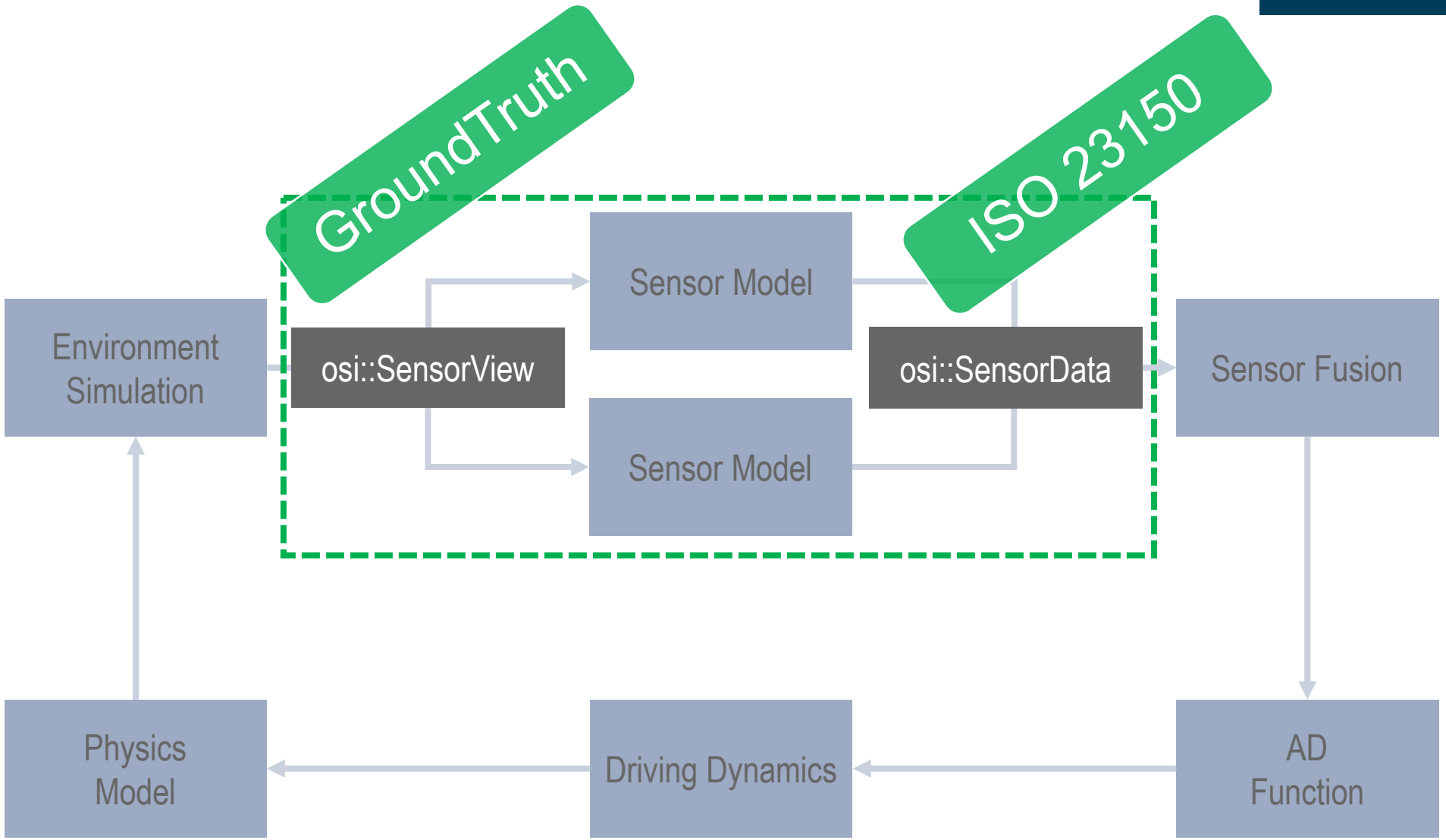



Video by courtesy of BMW

Video by courtesy of BMW

# Open Simulation Interface (OSI)




PEGASUS RESEARCH PROJECT

SECURING AUTOMATED DRIVING EFFECTIVELY.

PEGASUS

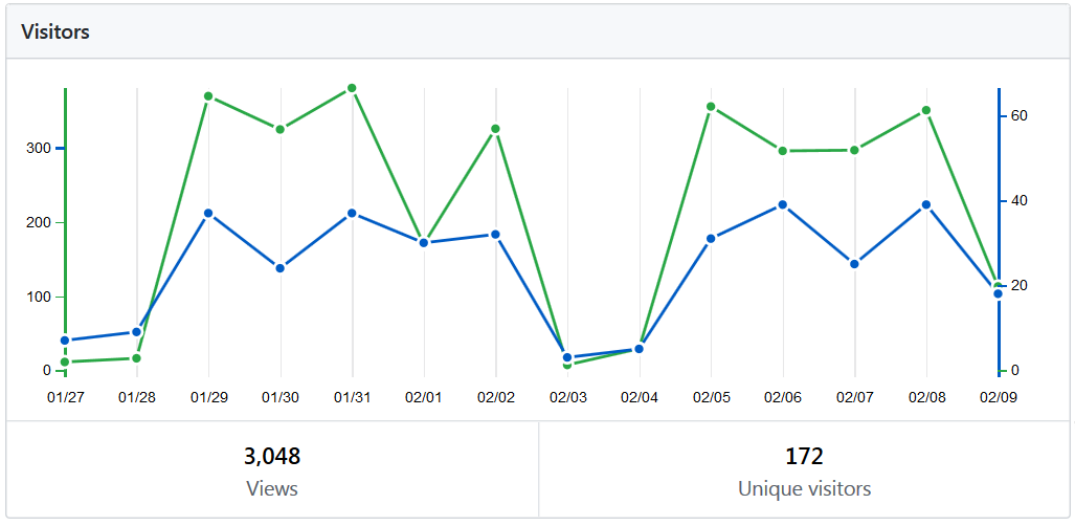
http://www.pegasus-projekt.info/en/home

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

# GitHub




Bing 2

5 members

17 members

34 members

## Open Simulation Interface (OSI)

https://www.hot.ei.tum.de/forschung/automotive-veroeffentlichungen/

Repositories 3 | People 40 | Teams 4 | Projects 1 | Settings

Pinned repositories

Customize pinned repositories

**open-simulation-interface**

A generic interface for the environmental perception of automated driving functions in virtual scenarios.

CMake 26 13

**osi-sensor-model-packaging**

This document specifies the packaging which sensor models are to be packaged to be in simulation environments with

4

**osi-visualizer**

A tool to visualize OSI data from different sources. Data can be stored in files and replayed afterwards, or validated using the Python interface.

C++ 1 3

Interface

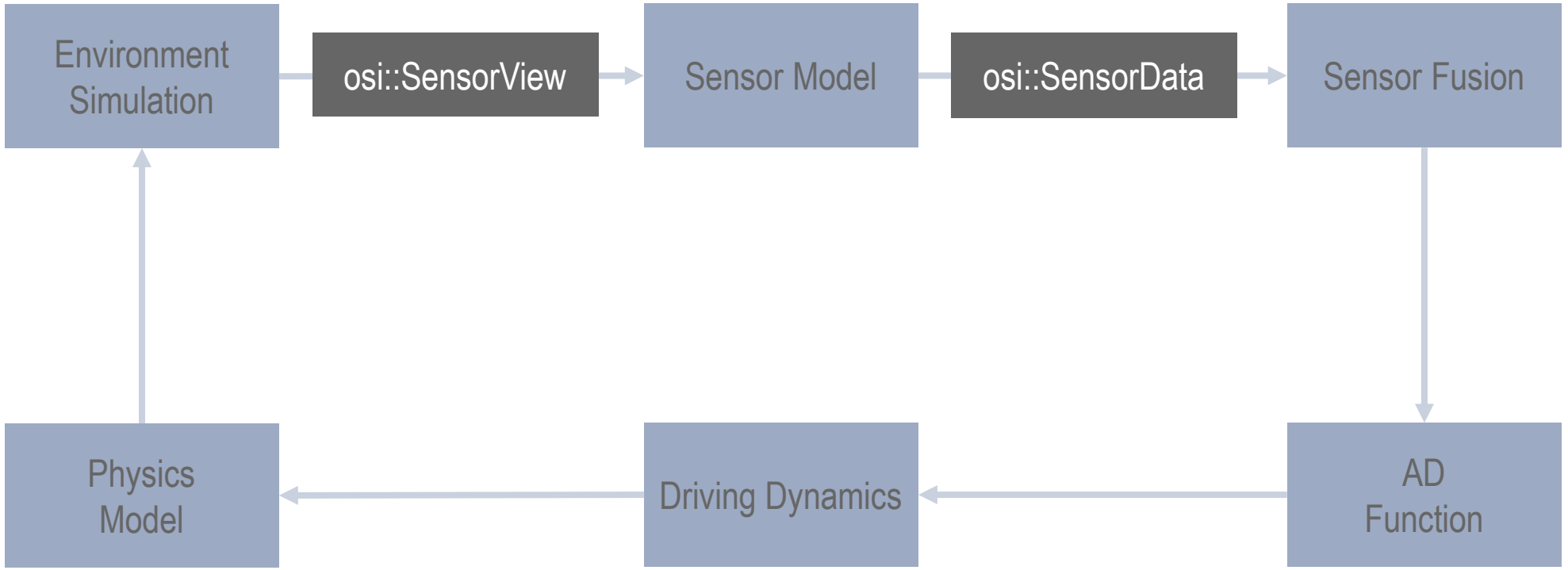
Packaging

Tools

open source initiative

ASAM

# OSI Sensor Model Packaging (OSMP)



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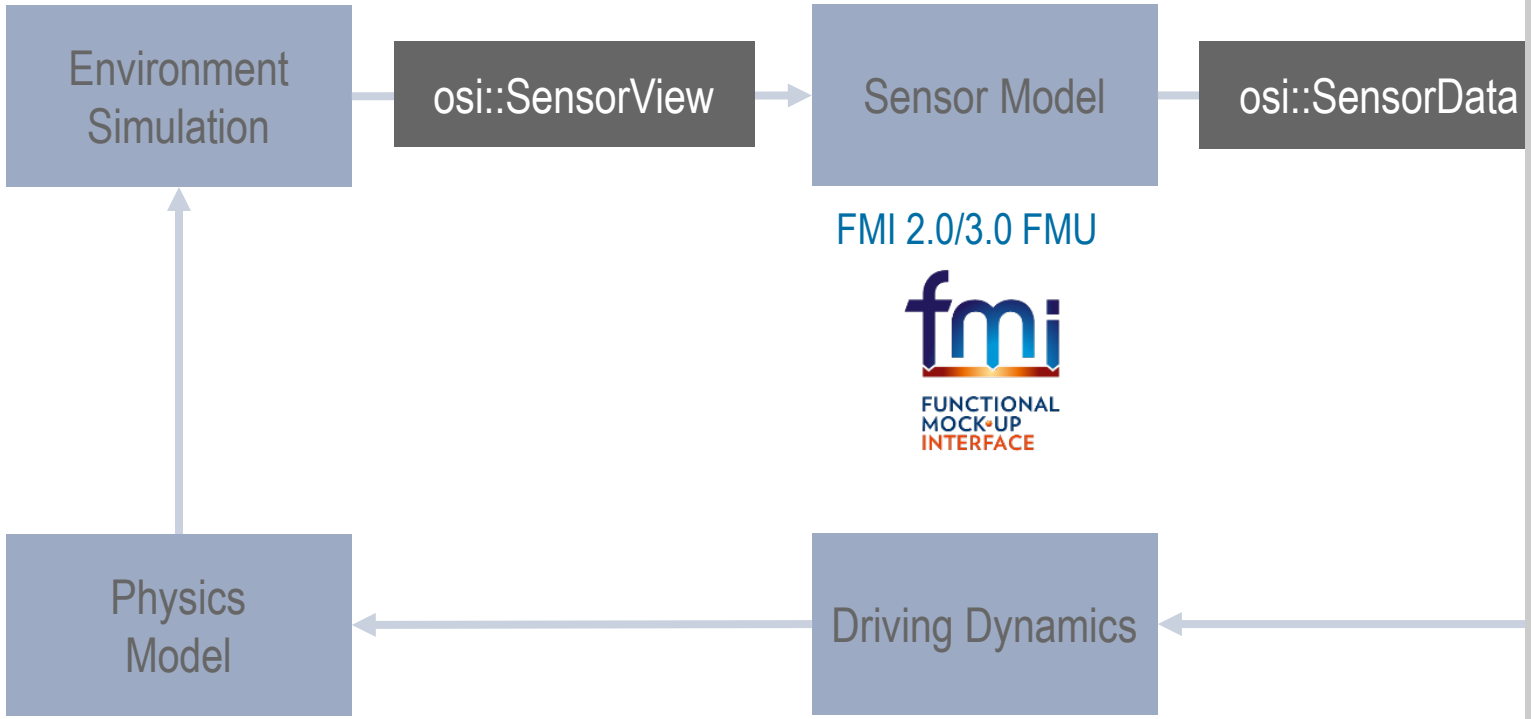


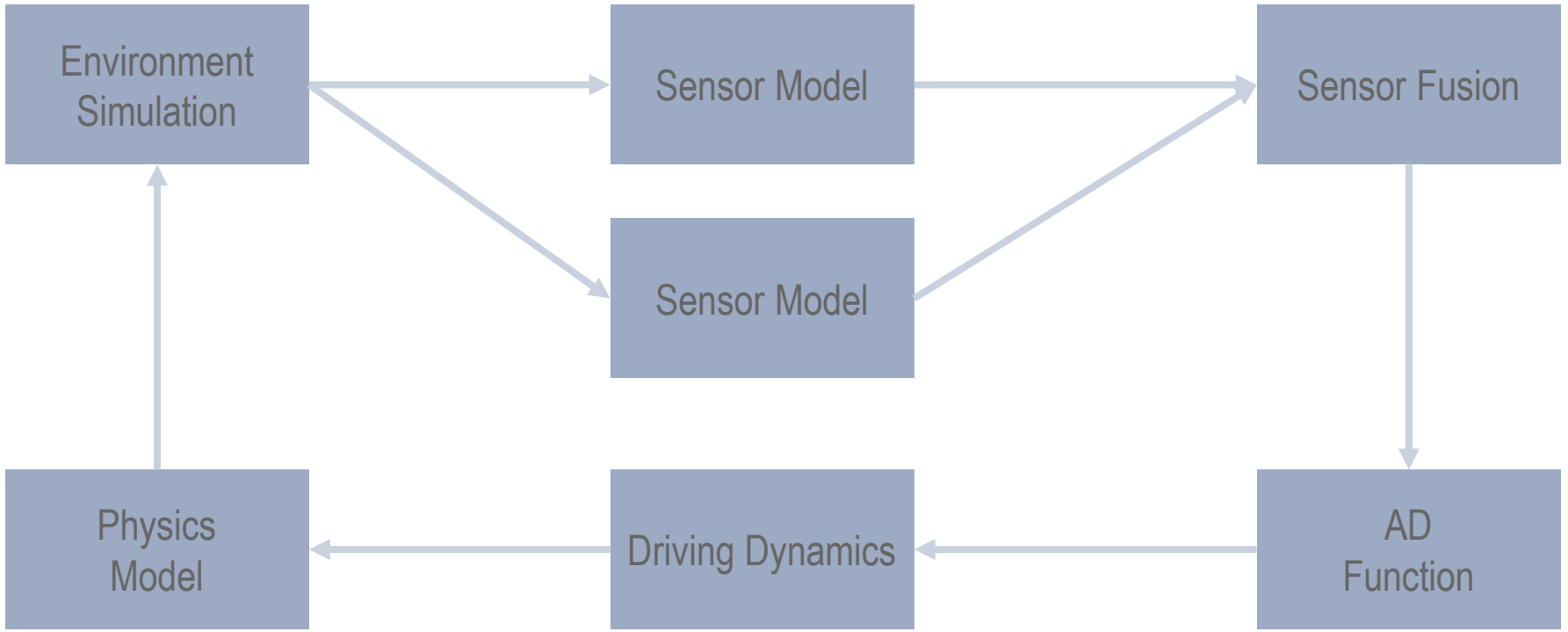

**FMI 2.0**
- Modelica Association Standard
- Packaging as Loadable Module
- Parametrization
- Co-Simulation Interface
- Cross Platform Support
- …

**FMI 3.0 (ETA 2019)***
- Binary Types (-> OSI ProtoBuf)
- Advanced Multi-Rate Support
- …

**OSMP 1.0**
- Specifies Packaging of Sensor Models as OSI-using FMUs.
- Auto-Configuration of Environment Simulation.

* Official Preliminary Feature List (excerpt)

# Simulation Architecture: MAP SSP Standard



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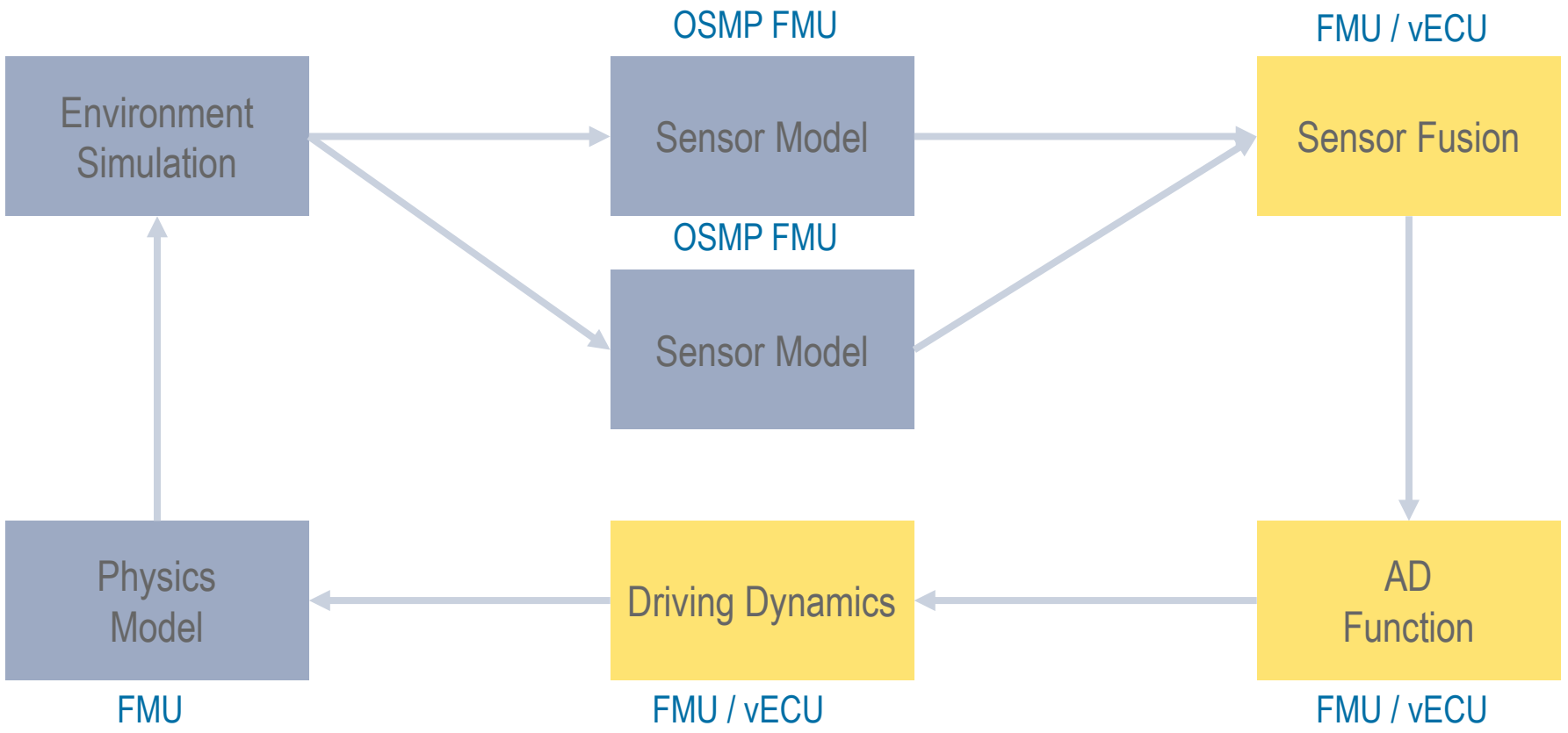

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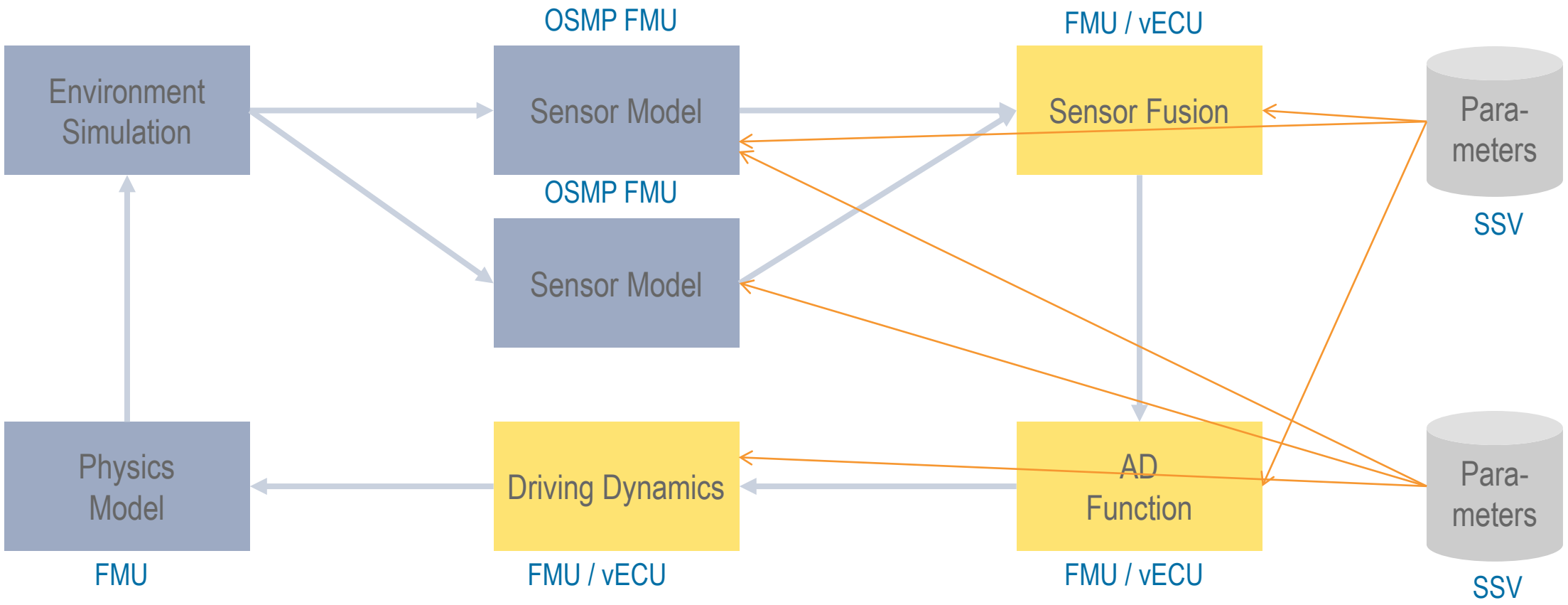

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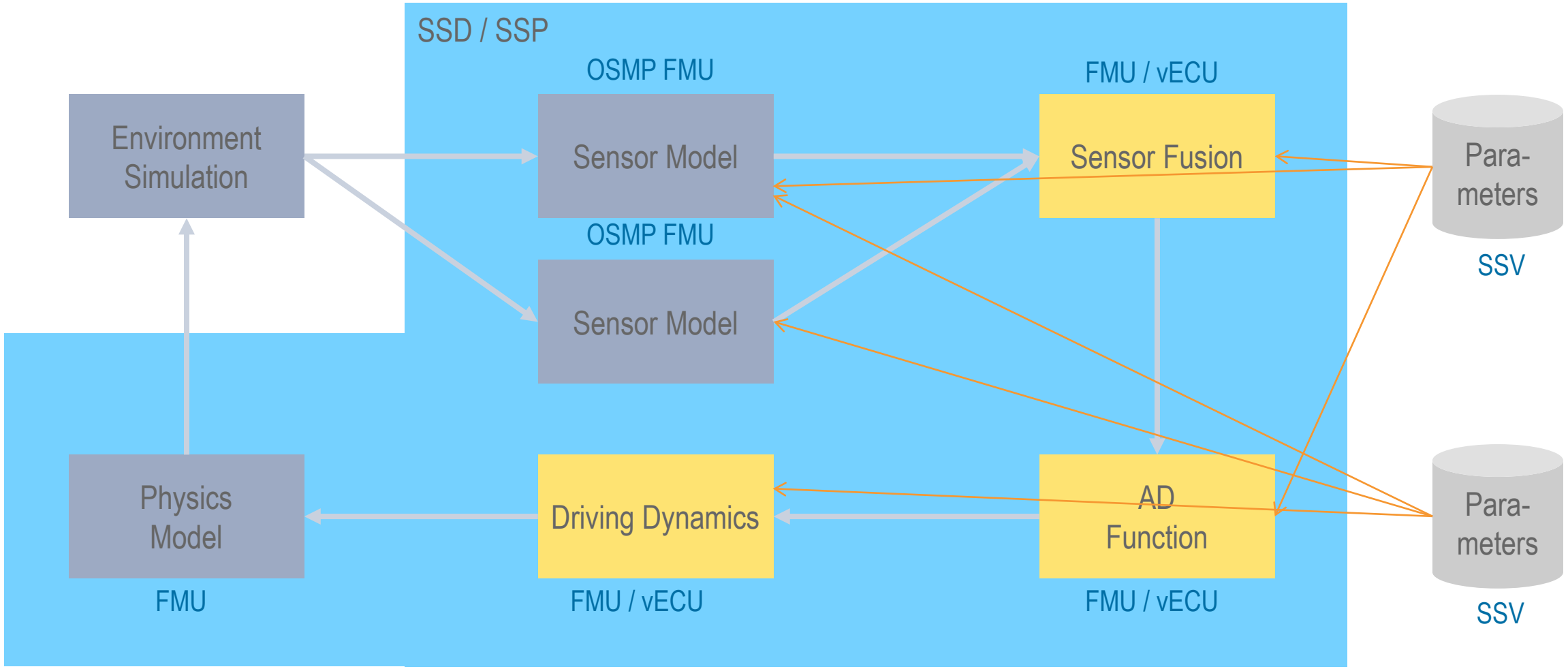

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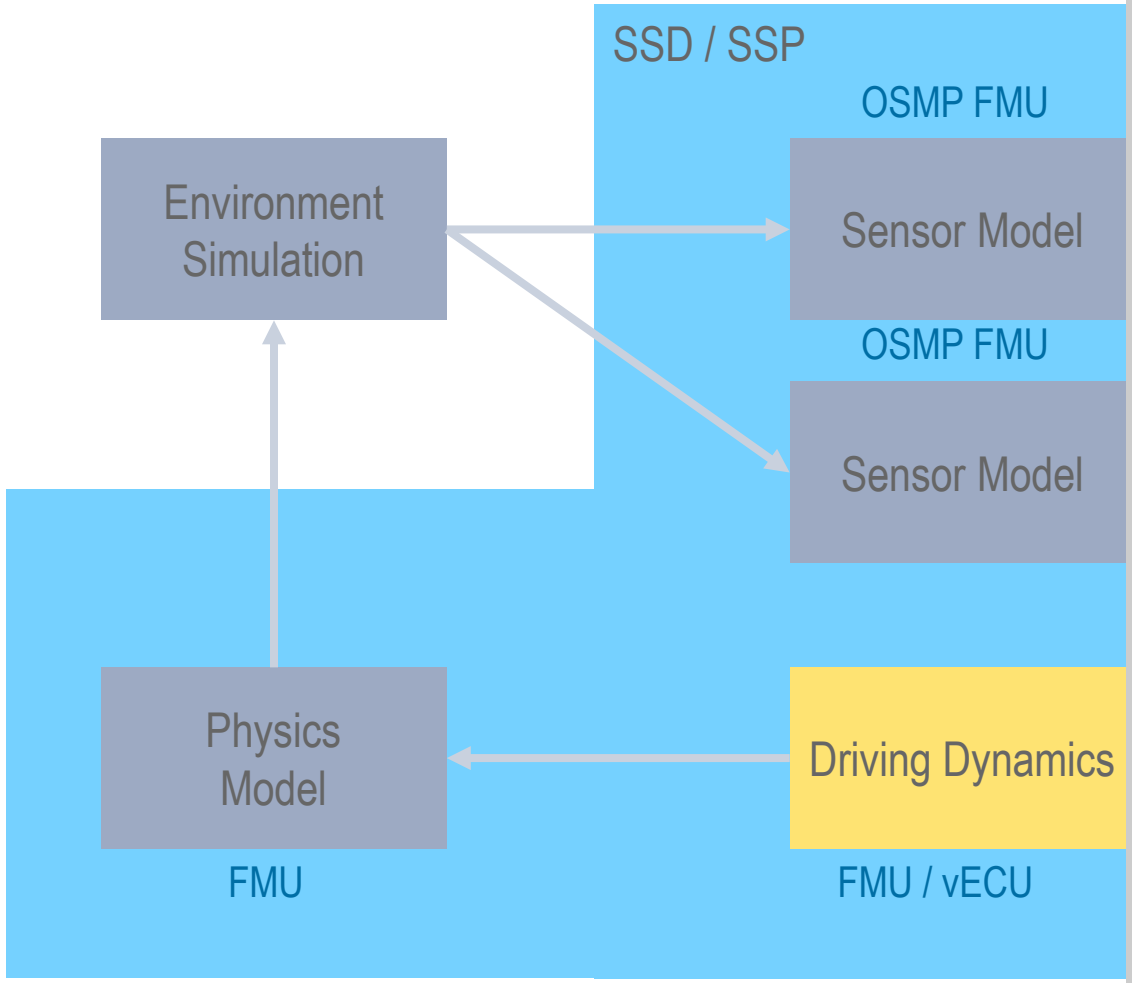
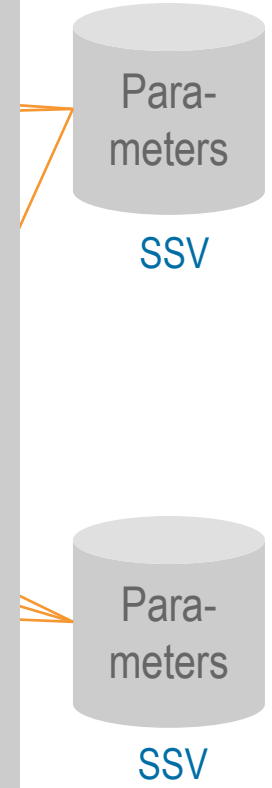



**SSP 1.0**

- Modelica Association Standard for System Structure and Parametrization
- **System Structure Description (SSD)**: Hierarchical System Topology, Parameter Binding & Propagation
- **SSV**: Interchange of Parameter Values
- **Signal Dictionaries (SSB)**: Busses, Pre-Defined Signal Catalogs, etc.
- **System Structure Package (SSP)**: Packaging for Interchange (incl. Minimal Variant Handling)



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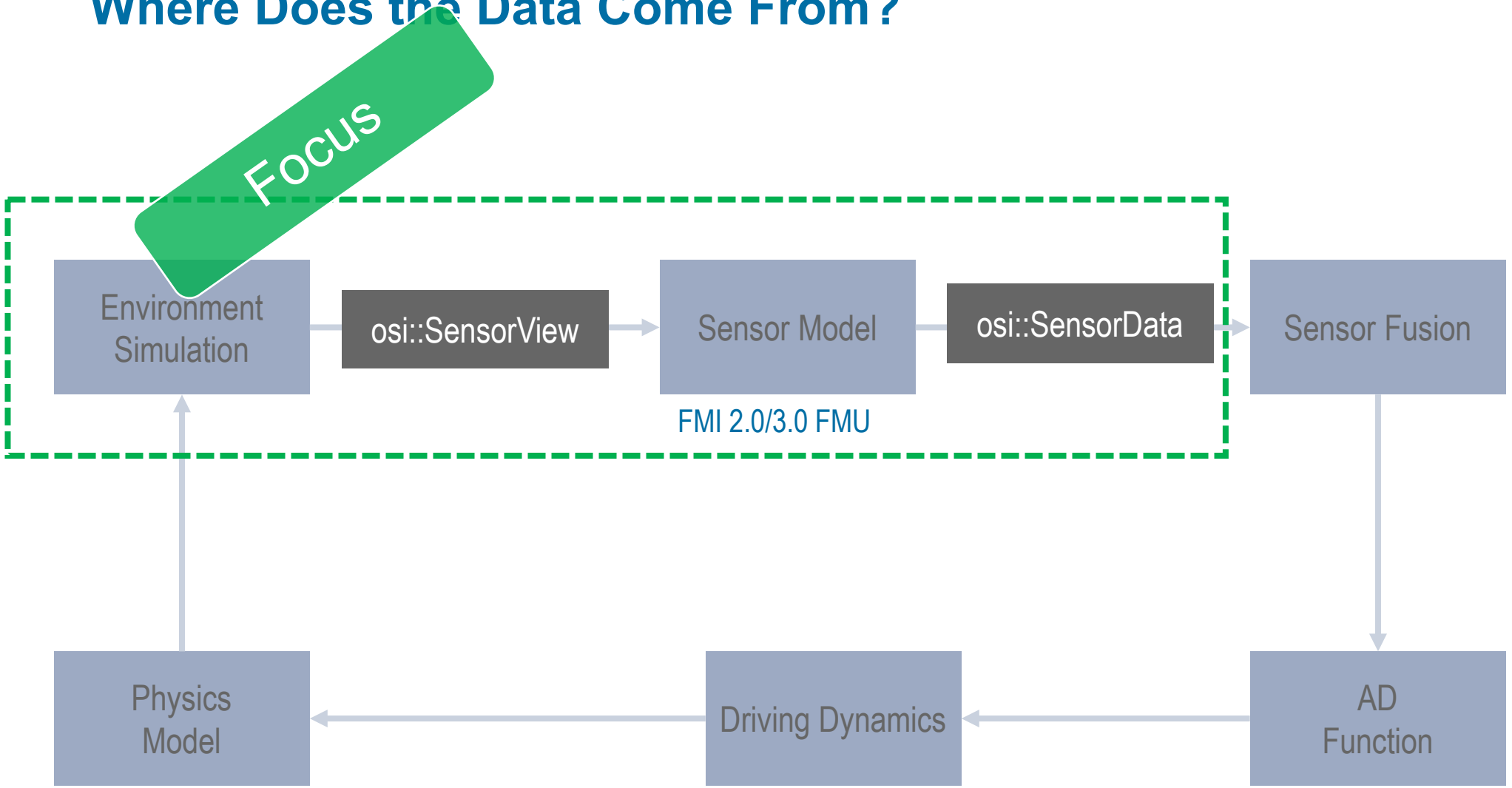

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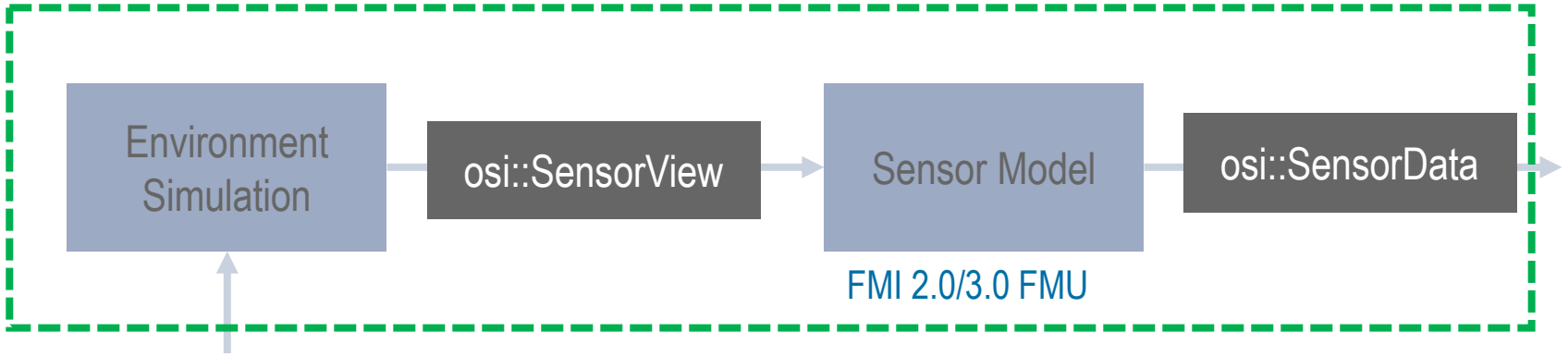
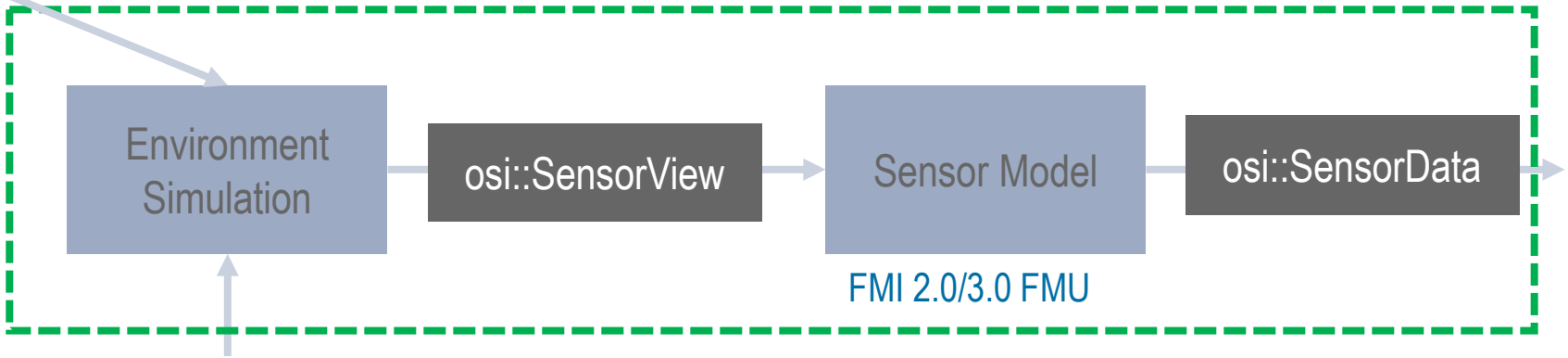


# Where Does the Data Come From?

OpenDRIVE®
managing the road ahead

- Road Networks
- OpenDRIVE Core Team
- XML-based format
  (+ CSV/BIN companion format OpenCRG)



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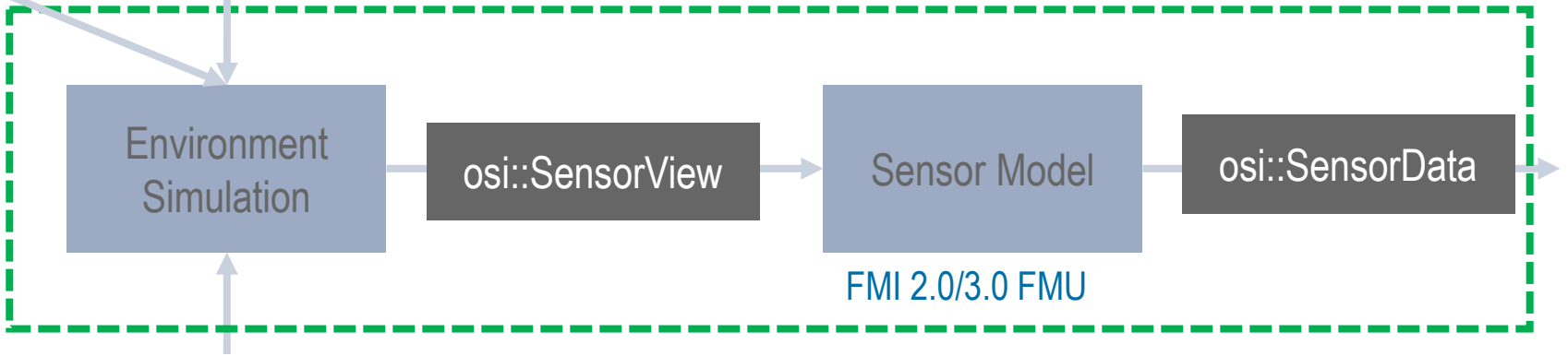
Navigation Data Standard

- MAP Data
- NDS e.V.
- SQLite-based format



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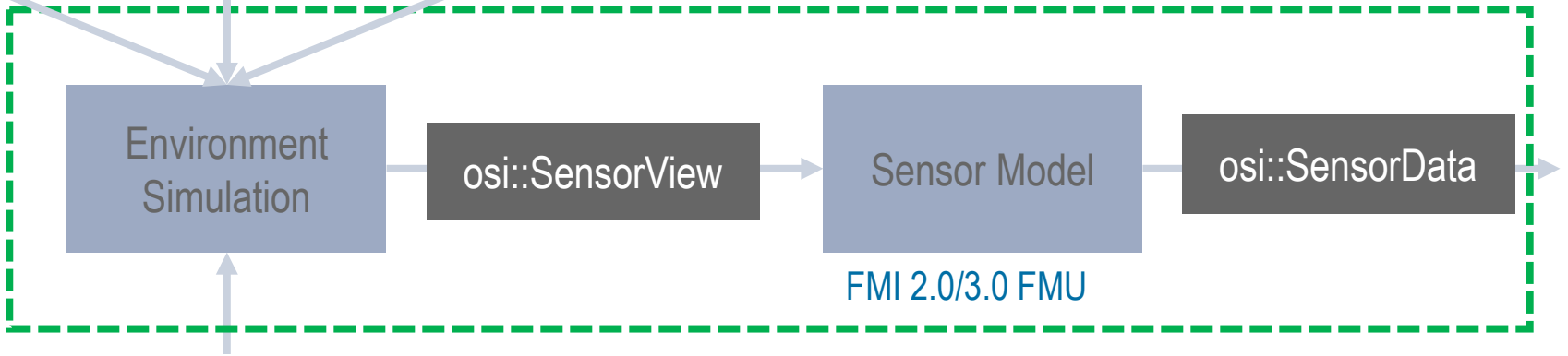
OpenSCENARIO bringing content to the road

- Dynamic Content
- OpenSCENARIO Core Team
- XML-based format



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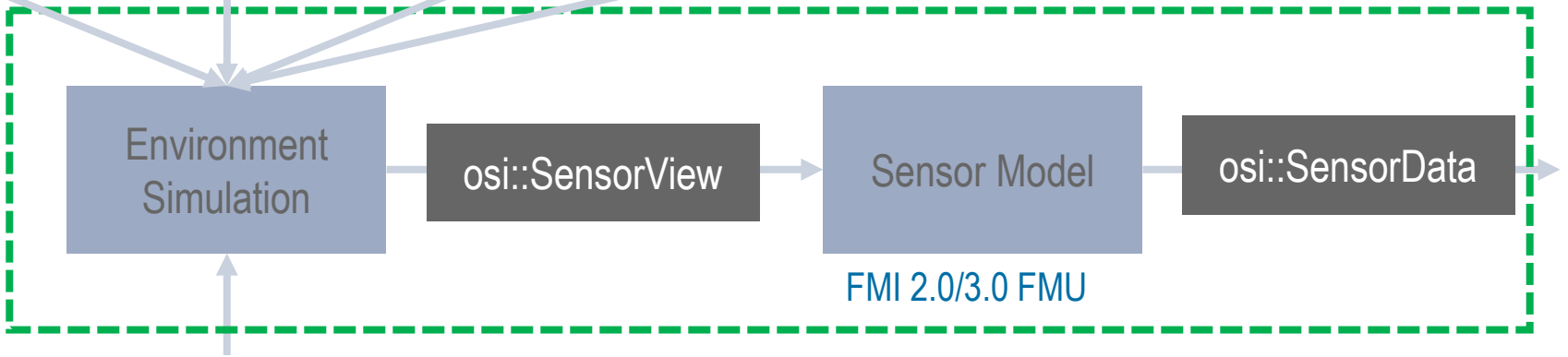
cityGML
glTF
…



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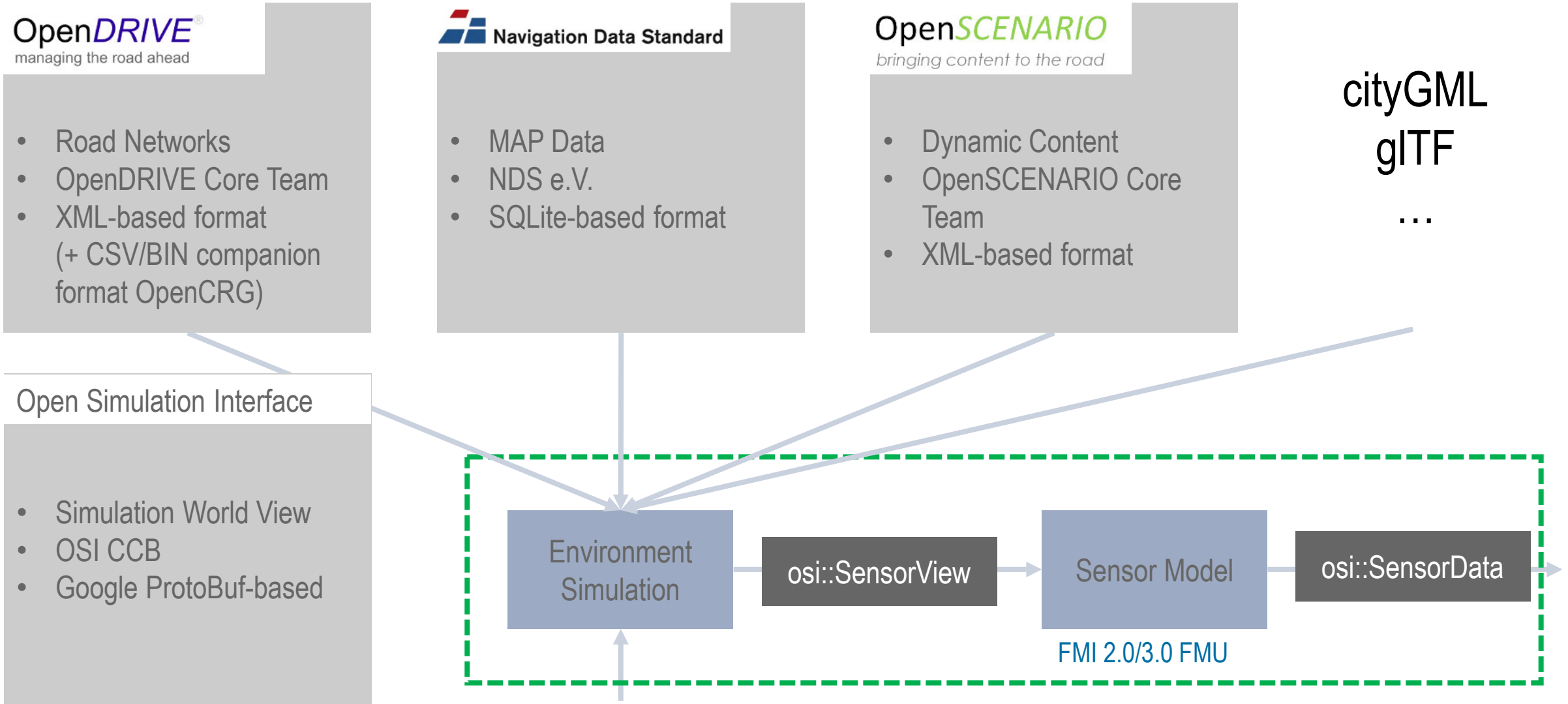

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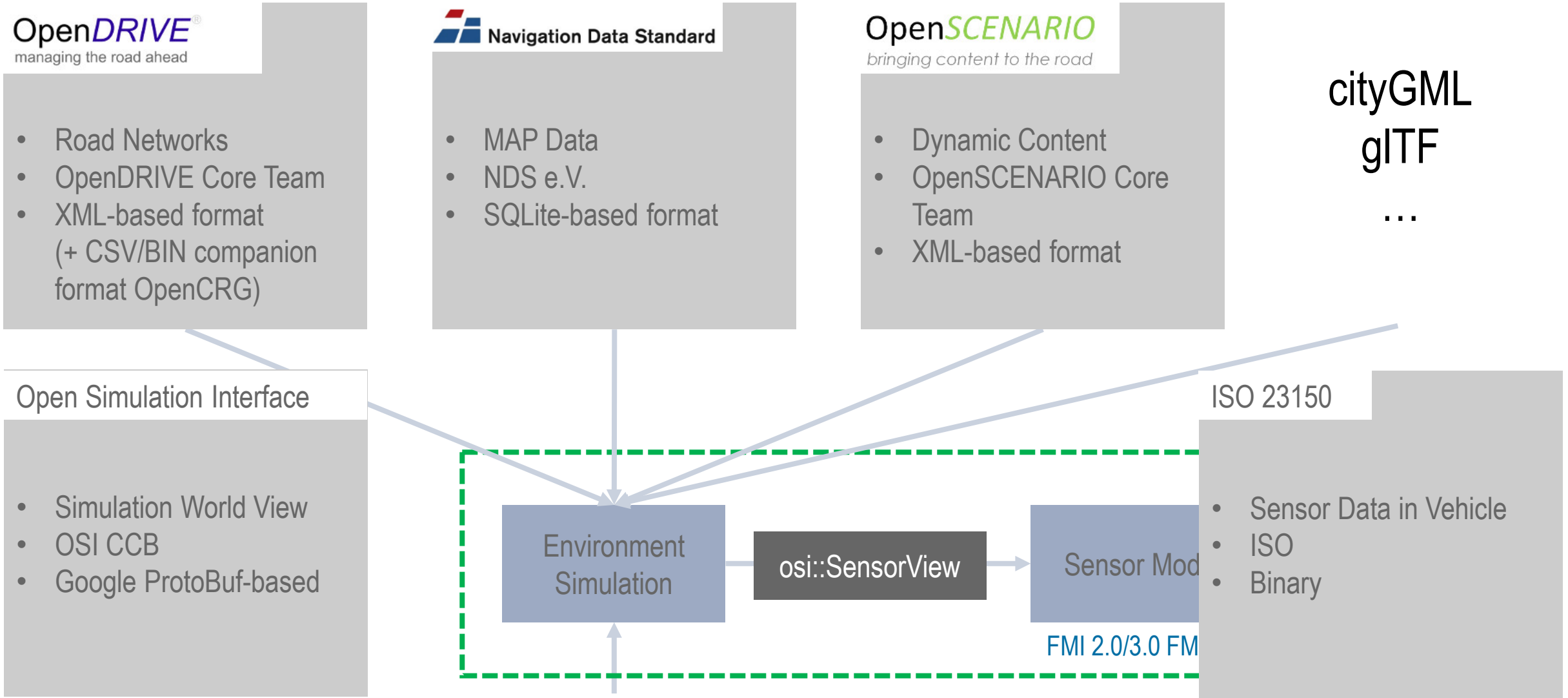

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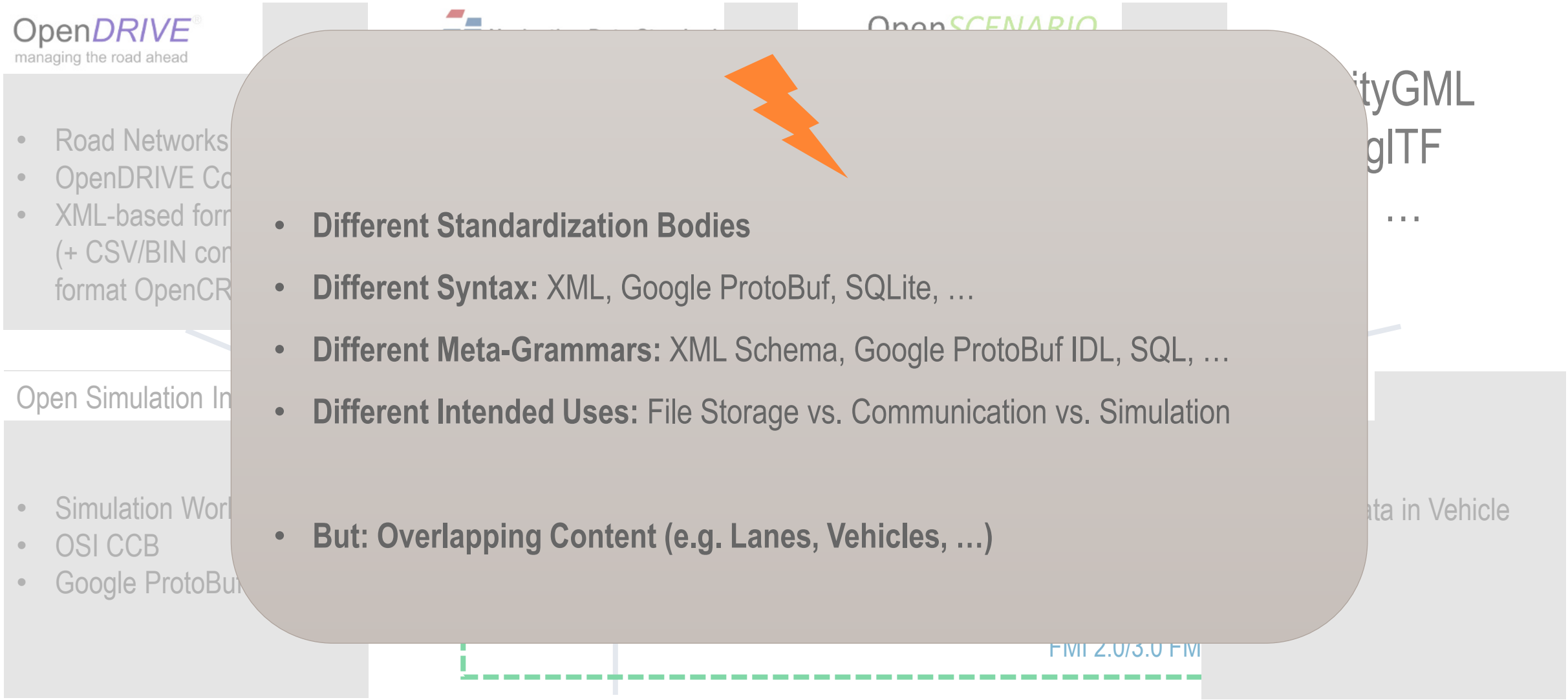

# Harmonized Standardization of Interfaces Offers Huge Potential

## Testing

- Reduce integration and validation effort by encapsulating components

## Development

- Less adaptation for everyone
- Reduced effort and costs


## Simulation

- Reuse and exchange of recorded validation data

## Innovation, Sensor exchange

- Ease component replacement / upgrade

## Machine Learning, Validation

- Ensure data deployability over years

# Migration of Relevant Standards to ASAM

Relocate Core Set Standards into ASAM

## Goals

- Ensure **long-term stable home** for **OpenX** standards
- Draw more **international participation**
- Increase **harmonization** across **OpenX** and **related standards** and **standards bodies**
- Retain **open** and **free access** to standards
- Retain and ensure **high speed** of **evolution**
- Retain **collaborative development model** where it is suited and established

## Status

- **OpenDRIVE migration to ASAM**
  - IP transferred
  - ASAM OpenDRIVE Transfer Project started
  - ASAM OpenDRIVE Concept Project started
- **OpenCRG migration to ASAM**
  - IP transferred
  - ASAM OpenCRG Transf. & Devel. Project starting
- **OpenSCENARIO migration to ASAM**
  - IP transferred
  - ASAM OpenSCENARIO Transfer Project started
  - ASAM OpenSCENARIO Concept Project starting
- **OSI and OSMP migration to ASAM**
  - IP transfer in progress
  - Collaborative development process in definition

# Harmonization with Outside Activities

Create Integrated Standardization Eco-System for Autonomous Driving Simulation

## OpenSCENARIO and ISO TC22 / SC33 / WG9 („Test scenario of autonomous driving vehicle”)

- ISO TC22 / SC33 / WG9 concentrates on architecture, framework and processes
- References ASAM standards as technical formats
- Potential for level C liaison (at working group level), cooperate on common content, e.g. Glossary

## OSI and ISO TC22 / SC31 / WG9 („Sensor data interface for automated driving functions”)

- Currently OSI harmonizes with upcoming ISO 23150 standard through participating companies
- Potential for level C liaison (at working group level) should be explored when necessary

## OpenDRIVE and NDS/Open AutoDrive Forum

- Ensure mapping between simulation road network and in-vehicle HD MAP data is possible and reliable
- Ensure conversion between different formats is efficient and reliable
- Establish liaison to this effect with NDS e.V./Open AutoDrive Forum

# Harmonization with Outside Activities

Create Integrated Standardization Eco-System for Autonomous Driving Simulation

## OpenDRIVE and Infrastructure (cityGML) and 3D Standards (glTF)

- OpenDRIVE is concerned with the road network
- For sensor simulation, the infrastructure outside the road network is also relevant
- Technical requirements for successful interaction need to be defined in relevant ASAM projects
- Potential liaisons with relevant standardization bodies and standards:
  - Open Geospatial Consortium (OGC): GML, cityGML
  - Khronos Group: glTF

# Harmonized Standardization of Interfaces…

**… is necessary to handle the complexity of virtual test & validation.**

**… yields benefits *for OEMs, as well as for sensor suppliers and tool vendors.***

**… takes place in ISO (VDA), Modelica Association and now at ASAM e.V..**

**… needs further harmonization efforts across ASAM and non-ASAM standards.**

**… needs to be driven by simulation standards architecture group at ASAM e.V..**

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Email: klaus.estenfeld@asam.net