

Efficient and modular integration of sensor models with OSI

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29.04.2021

Supported by:



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by the German Bundestag



DLR



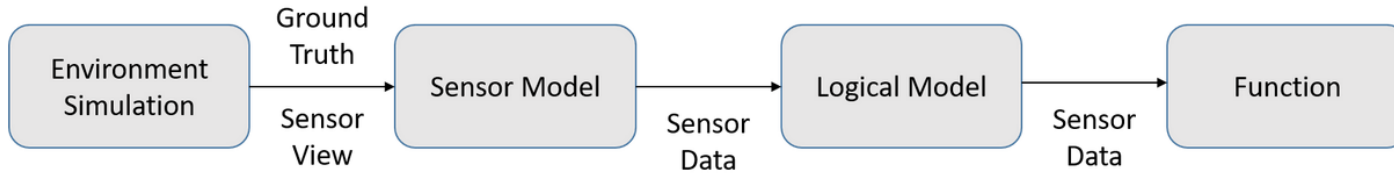
Institut für
Regelungstechnik



Agenda

- Introduction to the Open Simulation Interface (OSI)
- Application in Camera Model
- Application in Lidar Models
- Conclusions & Outlook
- Q&A Session

- Cost-effective and reliable simulation architectures need standardized interfaces:
Open Simulation Interface (OSI)

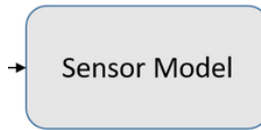


INPUT – Path

osi3::[Camera, Lidar, Radar]SensorView

osi3::GroundTruth

osi3::SensorView



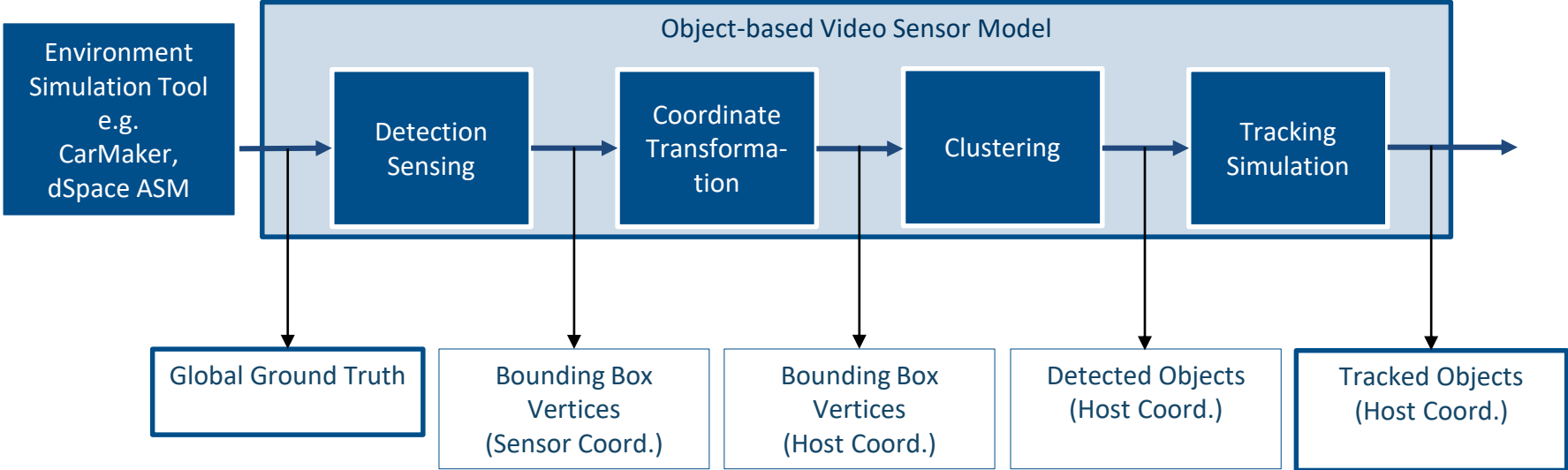
osi3::SensorData

OUTPUT – Path

osi3::FeatureData

osi3::Detected[...Objects]

Model Structure and Interfaces



osi3::GroundTruth
 Moving Objects
 Stationary Objects
 Traffic Signs
 Traffic Lights

osi3::VideoDetection

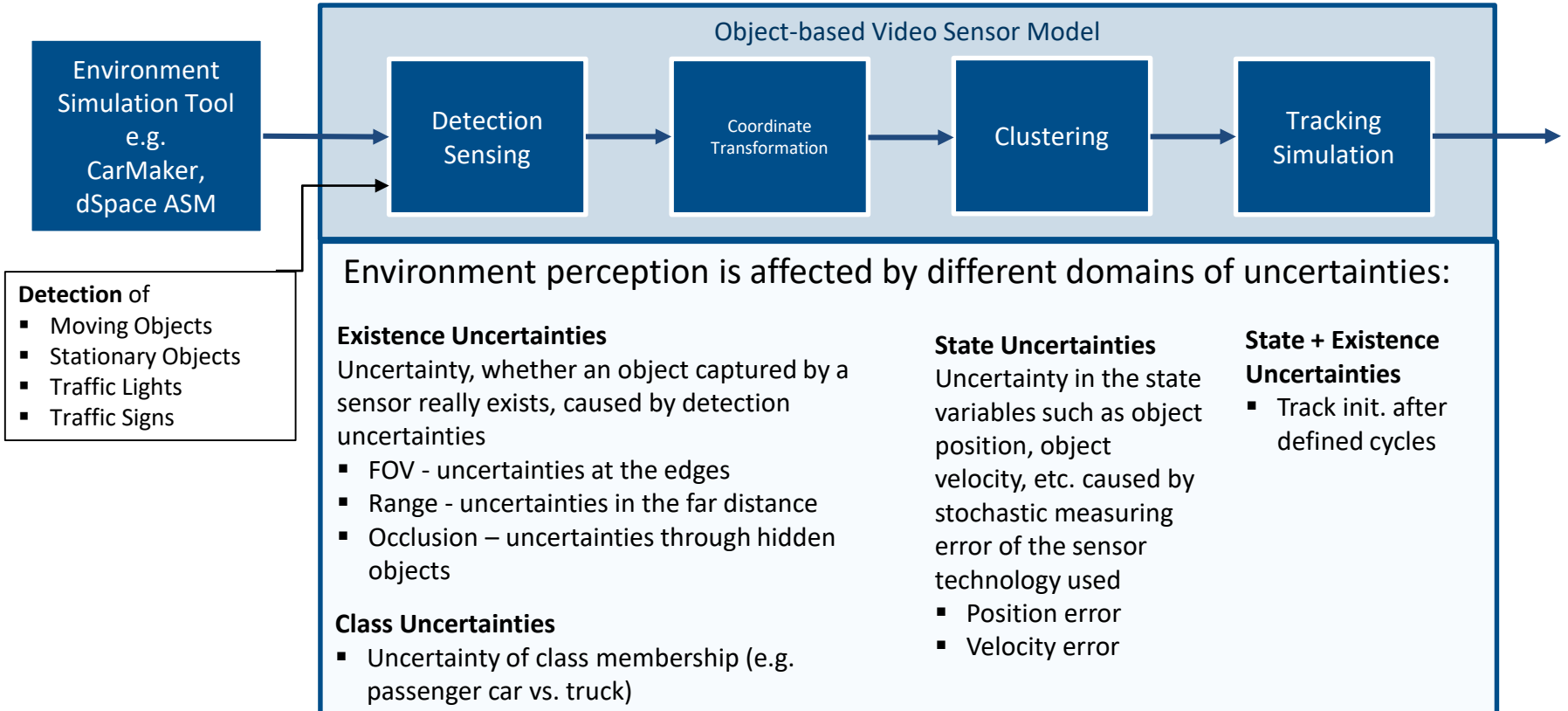
osi3::LogicalDetection*

osi3::DetectedMovingObject

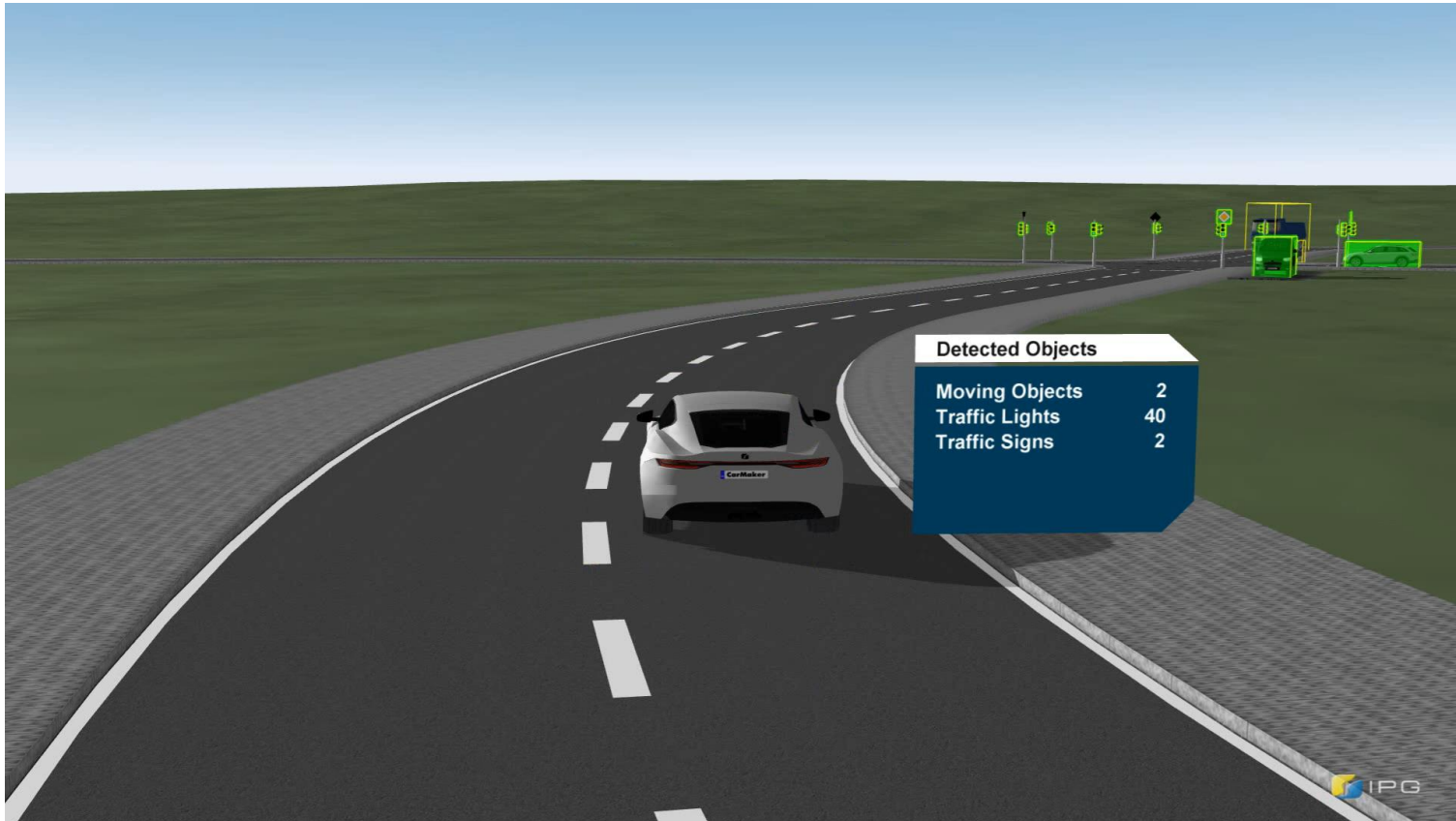
osi3::DetectedMovingObject
 osi3::DetectedStationaryObject
 OsI3::DetectedTrafficLights
 OsI3::DetectedTrafficSigns

*SET Level Development

External Interface
 Internal Interface



Sensor Model Integration – Video



Sensor Model Integration – Video

The screenshot displays a simulation environment with a white car in the foreground and a green truck in the distance. A 'Detected Objects' table is visible in the lower right of the simulation area.

Detected Objects	
Moving Objects	1
Traffic Lights	0
Traffic Signs	0

The right side of the image shows a vertical axis with numerical values from 0 to 1.0. At the top of this axis, two file paths are listed: C2::OSI.User.movObjs.T00.exProb and C2::OSI.User.movObjs.T01.exProb. The bottom of the image shows a timeline with markers at 14, 16, 18, 20, 22, and 24 seconds.

Sensor Model Integration

The image displays two side-by-side windows from a simulation environment. The left window shows a top-down view of a car in a traffic scenario with other vehicles and a road. The right window shows a 3D sensor model view with a large 'FZD' logo and a legend for reflections and detections. Below the windows is a session log window.

Legend:

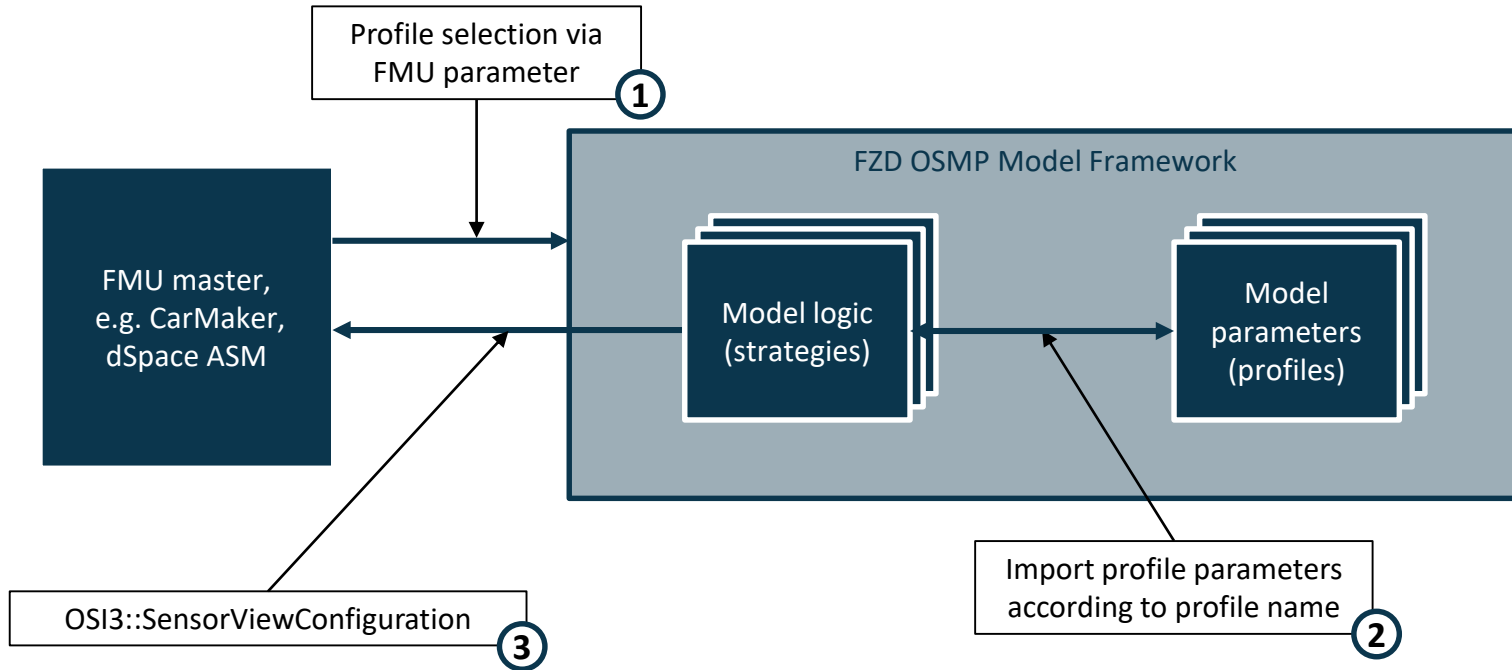
- Reflections from tool
- Detections from model
- Ego car
- GT objects
- Detected objects

Session Log 'simf_20210325_22213.log':

```
FW: ReflectionBasedLidarModel: OCPP: Providing 6000581 15210250, writing from Bc55b1321805d ...
FW: ReflectionBasedLidarModel: OCPP:
FW: ReflectionBasedLidarModel: OCPP:
FW: ReflectionBasedLidarModel: OCPP: Got 00005501 00304509, reading from Bc55b1321805d ...
FW: ReflectionBasedLidarModel: OCPP: Starting Reflection Based Lidar Model
FW: ReflectionBasedLidarModel: OCPP: Number of simulated lidar sensors: 1
FW: ReflectionBasedLidarModel: OCPP: GT Limitup: 4.960000
FW: ReflectionBasedLidarModel: OCPP: No. of rays shot in simulation tool for lidar 1: 698228
FW: ReflectionBasedLidarModel: OCPP: No. of processed valid reflections in Lidar cuboid 1: 141176
FW: ReflectionBasedLidarModel: OCPP: No. of Beams for Lidar 1: 2364
FW: ReflectionBasedLidarModel: OCPP: No. of Detections from lidar model for lidar 1: 1331
FW: ReflectionBasedLidarModel: OCPP: Starting Particulate Fusion
FW: ReflectionBasedLidarModel: OCPP: Size of logical detections after point cloud fusion: 1331
FW: ReflectionBasedLidarModel: OCPP: Starting Segmentation
FW: ReflectionBasedLidarModel: OCPP: No. of moving objects from GT to 5 (incl. ego vehicle)
FW: ReflectionBasedLidarModel: OCPP: Segment size of detected object 1 with object id 1000000: 71
FW: ReflectionBasedLidarModel: OCPP: Segment size of detected object 2 with object id 1000001: 169
FW: ReflectionBasedLidarModel: OCPP: Segment size of detected object 3 with object id 1000002: 4
FW: ReflectionBasedLidarModel: OCPP: Segment size of detected object 4 with object id 1000003: 171
FW: ReflectionBasedLidarModel: OCPP: Starting Tracking
FW: ReflectionBasedLidarModel: OCPP: Ego car 1000000: absolute velocity: 46.403952 km/h
FW: ReflectionBasedLidarModel: OCPP: Object 1000000: position: x: 36.720004 m, y: -9.732461 m, z: 0.729422 m
FW: ReflectionBasedLidarModel: OCPP: Object 1000000: orientation: roll: 0.295213°, pitch: 0.018335°, yaw: 99.348827°
FW: ReflectionBasedLidarModel: OCPP: Object 1000000: relative velocity: x: -65.90265 km/h, y: 10.9005 km/h, z: -0.981223 km/h
FW: ReflectionBasedLidarModel: OCPP: Object 1000000: existence probability: 1.000000, age: 122.903009
FW: ReflectionBasedLidarModel: OCPP: Object 1000001: type: VEHICLE, vehicle type: MERCEDES_CAR
FW: ReflectionBasedLidarModel: OCPP: Object 1000001: position: x: 36.625691 m, y: 1.803959 m, z: 0.750984 m
FW: ReflectionBasedLidarModel: OCPP: Object 1000001: orientation: roll: 0.120001°, pitch: 0.274400°, yaw: 129.014872°
FW: ReflectionBasedLidarModel: OCPP: Object 1000001: relative velocity: x: -88.00000 km/h, y: 29.182572 km/h, z: 0.588112 km/h
FW: ReflectionBasedLidarModel: OCPP: Object 1000001: existence probability: 1.000000, age: 122.903009
FW: ReflectionBasedLidarModel: OCPP: Object 1000001: type: VEHICLE, vehicle type: MERCEDES_CAR
FW: ReflectionBasedLidarModel: OCPP: Object 1000001: position: x: 36.820301 m, y: -0.580319 m, z: 0.860137 m
FW: ReflectionBasedLidarModel: OCPP: Object 1000002: orientation: roll: 0.287457°, pitch: 0.102129°, yaw: -116.903003°
FW: ReflectionBasedLidarModel: OCPP: Object 1000002: relative velocity: x: -84.288178 km/h, y: 2.221265 km/h, z: 0.832959 km/h
FW: ReflectionBasedLidarModel: OCPP: Object 1000002: existence probability: 1.000000, age: 114.903009
FW: ReflectionBasedLidarModel: OCPP: Object 1000002: has no vehicle type
FW: ReflectionBasedLidarModel: OCPP: Object 1000002: type: PEDESTRIAN, vehicle type: UNKNOWN
FW: ReflectionBasedLidarModel: OCPP: Object 1000002: position: x: 22.620482 m, y: -7.092098 m, z: 0.730485 m
FW: ReflectionBasedLidarModel: OCPP: Object 1000002: orientation: roll: 0.620017°, pitch: 0.294004°, yaw: 177.108308°
FW: ReflectionBasedLidarModel: OCPP: Object 1000002: relative velocity: x: -42.834997 km/h, y: 0.222724 km/h, z: -0.118602 km/h
FW: ReflectionBasedLidarModel: OCPP: Object 1000002: existence probability: 1.000000, age: 122.903009
FW: ReflectionBasedLidarModel: OCPP: Object 1000003: type: VEHICLE, vehicle type: MERCEDES_CAR
FW: ReflectionBasedLidarModel: OCPP: Starting ROS output for green GT objects
FW: ReflectionBasedLidarModel: OCPP: Starting ROS output for reflections
FW: ReflectionBasedLidarModel: OCPP: Starting ROS output for logical detections
FW: ReflectionBasedLidarModel: OCPP: Starting ROS output for detected objects
FW: ReflectionBasedLidarModel: OCPP: Providing 6000581 15842220, writing from Bc55b139442220 ...
FW: ReflectionBasedLidarModel: OCPP: .....
```

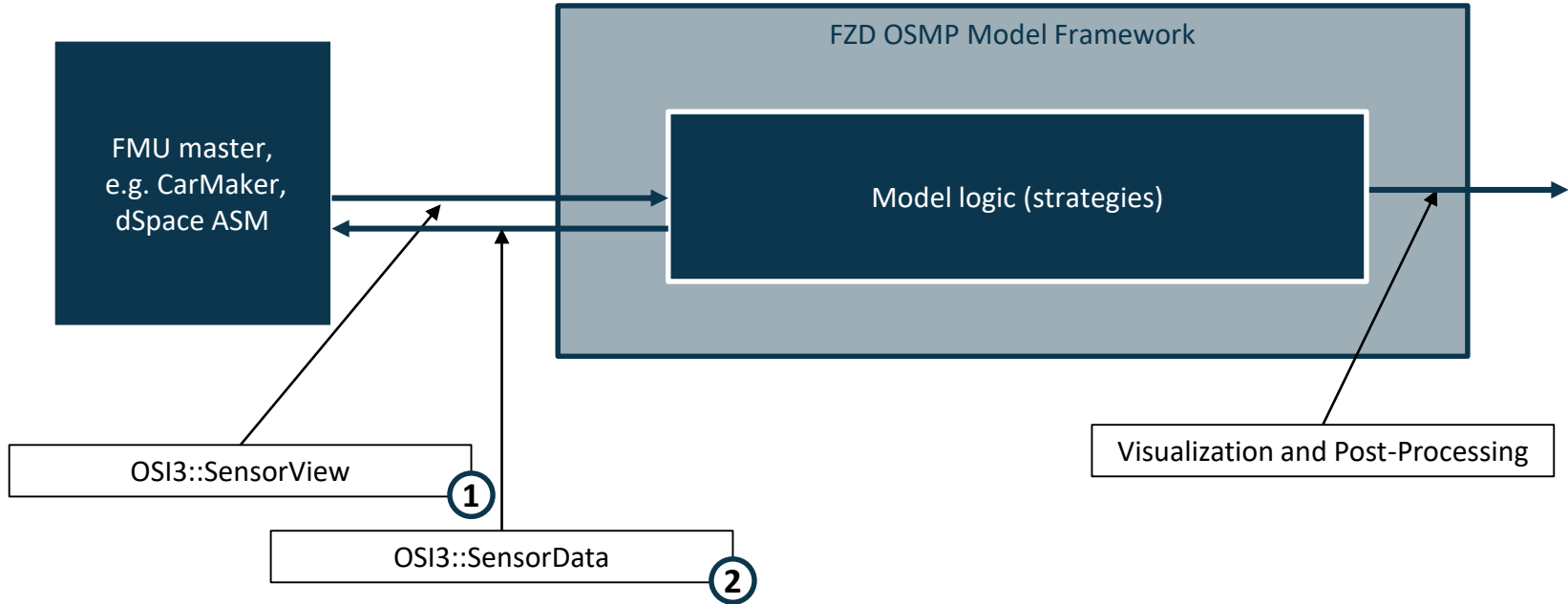

Sensor Model Integration

Model Parameterization Procedure (FMU-Init)



Sensor Model Integration

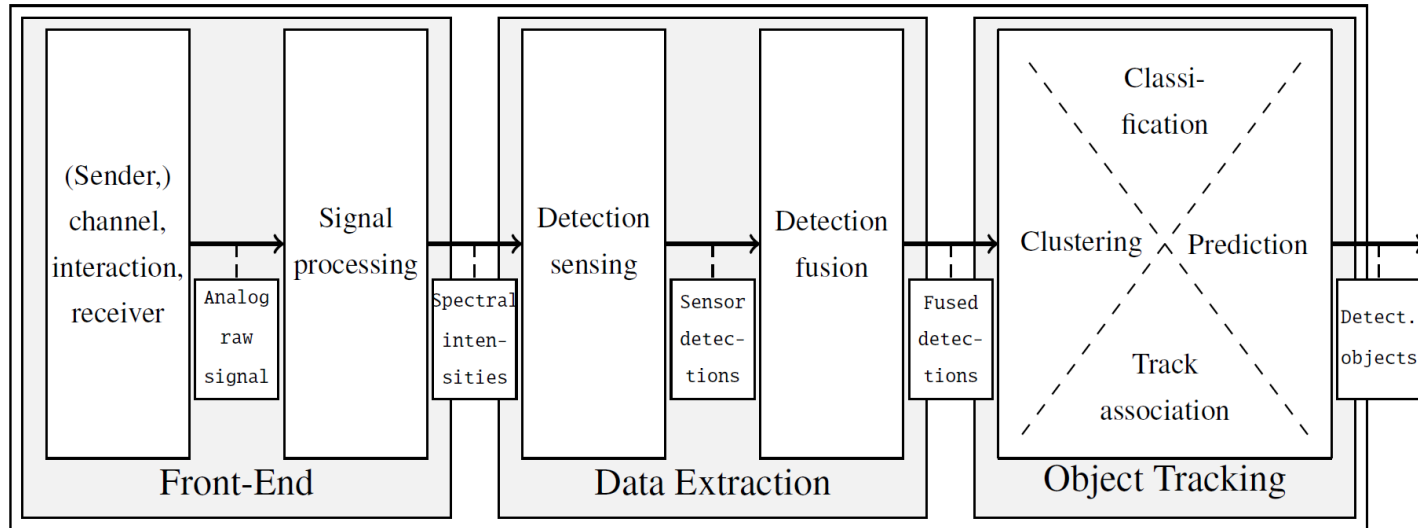
Model Running (FMU-DoStep)



Sensor Model Integration

Generic and Modular Architecture

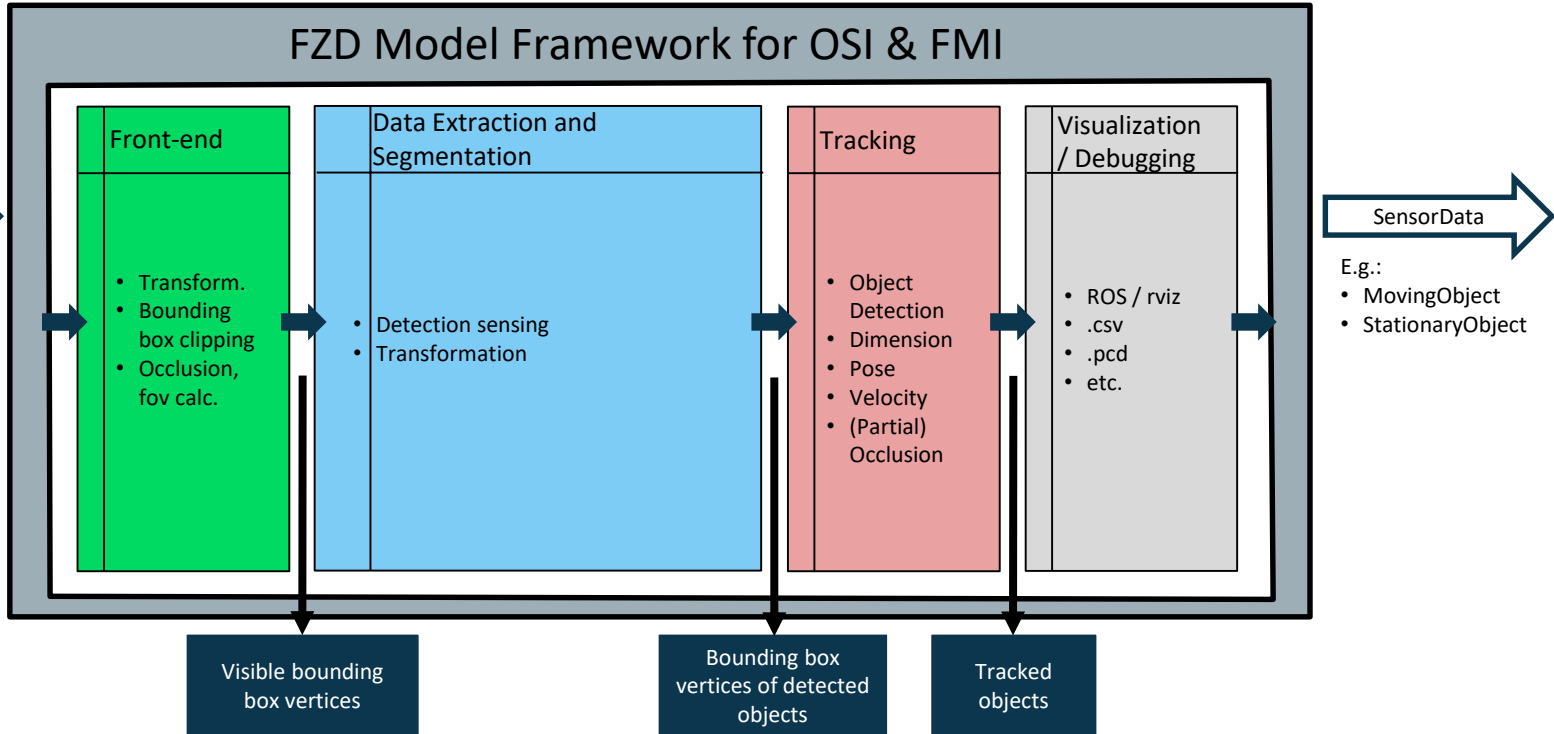
Generic functional decomposition of current automotive perception sensor systems for object detection:



C. Linnhoff, P. Rosenberger, M. F. Holder, N. Cianciaruso, and H. Winner, "Highly parameterizable and generic perception sensor model architecture", in 6. Internationale ATZ-Fachtagung Automated Driving, 2020

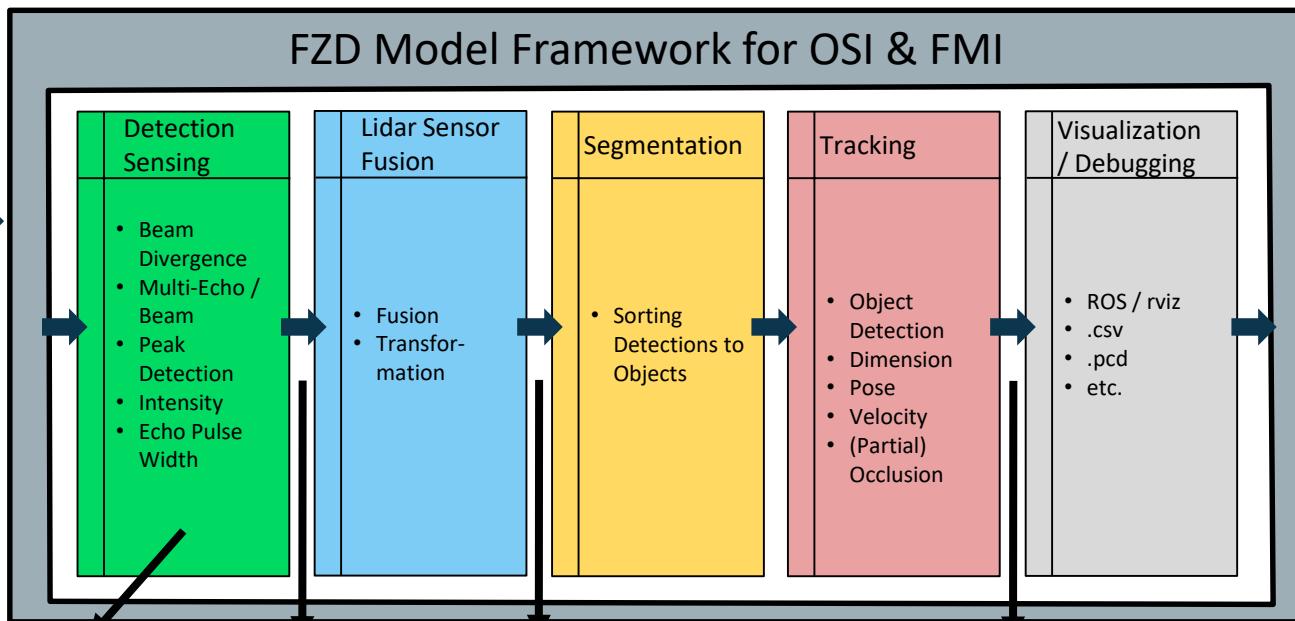
Sensor Model Integration

Exchangeable Strategies: Object Based Model



Sensor Model Integration

Exchangeable Strategies: Reflection Based Model



- E.g.:
- GroundTruth:: MovingObject / StationaryObject
 - LidarSensorView
 - RadarSensorView

- E.g.:
- MovingObject
 - StationaryObject
 - LidarDetection
 - RadarDetection
 - LogicalDetectionData

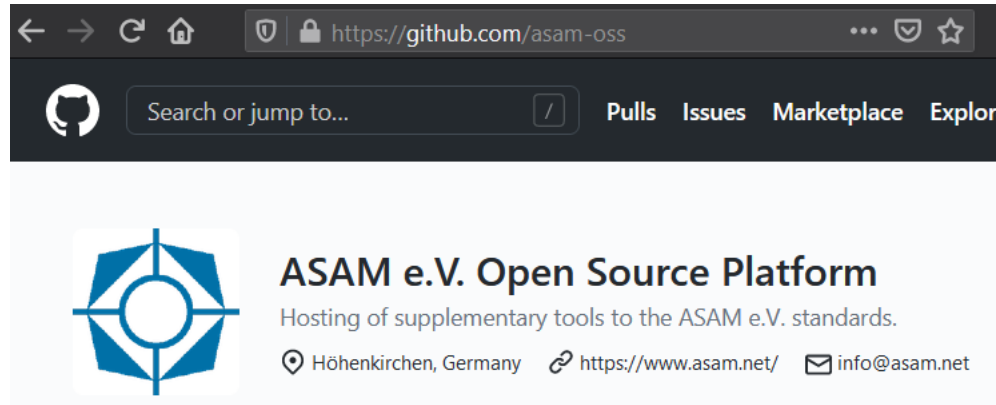


Sensor Model Integration

Open Source Availability



- The FZD Model Framework for OSI & FMI will be made open source.
- It is subject to approval by ASAM CG:Sim for <https://github.com/asam-oss>.



- Contributions for perception sensor simulation to OSI by SET Level, so far:
 - FZD Model Framework for OSI & FMI
 - LogicalDetectionData
 - Documentation (e.g. GroundClearance, MountingPositions, etc.)
- Possible changes / additions in second half of SET Level:
 - Update of SensorViewConfiguration and the initialization process
 - LidarSensorViewConfiguration
 - RadarSensorViewConfiguration
 - More efficient LidarReflection and RadarReflection structures
 - ModelReference for 3D object data input to geometry-based radar model
 - GoogleFlatbuf instead of GoogleProtobuf for serialization
 - Documentation, wherever needed