



Situation Understanding & Planning Layer

Final Event
Ulm, 16 May 2018

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Reconcile: The RobustSENSE approach



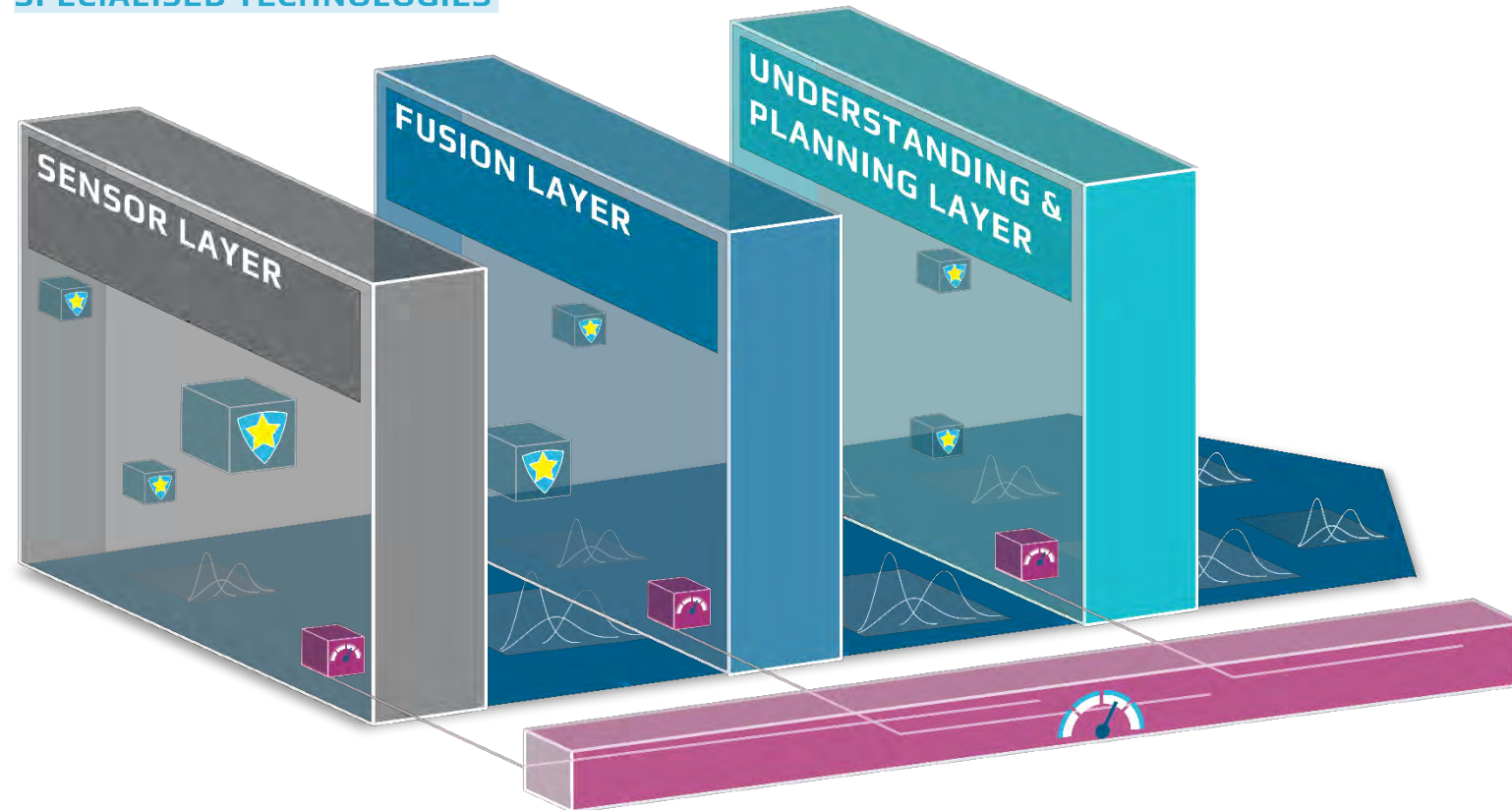
PROBABILISTIC PROCESSING



PERFORMANCE ASSESSMENT



SPECIALISED TECHNOLOGIES



Reconcile: The RobustSENSE approach



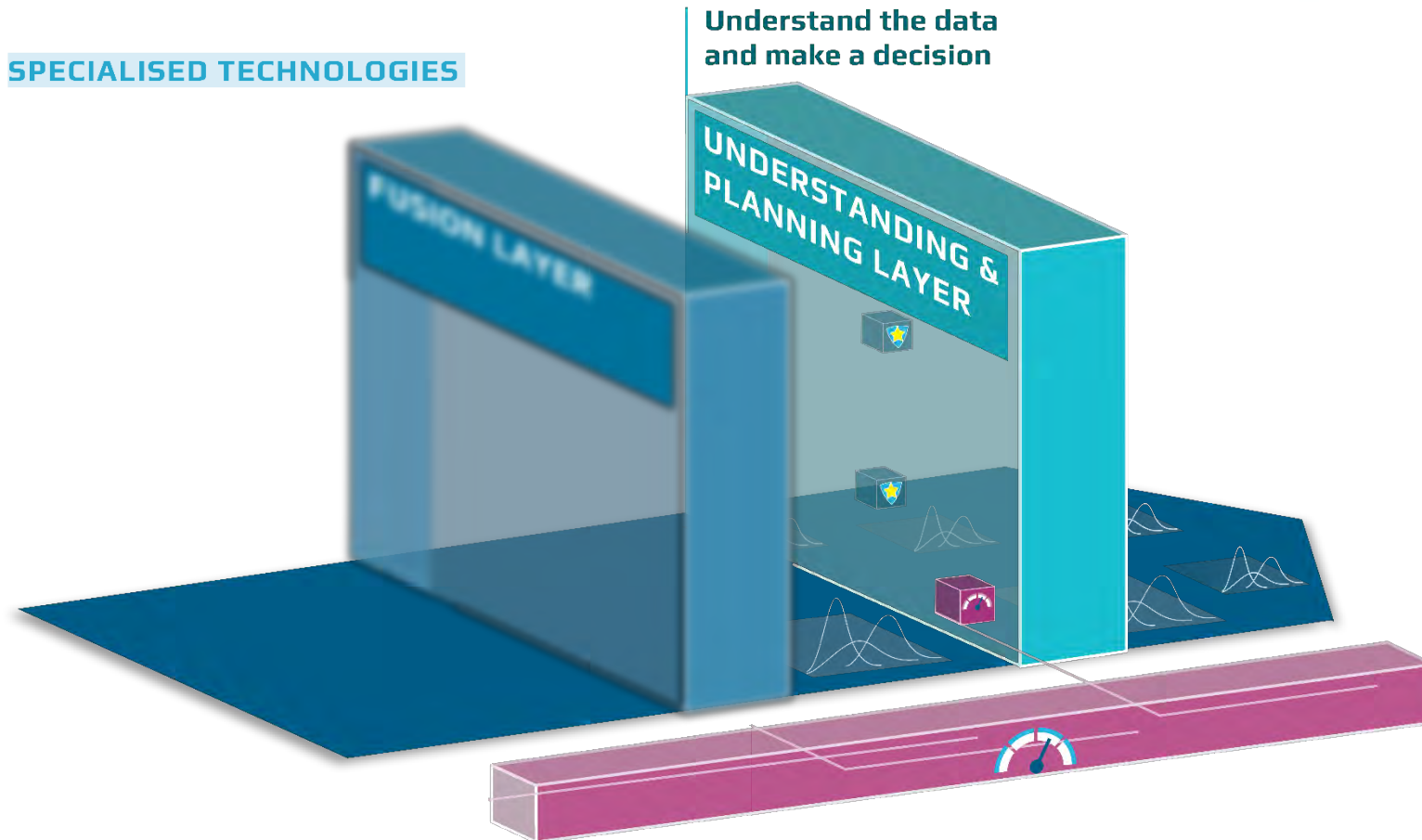
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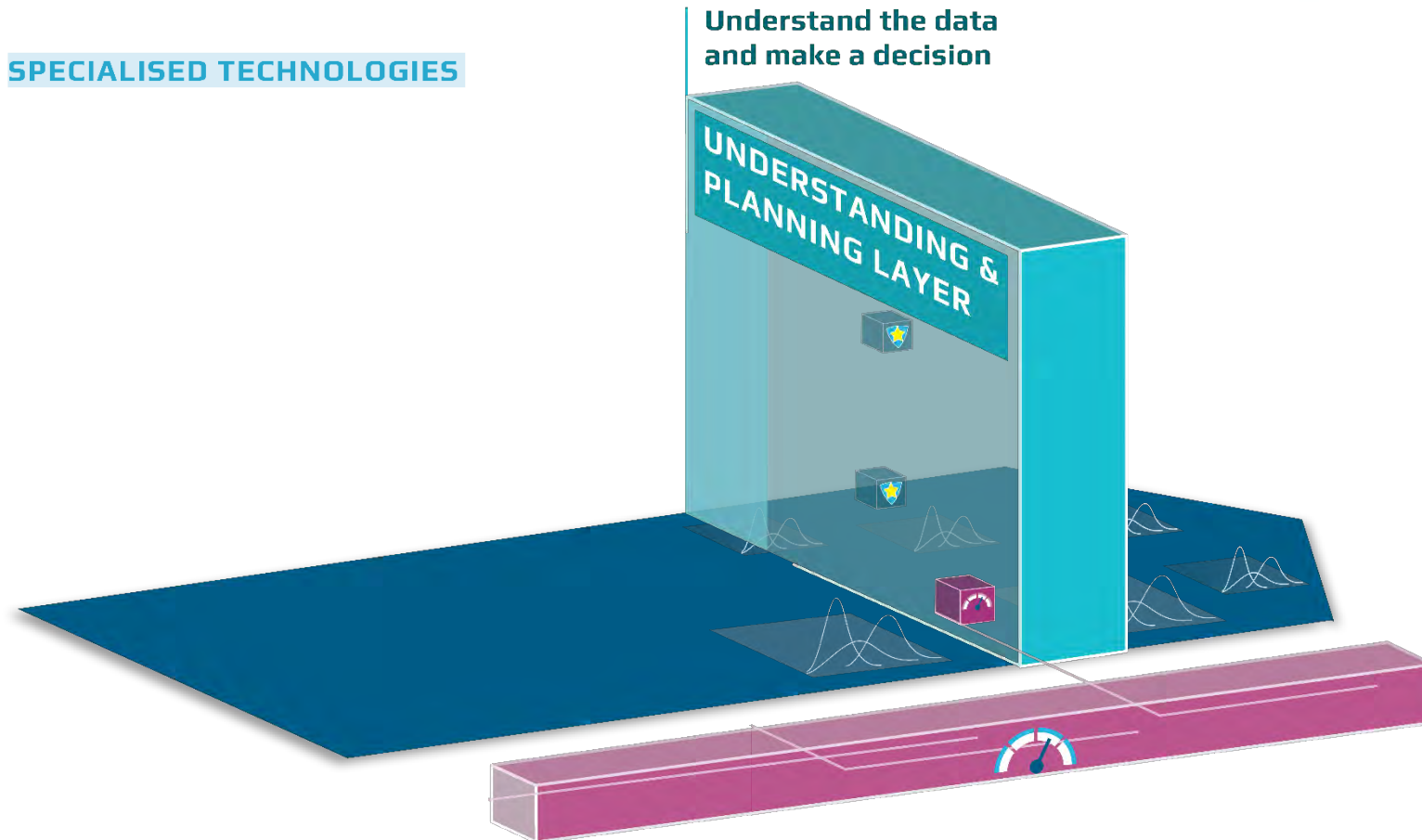
PROBABILISTIC PROCESSING



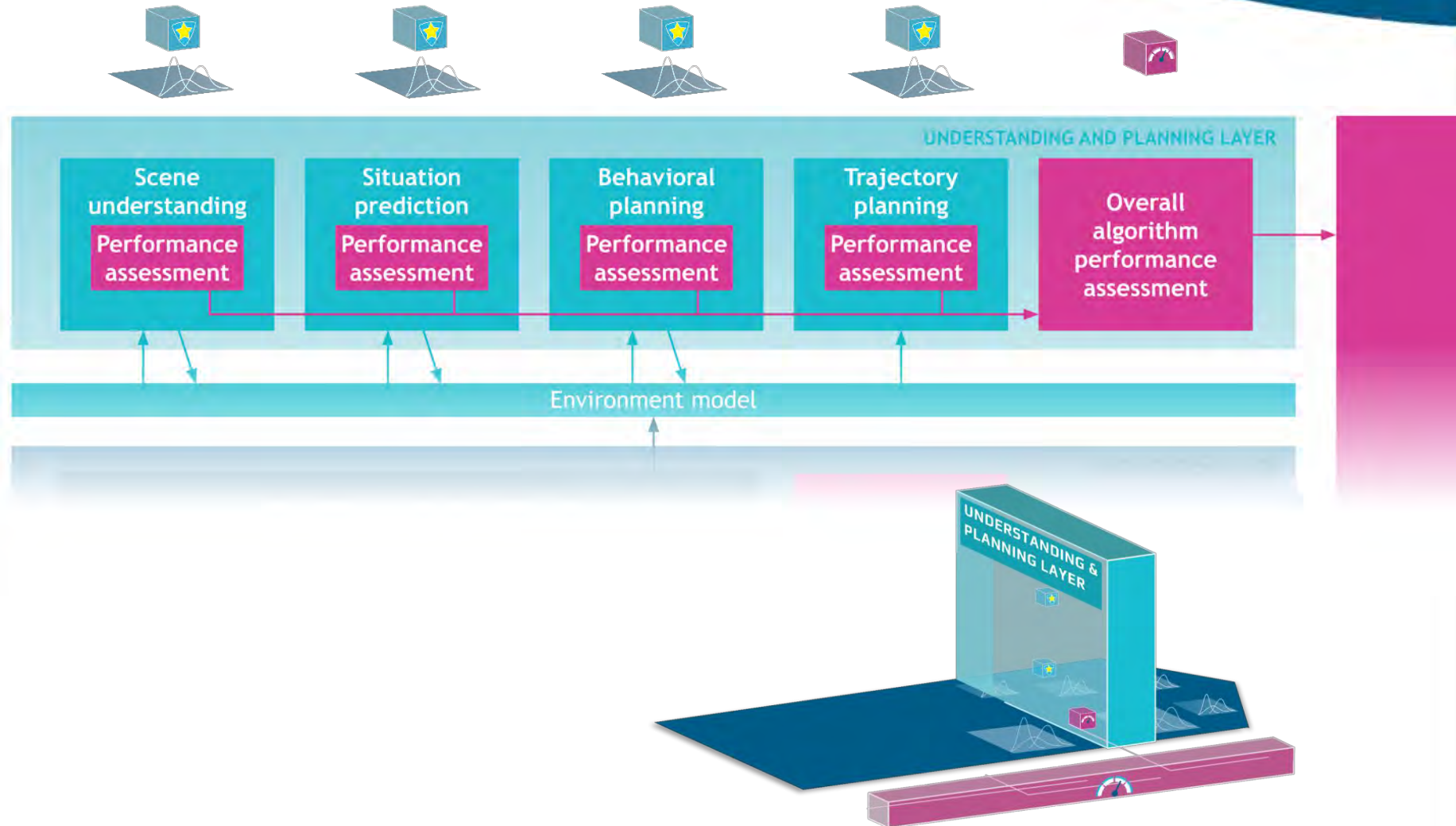
PERFORMANCE ASSESSMENT



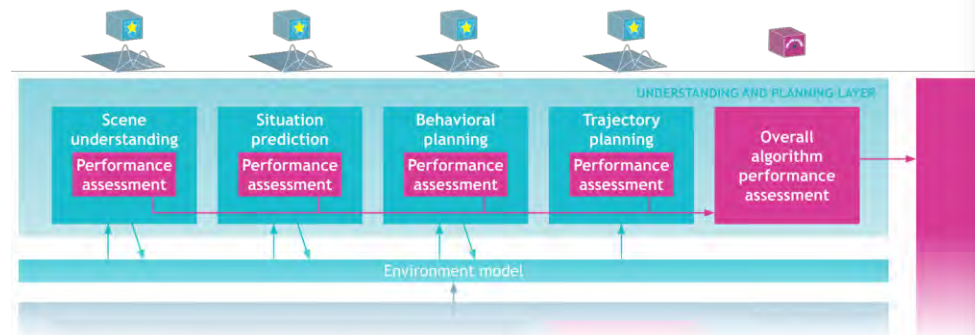
SPECIALISED TECHNOLOGIES



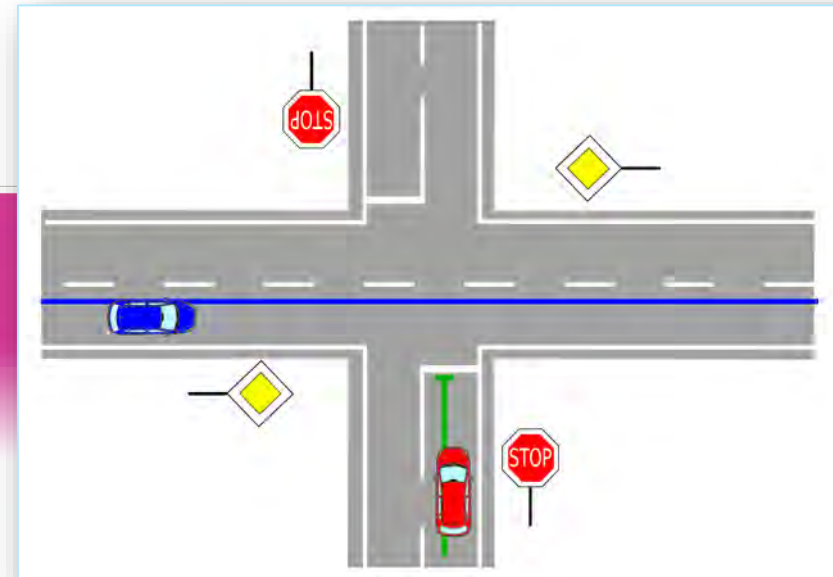
Inside the Understanding & Planning Layer



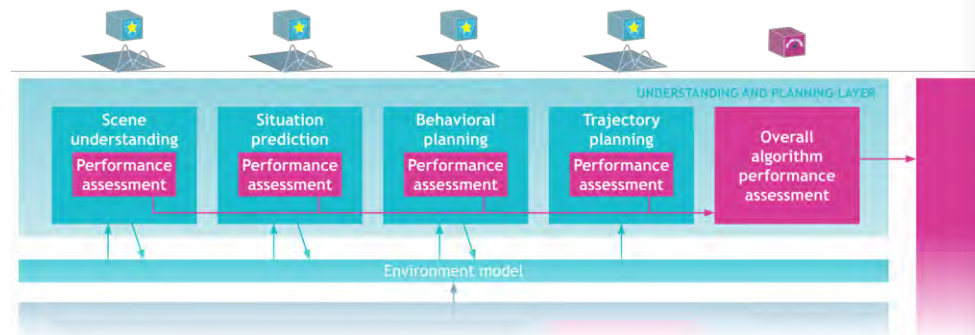
Goal of WP4



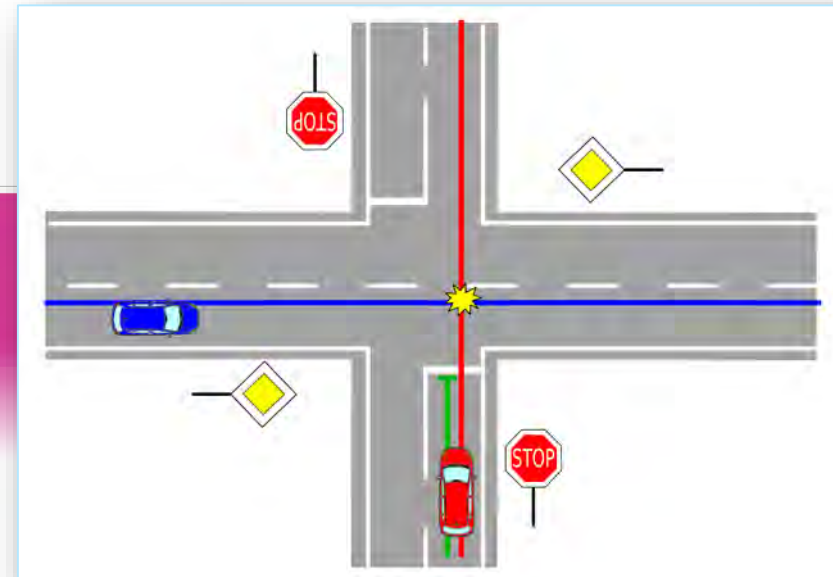
▼ Example: Non-compliant behaviours



Goal of WP4

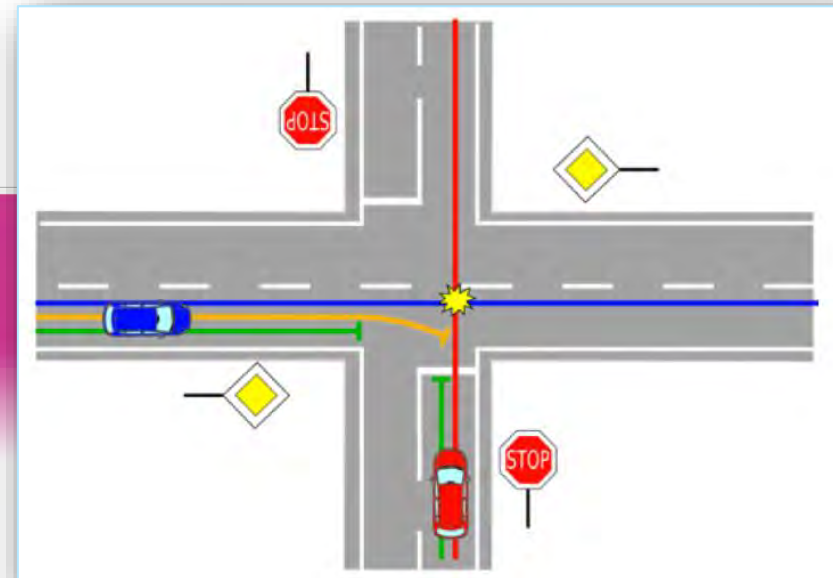
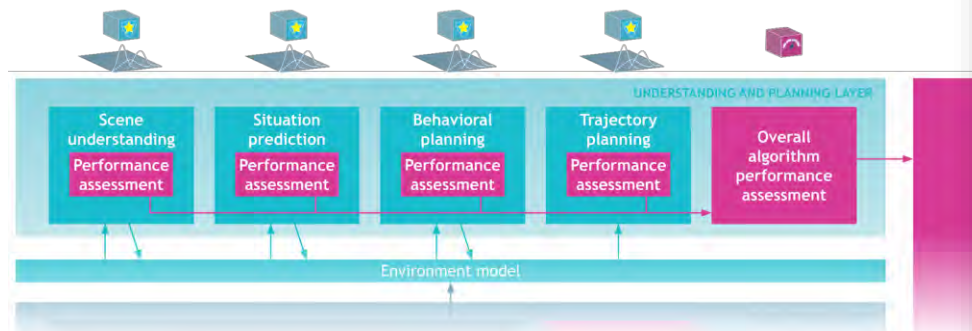


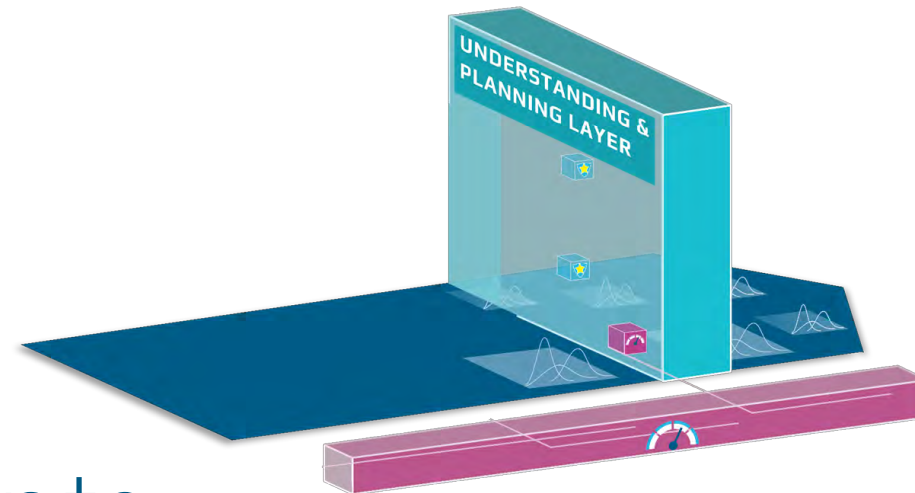
▼ Example: Non-compliant behaviours



Goal of WP4

- ▼ Derive scene logic from object relations
- ▼ Predict possible object trajectories
- ▼ Plan a set of behaviour options
- ▼ Plan a safe trajectory
- ▼ Be aware of all modules' performances





Key Achievements

Road Understanding

- ▼ Training set with 4-point path ahead
- ▼ Learned Convolutional Neural Network (CNN)
- ▼ Evaluation of multiple
 - ▼ Initialization strategies
 - ▼ Network patch sizes
 - ▼ Network structures
 - ▼ Training strategies
- ▼ Good results in different weather conditions

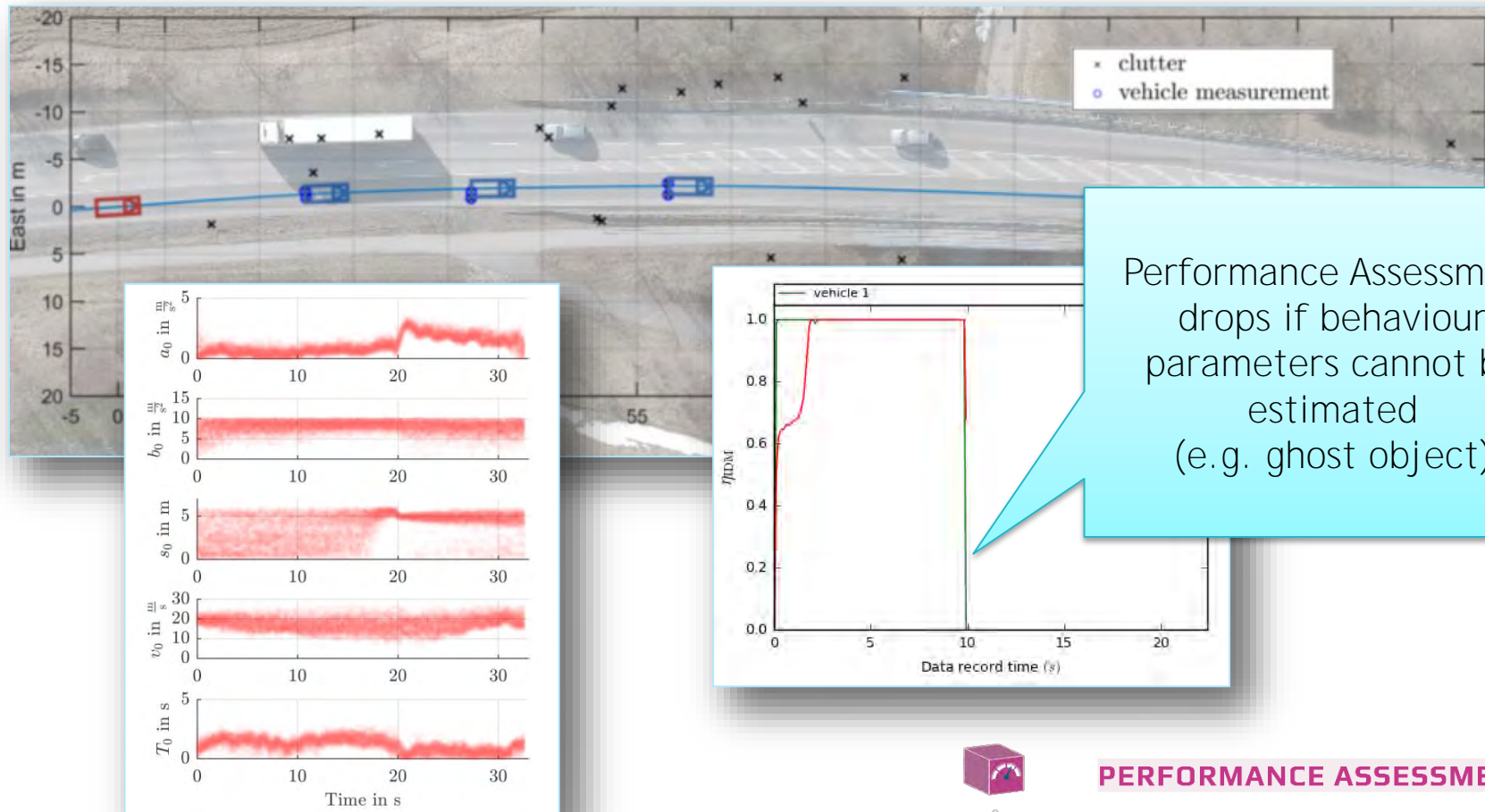


SPECIALISED TECHNOLOGIES

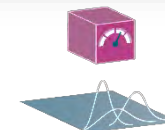
Behaviour Parameter Estimation

Parameters of Intelligent Driver Model (IDM) are estimated online

[Hoermann2017]



Performance Assessment drops if behaviour parameters cannot be estimated (e.g. ghost object)



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Behaviour Parameter Estimation

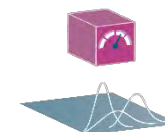


- ▼ Prediction from Intelligent Driver Model is compared to Constant Acceleration Prediction

Constant-Acceleration Prediction

IDM Prediction

Performance Assessment drops if IDM prediction is worse than CA Prediction



PERFORMANCE ASSESSMENT

PROBABILISTIC PROCESSING

Grid-based model-free prediction

▼ Learned Convolutional Neural Network (CNN)

▼ Input

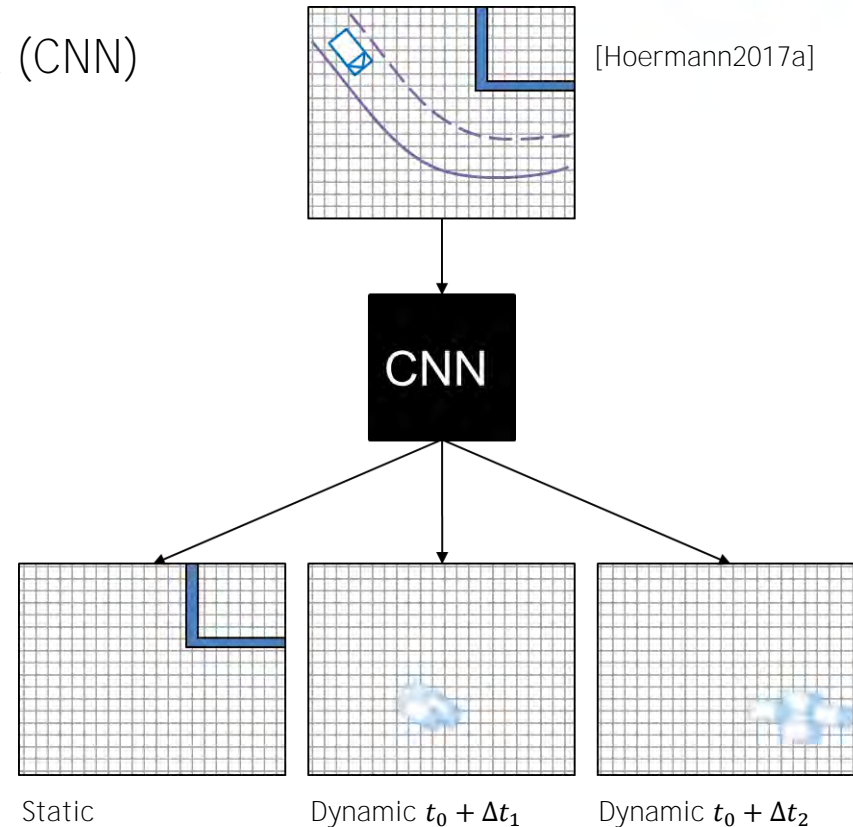
▼ Dynamic grid map at t_0

▼ Output

▼ Segmentation in dynamic and static

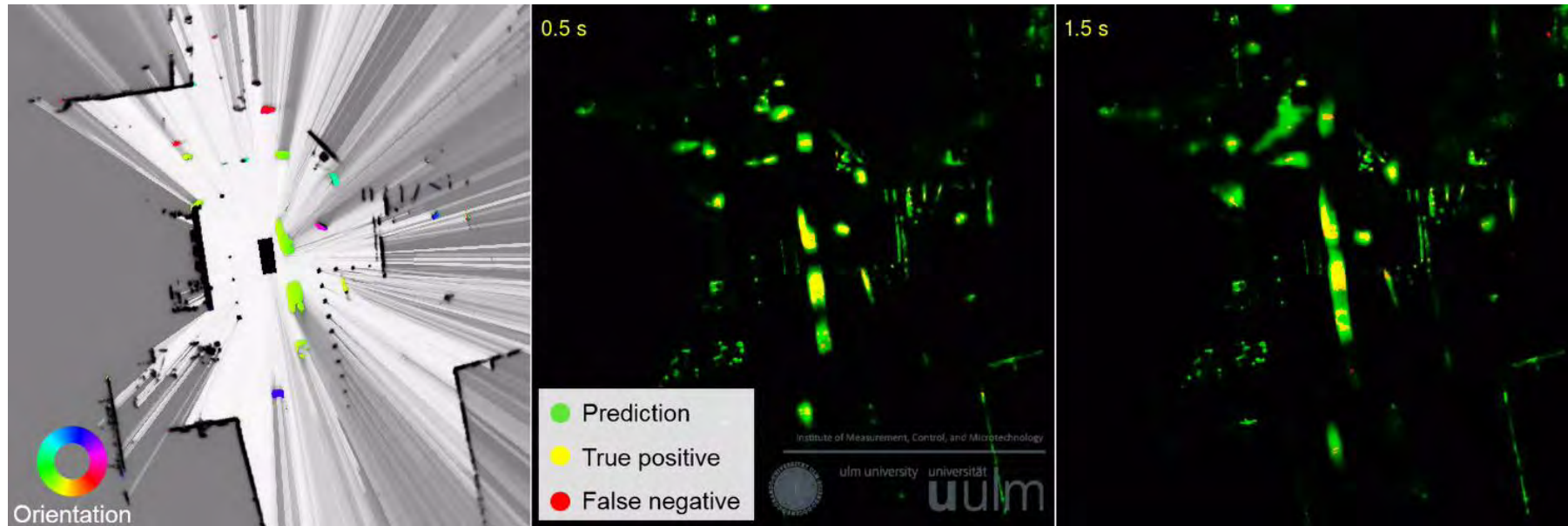
▼ Prediction of dynamic environment

▼ Complementary trajectory prediction increasing overall robustness



PROBABILISTIC PROCESSING

Grid-based model-free prediction

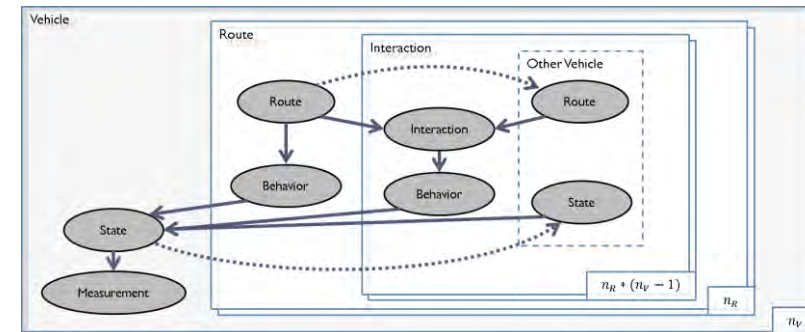
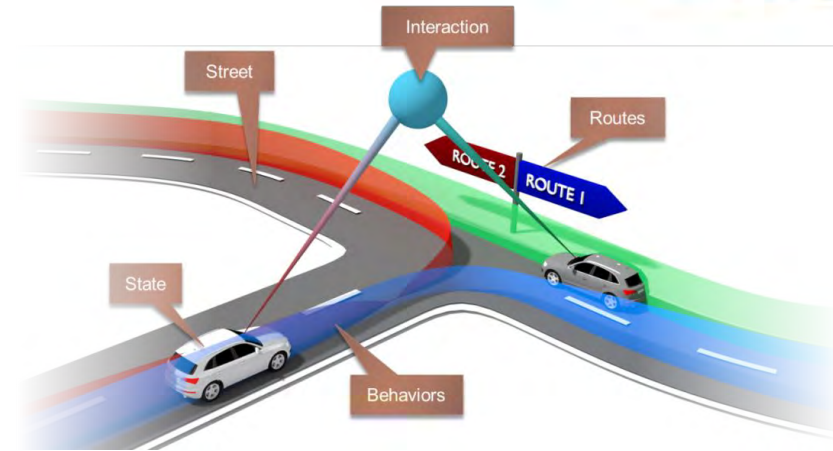


PROBABILISTIC PROCESSING

Interaction Detection and Route Prediction



- ▼ Modeling of relations and interactions via Probabilistic Relational Model
- ▼ Interaction-dependent motion models based on interacting driver model (IDM)
- ▼ Behaviour-based route and trajectory prediction
- ▼ Integration with probabilistic environment model



[Kuhnt2016]



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Interaction Detection and Route Prediction

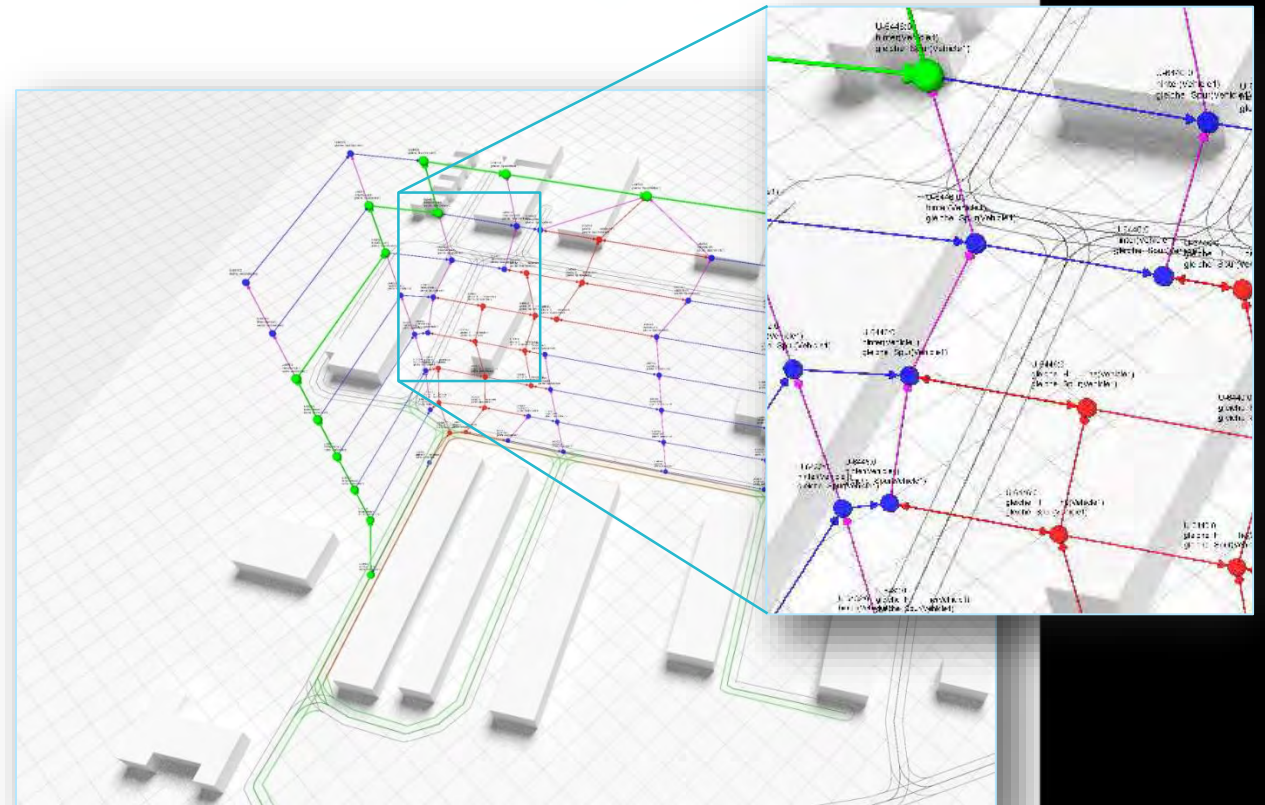


PROBABILISTIC PROCESSING

Probabilistic Behaviour Planning based on Semantic State Space

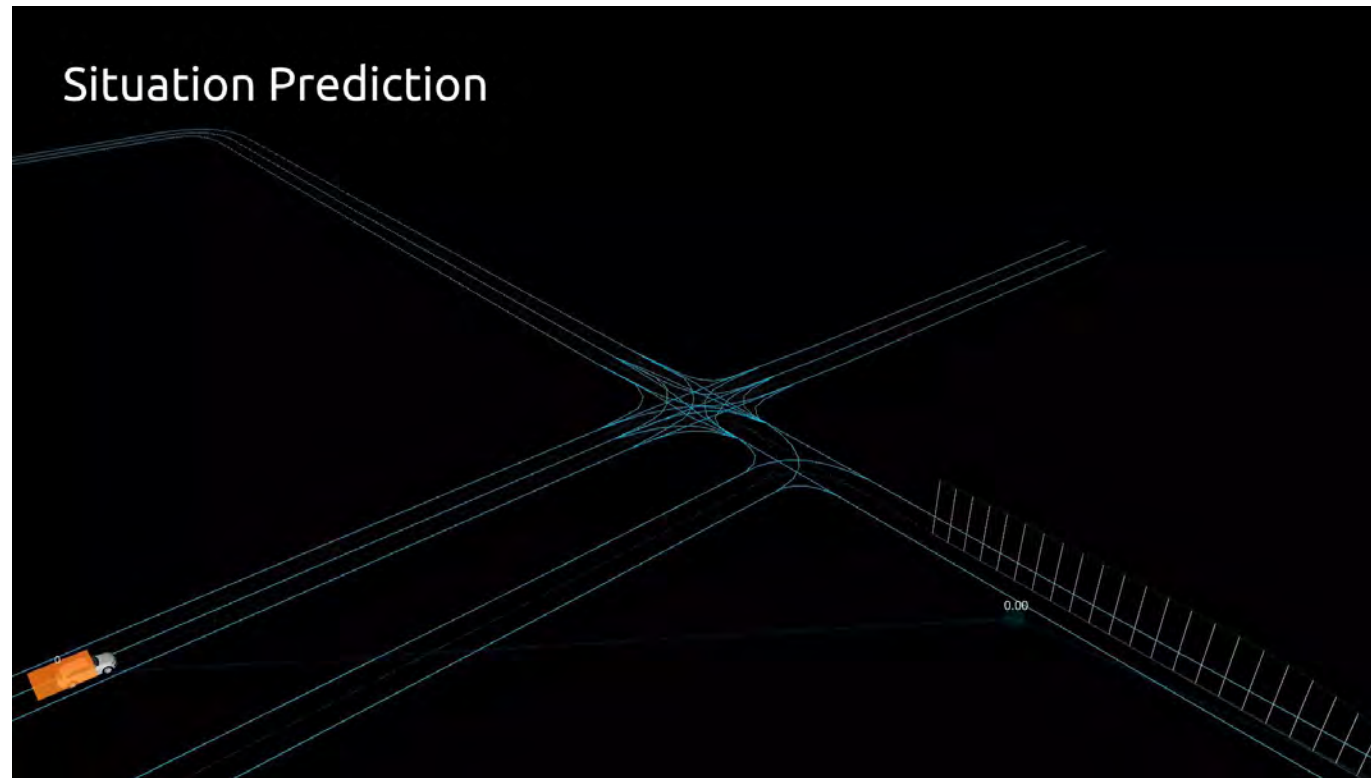


- ▼ Multi-hypothesis Semantic State Space built from Environment Model
- ▼ Discrete Planning on Semantic State Space
- ▼ Output: Maneuver chains



PROBABILISTIC PROCESSING

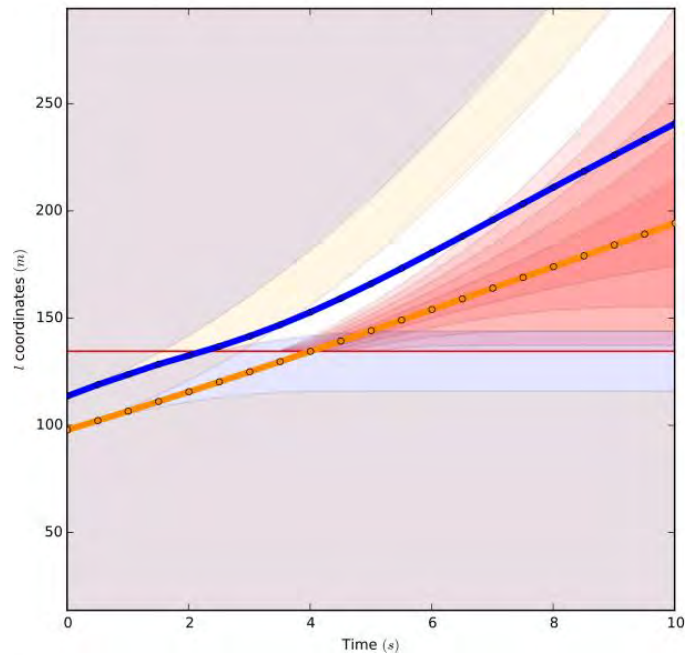
Probabilistic Behaviour Planning based on Semantic State Space



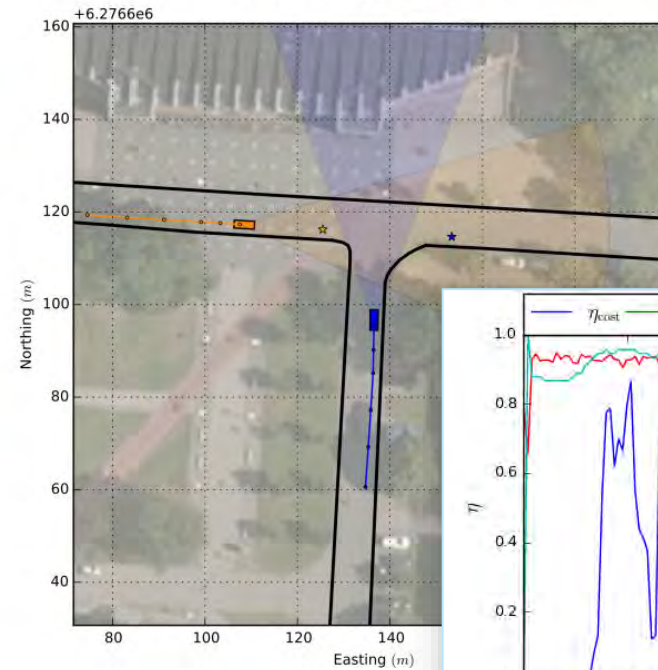
PROBABILISTIC PROCESSING

Safe Trajectory Generation Considering Traffic Uncertainties

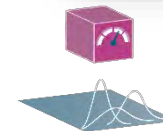
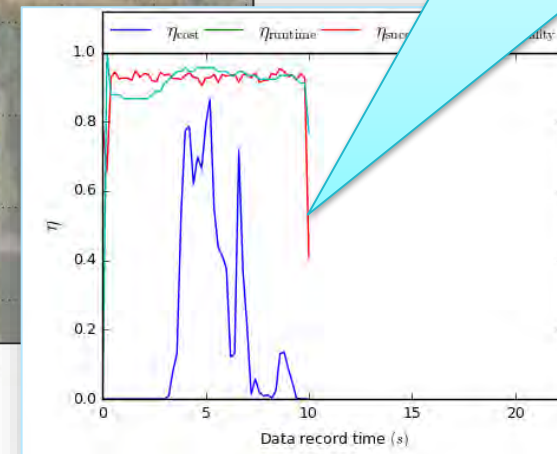
Safety Analysis on Path-Time Diagram



Cartesian Mapping of Motion



Performance Assessment
drops if planner metrics drop

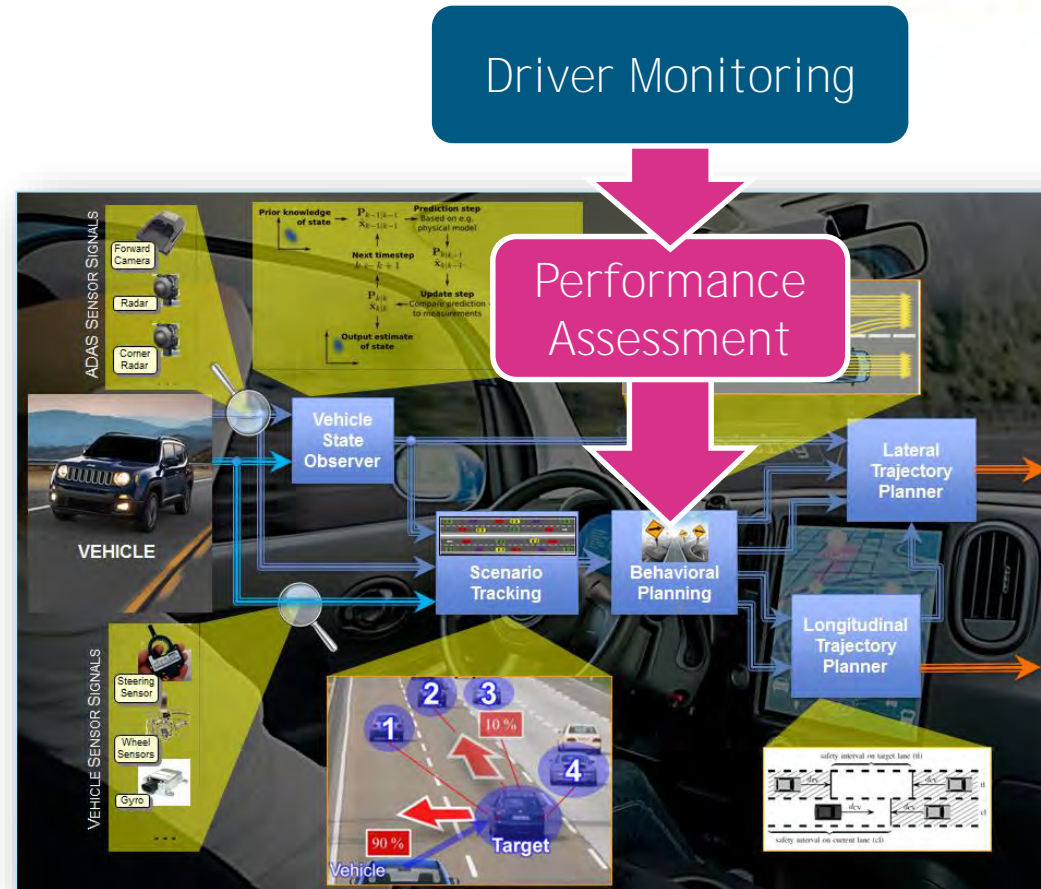


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PROBABILISTIC PROCESSING

Driver State Dependent Behaviour Planning

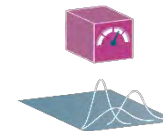
- ▼ Lateral and Longitudinal Trajectory Planners based on Model Predictive Control (MPC) theory
- ▼ Trajectory Planning Model-based approach uses a series of Kalman Filters
- ▼ Driver Monitoring is used to avoid critical maneuvers if driver is distracted



SPECIALISED TECHNOLOGIES

Multilane Trajectory Planning based on Human Behaviour and Collision Risk

- ▼ Scene Understanding
 - ▼ Brings objects and road into relation
- ▼ Situation Prediction
 - ▼ Estimate all possible trajectories on multilane road layout
- ▼ Trajectory Planning
 - selects safe trajectories based on
 - ▼ Collision risk
 - ▼ Human behaviour
- ▼ Shown on real test drive on multilane scenario



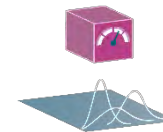
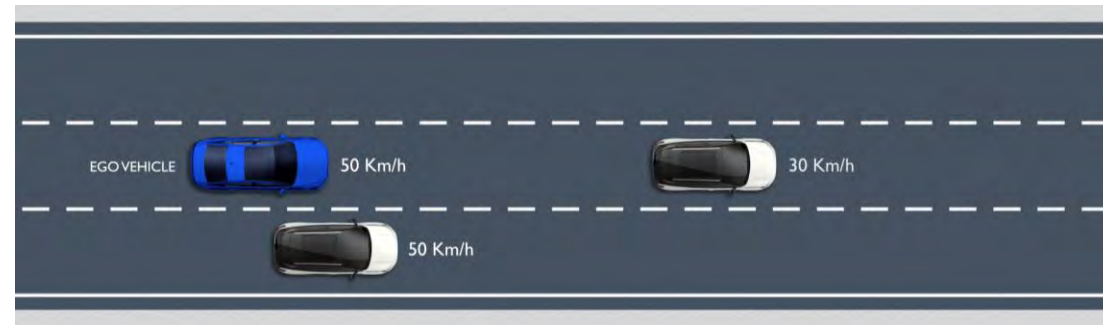
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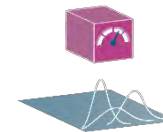
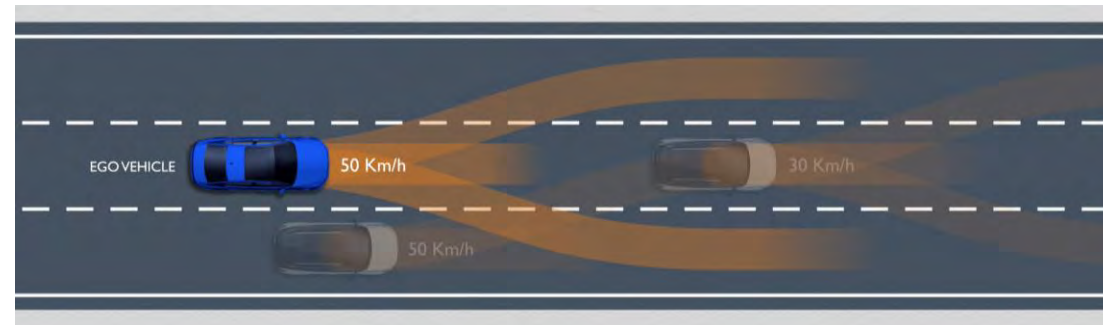


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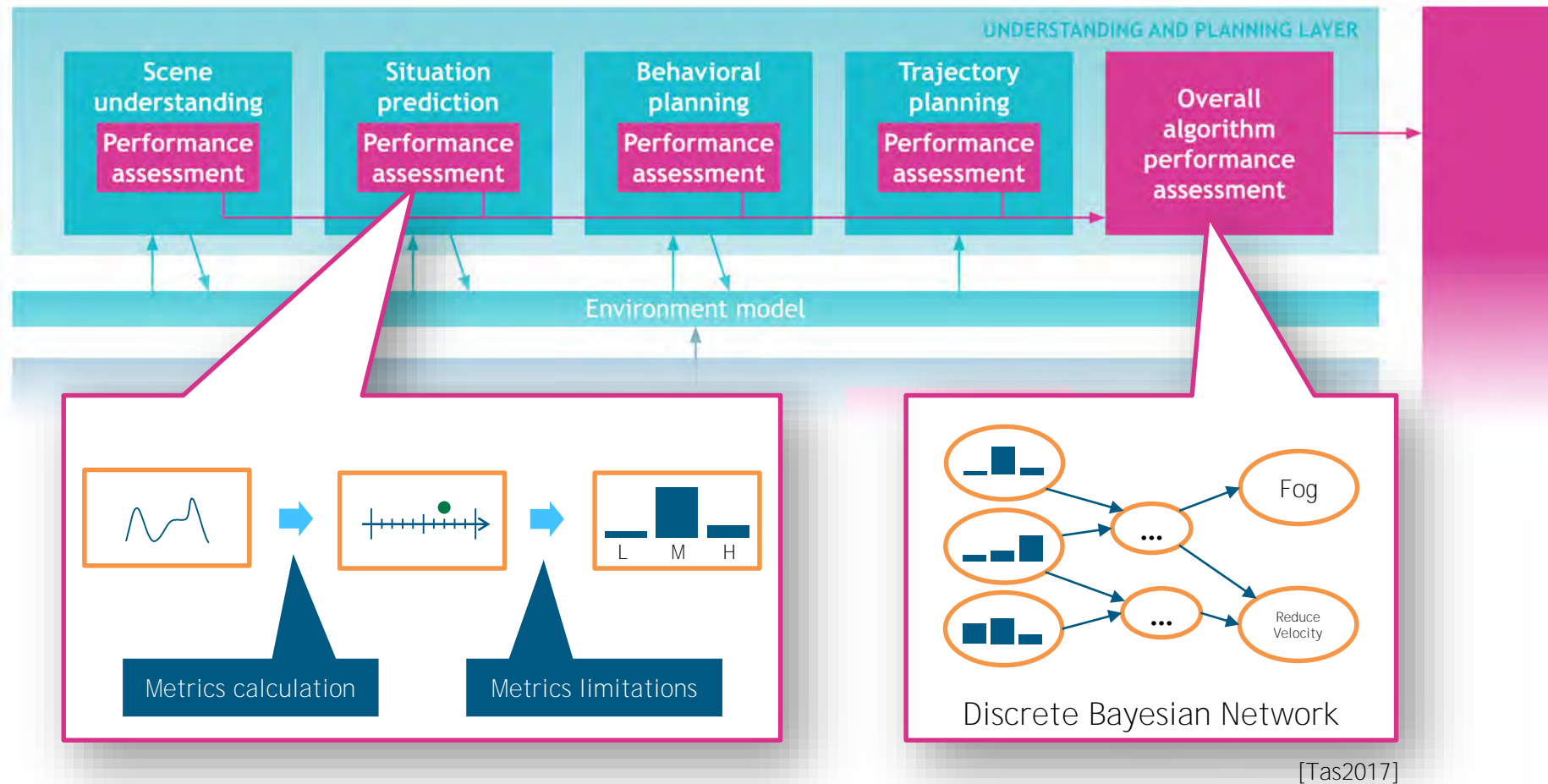
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PERFORMANCE ASSESSMENT

PROBABILISTIC PROCESSING

Bayesian Inference of Overall Performance Assessment



References



- ▼ [Hoermann2017] Probabilistic Long-Term Prediction for Autonomous Vehicles, In IEEE Intelligent Vehicles Symposium (IV), 2017.
- ▼ [Hoermann2017a] Dynamic Occupancy Grid Prediction for Urban Autonomous Driving: A Deep Learning Approach with Fully Automatic Labelling. <https://arxiv.org/abs/1705.08781>
- ▼ [Kuhnt2016] Kuhnt, F., Schulz, J., Schamm, T., & Zöllner, J. M. (2016). Understanding Interactions between Traffic Participants based on Learned Behaviours. In IEEE Intelligent Vehicles Symposium (IV).
- ▼ [Kuhnt2016b] Kuhnt, F., Pfeiffer, M., Zimmer, P., Zimmerer, D., Gomer J., Kaiser, V., Kohlhaas, R. & Zöllner, J. M. (2016). Robust Environment Perception for the Audi Autonomous Driving Cup. In IEEE Intelligent Transportation Systems Conference (ITSC).
- ▼ [Tas2017] Tas, Ö., Hörmann, S., Schäufele, B., Kuhnt, F. (2017). Automated Vehicle System Architecture with Performance Assessment. In IEEE Intelligent Transportation Systems Conference (ITSC).