TECHNISCHE UNIVERSITÄT DARMSTADT

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System Architecture & Behavior Planning

System Architecture & Behavior Planning

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Agenda

- Motivation and Challenges of Architecture Design
- PRORETA 3 Functional Architecture
- Insight into PRORETA3 Behavior Planning Algorithm
- Summary

System Architecture

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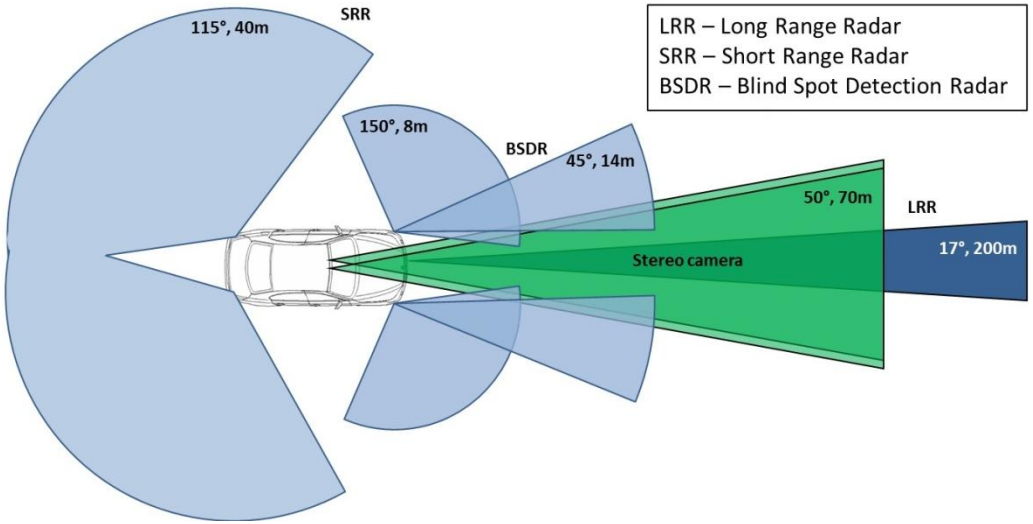
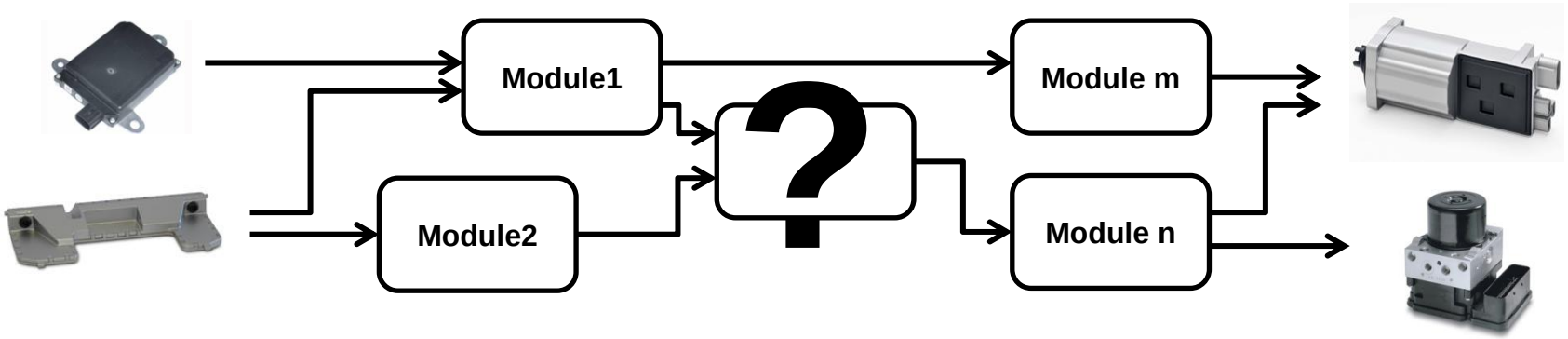
Motivation & Challenge

- System Architecture
  - Hardware Architecture



  - (Functional) Software Architecture



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System Architecture

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Motivation & Challenge

- **Challenge 1: „Blank sheet of paper“**
  - **Problem with high degrees of freedom**

- **Challenge 2: Significance of software architecture**
  - **Architecture design takes place in early phase of system development**
  - **Architecture influences the development and implementation efficiency**
  - **Architecture influences the system understanding and complexity**

System Architecture

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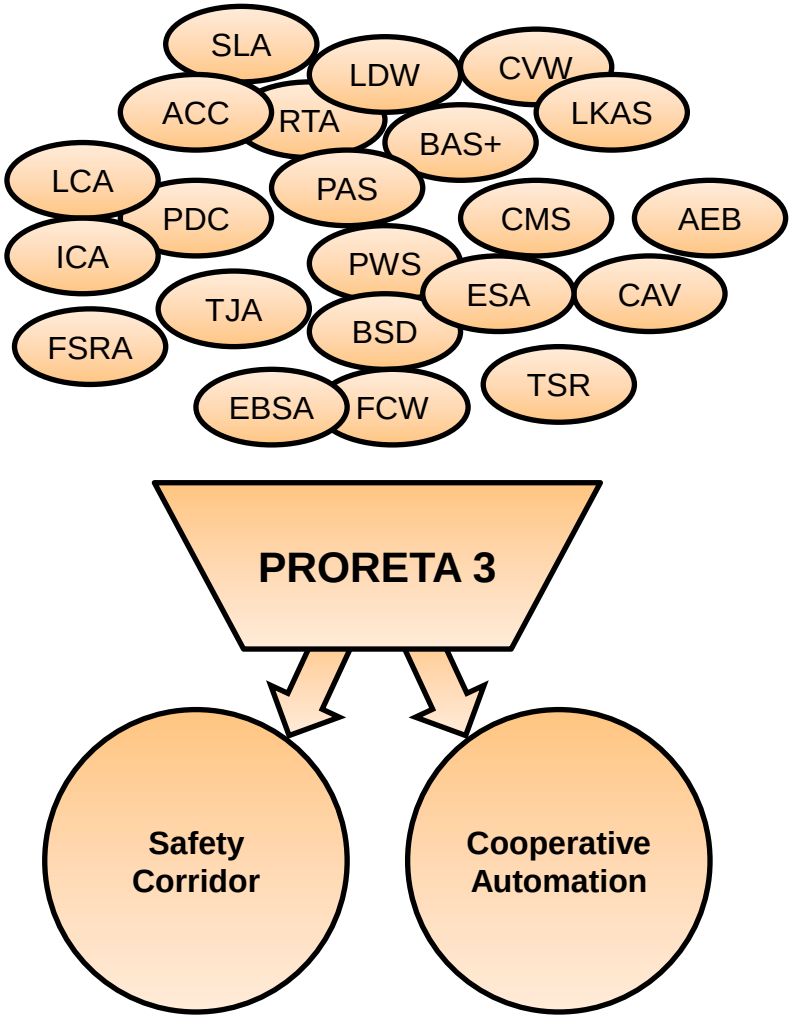
Motivation & Challenge

- **Functional Requirements within PRORETA3**



PRORETA

System Architecture

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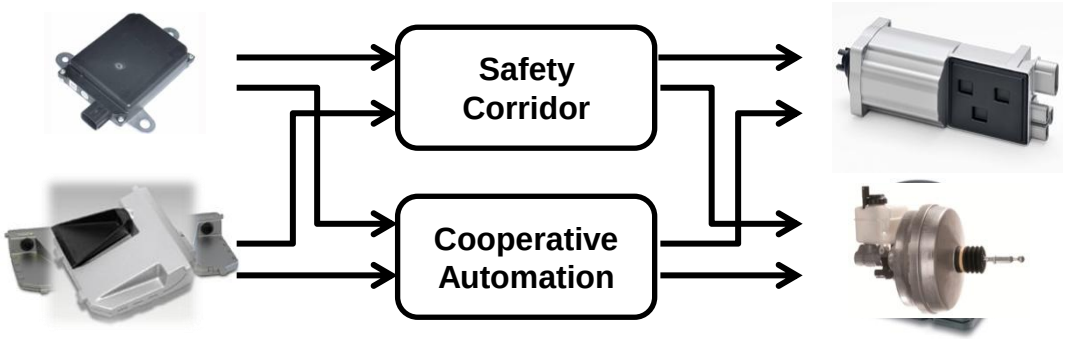
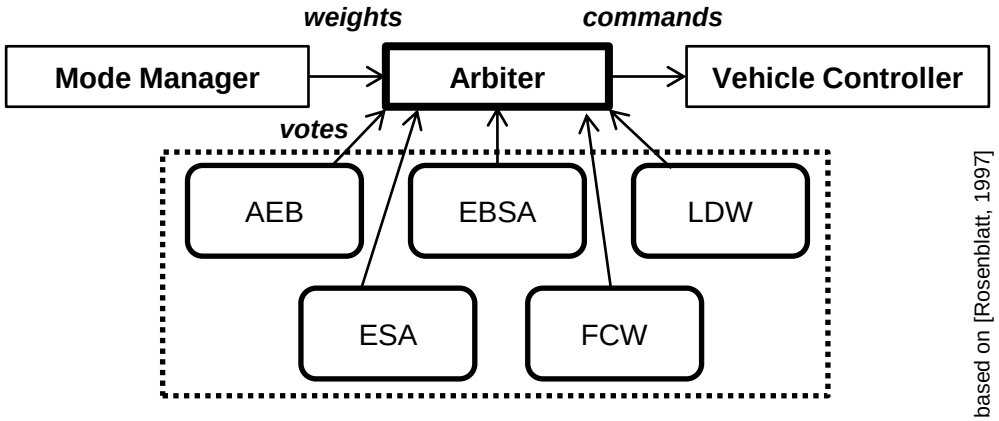
Motivation & Challenge

- **Direct functional partitioning**
  - **modules directly depend on sensors and actuators**
  - **duplication of effort**



- **Reactive Architectures**
  - **Different behaviors compete over vehicle actuators**
  - **Command arbitration is required**
  - **Hard to optimize in complex environments / situations**



PRORETA

System Architecture

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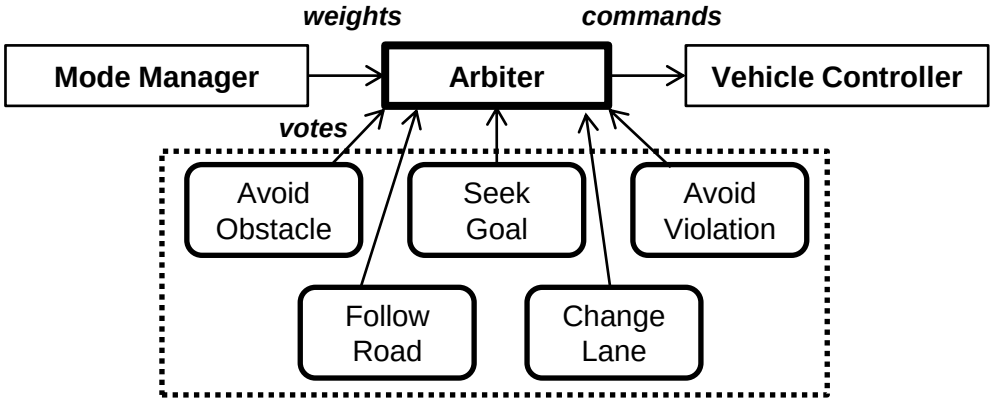
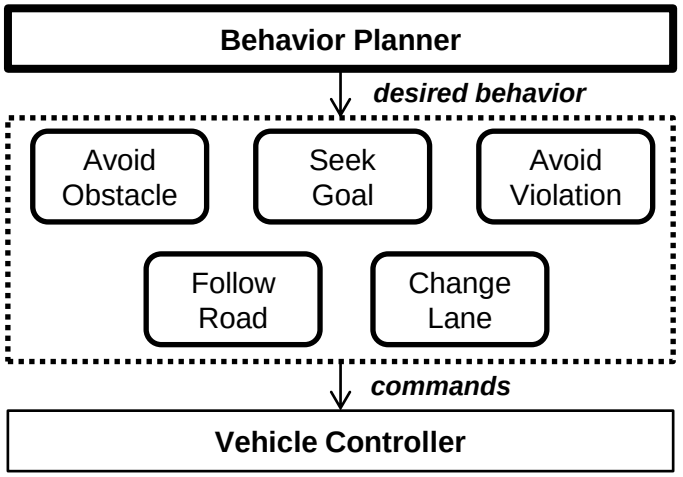
Behavior-based Approach for Mobile Robotics

- Generalized vehicle behaviors
- Reconfigure the decision process



- Layered Architectures
  - Hierarchically layered modules, e.g. organizational hierarchy
  - Decomposition of driving task in subtasks
  - Enables deliberate planning to reach long-term goals



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System Architecture

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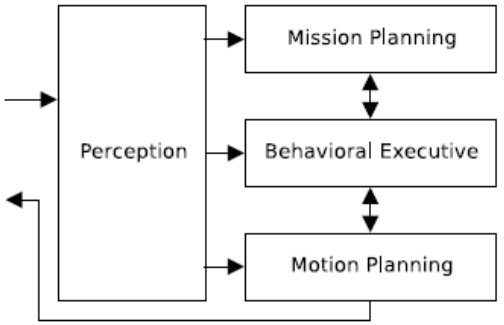
Layered Architectures in Praxis

- **Fully automated vehicles**

[Urmson, 2008]



Unique selling points of PRORETA 3

- **Intensive driver integration (shared vehicle control)**
  - **Safety Corridor: Assisted conventional driving**
  - **Cooperative Automation: Maneuver-based vehicle automation**

PRORETA3 Architecture Overview

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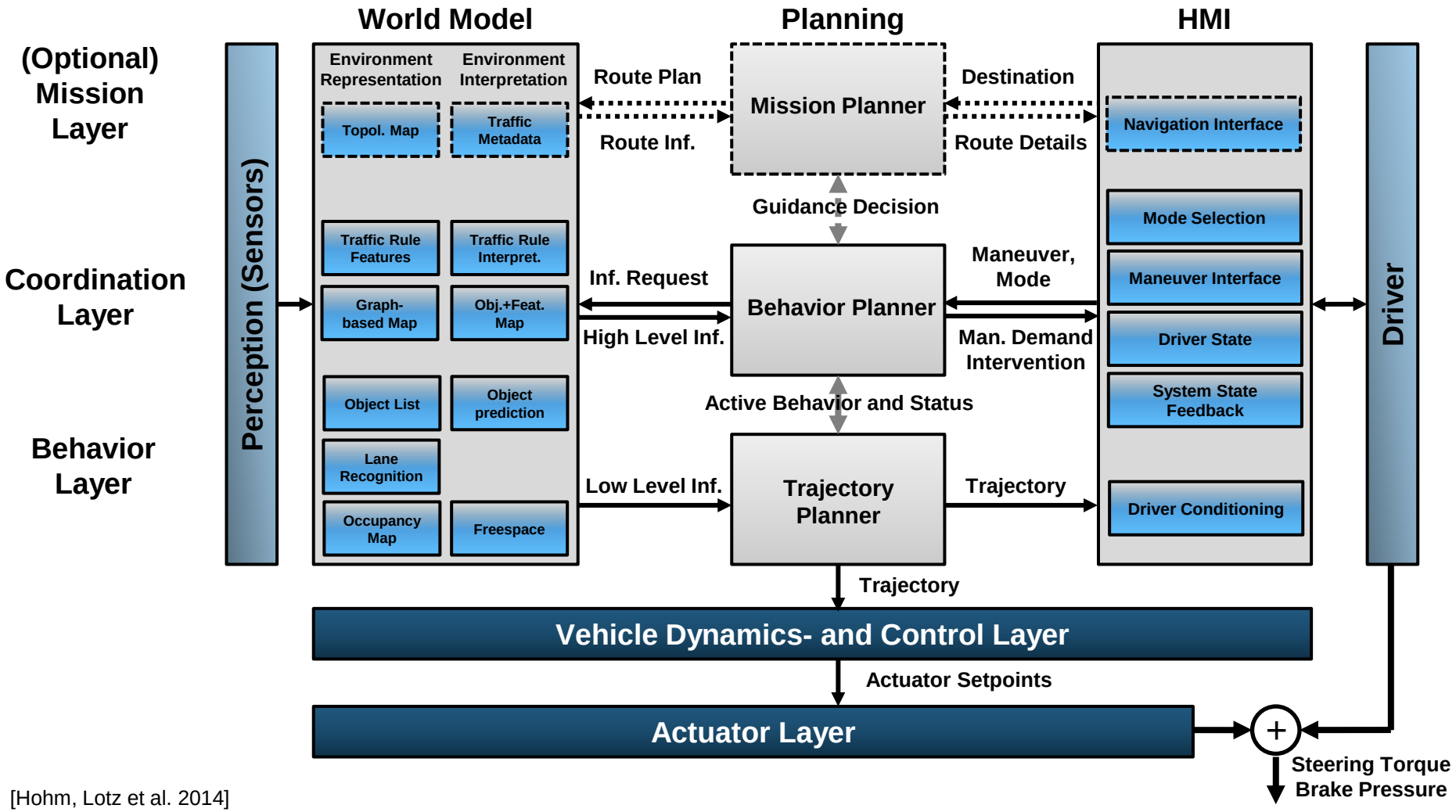

[Hohm, Lotz et al. 2014]

PRORETA

Example: Safety Corridor Intervention

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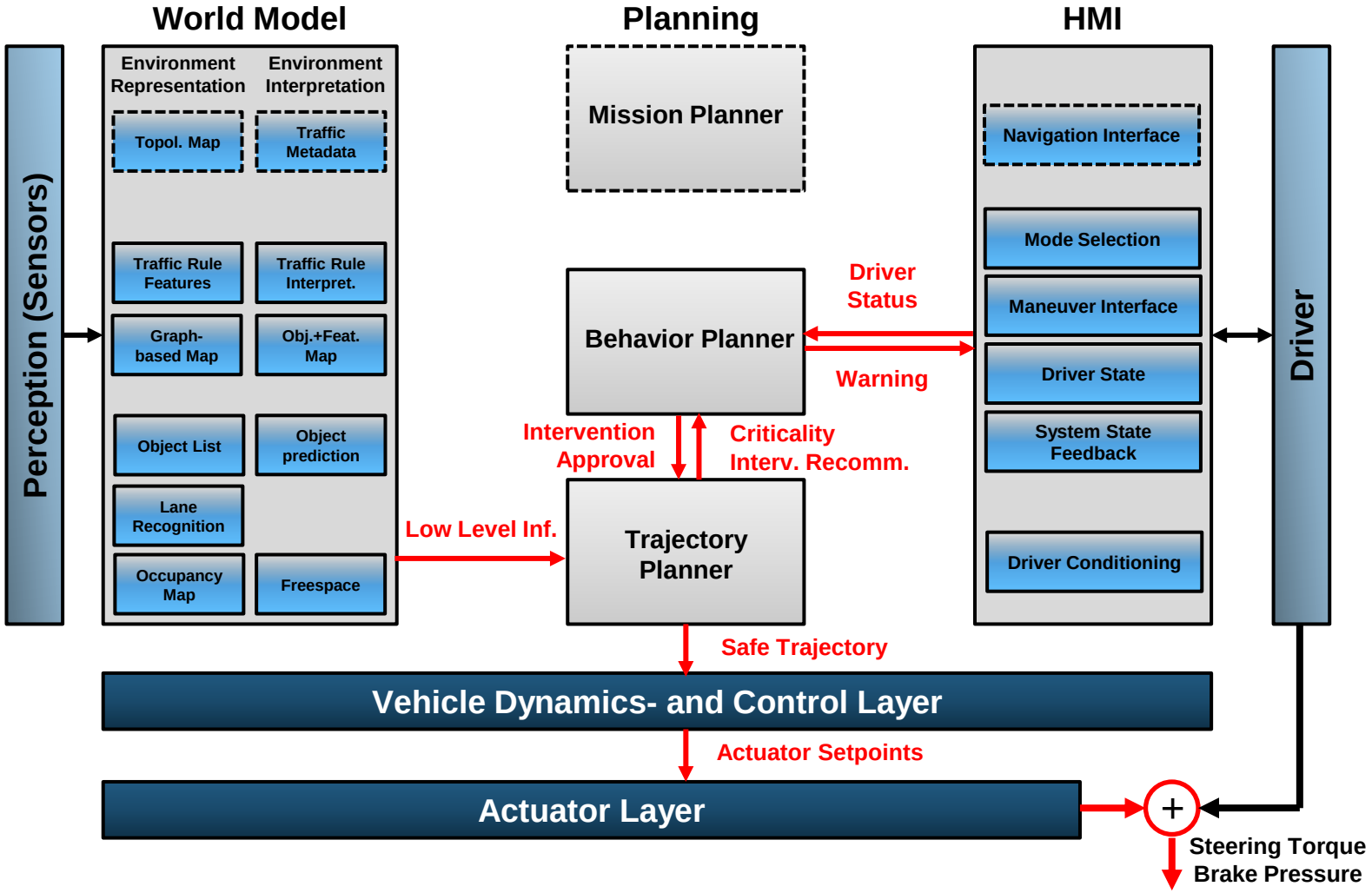

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Behavior Planning

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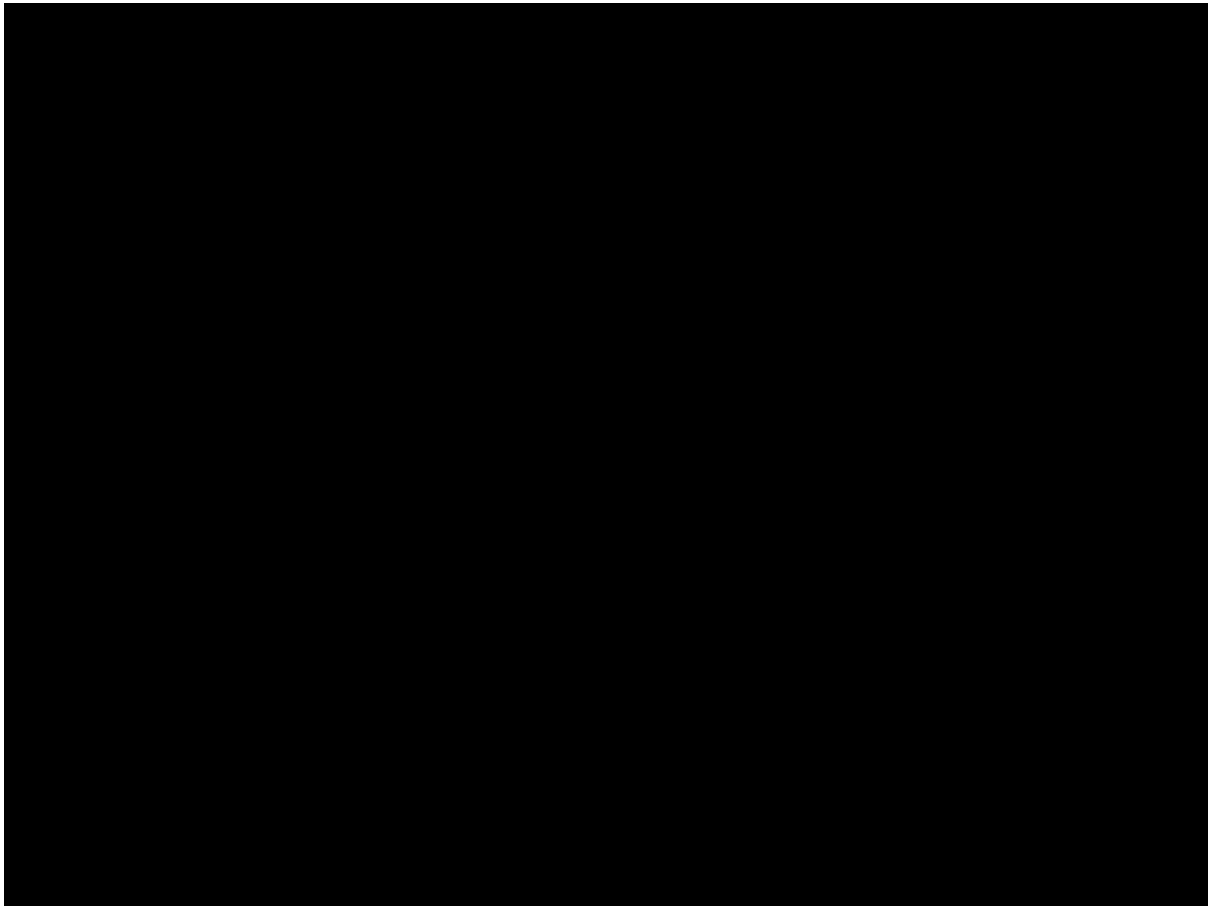
Exemplary Situation within Cooperative Automation Mode



Behavior Planning

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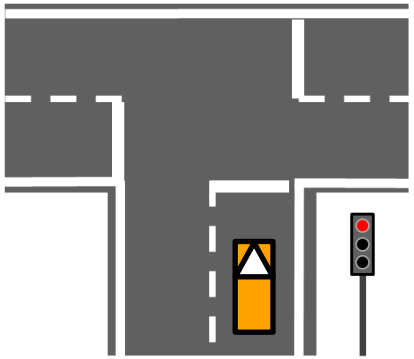
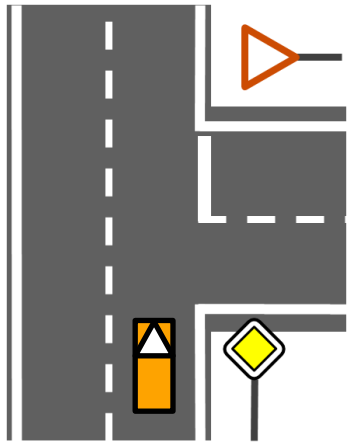
Requirements and Design Questions

- **Mode Change SC → KA**
- **Approach / Crossing of Intersection:**
  - **How / when / how long are available maneuvers offered?**
  - **Is there a *default maneuver*?**
  - **What if driver suddenly changes decision?**
  - **How is yielding represented within implementation?**
  - **When is the turning maneuver finished?**
  - **…**





Behavior Planner

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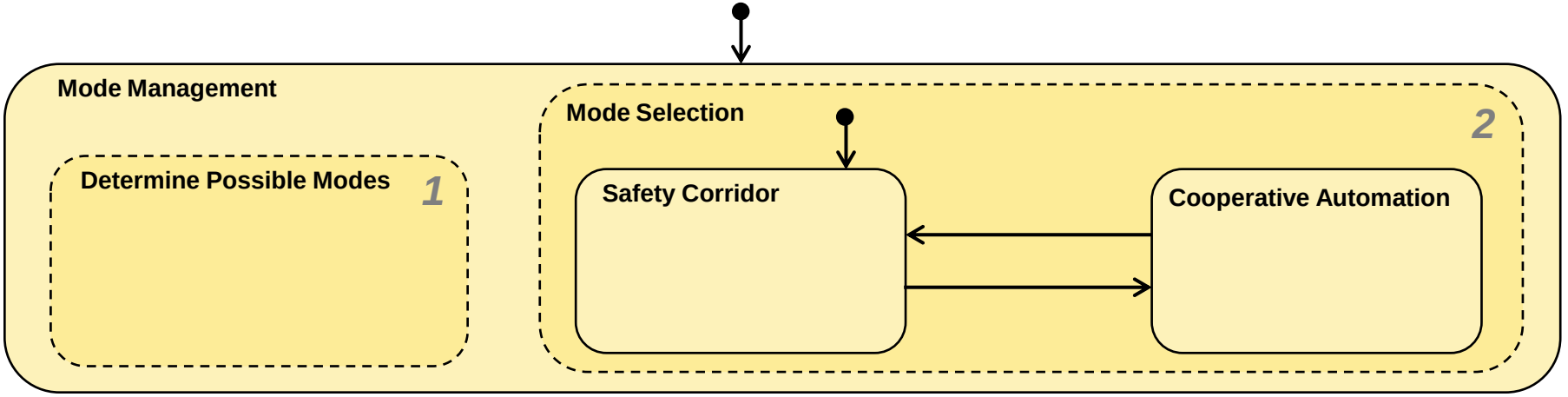
Implementation

- **Requirements:**
  - **Traffic rules dictate specific vehicle behaviors**
  - **Driver delegates discrete vehicle maneuvers**
  - **→Implementation approach has to cope with discrete system states**

Selected Implementation Approach: Hierarchical State Machine



PRORETA

PRORETA 3 System Architecture

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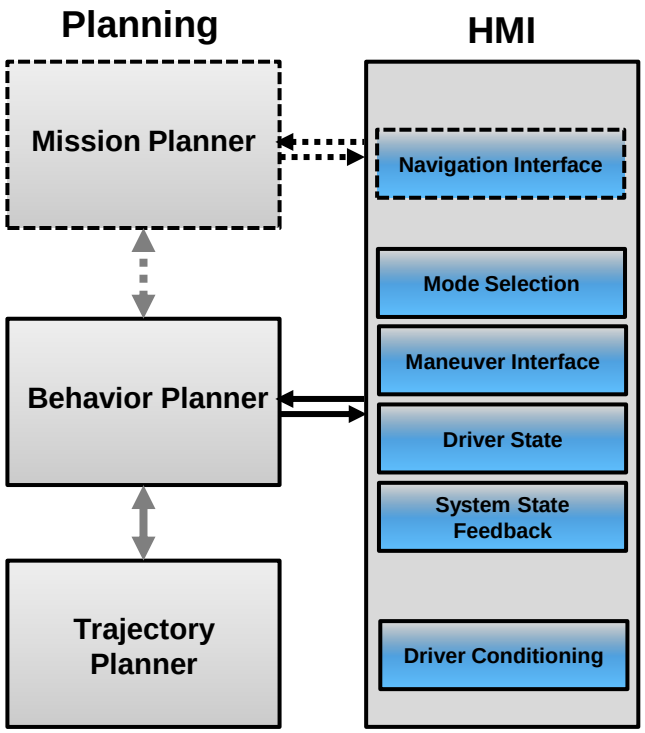
Summary

- The modular and layered architecture design allows a division of behavior decision and behavior execution

  → Each layer can be implemented independently

- Functional encapsulation results in error isolation and reduces the testing and debug effort
- The driver is explicitly represented within the system design → shared vehicle control
- Optional Mission Layer gives the opportunity to achieve higher degrees of automation without changing the architecture design



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Literaturverweise

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PRORETA