Secure Autonomous and Cyber-Physical Systems

CS 599 001/ECE 599 004

Winter 2022

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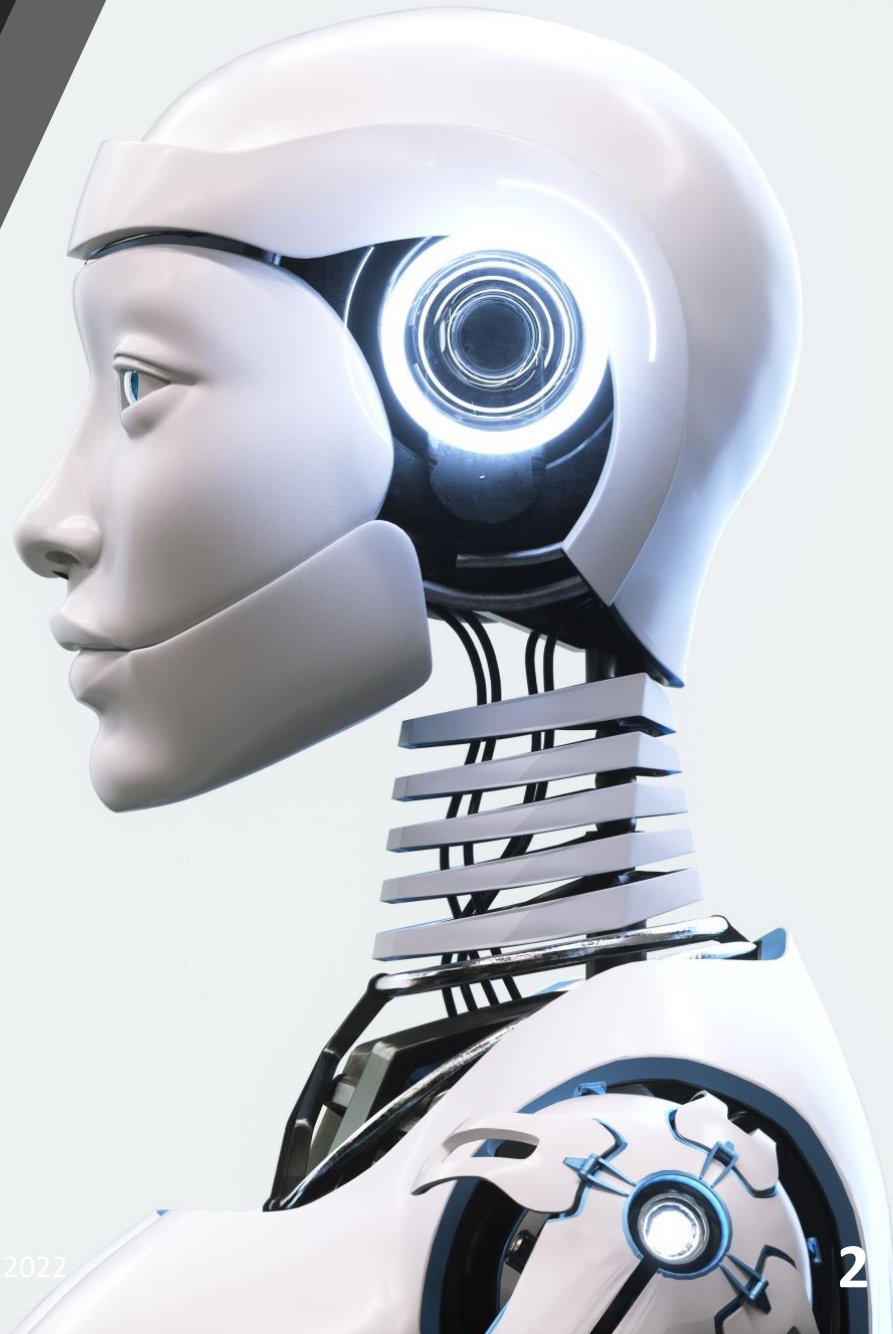
https://bit.ly/secureauto2022

Autonomy | A Definition

Autonomy is the **ability to perform given tasks** based on the **system's perception without human intervention**



Aspects of Autonomy

- Perception
- Compute
- Actuation
- Planning
- Sensing
- Motion

Automotive Standards and Definitions

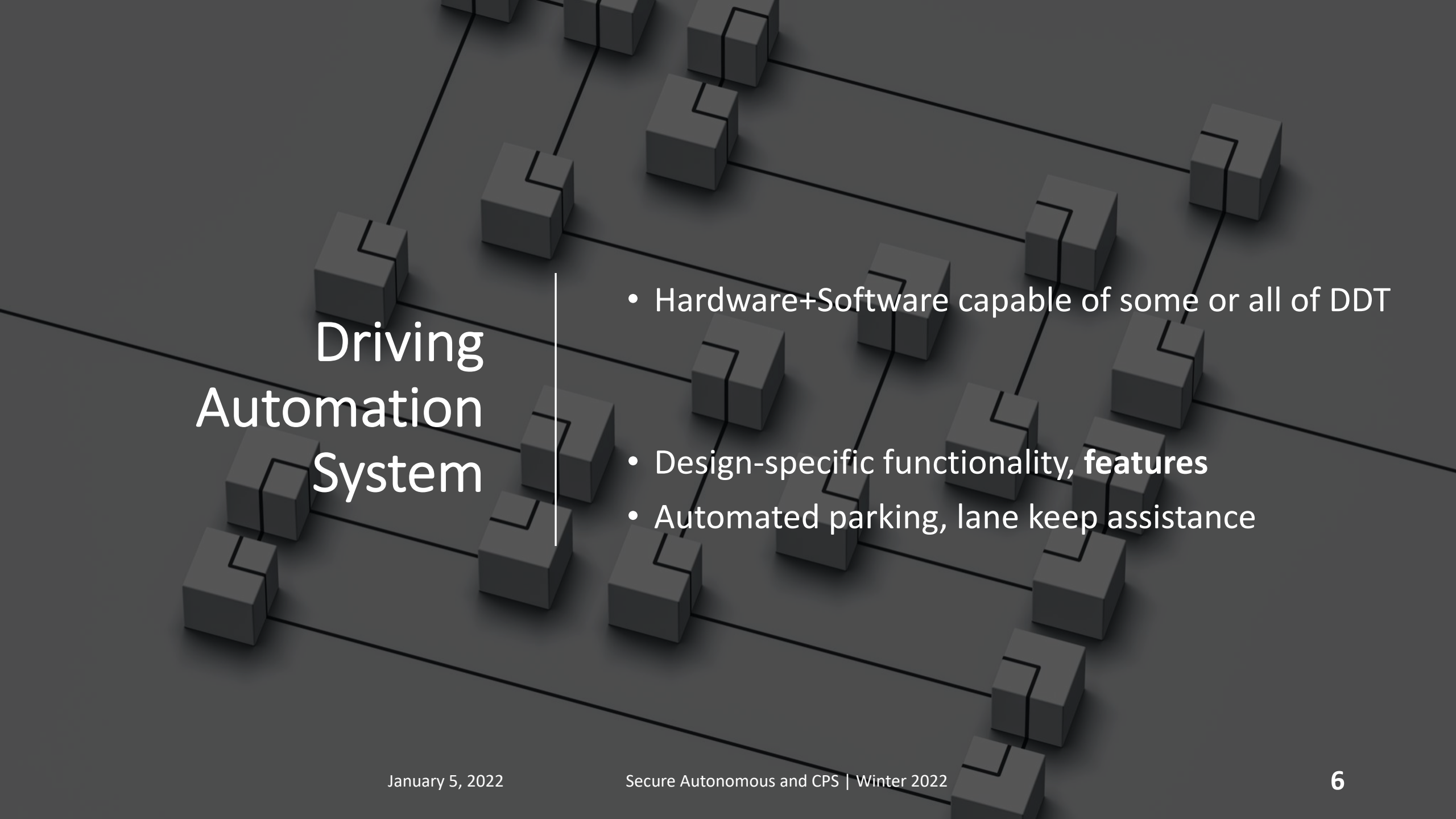
SAE J3016 Standards

- Dynamic Driving Task (DDT)
- Driving Automation System
- Operational Design Domains (ODD)
- DDT fall-back
- DDT fall-back-ready user
- DDT feature

Dynamic Driving Task [DDT]

- Real-time **operational** and **tactical** functions to operate a vehicle

- Driving a car on fixed trajectory
- Actuator control
- Keeping vehicle in lanes
- Maintaining distance from other vehicles



Driving Automation System

- Hardware+Software capable of some or all of DDT

- Design-specific functionality, **features**
- Automated parking, lane keep assistance

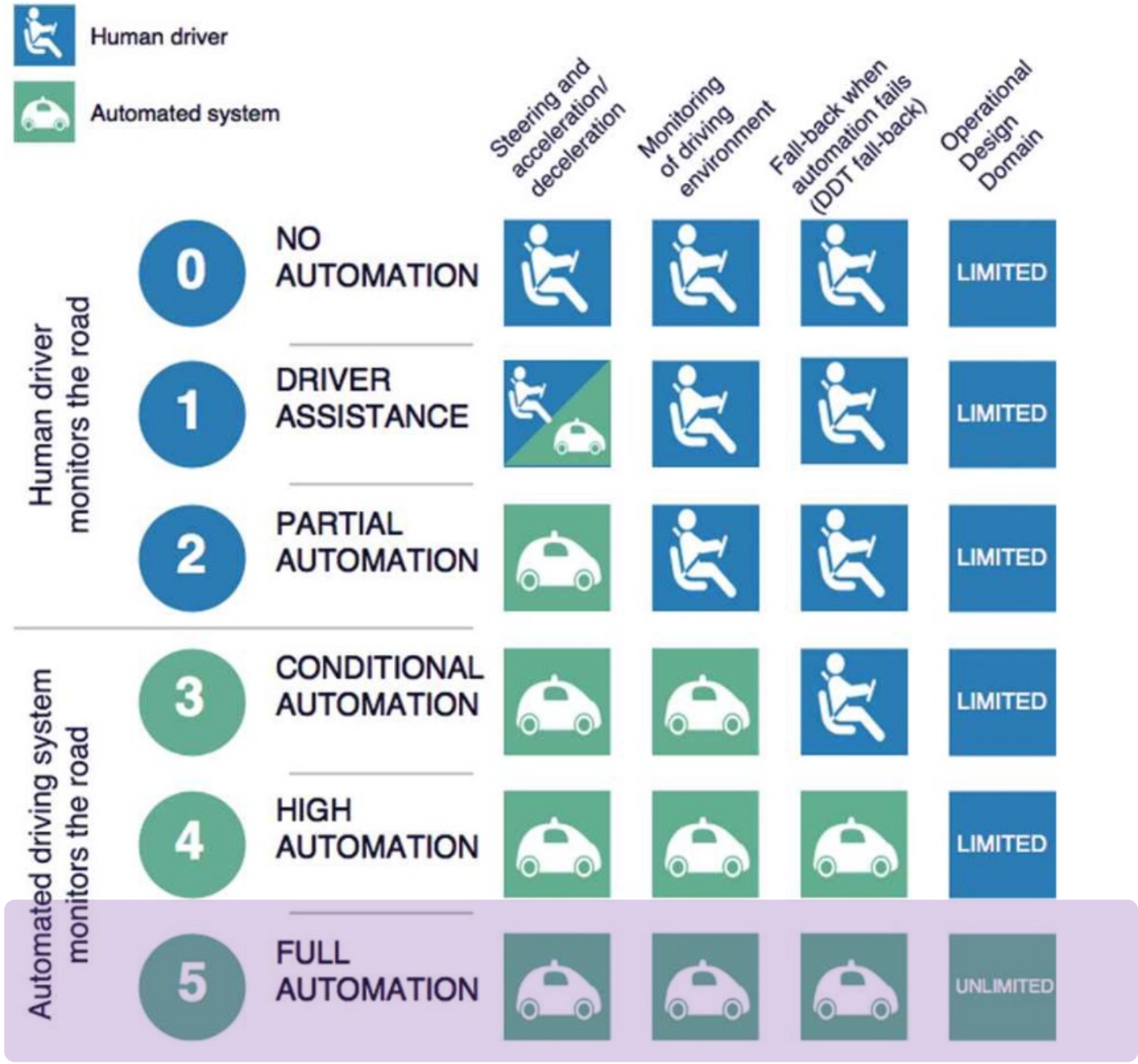
Operational Design Domains [ODD]

- **Specific conditions** under which driving automation system is to function
- **Design phase** requirements
- E.g. Work in sunny weather in city grid

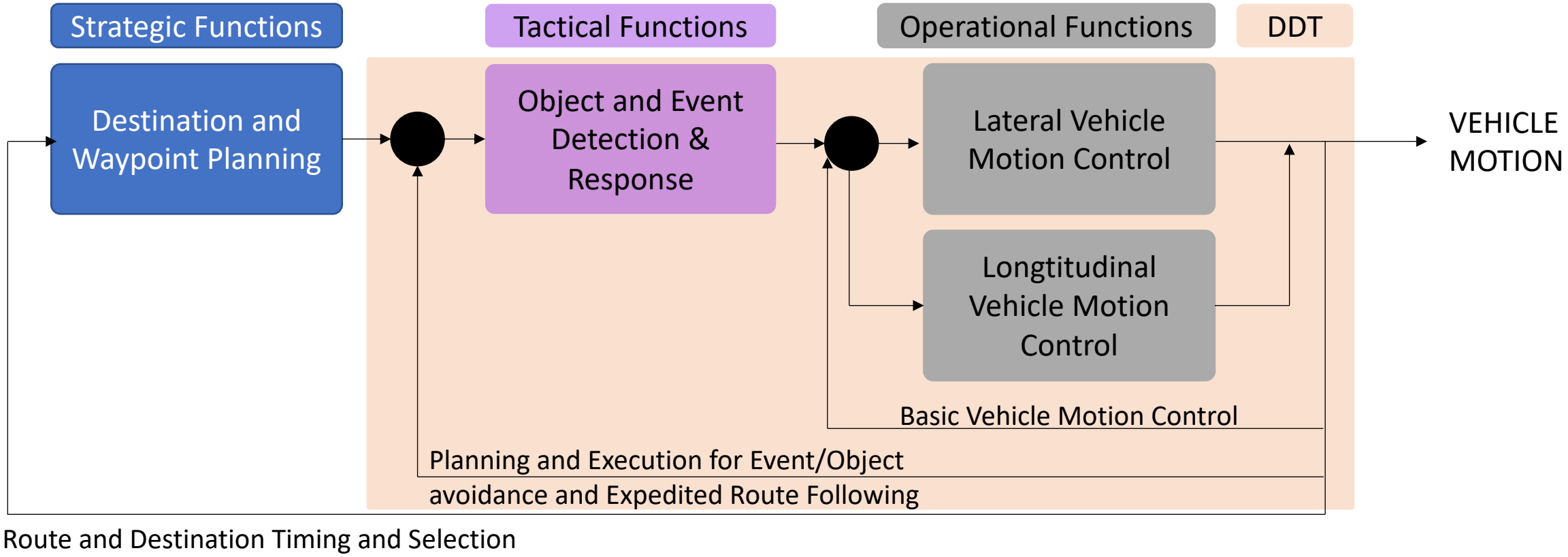
Some more definitions

- DDT fall-back
- DDT fall-back-ready-user
- DDT feature

SAE Classification

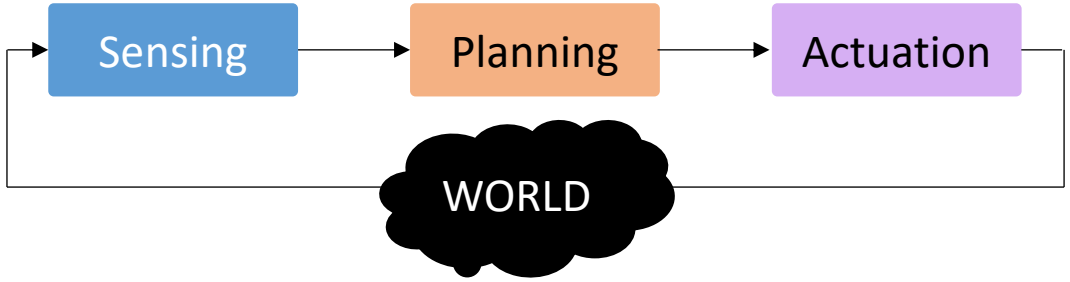


Functional Components

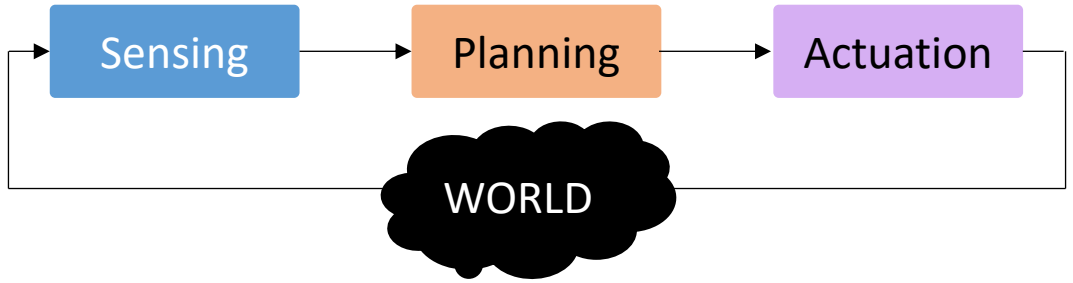


Software Design

- Analogous to real-time systems design

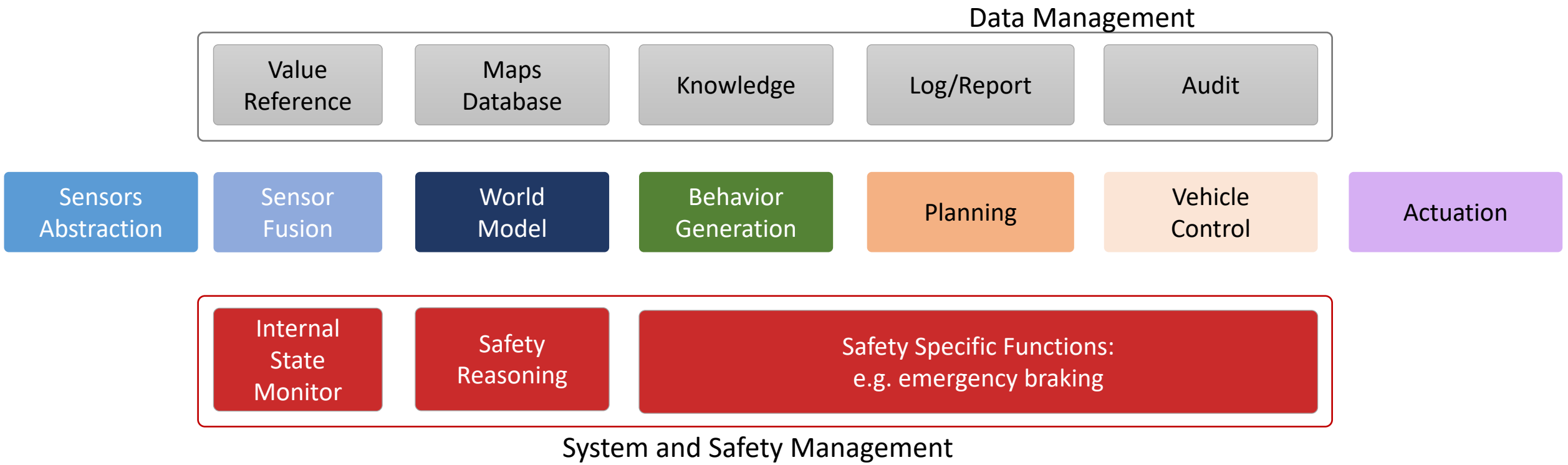


Sensing, Planning, Actuation

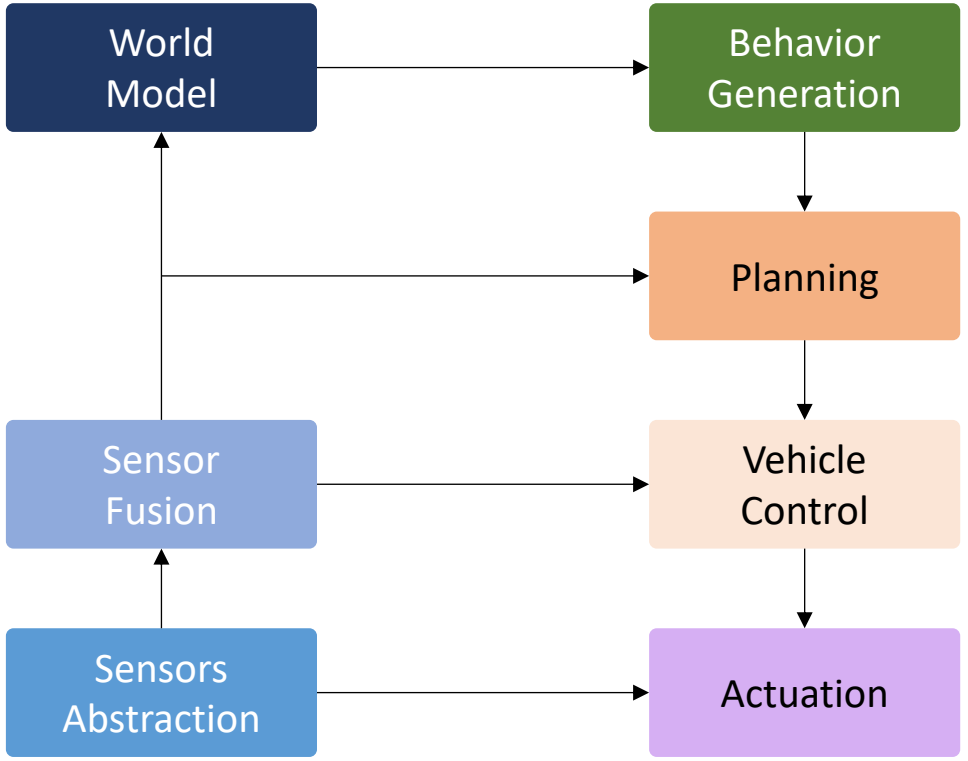


Sensors Abstraction	Sensor Fusion	World Model	Behavior Generation	Planning	Vehicle Control	Actuation
RADAR LIDAR Cameras GPS V2X Internal St	Object Det Global Pos Local Pos Vehicle State	Internal Model External Model Data Sinks Bird's Eye View	HMI Route i/p Global Routing Behavior Gen. Behavior Select	Path Planning Monitoring Lane Keeping Lane Change Collision Avoid HMI Driver Alert	Lateral Longitudinal Trajectory Intention Comm.	Steering Brake Throttle Transmission

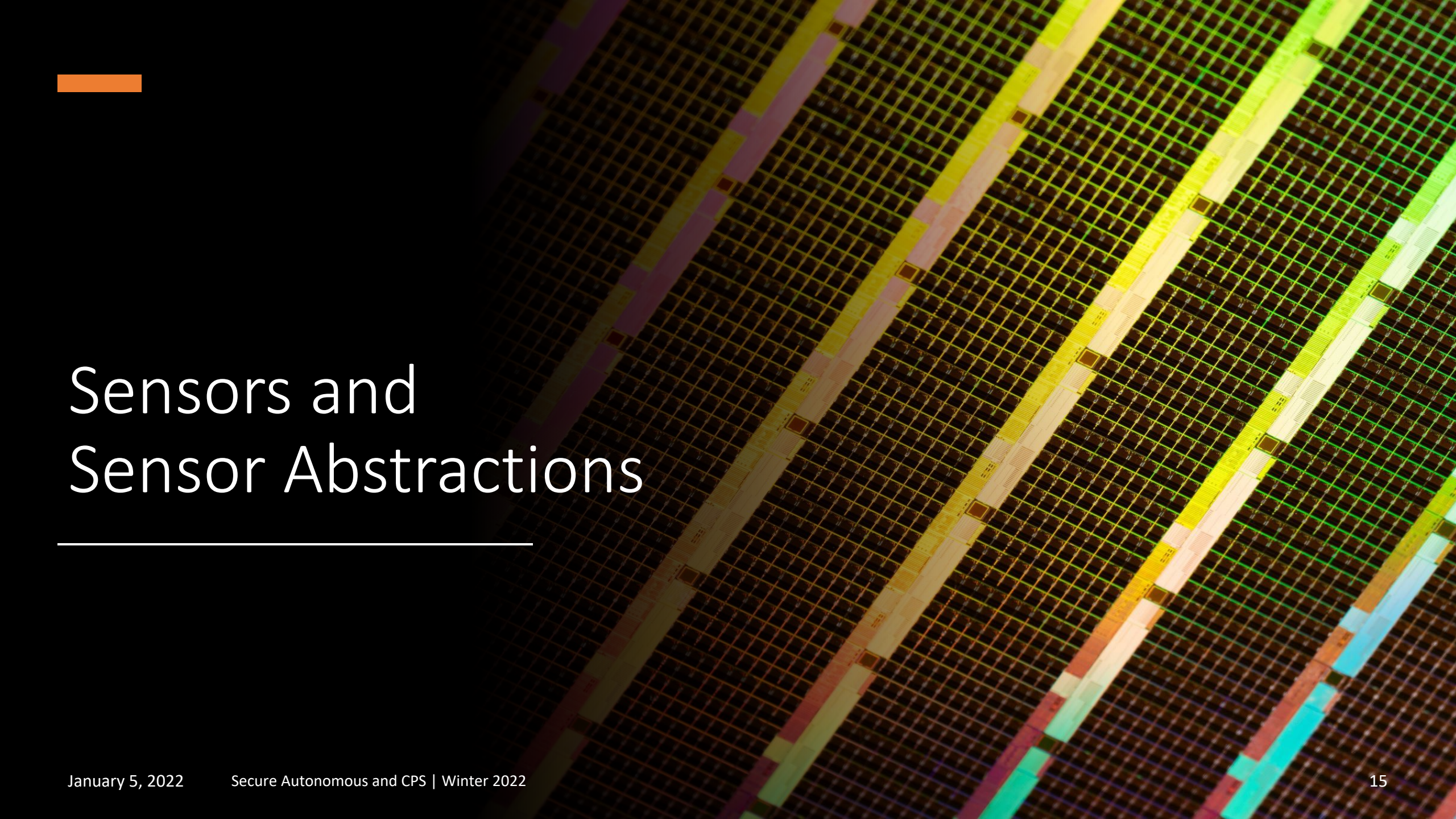
Orthogonal Classes



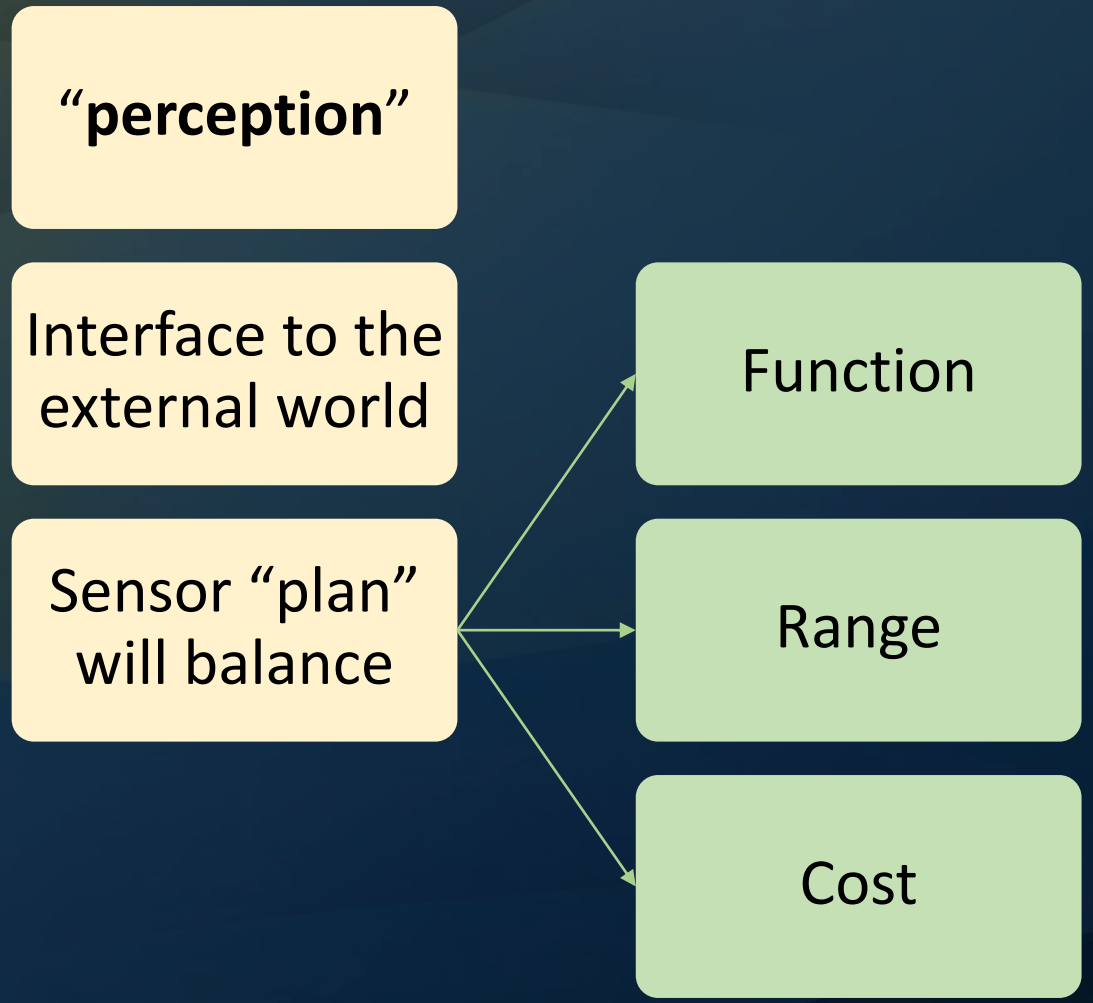
Functional Architecture



Sensors and Sensor Abstractions



Sensors

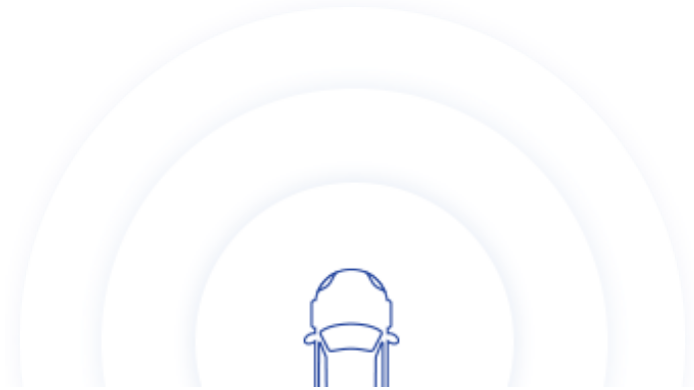

“perception”
Interface to the external world
Sensor “plan” will balance
Function
Range
Cost

Common Sensor Types

- **LiDAR/Millimeter Rada**
- **GPS**
- **Cameras**: lane, road, traffic light, stop line, surroundings
- **Stereo Vision**
- **Sonic**

LiDAR

- **Li**ght **D**etection **A**nd **R**anging
- Laser scanning/3D scanning
- Uses eye-safe laser beams ➔ create 3D representation of environment



A typical lidar sensor emits pulsed light waves into the surrounding environment

These pulses bounce off surrounding objects and return to the sensor

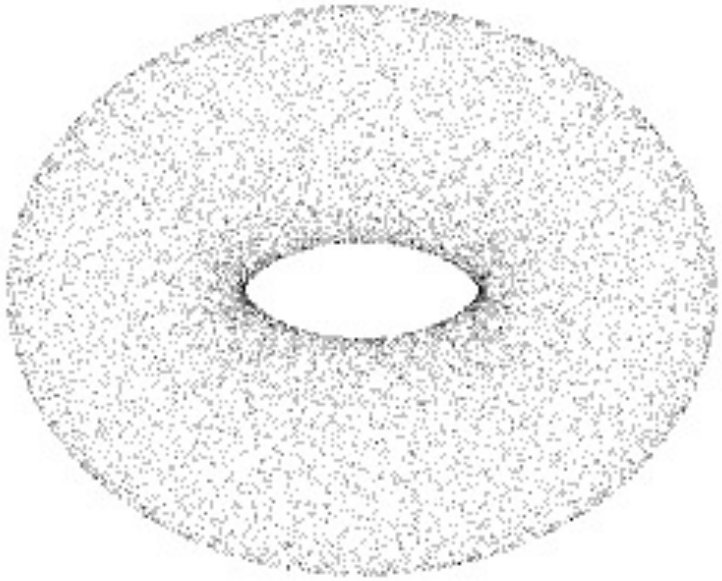
The sensor uses the time it took for each pulse to return to the sensor to calculate the distance it traveled

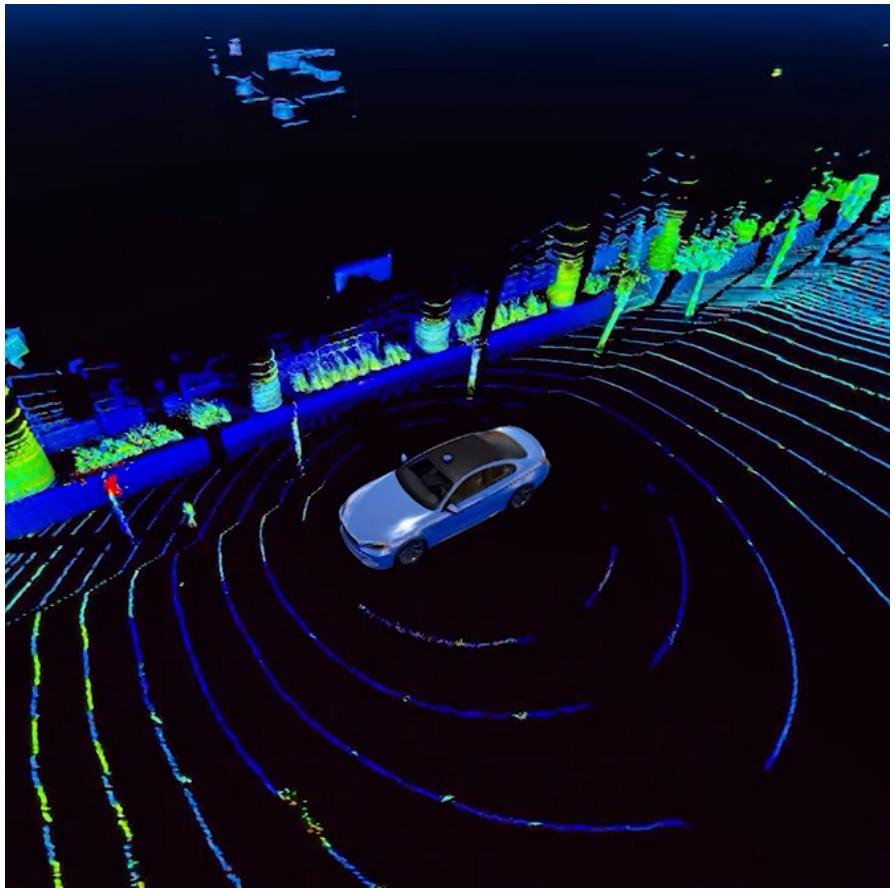
LiDAR Output

Point clouds In 3D

Range: **70-100** m

View: **360 degrees**





References

- SAE J3016 Standard:

https://sibin.github.io/teaching/cs599-osu-secure-autonomous-cps/winter_2022/other_docs/J3016_201609.pdf

- A better explanation of the standard and its components:

https://www.atlantis-press.com/journals/jase/125934832/view

- Velodyne LiDAR Video:

https://sibin.github.io/teaching/cs599-osu-secure-autonomous-cps/winter_2022/other_docs/What-is-Lidar-video.mp4