Introduction to Intelligent Vehicles
[1. System Architecture]

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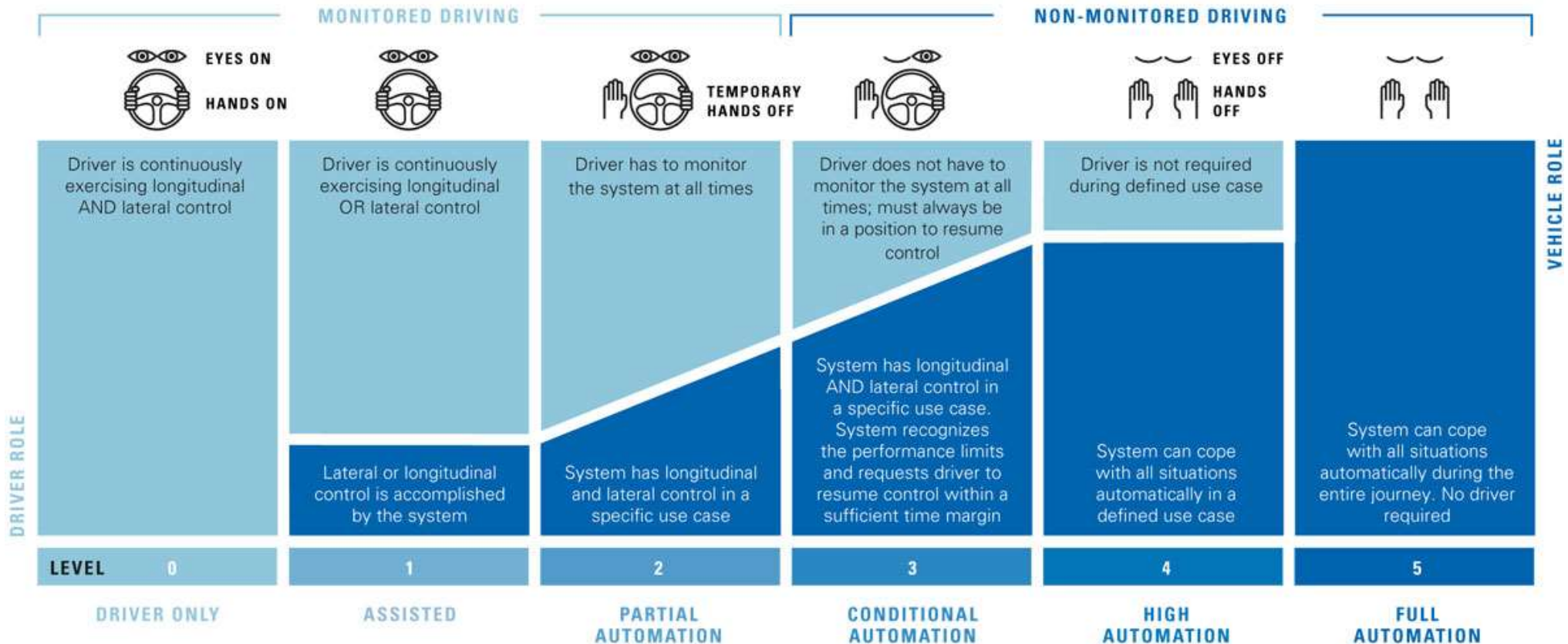
National Taiwan University

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Levels of Autonomy

❑ Levels of driving automation [SAE J3016 / Wikipedia]

➢ Level 1 (Drive Assistance): Adaptive Cruise Control (ACC), Parking Assistance, etc.

➢ Level 2 (Partial Automation)

- The vehicle takes full control of accelerating, braking, and steering
- The driver must monitor the driving

➢ Level 3 (Conditional Automation)

- The driver can safely turn his/her attention away from the driving tasks
- The driver must be prepared to intervene, when called upon by the vehicle

➢ Level 4 (High Automation)

- No driver attention is ever required for safety
- Self driving is supported only in limited spatial areas or under special circumstances

➢ Level 5 (Full Automation)

Levels of Autonomy

https://www.birmingham.ac.uk/news/thebirminghambrief/items/2016/11/driving-the-revolution.aspx
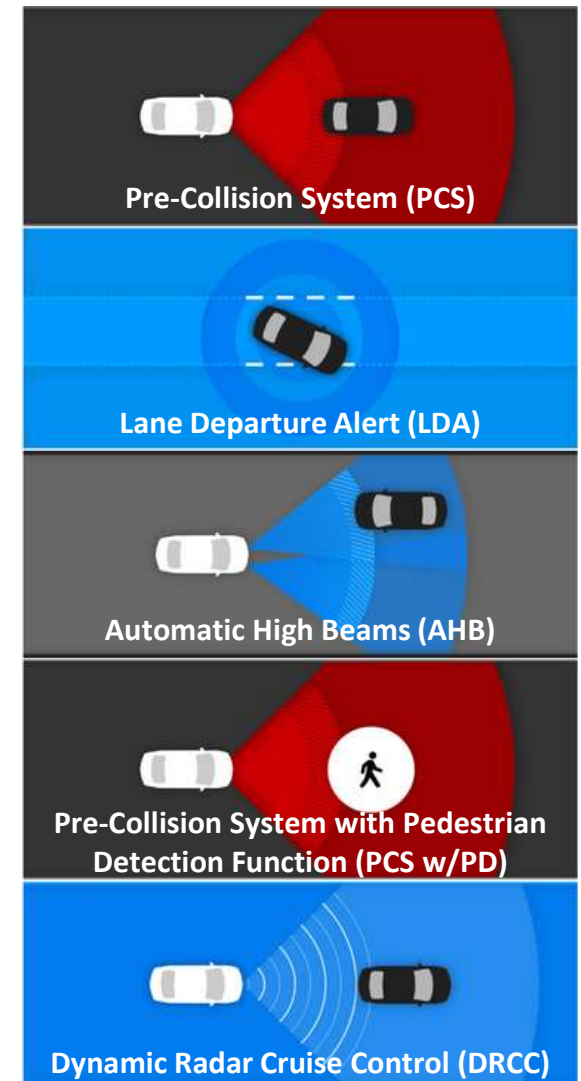
Mike Lemanski

Status of Connectivity

❑ Communication standards

➢ Dedicated Short-Range Communications (DSRC)
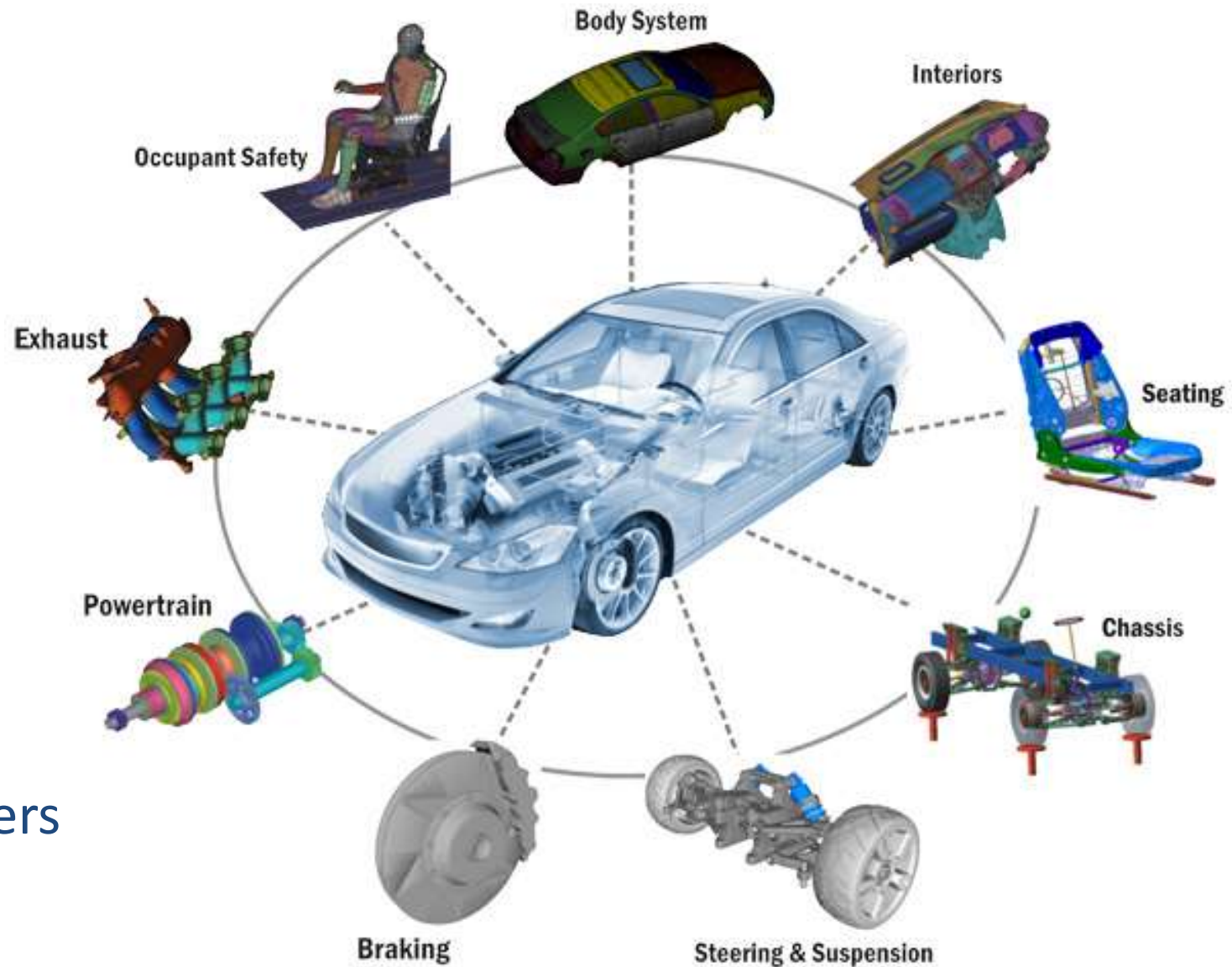
➢ C-V2X (Cellular Vehicle-to-Everything)

Software Design

❑ Various applications including Advanced Driver Assistance Systems (ADAS) and autonomous functions

❑ Various software programs for sensing, signal processing, control, decision making, etc.

➢ Embedded software value to vehicle's total value
  • 2% → 13% from 2000 to 2010

➢ Number of lines of code
  • 1 → 10+ → 100 million from 2000 → 2010 → now

❑ Due to the safety-critical nature, correctness and quality of software are extremely important
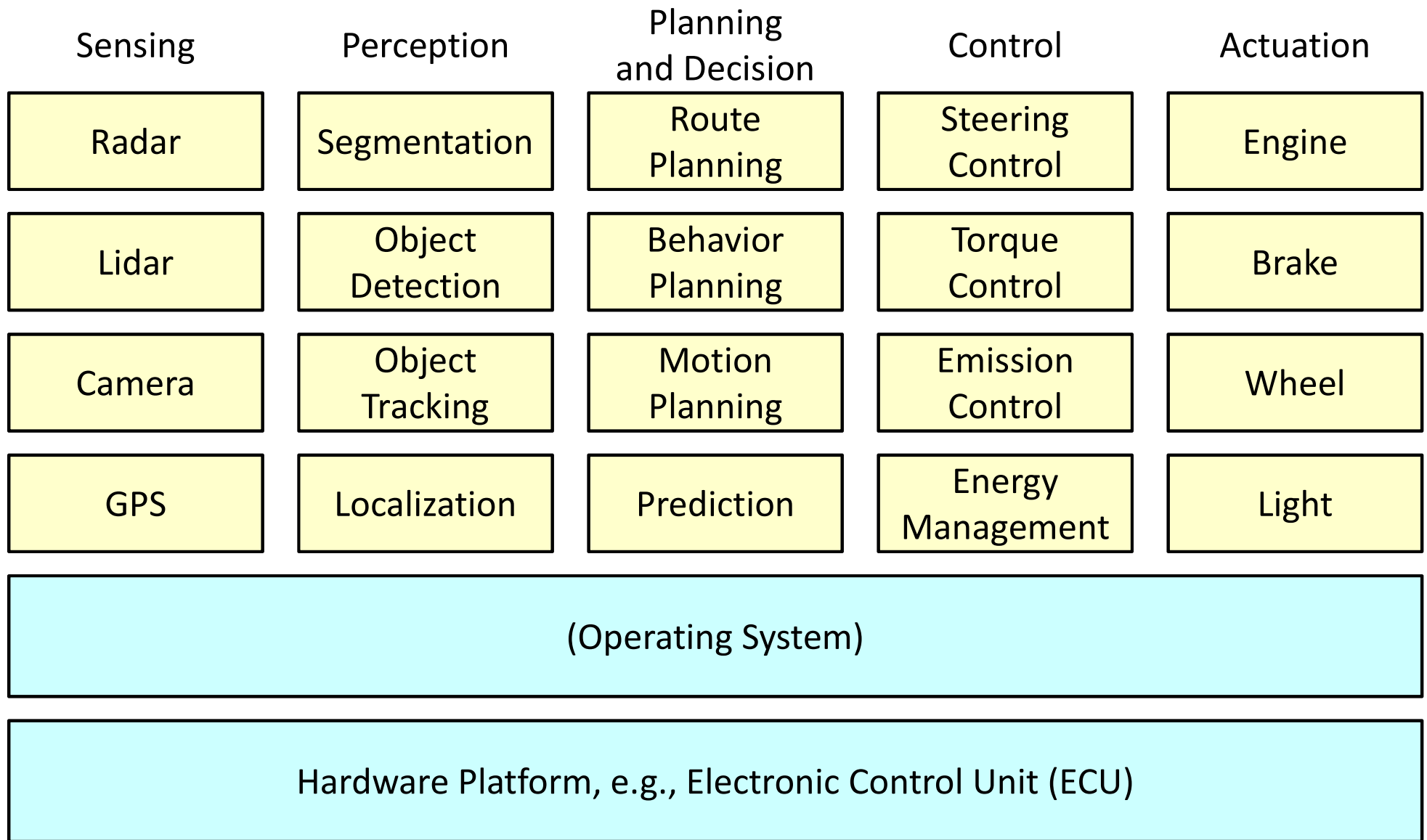
Pre-Collision System (PCS)

Lane Departure Alert (LDA)

Automatic High Beams (AHB)

Pre-Collision System with Pedestrian Detection Function (PCS w/PD)

Dynamic Radar Cruise Control (DRCC)

http://www.toyota.com/safety-sense/

Subsystems

- Body
- Chassis
- Suspension
- **Control**
- Engine
- Transmission
- Braking
- Wiring
- **Electronics**
- And many others

Occupant Safety · Body System · Interiors · Exhaust · Seating · Powertrain · Chassis · Braking · Steering & Suspension

http://www.axiscades.com/automotive.html

Layered View of Autonomous Vehicles

Sensing	Perception	Planning and Decision	Control	Actuation
Radar	Segmentation	Route Planning	Steering Control	Engine
Lidar	Object Detection	Behavior Planning	Torque Control	Brake
Camera	Object Tracking	Motion Planning	Emission Control	Wheel
GPS	Localization	Prediction	Energy Management	Light

(Operating System)

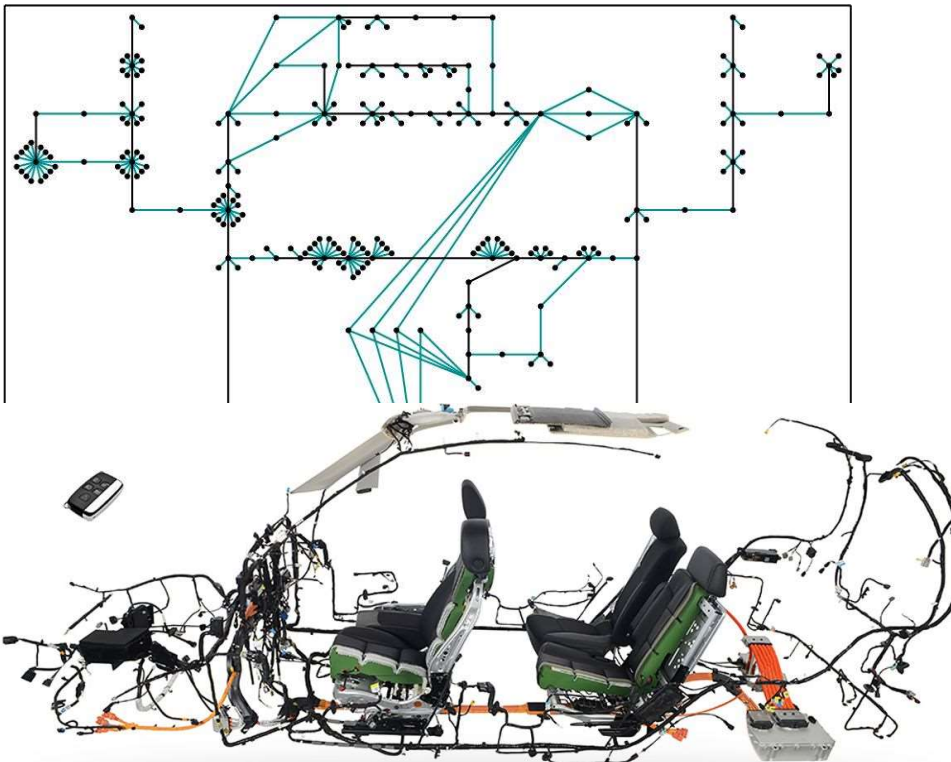Hardware Platform, e.g., Electronic Control Unit (ECU)

Electronic Control Unit (ECU)

❑ **Is an ECU like a Central Processing Unit (CPU)?**

➢ Yes? It does some computation

➢ No? It is not centralized

❑ **How many ECUs are there?**
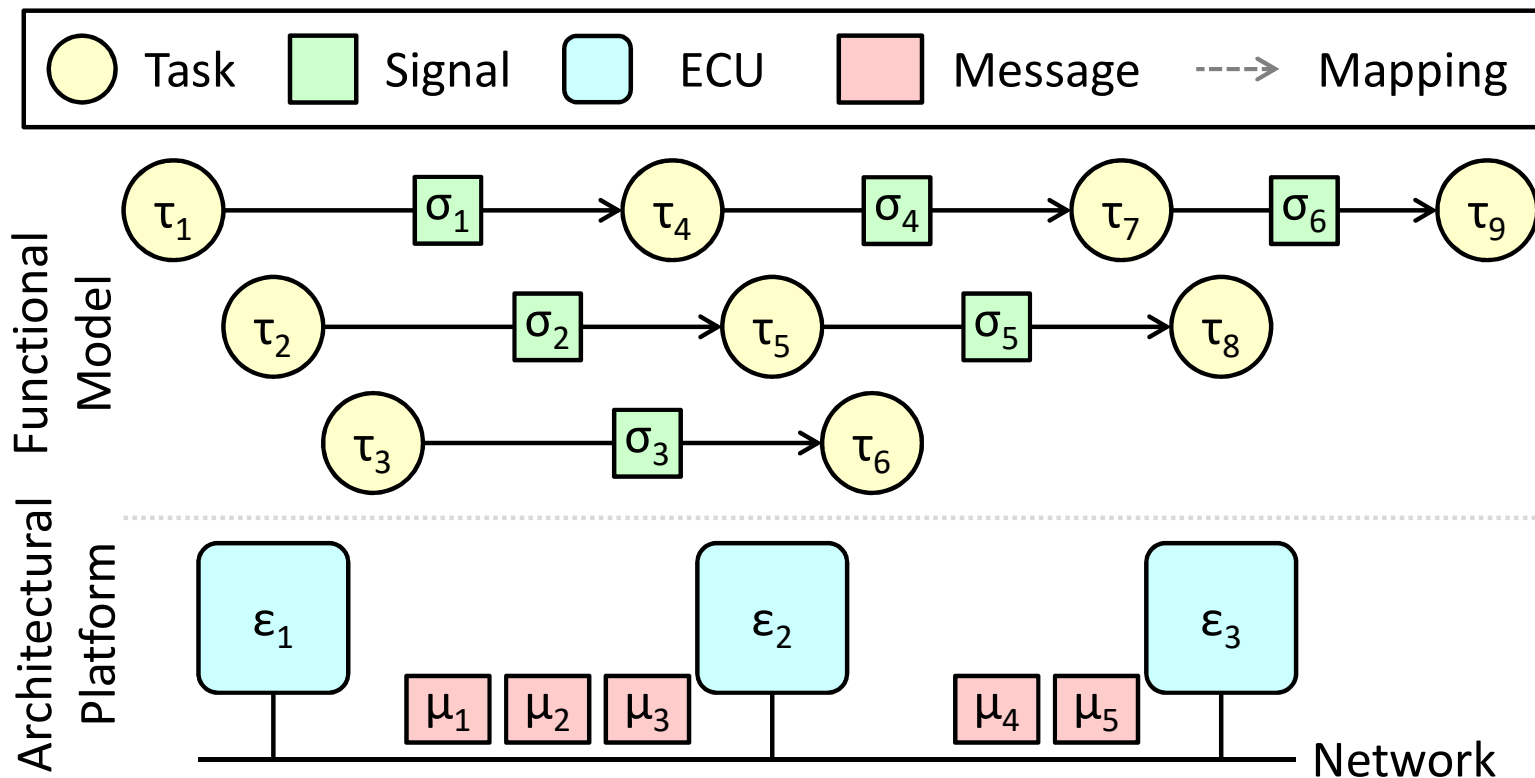
➢ 20 ➔ 50+ in the past decade

http://www.denso.co.id/Electro_ecu.html

https://www.indiamart.com/proddetail/denso-engine-electronic-control-unit-18672409991.html


http://www.lear.com/Site/Products/

Mapping from Software to Hardware

- ❑ Software (functional model): task graph
- ❑ Hardware (architectural platform): distributed Electronic Control Units (ECUs) connected by a network
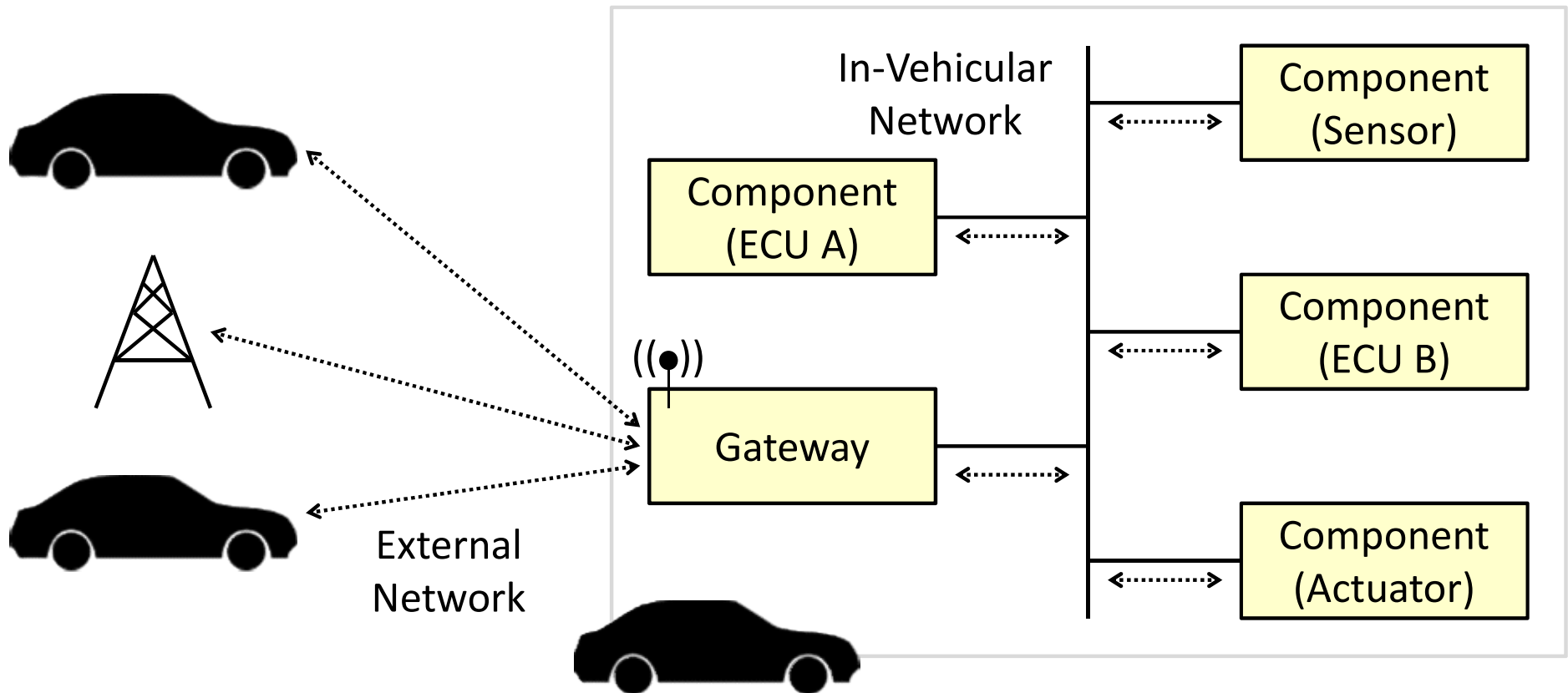
One Example Solution

❑ Decide task allocation and assign priorities to tasks on ECUs and messages on the network

❑ Satisfy timing constraints for tasks, signals, and paths
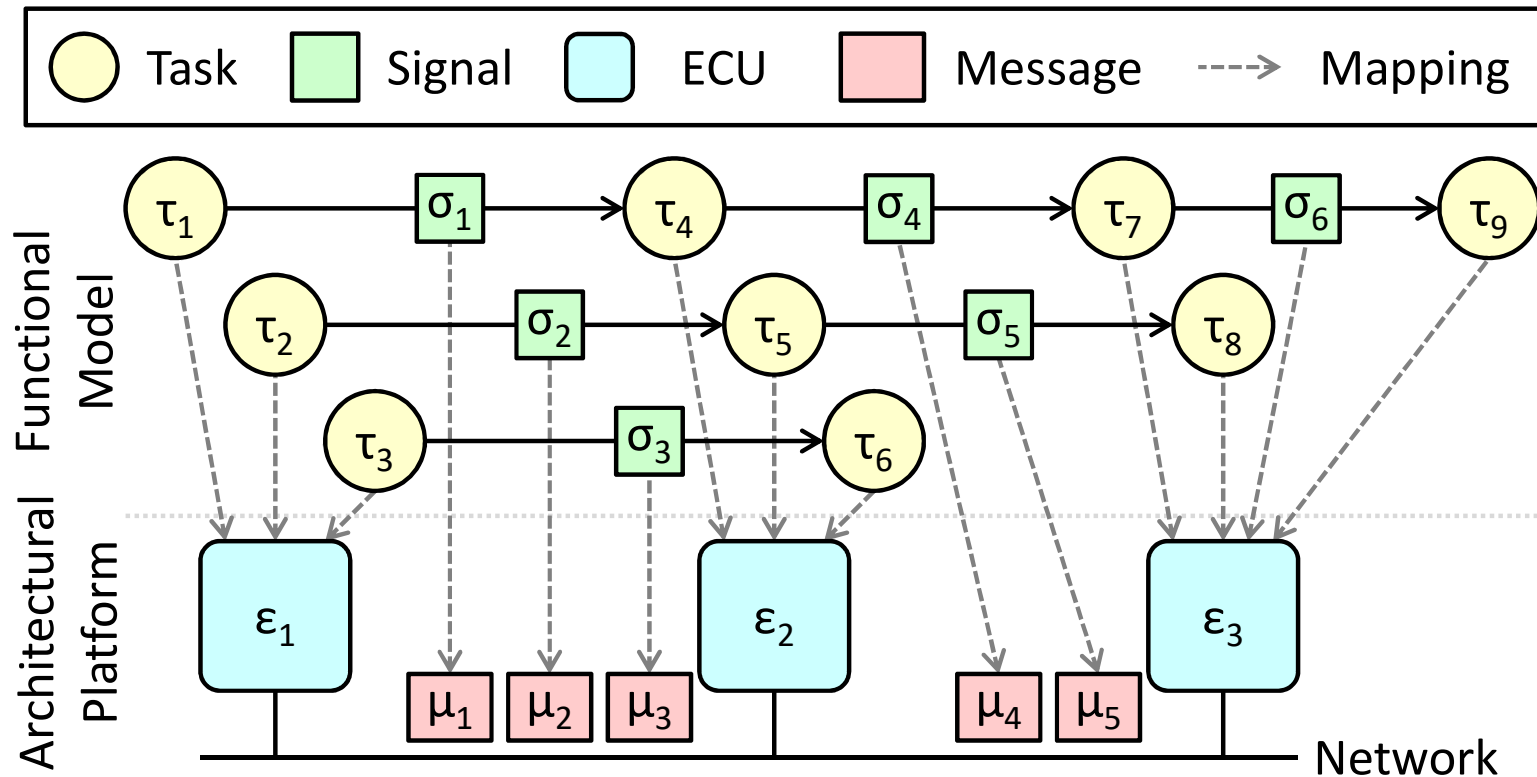
Layered View of Connected Vehicles

❑ From multiple vehicles to components in a single vehicle

Design-Time vs. Runtime

❑ **Runtime software is executed during vehicle operation**

  ➢ It is usually designed during design-time

  ➢ Examples of runtime software / functions

   • Localization algorithm

   • Object detection algorithm

   • Vehicle control algorithm

❑ **Design-time software is executed during the design stage**

  ➢ It is more and more difficult to manually design a vehicle

  ➢ Examples of design-time software / tools

   • Modeling

   • Design including optimization

   • Analysis including simulation, verification, and testing

Q&A