Electronic Control Unit(ECU) - Webinar
Basics of Automotive ECU

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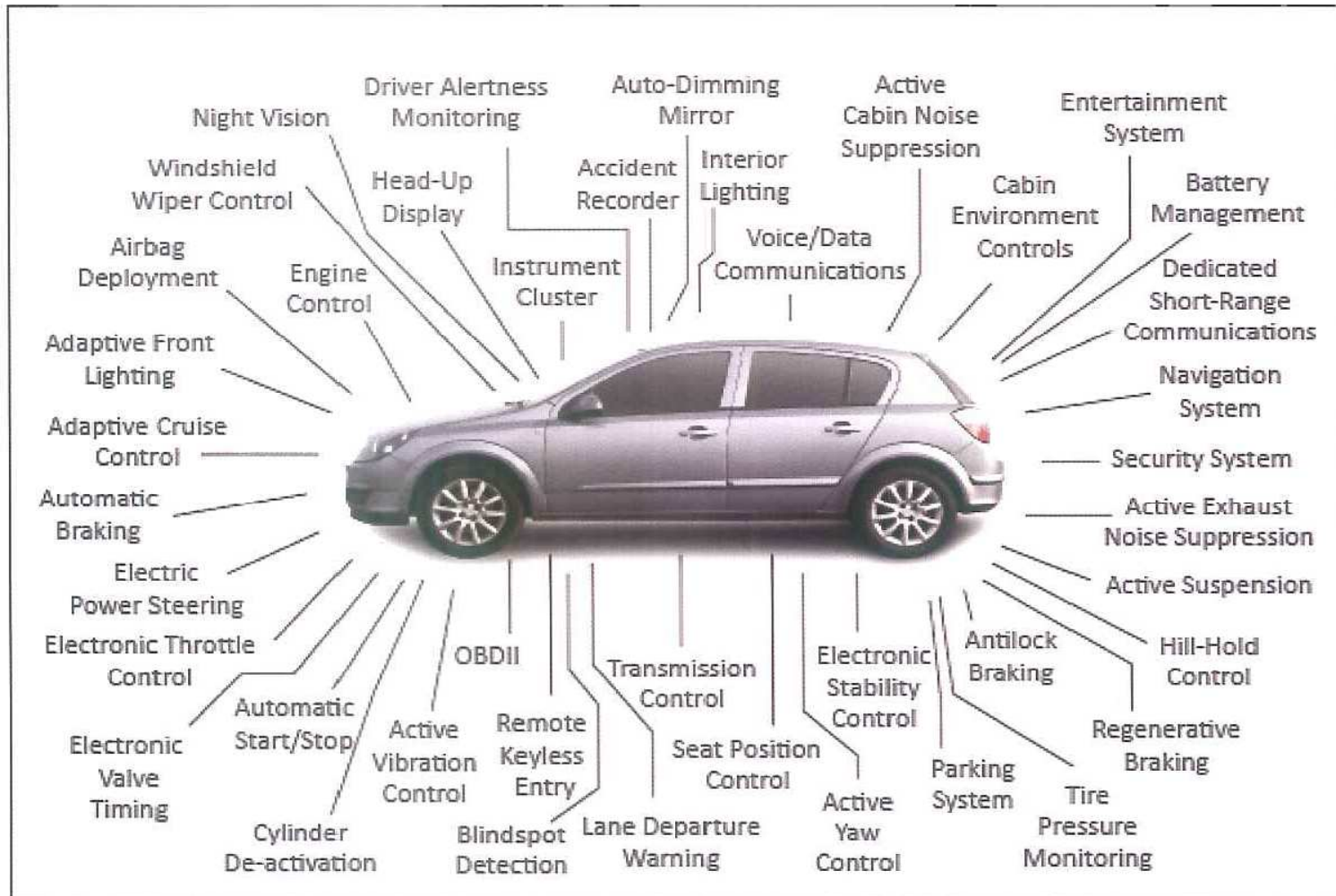
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- Basics of Automotive ECU

    - Importance of electronics and software within vehicles

    - Hardware architecture of a typical ECU.

    - Software Architecture , functions and implementation

    - Sample application of ECU within the vehicle.

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Night Vision
Driver Alertness
Monitoring
Auto-Dimming
Mirror
Active
Cabin Noise
Suppression
Entertainment
System

Windshield
Wiper Control
Head-Up
Display
Accident
Recorder
Interior
Lighting
Cabin
Environment
Controls
Battery
Management

Airbag
Deployment
Engine
Control
Instrument
Cluster
Voice/Data
Communications
Dedicated
Short-Range
Communications

Adaptive Front
Lighting
Navigation
System

Adaptive Cruise
Control
Security System

Automatic
Braking
Active Exhaust
Noise Suppression

Electric
Power Steering
Active Suspension

Electronic Throttle
Control
OBDII
Transmission
Control
Electronic
Stability
Control
Antilock
Braking
Hill-Hold
Control

Automatic
Start/Stop
Active
Vibration
Control
Remote
Keyless
Entry
Seat Position
Control
Parking
System
Regenerative
Braking

Electronic
Valve
Timing
Cylinder
De-activation
Blindspot
Detection
Lane Departure
Warning
Active
Yaw
Control
Tire
Pressure
Monitoring

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Major Systems in Automobiles

- ENGINE
- DRIVETRAIN
- INSTRUMENTATION
- SUSPENSION
- STEERING
- BRAKES
- INFOTAINMENT

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Electronics growing

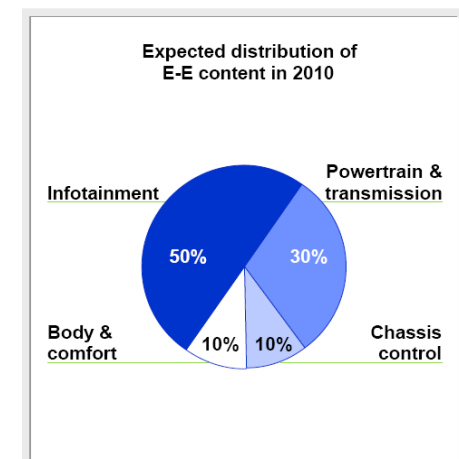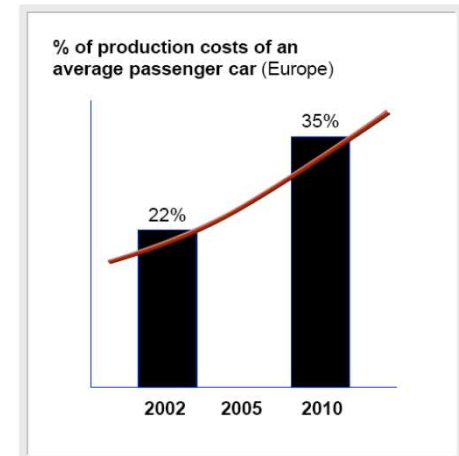Forecast about "Automotive Electronics" in 2010
   35% of the vehicle value will be electronics
   5 to 8 Million lines of software code
   Close to 70 ECUs in Cars

   Almost Every subsystem will have electronic controls
- Powertrain (Engine, Transmission, Hybrid etc.)
- Chassis (Brakes, Steering, Roll Stability, etc.)
- Body (Crash - Passive and in the future Active)
- Body (Lighting, Windows, Locks)
- Climate Control (Multi Zone, Instant Heat/Cool etc.)
- Instrumentation
- Infotainment (connecting both driver and passenger to any available information ,Multi-media, Navigation etc.)

% of production costs of an average passenger car (Europe)

35%

22%

2002   2005   2010

Expected distribution of E-E content in 2010

Infotainment

Powertrain & transmission

50%   30%

Body & comfort   10%   10%   Chassis control

Legislative Requirements for emission and fuel efficiency becoming critical driving factors

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≈ 100,000 SLOC

≈ 6,500,000 SLOC

> 20,000,000 SLOC

– Estimates of 100-200 million source lines of code (SLOC)

– To put this into perspective

– There are ≈ 10,000 lines in a novel

Sources
Pavey & Winsborrow, "Demonstrating Equivalence of Source Code and PROM Contents", Computer Journal Vol 36, No 7, 1993
Charette, "This car runs on code", IEEE Spectrum, Feb 2009

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Need for an ECU

- Emission Legislation

- Higher Power and Torque

- Fuel Efficient

- Smoother drivability

- Cost effective

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Engine management ECU

Function

Engine Control Units provide real-time regulation of both Fuel Injection and Ignition Timing thus simultaneously guaranteeing maximum engine performance and minimum fuel consumption.

Customer Benefits

Improved exhaust-gas after-treatment systems
Greater fuel savings
Better engine protection

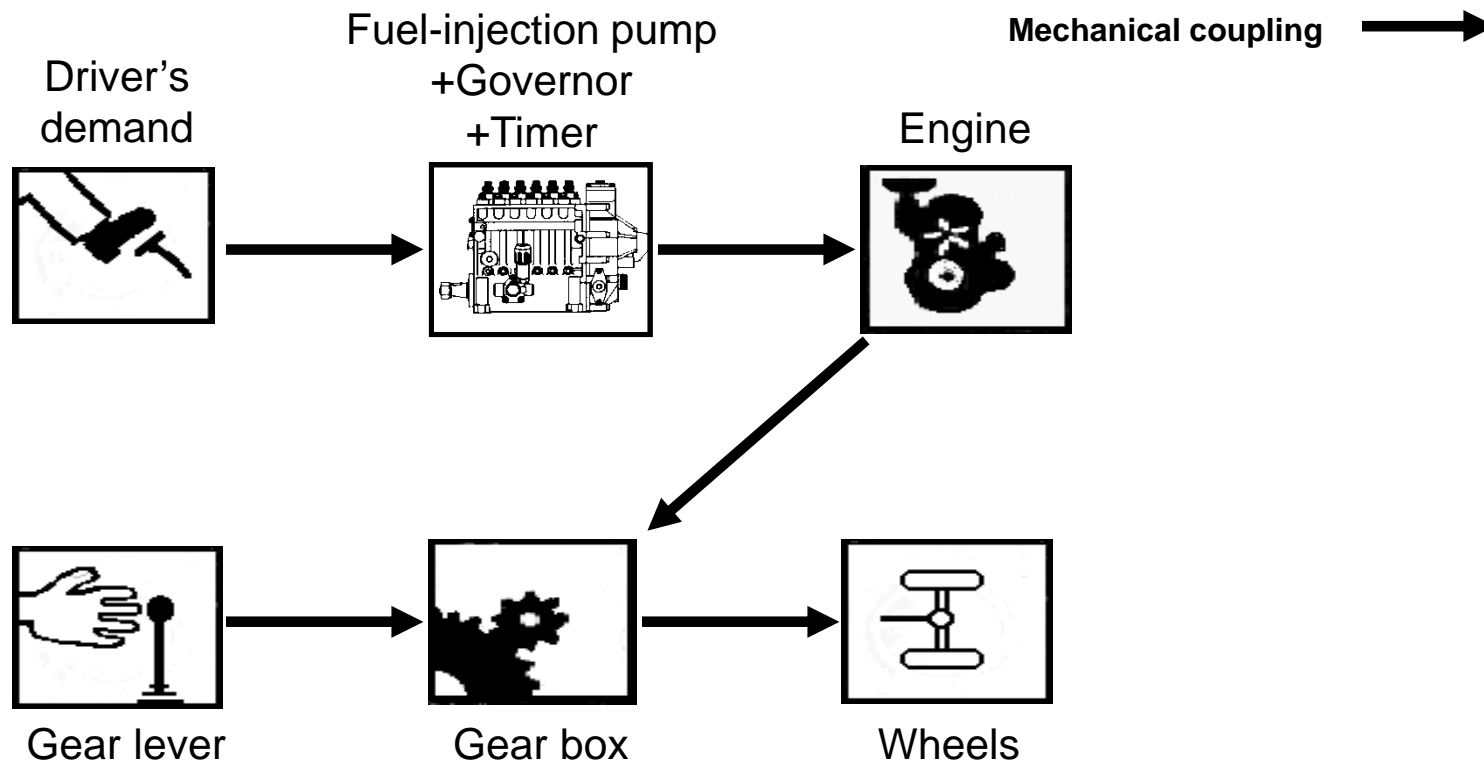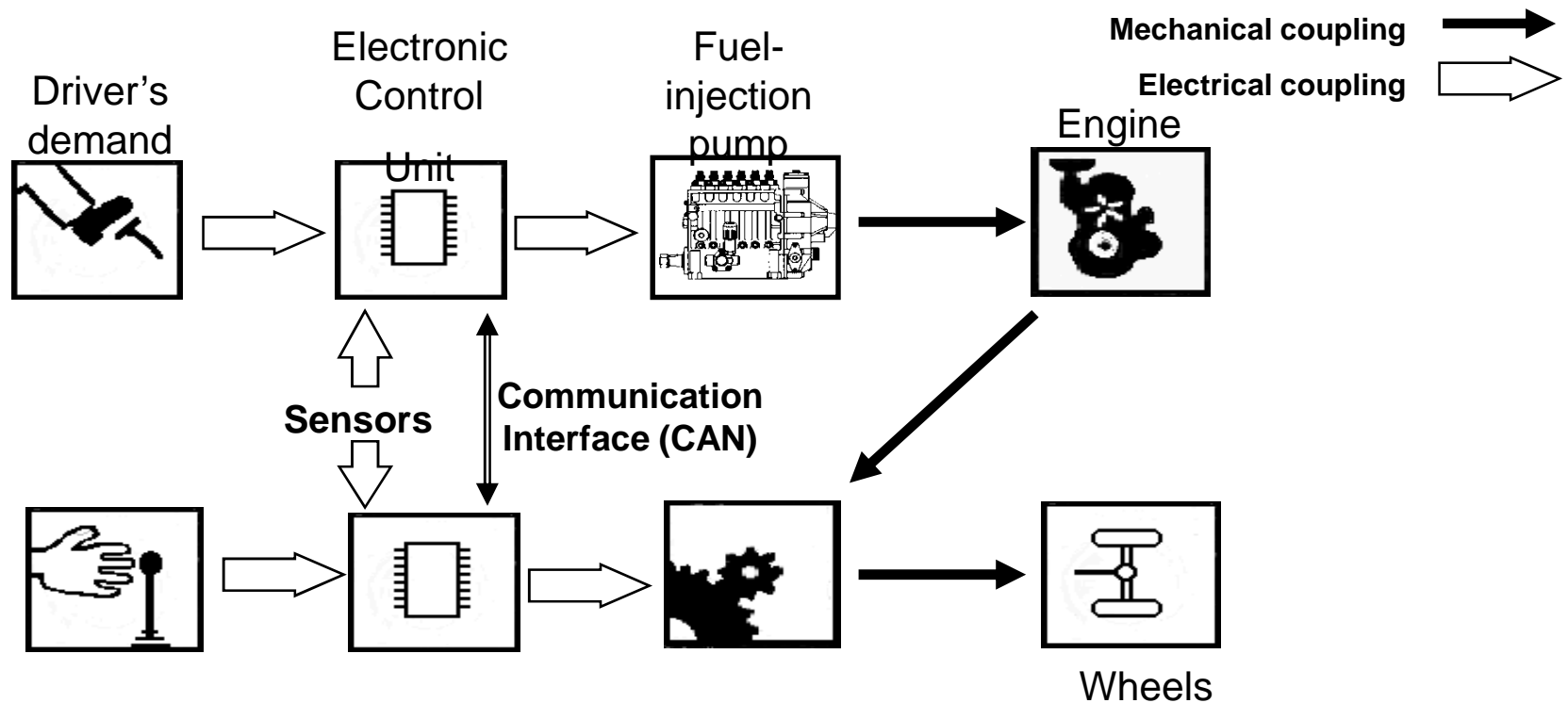DRIVING **EMBEDDED EXCELLENCE**

ETAS
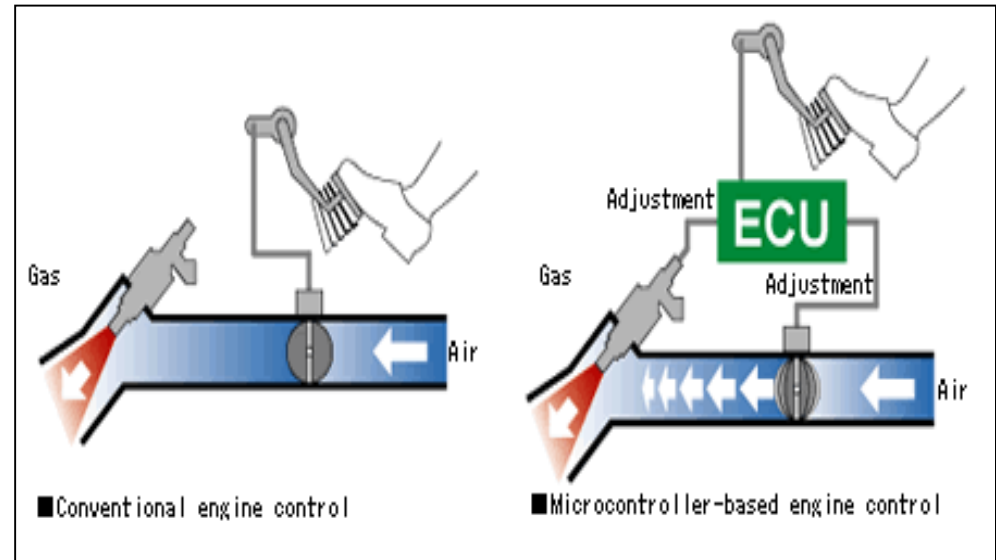
Advantages of an ECU

- Reduced exhaust emission

- Increased fuel efficiency

- Improved drive-ability

- Smoother and/or quieter engine operation

- Safety functions

- Comfort functions

- Interactions with other systems

- Diagnostics

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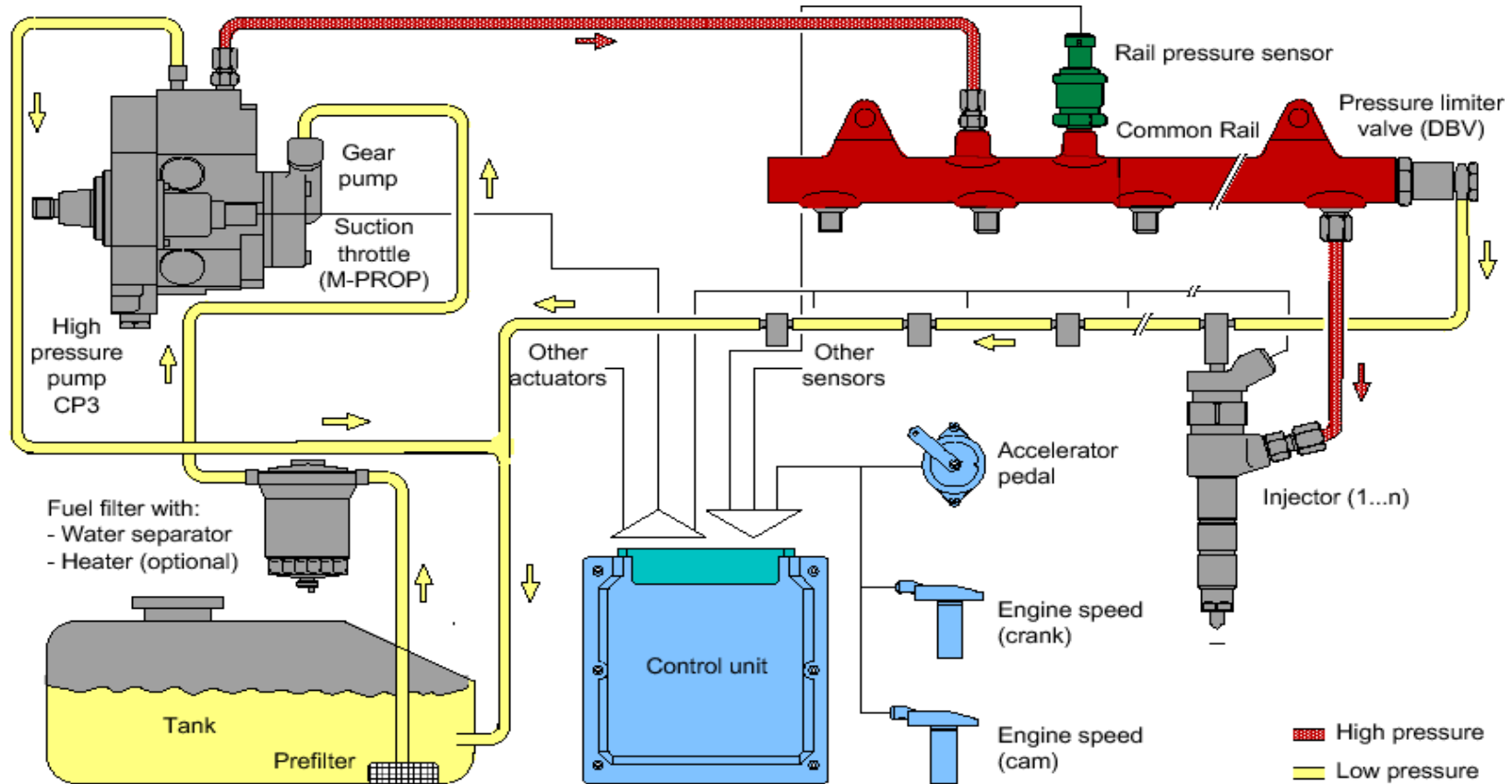
Automobile without ECU

Driver's demand → Fuel-injection pump +Governor +Timer → Engine

Mechanical coupling →

Gear lever → Gear box → Wheels

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Automobile with ECU

Driver's demand	Electronic Control Unit	Fuel-injection pump	Engine

Mechanical coupling →

Electrical coupling ⇨

Sensors

Communication Interface (CAN)

Wheels

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ECU Hardware
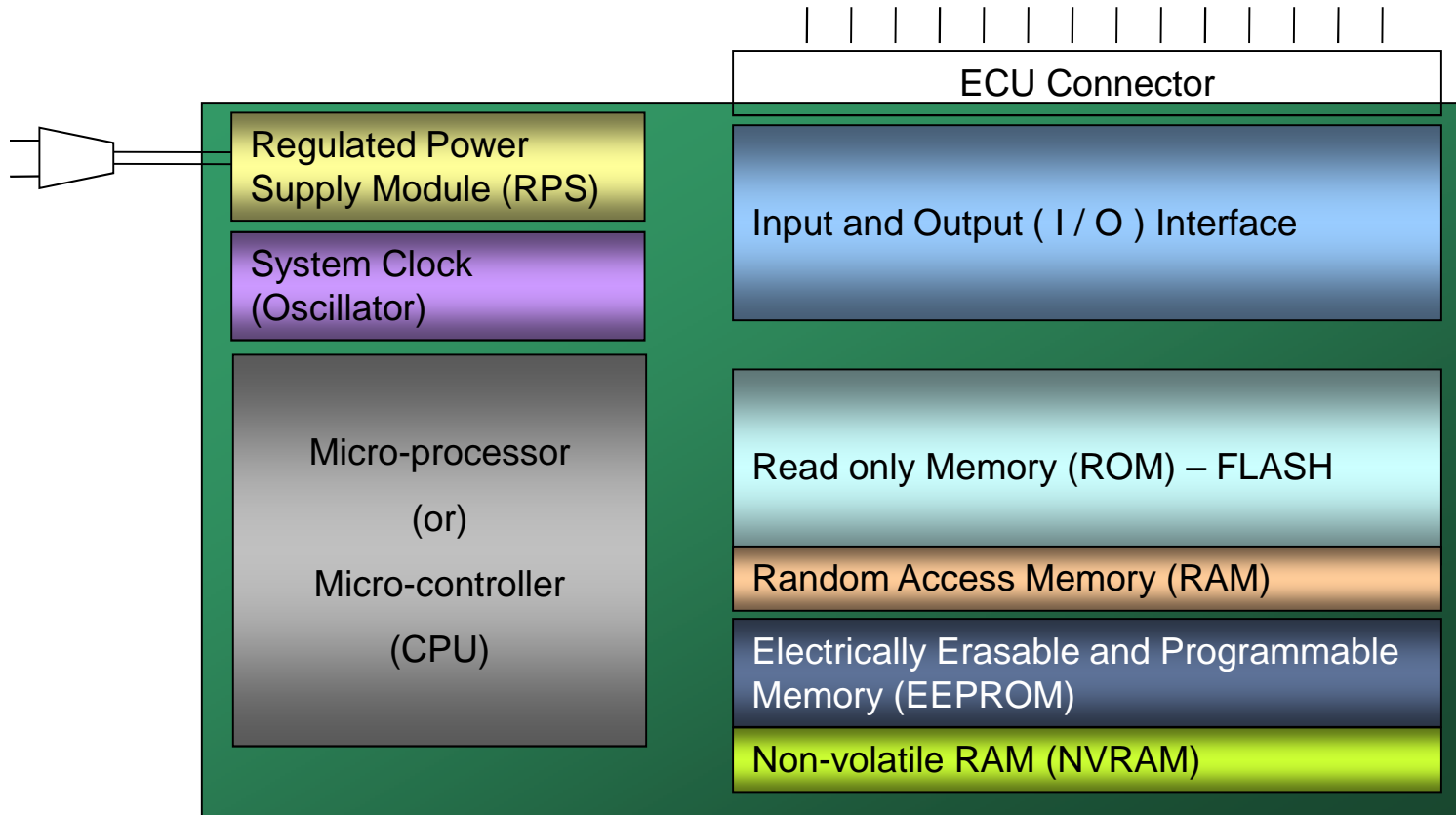
ECU system blocks

– Microprocessor/ Microcontroller

  Executes the instructions as coded and generates output signals by processing the information using specified control algorithms.

– Input Output interface

  • Sensors - Registers the operating conditions and the desired values.

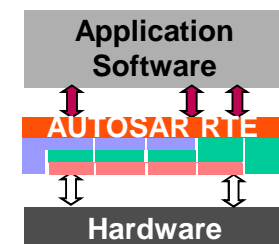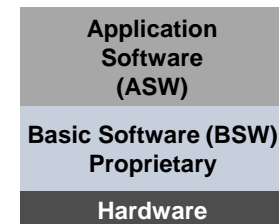 • Actuators - Convert the electrical output from ECU to mechanical parameters.

– Memory Unit

  • Boot Memory (ROM/Flash)

  • Program memory (Flash)

  • Calibration memory (Flash)

  • Data memory (Flash, EEPROM, SRAM/Battery backed RAM)
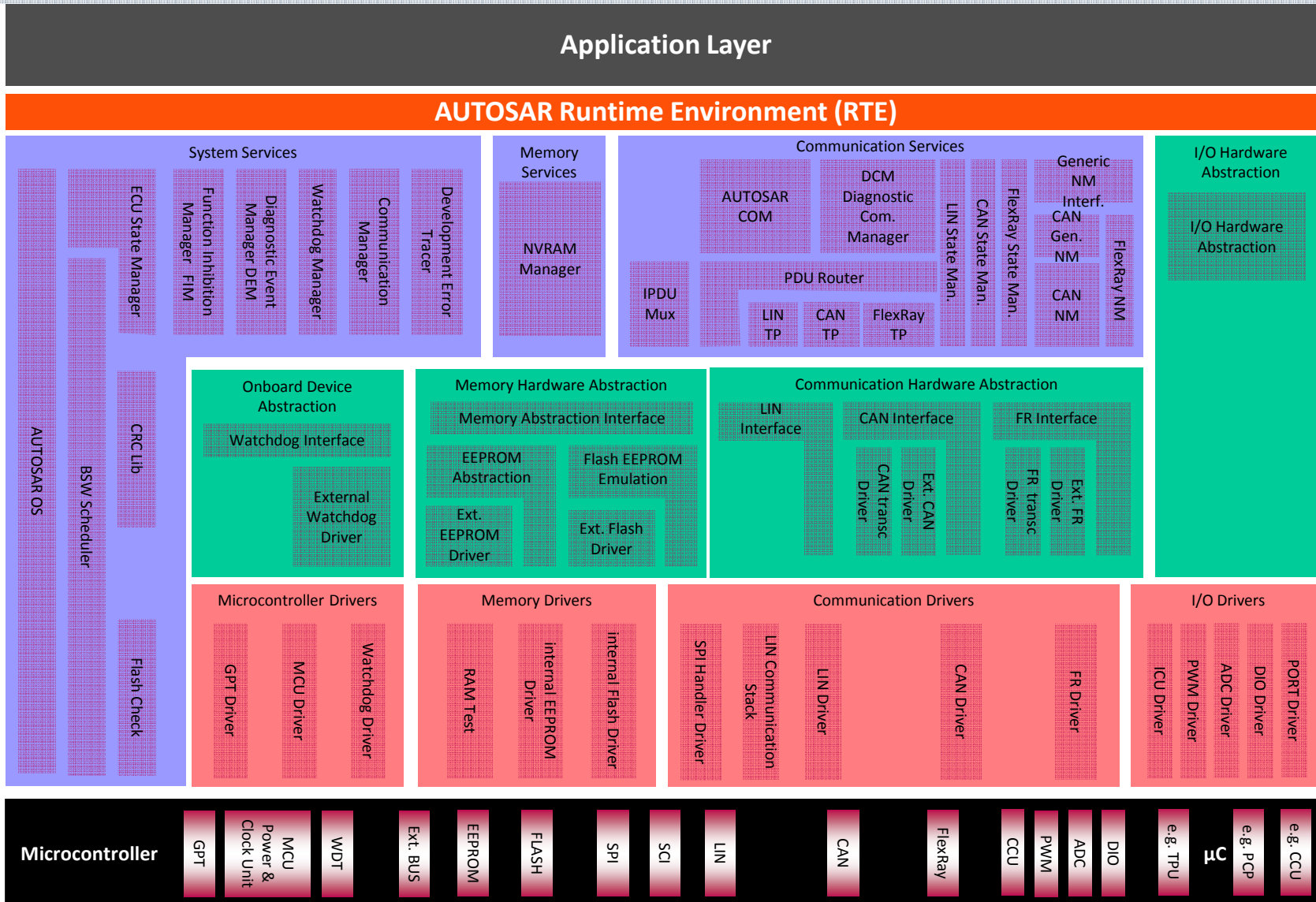
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Standardize the software architecture of ECUs, contributing to improved performance, safety and environmental friendliness.

- Increasing amount of networked functionality and software
    - CO_2 reduction (Hybrids, E-Motors),
    - Safety enhancements (active, passive), …

- Because there was no common standard …
    - Every company invented its own solutions
    - Integration of 3rd-party software creating prohibitive efforts
        - Who is responsible (for what), how to test (Methodology),
        - Implementation efficiency (e.g. Wrapper software, Interface components)
        - Several tool chains required (own, plus those of 3rd parties)

- Situation without AUTOSAR
    - OEM 'Standard Cores' to ensure correct network behavior
    - But Tier-1 had to integrate different SW for each OEM …
    - … integration problems difficult to identify and costly to debug

Software

Hardware

Application Software (ASW)

Basic Software (BSW) Proprietary

Hardware

Application Software

AUTOSAR RTE

Hardware

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Application Layer

AUTOSAR Runtime Environment (RTE)

System Services

ECU State Manager

Function Inhibition Manager FIM

Diagnostic Event Manager DEM

Watchdog Manager

Communication Manager

Development Error Tracer

AUTOSAR OS

BSW Scheduler

CRC Lib

Flash Check

Memory Services

NVRAM Manager

Communication Services

AUTOSAR COM

DCM Diagnostic Com. Manager

LIN State Man.

CAN State Man.

FlexRay State Man.

Generic NM Interf.

CAN Gen. NM

IPDU Mux

PDU Router

LIN TP

CAN TP

FlexRay TP

CAN NM

FlexRay NM

I/O Hardware Abstraction

I/O Hardware Abstraction

Onboard Device Abstraction

Watchdog Interface

External Watchdog Driver

Memory Hardware Abstraction

Memory Abstraction Interface

EEPROM Abstraction

Flash EEPROM Emulation

Ext. EEPROM Driver

Ext. Flash Driver

Communication Hardware Abstraction

LIN Interface

CAN Interface

FR Interface

CAN transc Driver

Ext. CAN Driver

FR transc Driver

Ext. FR Driver

Microcontroller Drivers

GPT Driver

MCU Driver

Watchdog Driver

Memory Drivers

RAM Test

internal EEPROM Driver

internal Flash Driver

Communication Drivers

SPI Handler Driver

LIN Communication Stack

LIN Driver

CAN Driver

FR Driver

I/O Drivers

ICU Driver

PWM Driver

ADC Driver

DIO Driver

PORT Driver

Microcontroller

GPT

MCU Power & Clock Unit

WDT

Ext. BUS

EEPROM

FLASH

SPI

SCI

LIN

CAN

FlexRay

CCU

PWM

ADC

DIO

e.g. TPU

µC

e.g. PCP

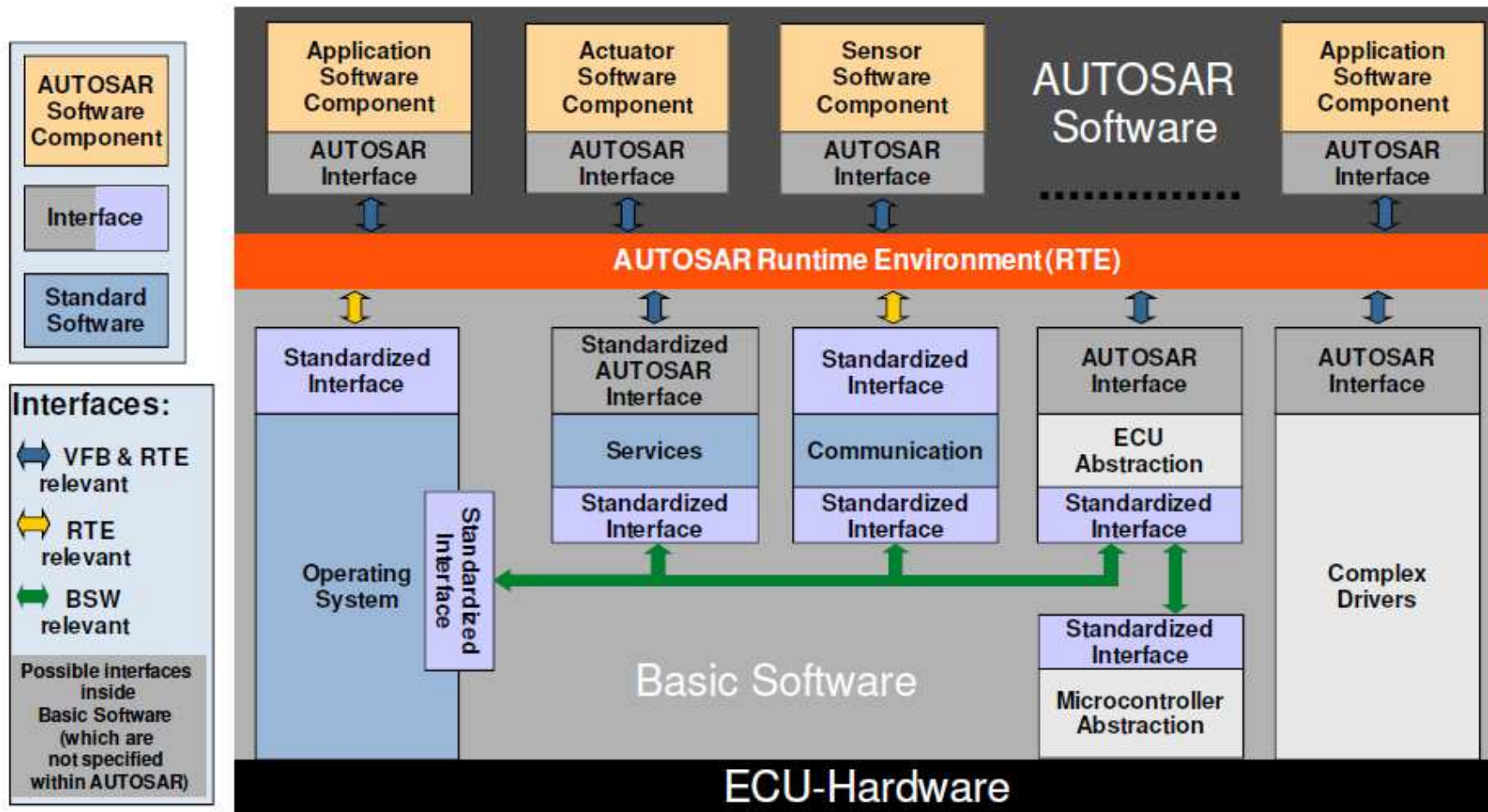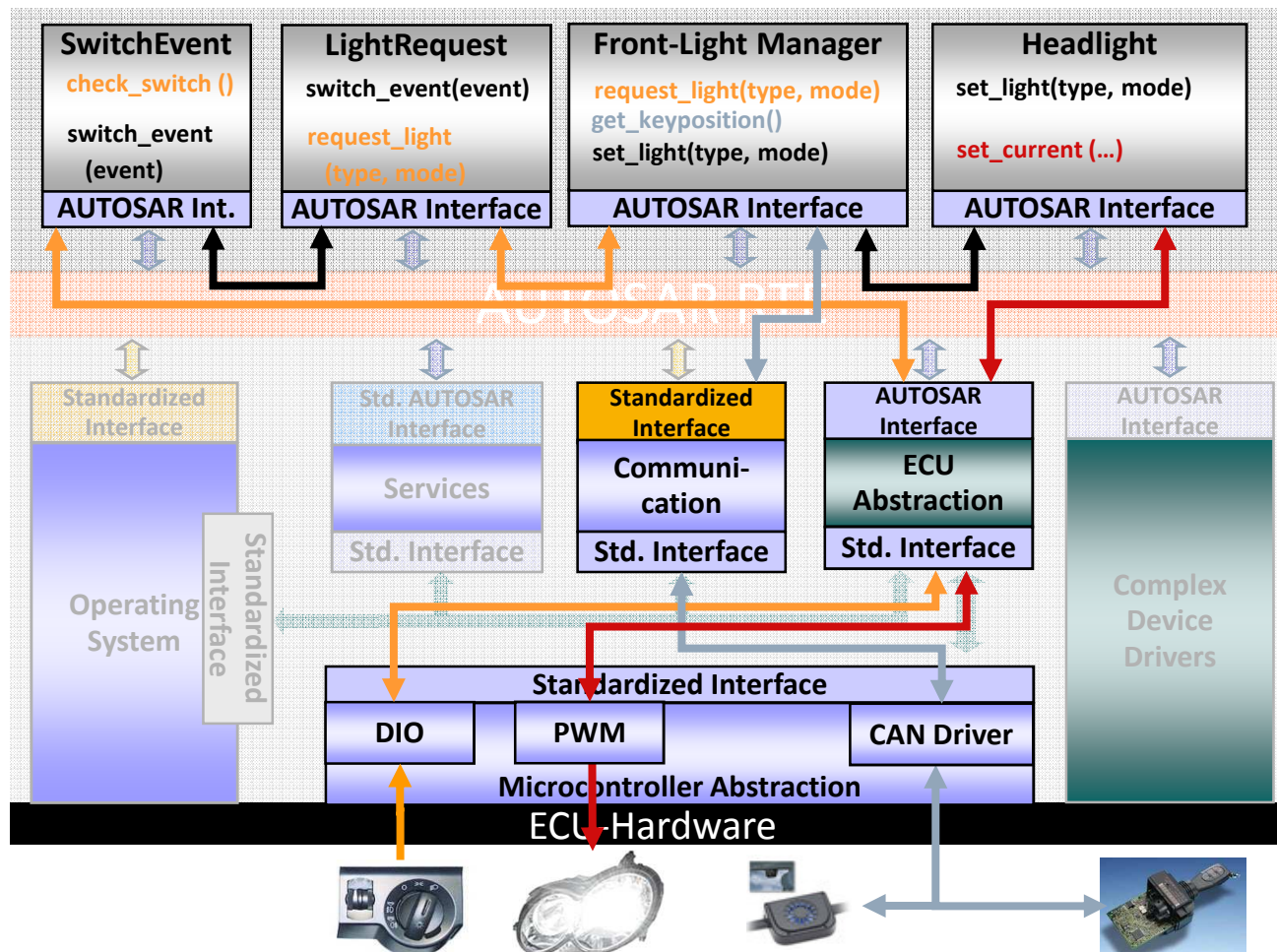e.g. CCU

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Figure 2: AUTOSAR Software Architecture – Components and Interfaces

Objectives: Basic SW: Decoupling of Hardware and Application Software
Application SW: Relocation / Reuse of SW-Components between ECUs

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Use case 'Front-Light Management'

SwitchEvent	LightRequest	Front-Light Manager	Headlight
check_switch ()	switch_event(event)	request_light(type, mode)	set_light(type, mode)
switch_event (event)	request_light (type, mode)	get_keyposition() set_light(type, mode)	set_current (…)
AUTOSAR Int.	AUTOSAR Interface	AUTOSAR Interface	AUTOSAR Interface

AUTOSAR RTE

Standardized Interface	Std. AUTOSAR Interface	Standardized Interface	AUTOSAR Interface	AUTOSAR Interface
Operating System	Services	Communi-cation	ECU Abstraction	Complex Device Drivers
Standardized Interface	Std. Interface	Std. Interface	Std. Interface	

Standardized Interface

DIO	PWM		CAN Driver

Microcontroller Abstraction

ECU-Hardware

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Example Software Function / Task

– Read the Accelerator Pedal value and calculate the required Torque to be generated from the Engine.

- This function has to be repeated every 20 milliseconds.

- Steps:
  - Read the data captured by the Analog-to-Digital Converter (ADC) on the Channel to which the Accelerator Pedal is Connected.
  - Using this data, look-up the value from a 3D Table (Map), which also contains the Engine RPM (Rotations per Minute), as another input axis.
  - Take the output value from the Map, multiply it by a correction factor (depending on, for e.g. Performance or Economy Mode).
  - The output of this calculation is the Torque to be generated by the Engine.
  - Repeat this sequence every 20 milliseconds.

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Chassis Systems ECU

Function

The active chassis control help divers maintain control over a wide range of challenging situations. It is blend of broad range of braking, steering and suspension technologies to enhance vehicle control and help make the drive experience safer. Modern automobiles are unthinkable without systems like ABS or ESP.

Customer Benefits

Improved steerability
Increased track stability
Reduced risk of skidding when braking
Reduced ABS braking distance

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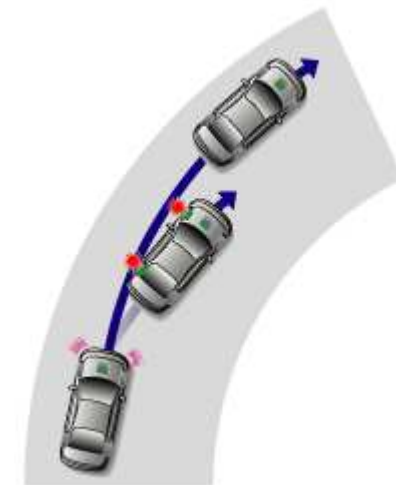
Body Control ECU

Function

The BCM handles various switch inputs, LAN data, and authentication for keyless entry devices in a concentrated manner. (Power Seat Electronic Control Unit, Anti-pinch Power Window Electronic Control Unit) and many other functions.
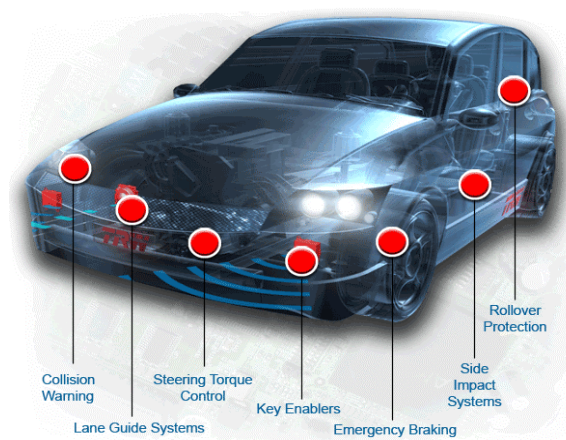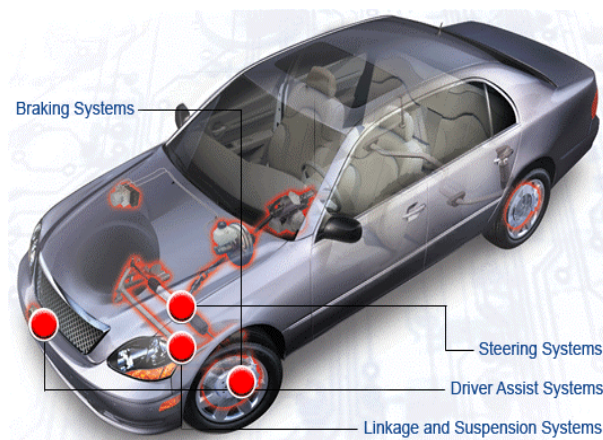

Conventional headlights
Headlights with AFS

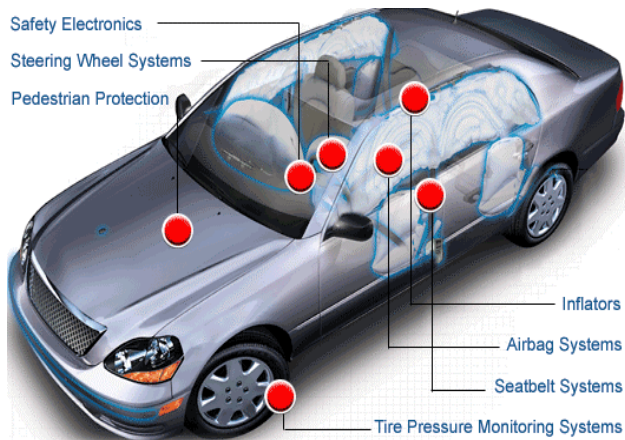DRIVING EMBEDDED EXCELLENCE
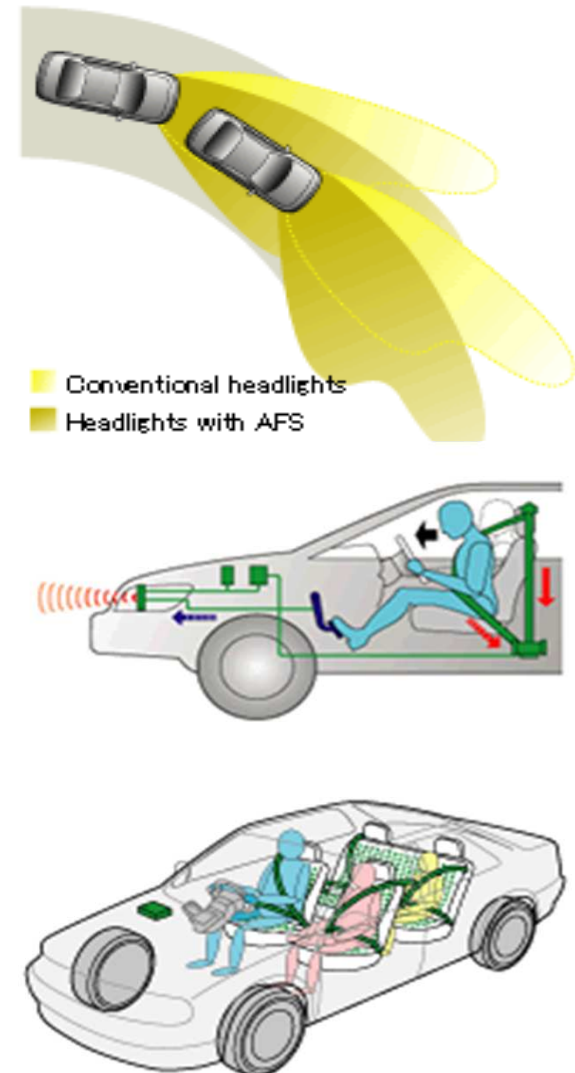
Safety systems

Passive Safety Systems
Airbag system
Seat Belt System
Steering Wheel System
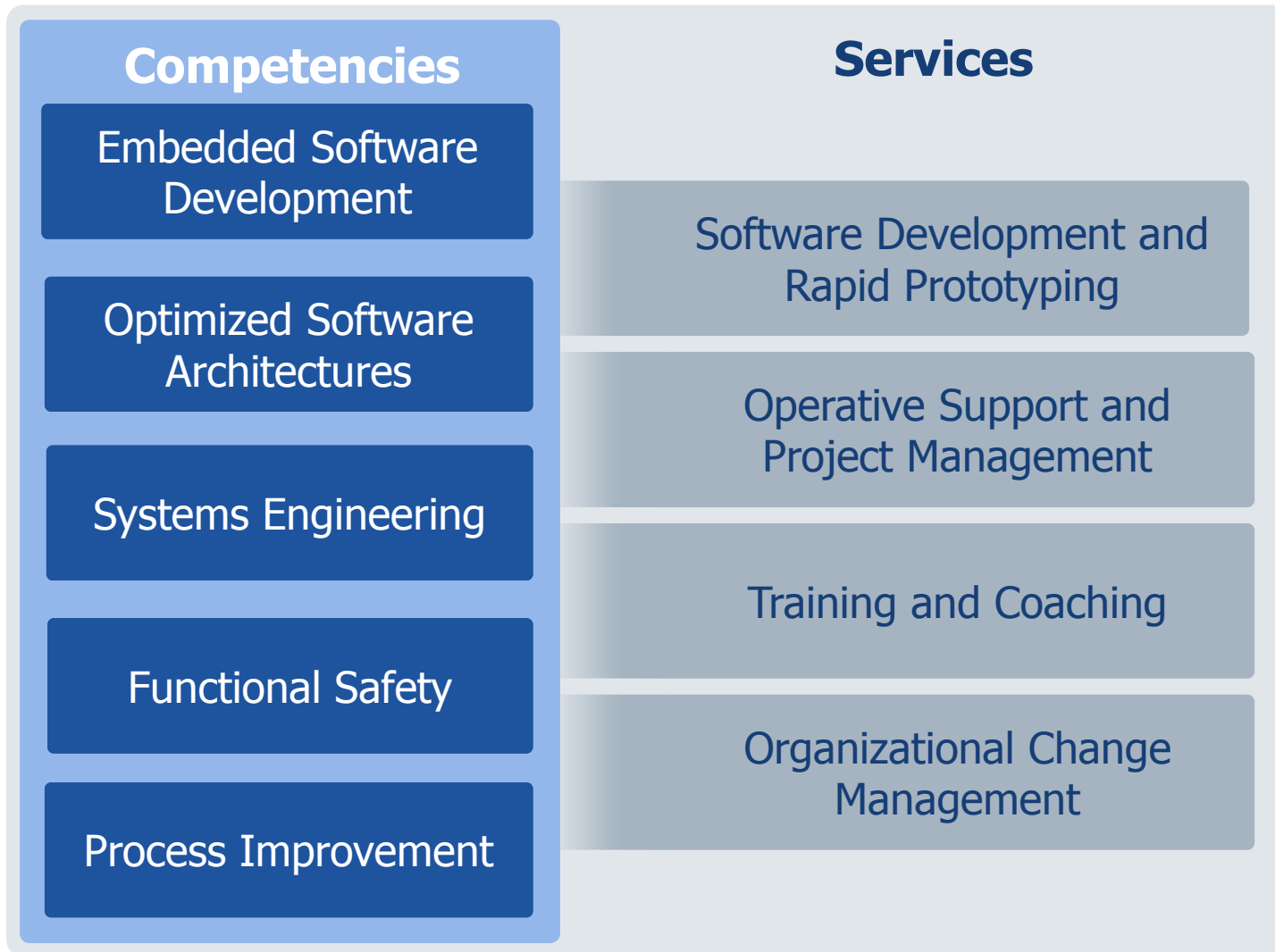Vision System
Pedestrian Protection
Tire Pressure Monitoring

Active Safety Systems
Brake systems
Driver Assist systems
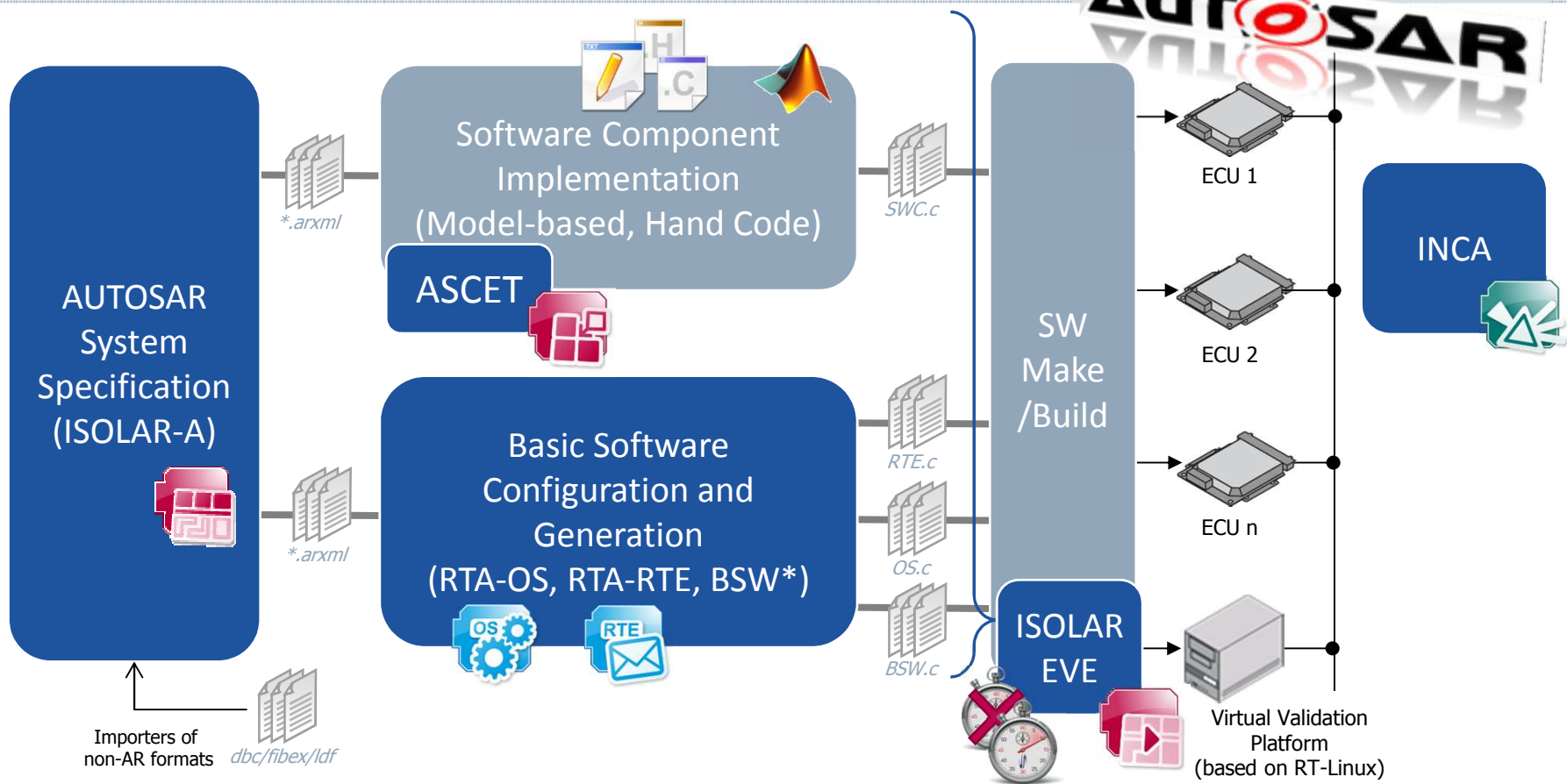Steering Control
Linkage & Suspension

Integrated Safety System
Pre-Crash Emergency Brake systems
Lane Departure warning
Park assist
Roll Over protection
Collision Warning

Safety Electronics
Steering Wheel Systems
Pedestrian Protection
Inflators
Airbag Systems
Seatbelt Systems
Tire Pressure Monitoring Systems

Braking Systems
Steering Systems
Driver Assist Systems
Linkage and Suspension Systems

Collision Warning
Lane Guide Systems
Steering Torque Control
Key Enablers
Emergency Braking
Rollover Protection
Side Impact Systems

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Competencies

- Embedded Software Development
- Optimized Software Architectures
- Systems Engineering
- Functional Safety
- Process Improvement

Services

- Software Development and Rapid Prototyping
- Operative Support and Project Management
- Training and Coaching
- Organizational Change Management

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*) AUTOSAR 4.0 Basic software modules developed and provided by Bosch.
  Developed to meet ASIL-D requirements. Roadmap details defined by Bosch.

ETAS

有難うございました

감사합니다.

谢
谢

Gracie Mille

Thank you

Merci beaucoup

Vielen Dank

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