



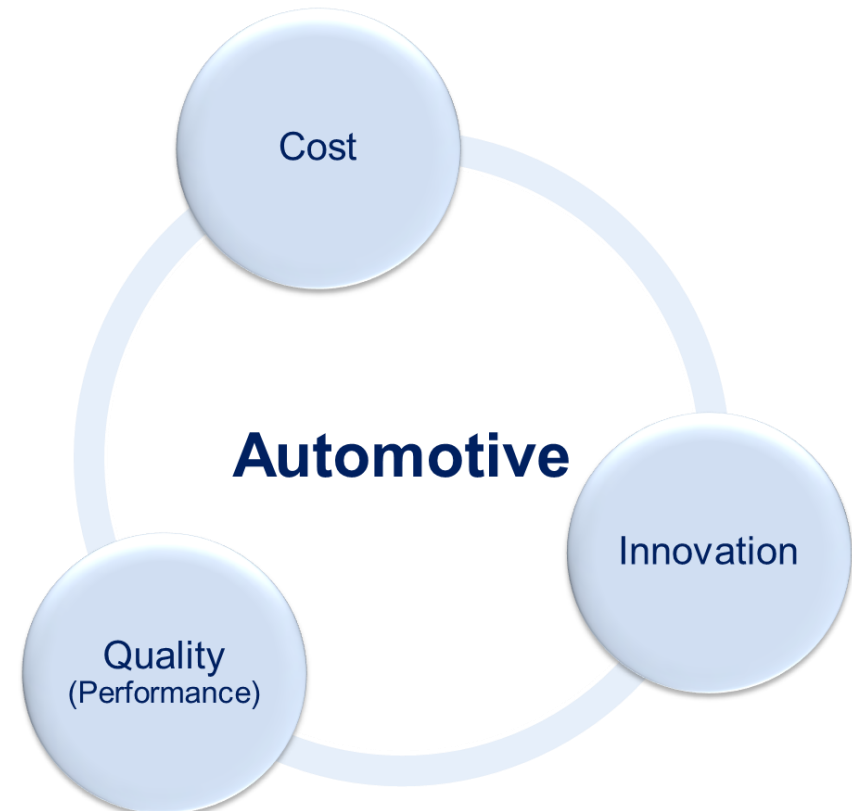
# AUTOSAR at the Cutting Edge of Automotive Technology

January 2012 – HiPEAC Conference

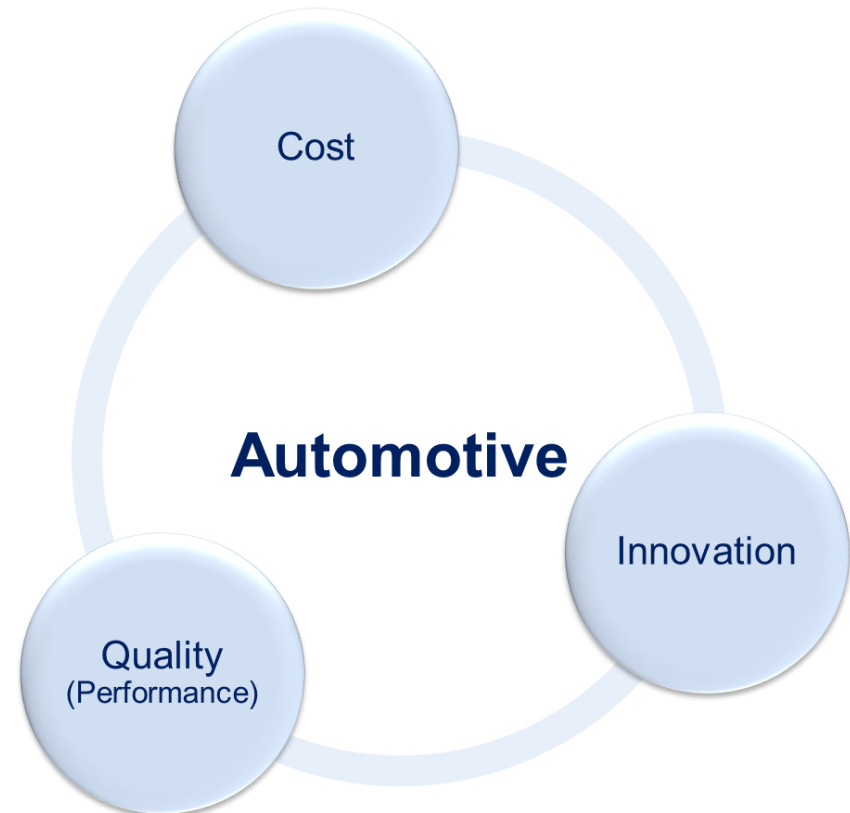
7<sup>th</sup> International Conference on High-Performance and Embedded Architectures and Compilers

Dr. Rafael Zalman - Infineon Technologies AG, Automotive Electronics  
Dr. Bert Böddeker – DENSO AUTOMOTIVE Deutschland GmbH

- Automotive Context
- AUTOSAR Introduction
- Automotive Challenges
  - Cost
  - Functional Safety
  - Energy Efficiency
  - Multi-Core
- Research Example: parMERASA
- Research Landscape
- Closing Words

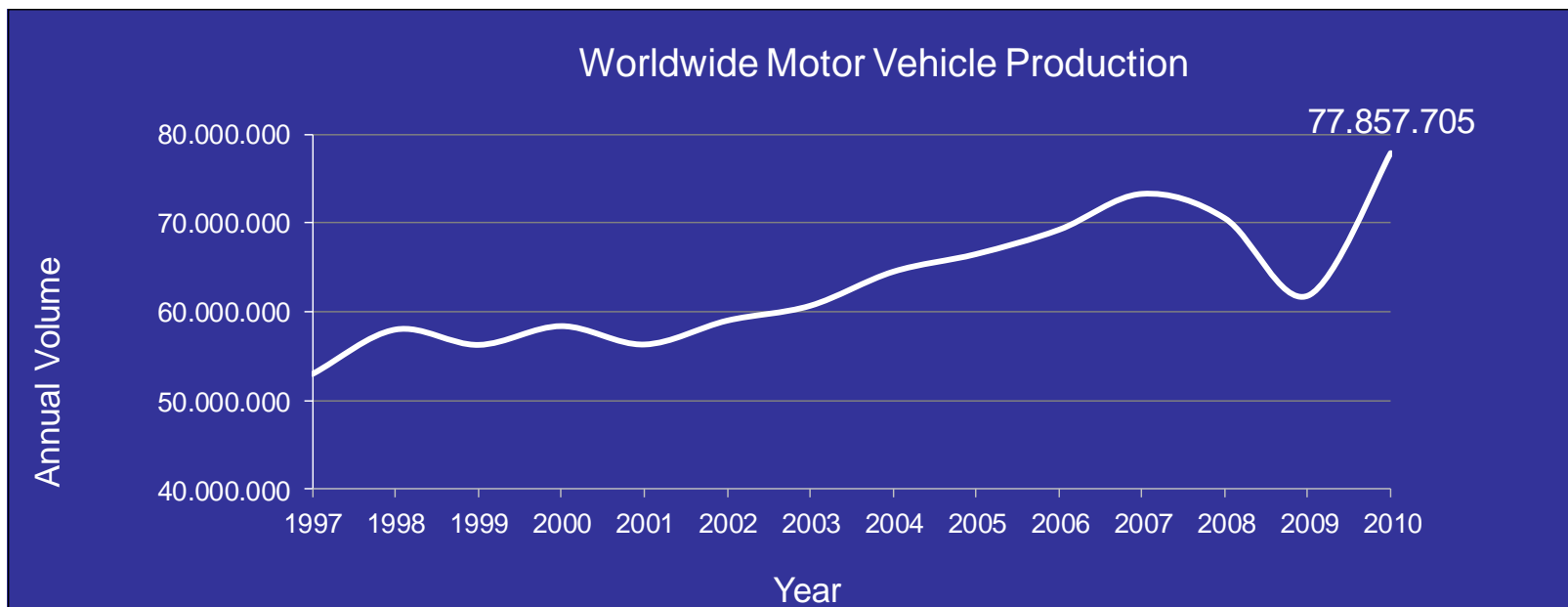


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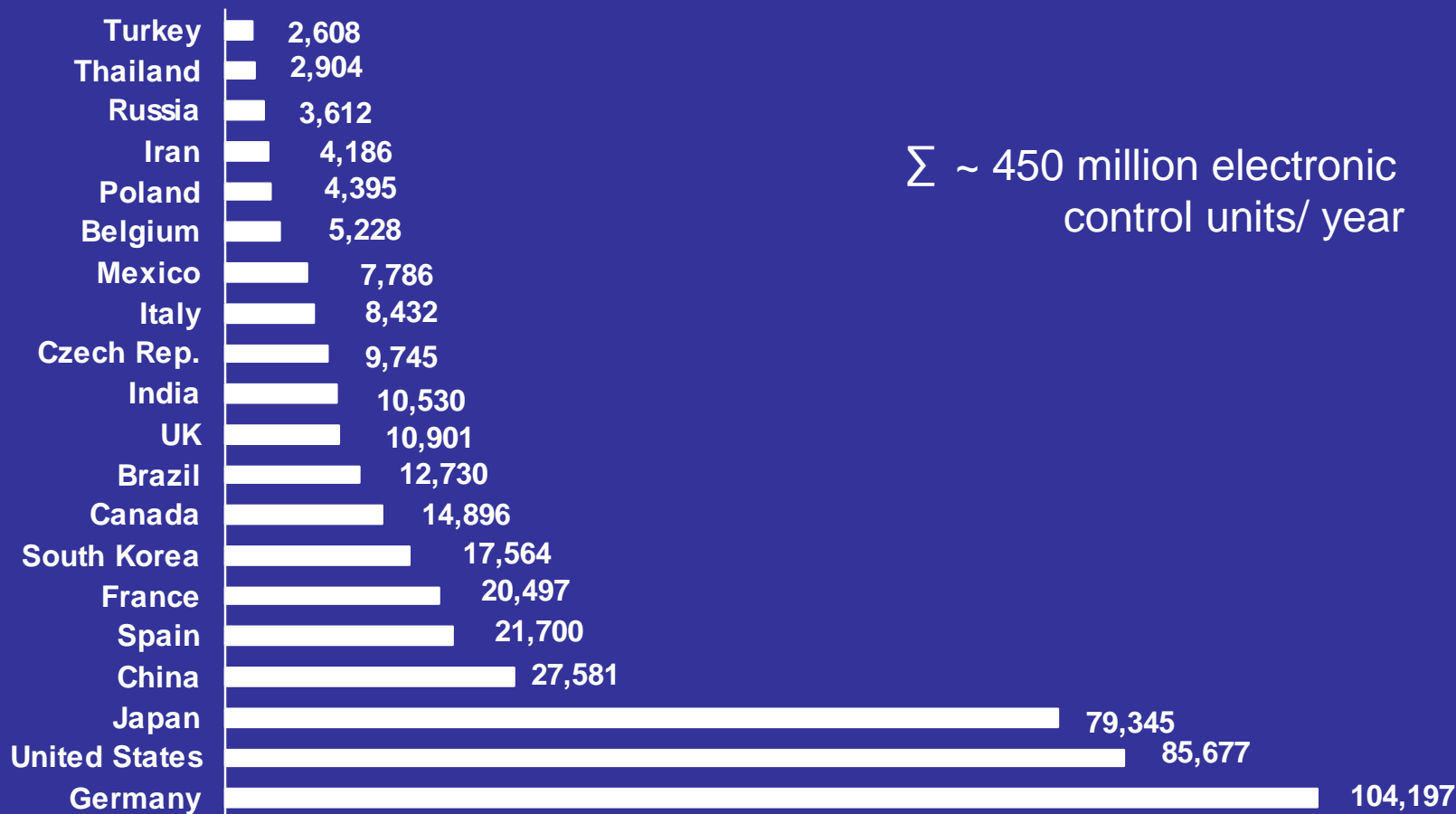
## Automotive Numbers

- Total estimated number of cars on the street worldwide  $\approx$  600 millions
- G7 countries have 749 vehicles / 1000 people
- Around 87% of total motor vehicles are passenger cars
  
- Car production worldwide:

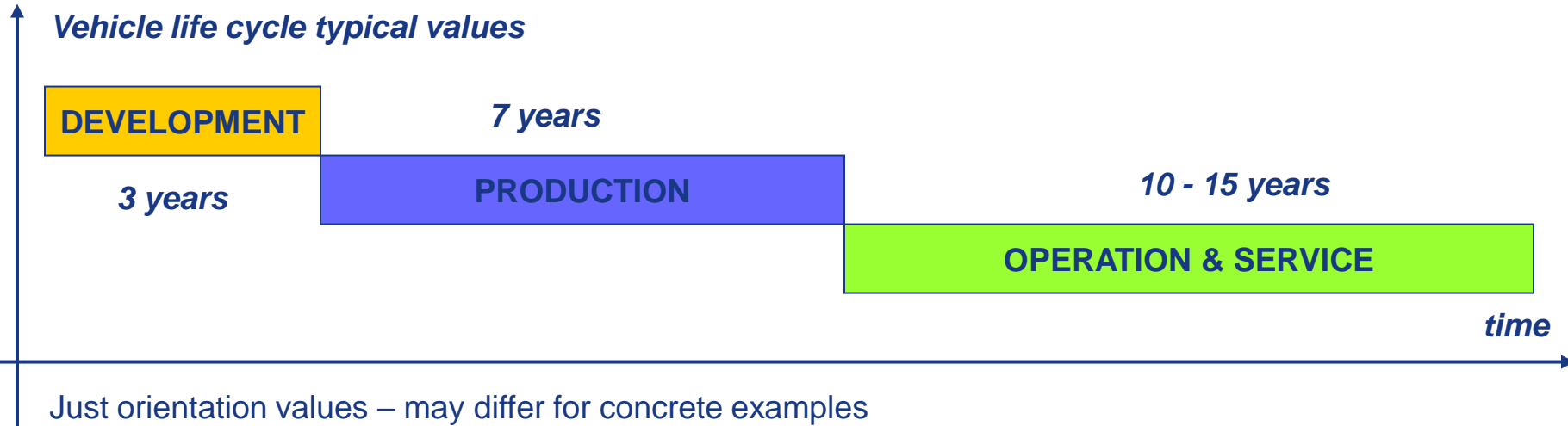


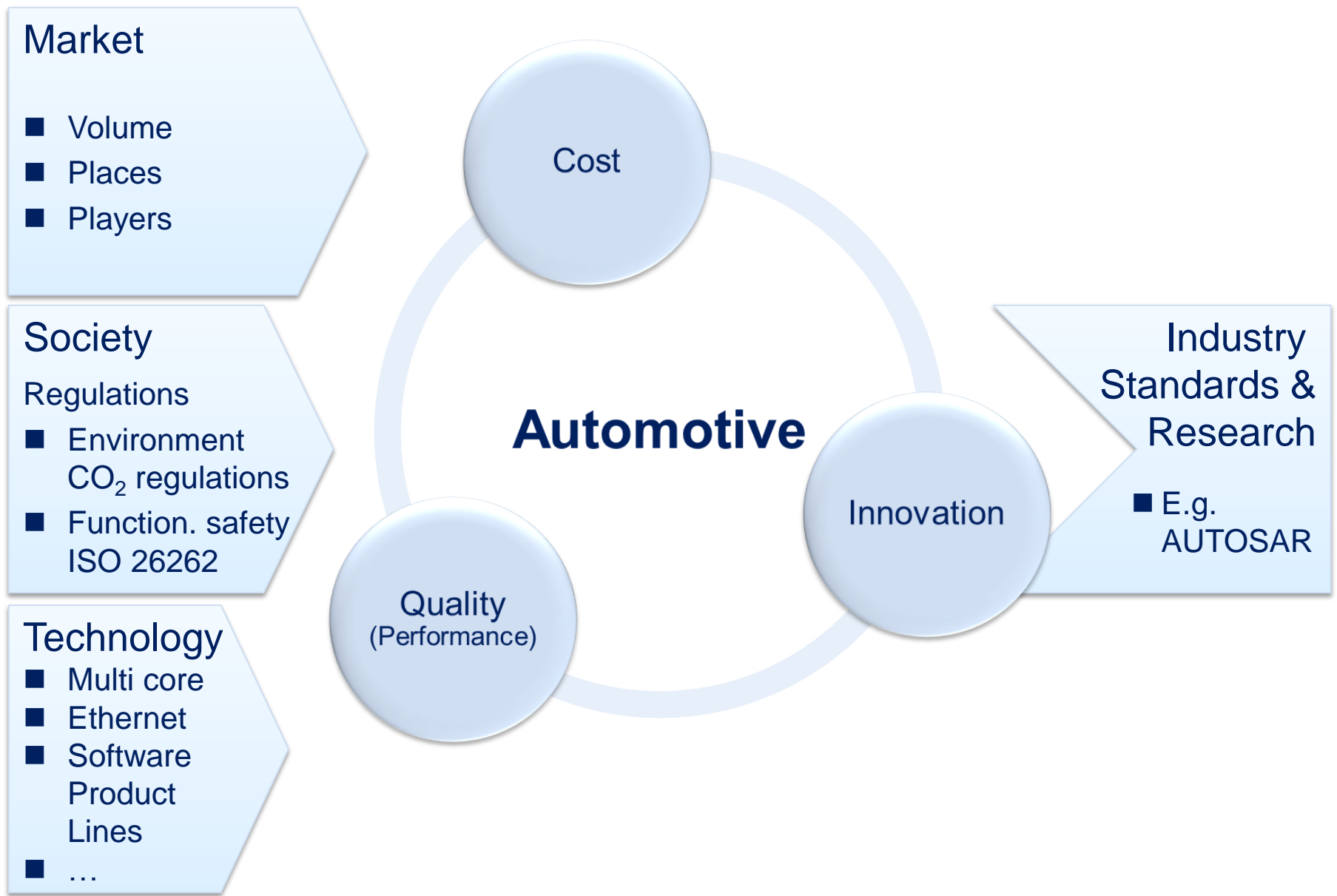
Source: OICA

## Estimated ECU Volume 2009 (K)

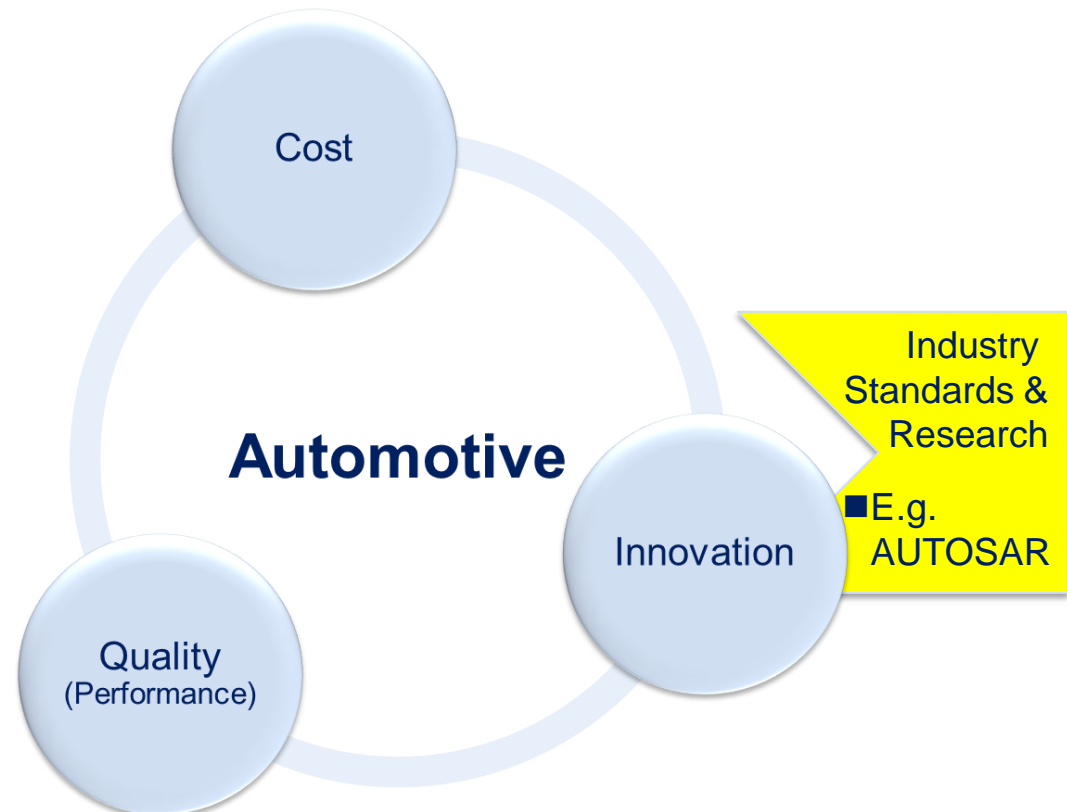


- Vehicles have a long life cycle – state of the art = 25 years
- Electronic components have a dramatically shorter life cycle
- Impact on the SW architectures!
  - Standardization of SW architectures
  - HW independent specification of SW functions
  - Updates = SW life cycle is shorter than ECU life cycle
  - Robustness instead of fast innovation





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AUTomotive  
Open  
System  
ARchitecture

## Core Members

Bayerische Motoren Werke AG  
Robert Bosch GmbH  
Continental AG  
Daimler AG  
Ford Motor Company  
General Motors Holding LLC  
Peugeot Citroën Automobiles S.A.  
Toyota Motor Corporation  
Volkswagen AG

## Premium Members

ALTRAN Group  
Autoliv  
B2i  
CEA List  
Dassault Systèmes  
Delphi Corporation  
Denso Corporation  
dSpace GmbH  
Elektrobit Group Plc  
ETAS Entwicklungs- und Applikationswerkzeuge für elektronische Systeme GmbH  
Electronics and Telecommunication Research Institute(ETRI)  
Fiat Auto S.p.A.  
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.  
Freescale Semiconductors  
Hella KGaA Hueck & Co.

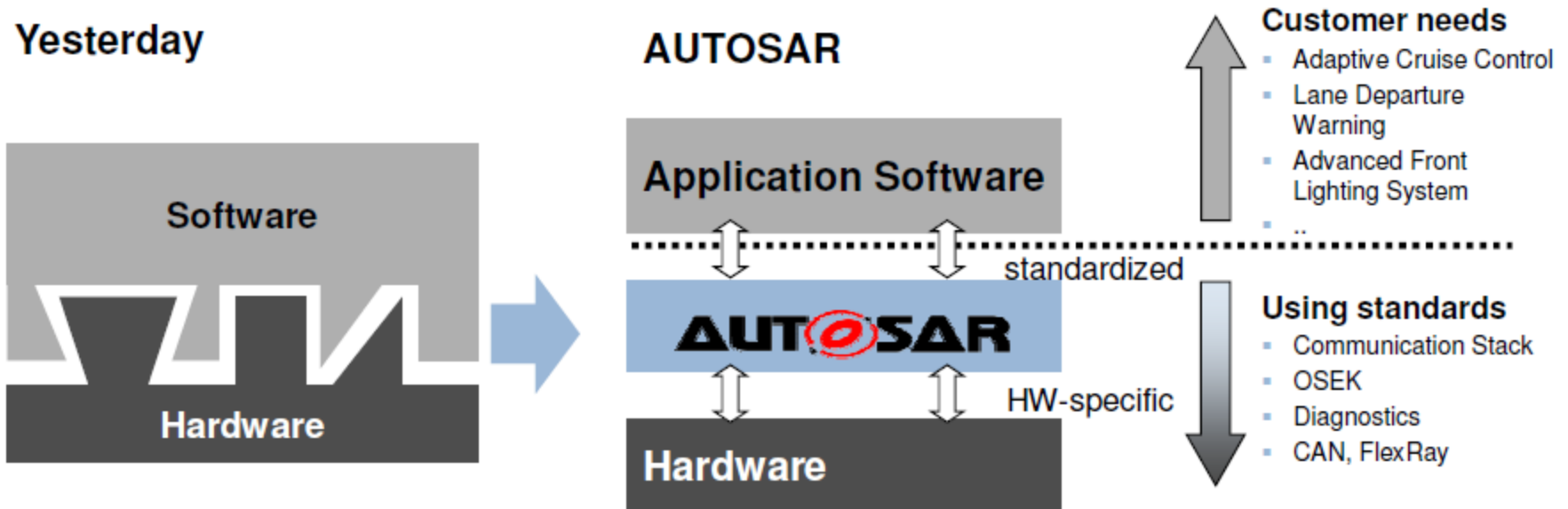
Honda Motor Co., Ltd. & Honda R&D Co., Ltd.  
Hyundai Motor Company  
IAV  
IBM Corporation  
INCHRON GmbH  
Infineon Technologies AG  
Intecs - Informatica e Tecnologia del Software SpA  
Johnson Controls GmbH  
JTEKT CORPORATION  
KPIT Cummins Infosystems Limited  
M/S Larson & Toubro Limited  
Lear Corporation  
Magna International Inc.  
Magneti Marelli Holding S.p.A  
Mazda Motor Corporation  
MB-Technology GmbH  
Mentor Graphics Corporation  
NXP B.V.

Patni Computer Systems Ltd.  
Dr. Ing. h.c. F. Porsche AG  
Renault SaS  
Renesas Electronics Corporation  
Saab Automobile AB  
See4sys  
STMicroelectronics NV  
TATA Elxsi Limited  
The MathWorks, Inc.  
TRW Automotive Inc.  
TTTech Computertechnik AG  
Valeo Electronique et Systèmes de Liaison - VESL  
Vector Informatik GmbH  
Volvo Cars  
AB Volvo  
ZF Friedrichshafen AG

# AUTOSAR Introduction

## AUTOSAR Vision in a nutshell

*AUTOSAR aims to standardize the SW architecture of the ECUs!*

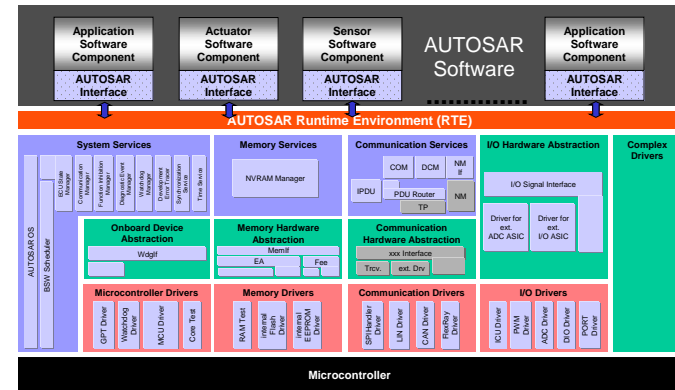


- HW and SW will be independent of each other
- Development can be de-coupled by horizontal layers reducing development time and costs
- SW re-use increase (OEM & suppliers) → efficiency and quality increase

## AUTOSAR Standardization areas

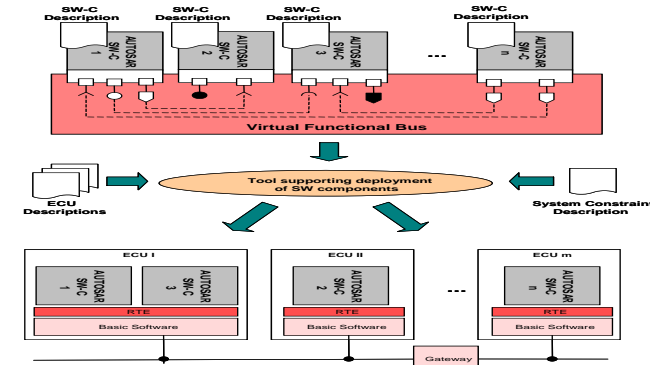
### Software & Architecture

- Automotive Basic Software
- Run Time Environment (RTE)



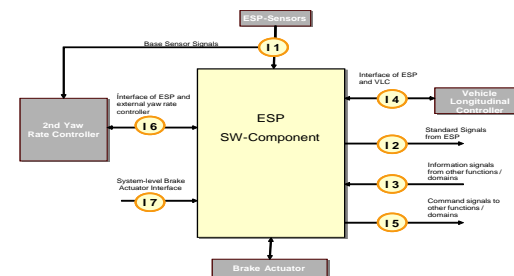
### Methodology

- Virtual Function Bus (VFB)
- Configuration Language

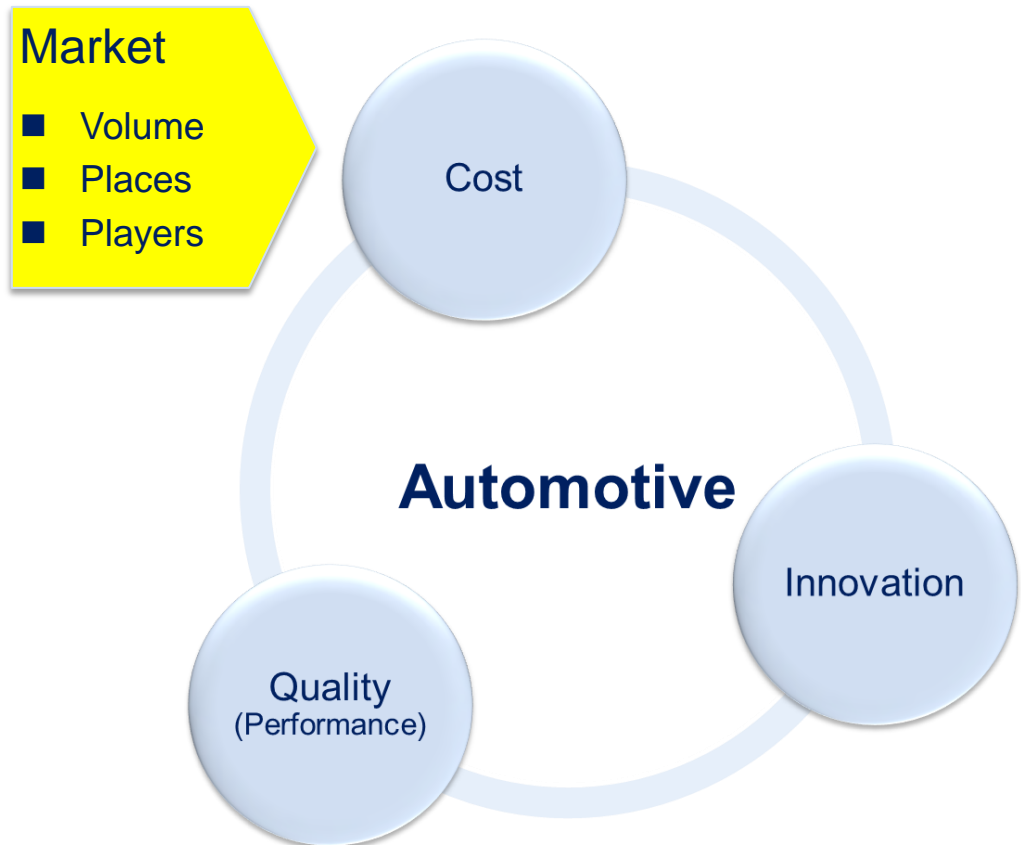


### Application interfaces

- all application domains



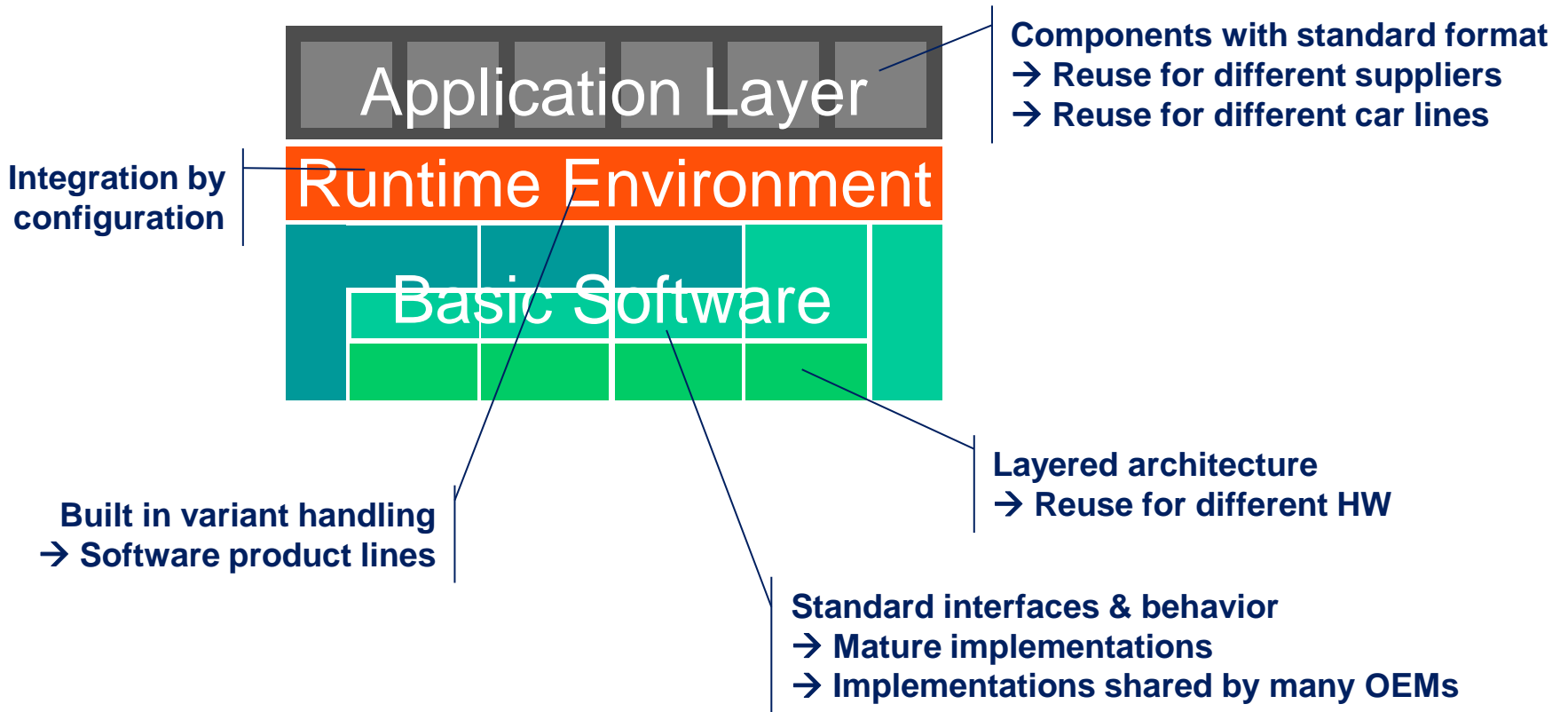
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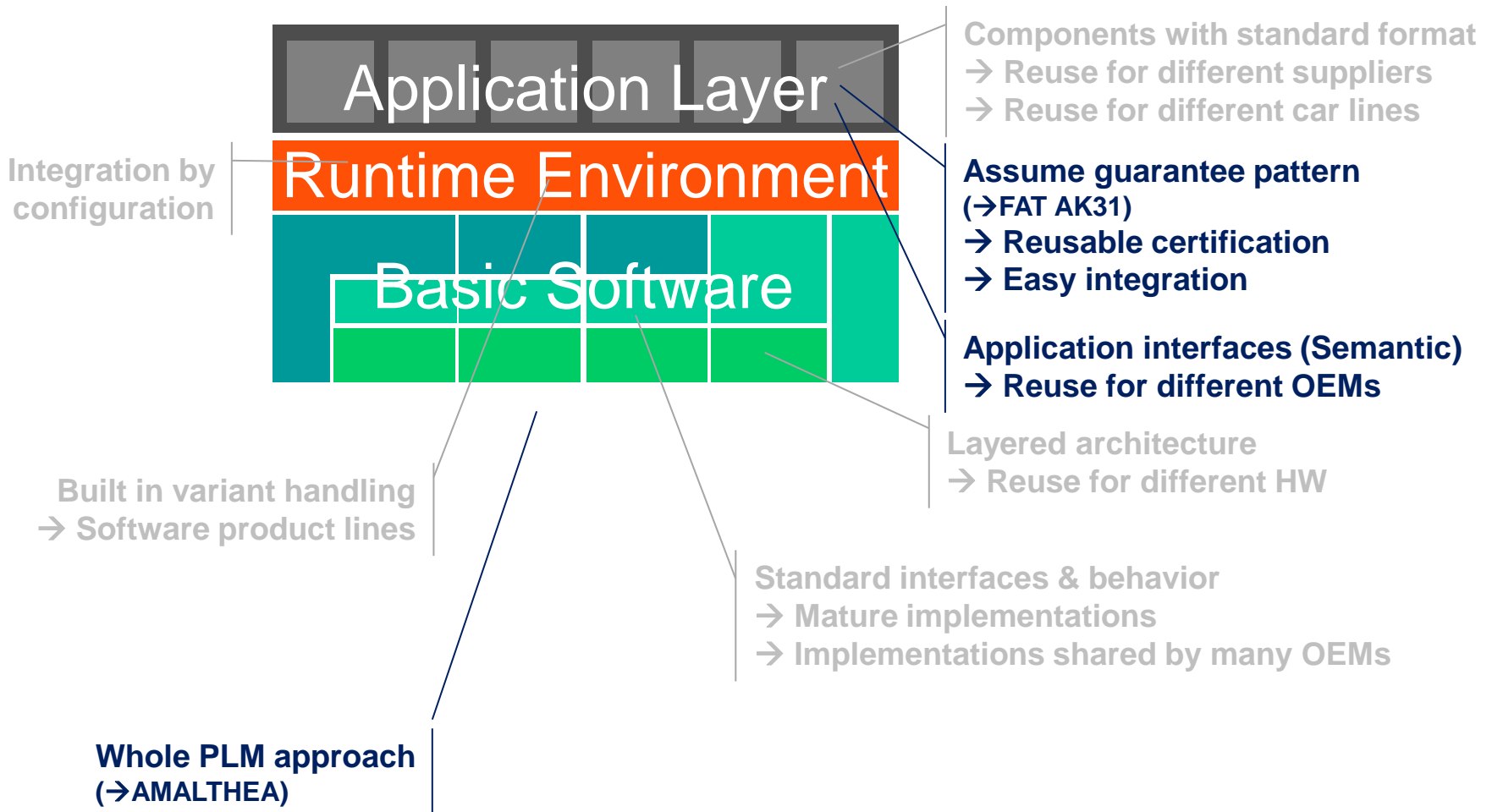
## Software Reuse

Vast majority of software development effort is spent on adaptation of existing solutions.

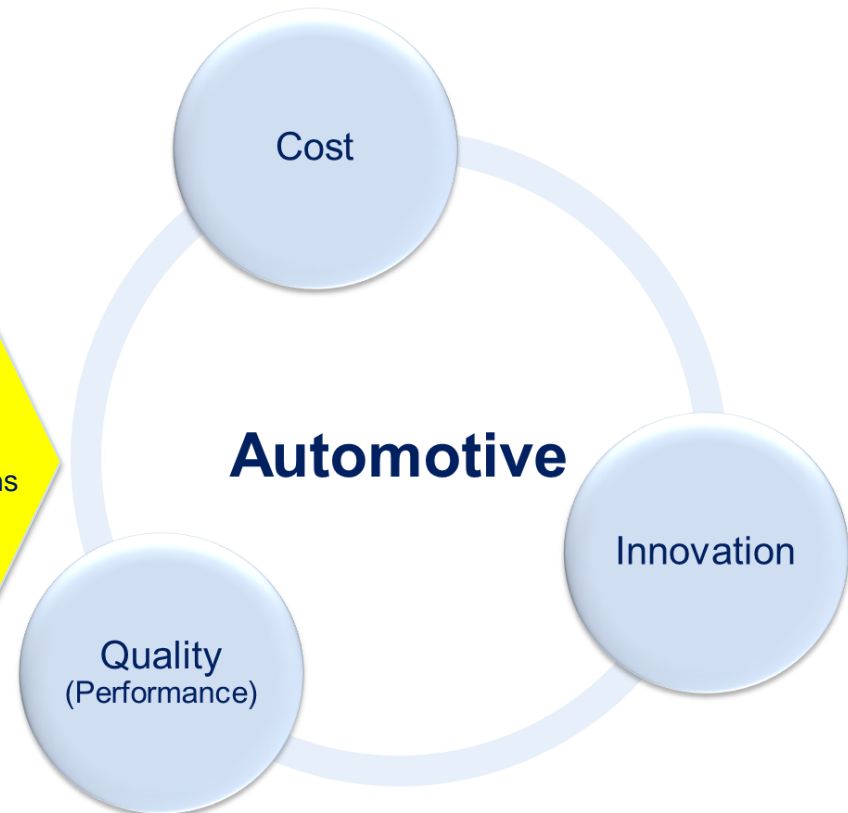
## Reusability of software



## Reusability of software still required:



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**Background**

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*Functional Safety is the absence of unreasonable risk due to hazards caused by malfunctioning behavior of E/E systems\**

- Avoid malfunctions of E/E systems
- Applicable to all E/E systems with intrinsic risks

\*) ISO 26262-1

*Safety is absence of unreasonable risk*

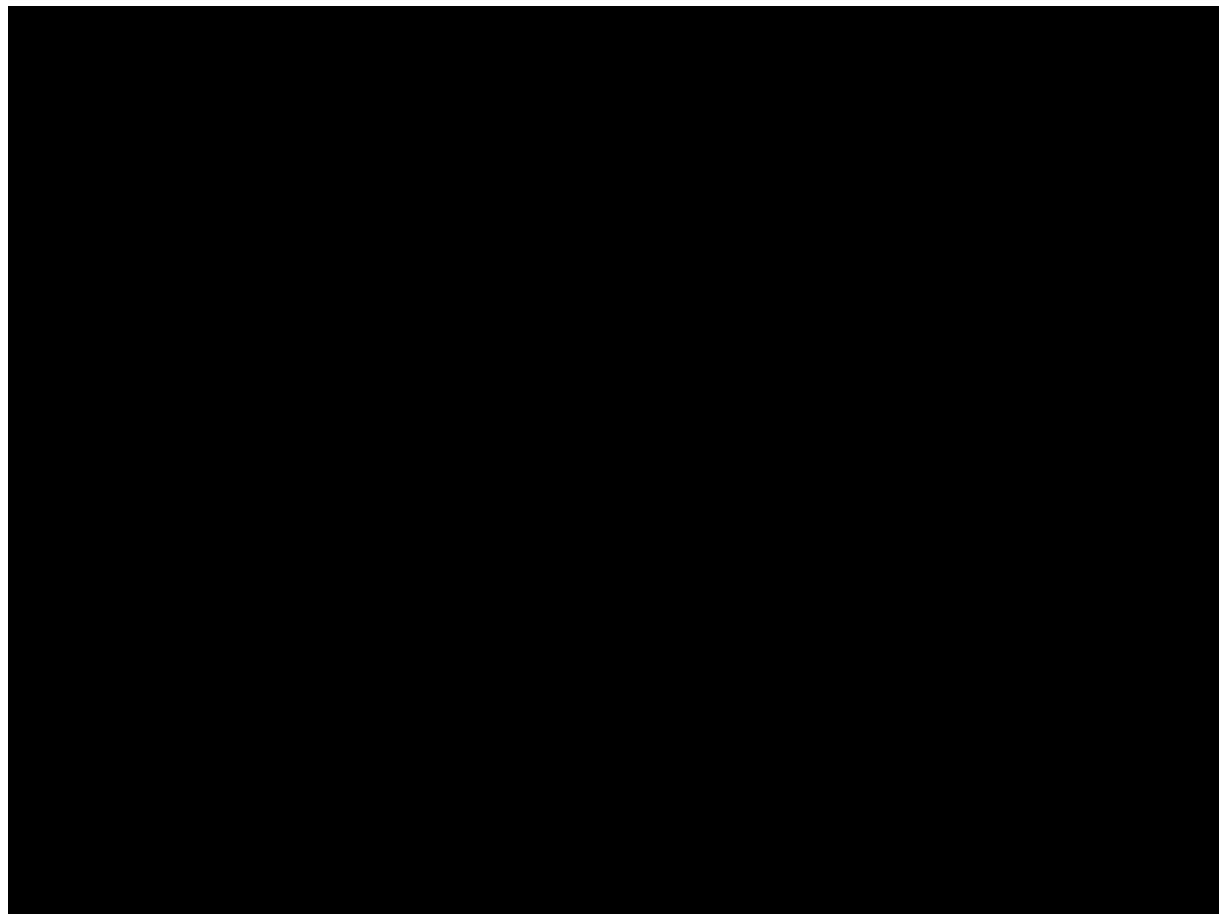
- A risk is at a tolerable level, if the involved persons (the society) can accept it
- Acceptable risk IS society specific!



**Background**

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## *Scope of ISO26262 Standard*

### *Target*

- Passenger cars < 3.5t
- OUT: Trucks, Motorbikes, Tractors,...

### *Hazards under consideration*

- Human damage
- OUT: material damage

### *Object under consideration*

- E/E System device, semiconductor, hardware design, software
- OUT: mechanic structure, material

### *Faults under consideration*

- Systematic design faults, random hardware faults, etc.
- OUT: abnormality due to high voltage, ageing, fire hazard, heat, corrosion, performance

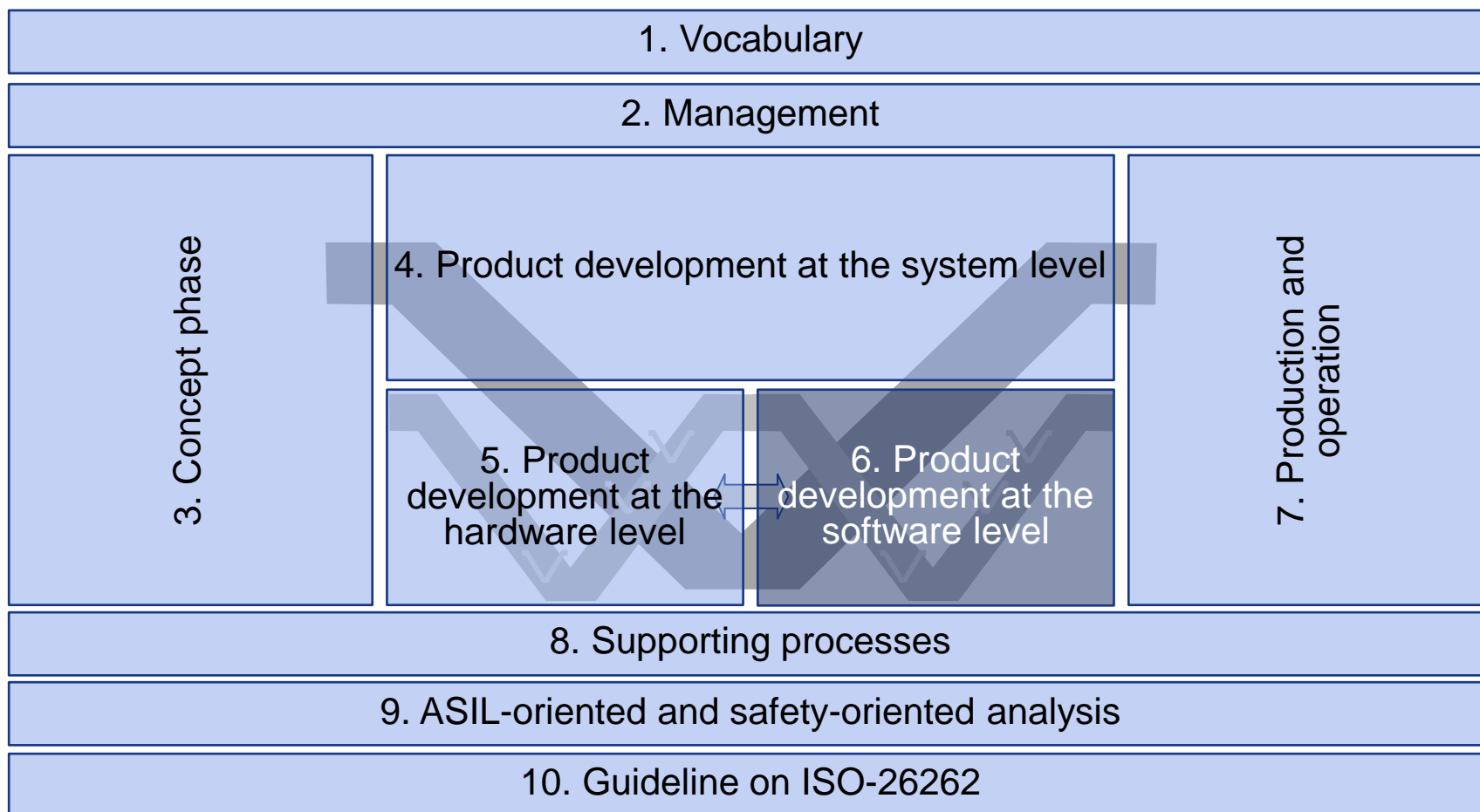
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Standard: ISO 26262  
Road vehicles — Functional safety

Release date: 2011/11/15



Background

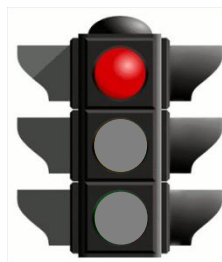
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## ISO 26262 Standard

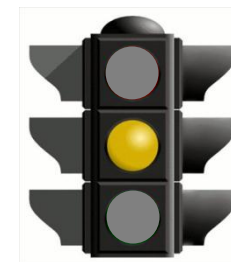
### ■ Is NOT:

- Certification** requirement



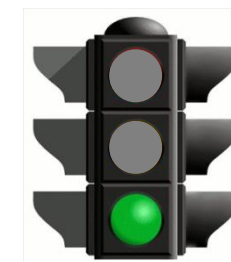
### ■ Is PARTIALLY:

- Legal** requirement  
only through product liability requirement for '**state of the art**'



### ■ IS:

- Guidance** to find right level of functional safety effort to spend.
  - Reduce number of callbacks for safety reasons.
- Defense** against liability claims.



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## Disclaimer

AUTOSAR (AR) does NOT guarantee any Functional Safety (FS) properties of the final system

- AR provides mechanisms to support FS (SW level)
- Helps during the design phase for SW level
- Each system has its own context of use, functionality and implementation



The full **responsibility** for selecting and implementing appropriate safety mechanisms as described inside the AUTOSAR framework fully resides on the **implementer**

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## Partitioning

- Memory protection
- Timing protection (time budgets)
- Selective stop of partitions for increased critical function availability

Untrusted partitions

- Permits separation
  - Mixed safety integrity levels
  - Responsibility sharing across SW vendors

1 Trusted partition



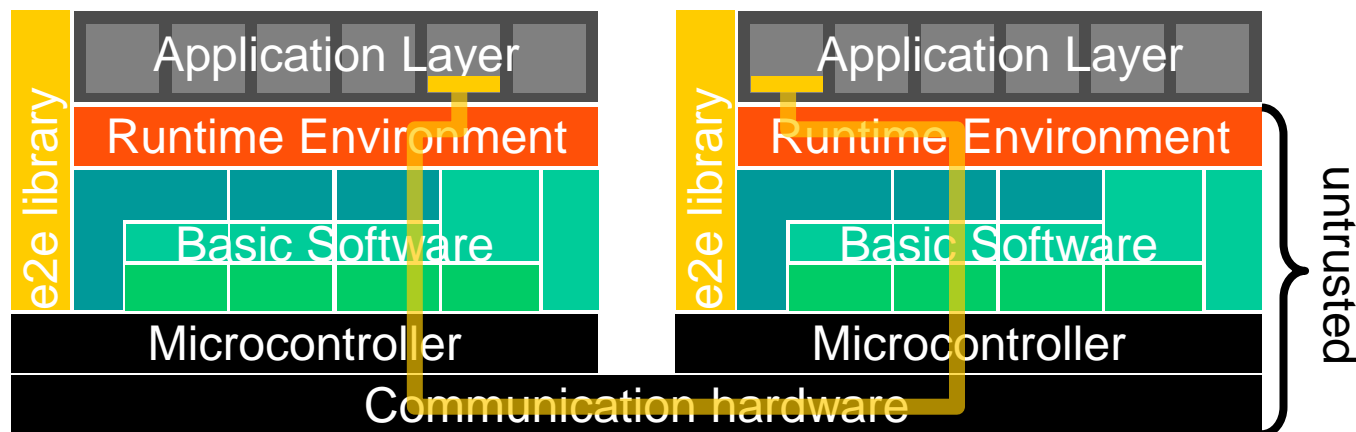
Background

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Partition

End to End Communication Protection



- Provides
  - Data integrity,
  - Authentication,
  - Sequence check
- Implemented by
  - Static end to end protection library
  - Wrapper code for handling protection context for communication

Background

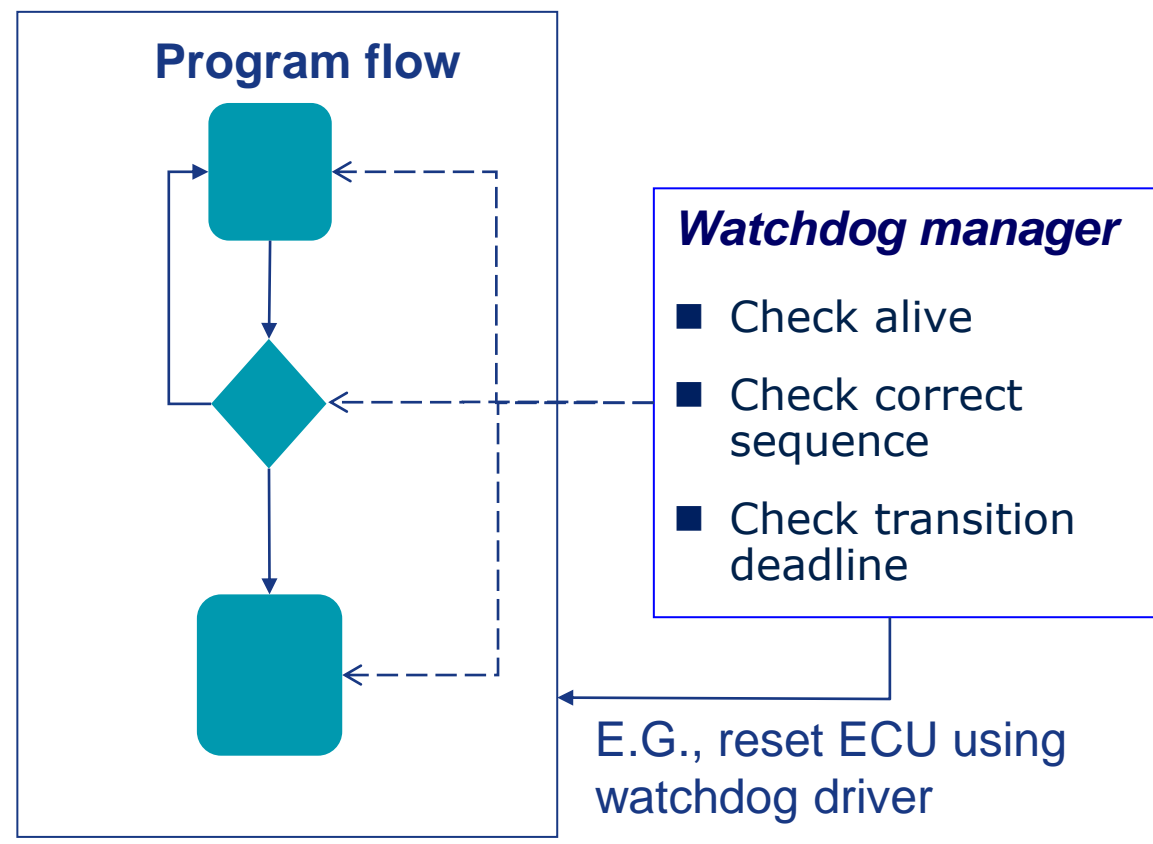
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Partition

End to End Commu

**Program Flow Monitoring**



A problem has been detected and windows has been shut down to prevent damage to your computer.

DRIVER\_IRQL\_NOT\_LESS\_OR\_EQUAL

If this is the first time you've seen this Stop error screen, restart your computer, If this screen appears again, follow these steps:

Check to make sure any new hardware or software is properly installed. If this is a new installation, ask your hardware or software manufacturer for any windows updates you might need.

If problems continue, disable or remove any newly installed hardware or software. Disable BIOS memory options such as caching or shadowing. If you need to use Safe Mode to remove or disable components, restart your computer, press F8 to select Advanced Startup Options, and then select Safe Mode.

Technical information:

\*\*\* STOP: 0x000000D1 (0x0000000C,0x00000002,0x00000000,0xF86B5A89)

\*\*\* gv3.sys - Address F86B5A89 base at F86B5000, DateStamp 3dd991eb

Beginning dump of physical memory

Physical memory dump complete.

Contact your system administrator or technical support group for further assistance.

Background

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Research

- Availability / fault operational concepts
- Safety related extensions for methodology (→SAFE, AR internal)
- Use of multi core for hardware partitioning
- Runtime HW tests integration
- Convergence of safety & security (→SESAMO proposal)
- Safe and reliable integration of components (→TIMMO-2-USE, recomp).
- Safe and robust software execution (AR internal)

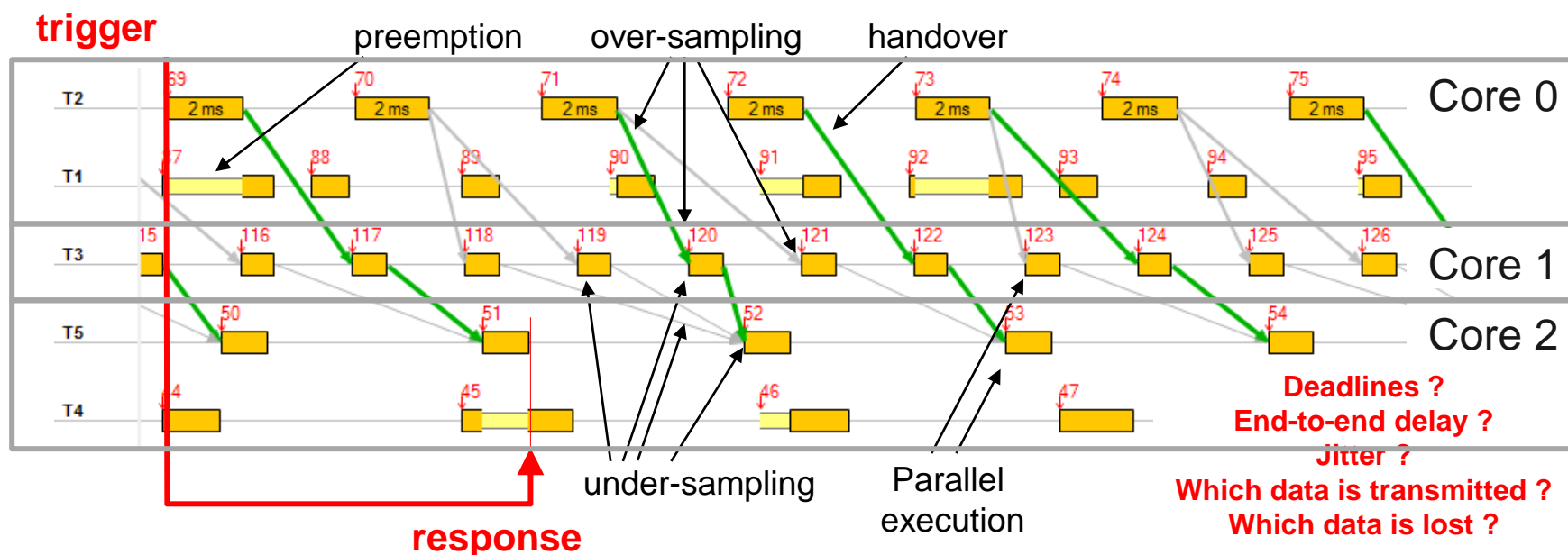


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## Timing Constraints and Scheduling



Scheduling effects are already complex in small systems

- More complex in multi cores

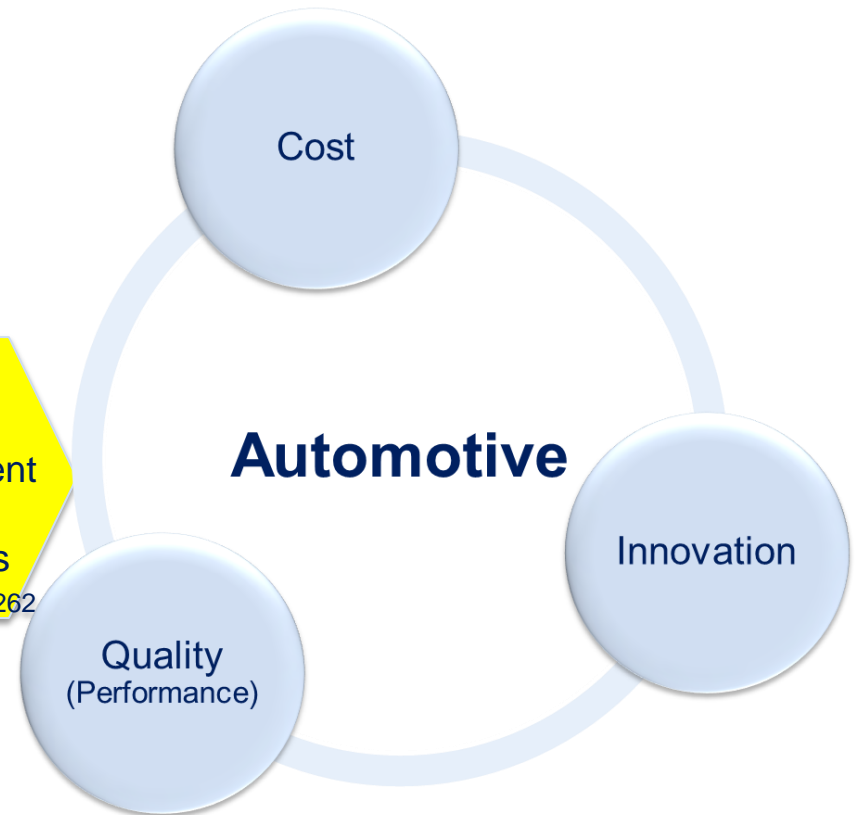
Fulfillment of timing constraints must be checked

- Already in single cores and even more in multi cores
- Scheduling Analysis is one way

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Society Regulations

- Environment CO<sub>2</sub> regulations
- Safety ISO 26262



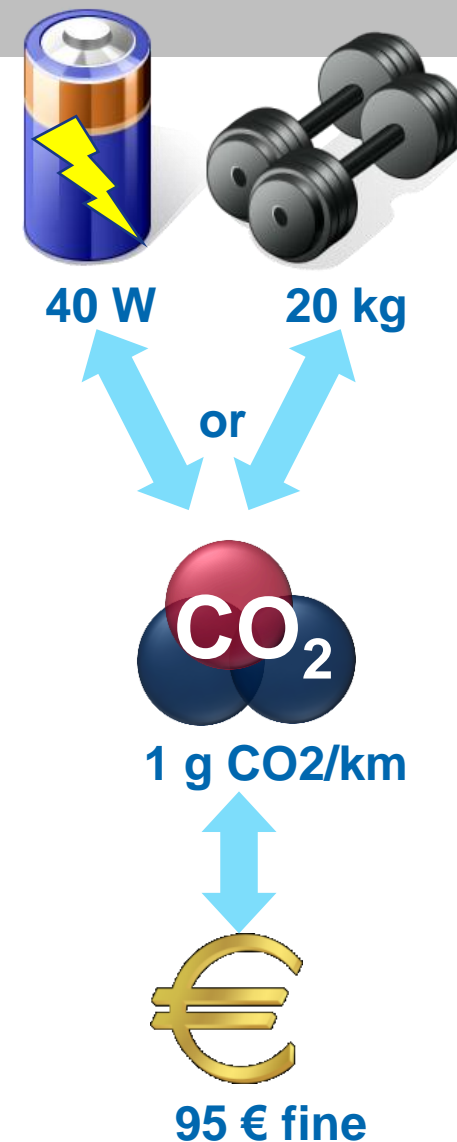
## Background

## AUTOSAR

## Research

\*EC CO<sub>2</sub> Emissions Regulation 443/2009

<b>100 W electrical</b>	⇔	<b>0.1 l/100km</b>
<b>50 kg</b>	⇔	<b>0.1 l/100km</b>
<b>1 l/100km Fuel</b>	⇔	<b>23.6 g CO<sub>2</sub>/km</b>
<b>1 l/100km Diesel</b>	⇔	<b>26.5 g CO<sub>2</sub>/km</b>
<b>1 g CO<sub>2</sub>/km</b>	⇔	<b>40 W electric</b>
<b>1 g CO<sub>2</sub>/km</b>	⇔	<b>20 kg</b>
<b>1 g CO<sub>2</sub>/km</b>	⇔	<b>95 €* current consumption per ECU ~200 mA</b>



Similar battery cost results for electric cars

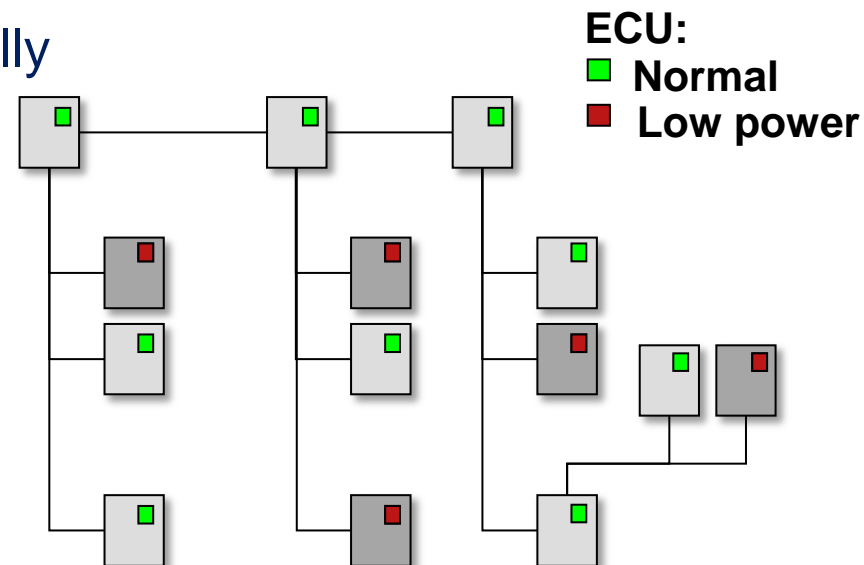
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## Partial Networking

- Many Functions are only sporadically required:
  - Seat heating
  - Trailer connector
  - Window lifter
  - In total: ~10 ECUs
- Idea: Turn off all nodes that do not contribute to any active function



## ECU Degradation

- ECU local measures (to be published in rev. 4.04)
- Power down parts of an ECU
- In multi-cores scenarios, power-down slave cores

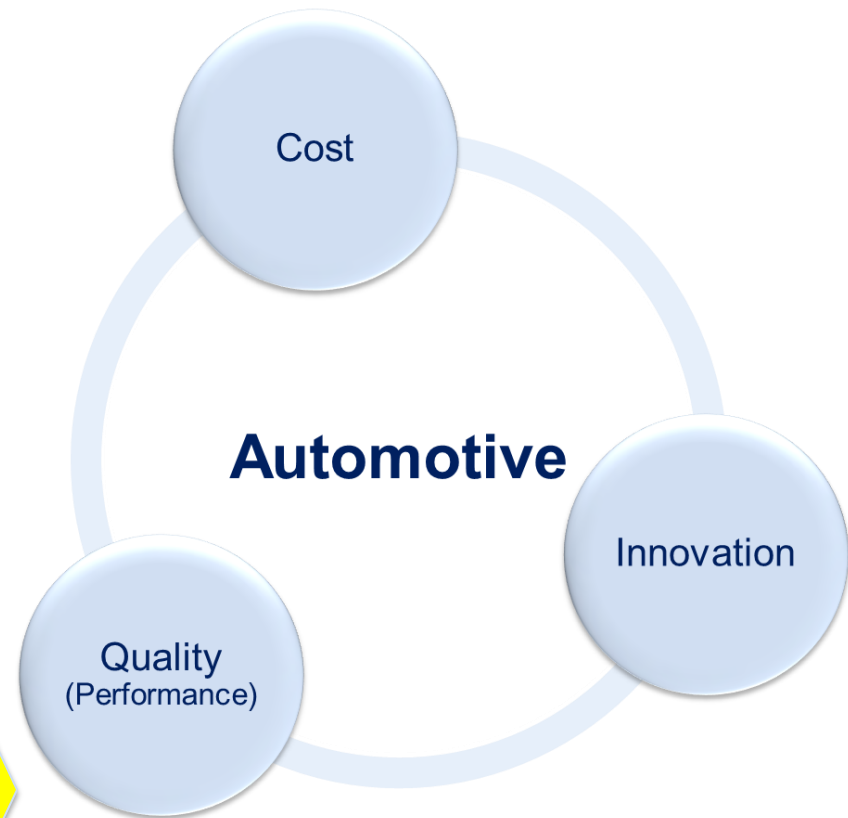
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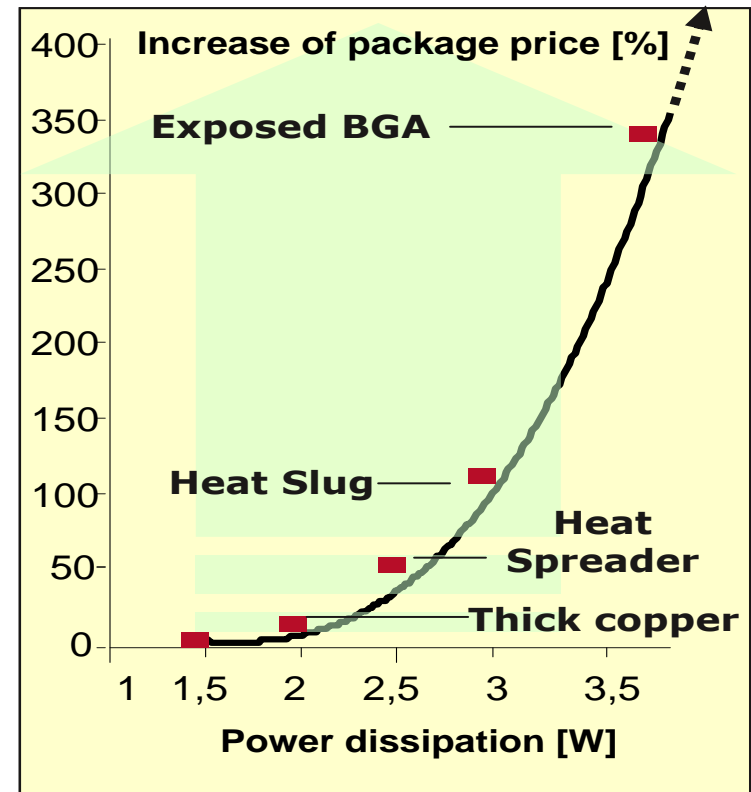
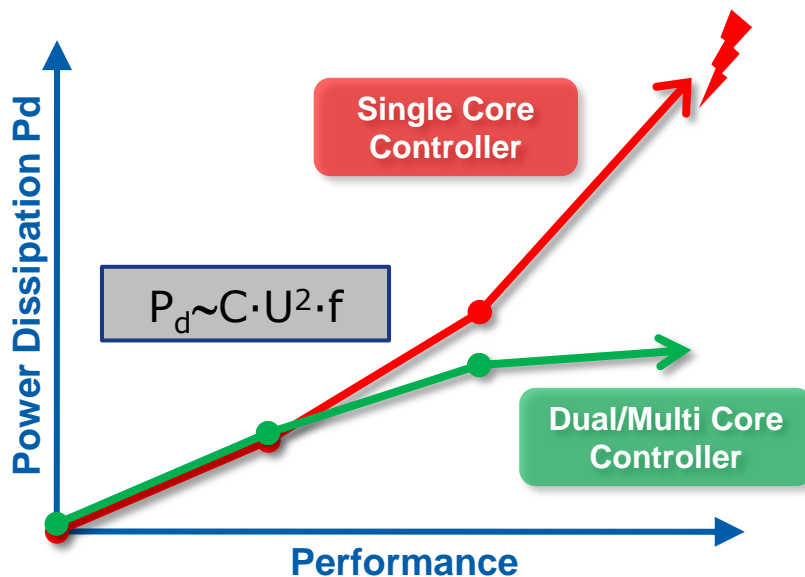
- vehicle mode architecture:  
How to consistently control vehicle resources and vehicle functions with contradicting optimization criteria like energy consumption, comfort, safety, ...

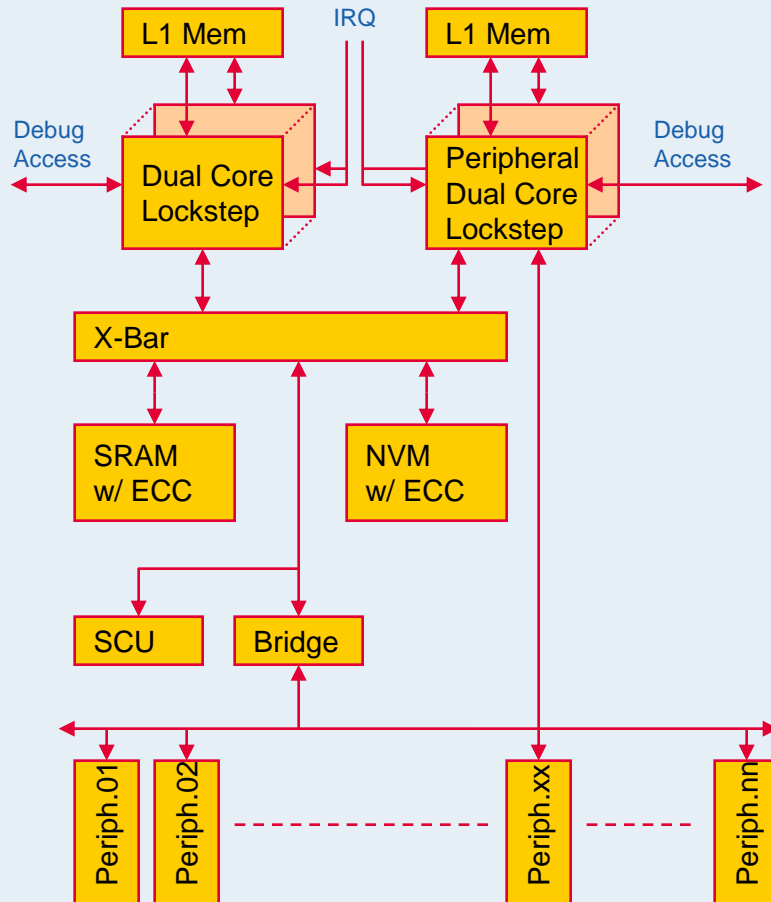
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## Multi Core – Energy efficiency & performance

- Dual (multi) core is the solution to the Moore law & power dissipation problem.



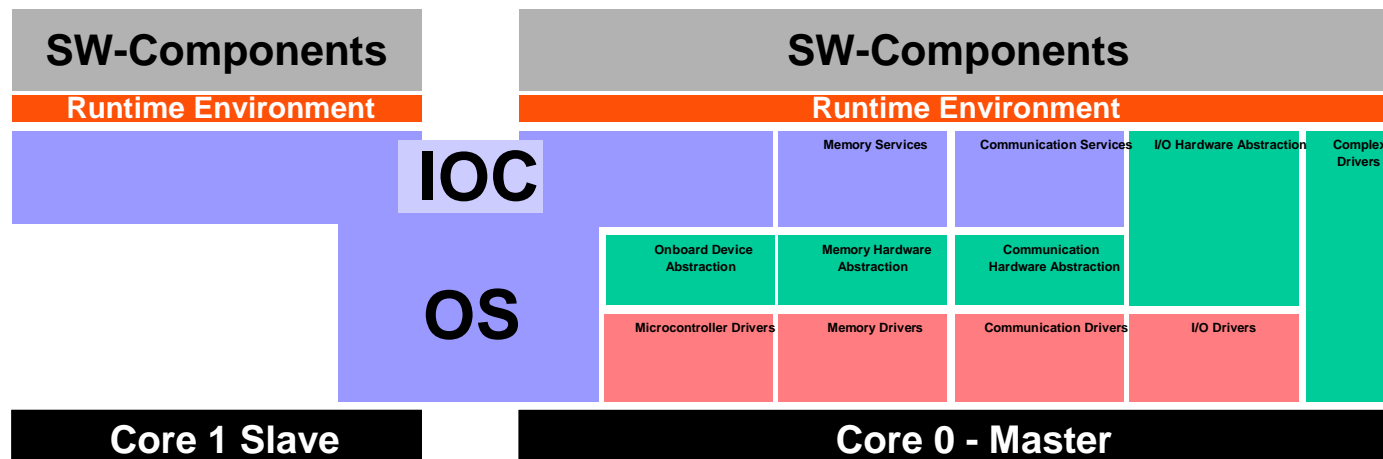


## Example Concept for Hybrid Architecture

- Safe Processing Concept (Aurix, Infineon)
- Lockstep application processor
- Lockstep peripheral control processor
- able to run diversity mode
- memory management for Cores and DMA have,
- ECC protection for memory and busses
- scalable and composable in performance and memory size

## Multi Core support:

- Single image OS
- Tasks and software components bound to cores
- Shared memory assumption (not exploited)
- Generic module for inter core communication (IOC)
- Spin-locks for explicit synchronization



Background

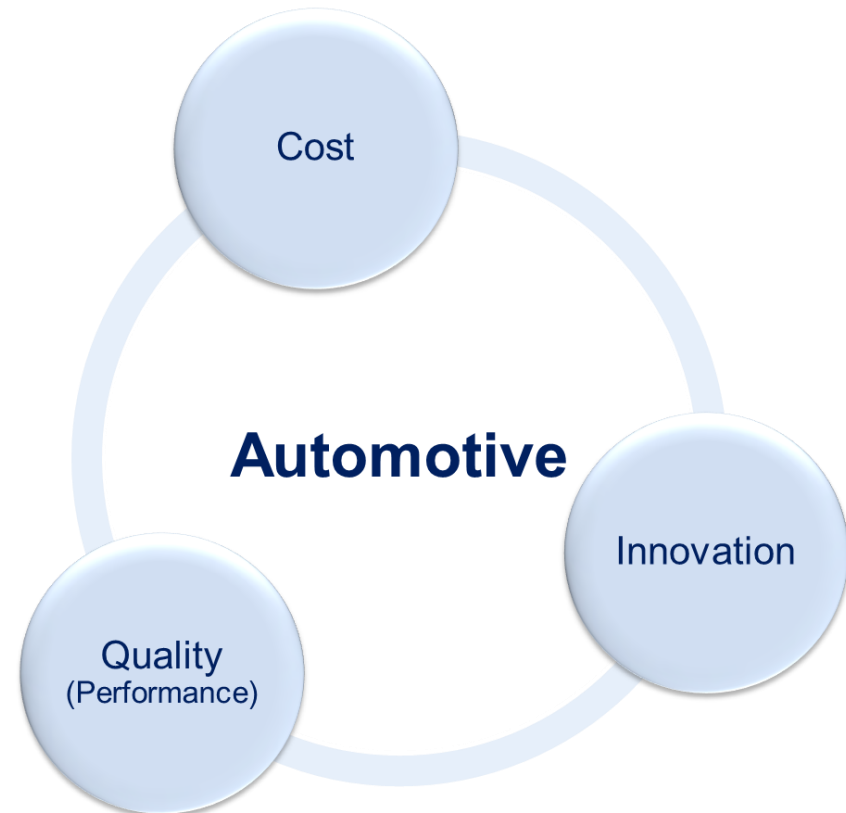
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## Automotive related multi-core research

- How to scale with large number of cores (TERAFLUX)
- Load balancing
- (Semi-) Automatic parallelization
- Better scheduling mechanisms than local PCP and spin locks.
  - Predictable multi core scheduling (parMERASA)

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## parMERASA

### Multi-Core Execution of *parallelised* Hard Real-Time Applications Supporting Analysability



EC FP-7 project 2011-2014

start: Oct. 1, 2011

3.3 Mio EC contribution

Project webpage: <http://www.parmerasa.eu>

## parMERASA Project partners



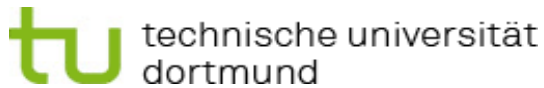
- **University of Augsburg** (Project Coordinator)



- **Barcelona Supercomputing Center**



- **Université Paul Sabatier**



- **Technical University of Dortmund**



- **Rapita Systems Ltd.**



- **Honeywell international s.r.o.**



- **BAUER Maschinen GmbH**



- **DENSO AUTOMOTIVE Deutschland GmbH**

parMERASA Industry Advisory Board**AIRBUS****esa****BMW Group**

- **Benoit Triquet**, Airbus,
- **Philippe Chevalley**, European Space Agency ESA,
- **Glenn Farrall**, Infineon Technologies UK Ltd,
- **Rafael Zalman**, Infineon Technologies AG,
- **Andre Lajtkep**, BMW Group,
- **Hakan Sivencrona**, MECEL AB,
- **Claus Stellwag**, Elektrobit Automotive GmbH,

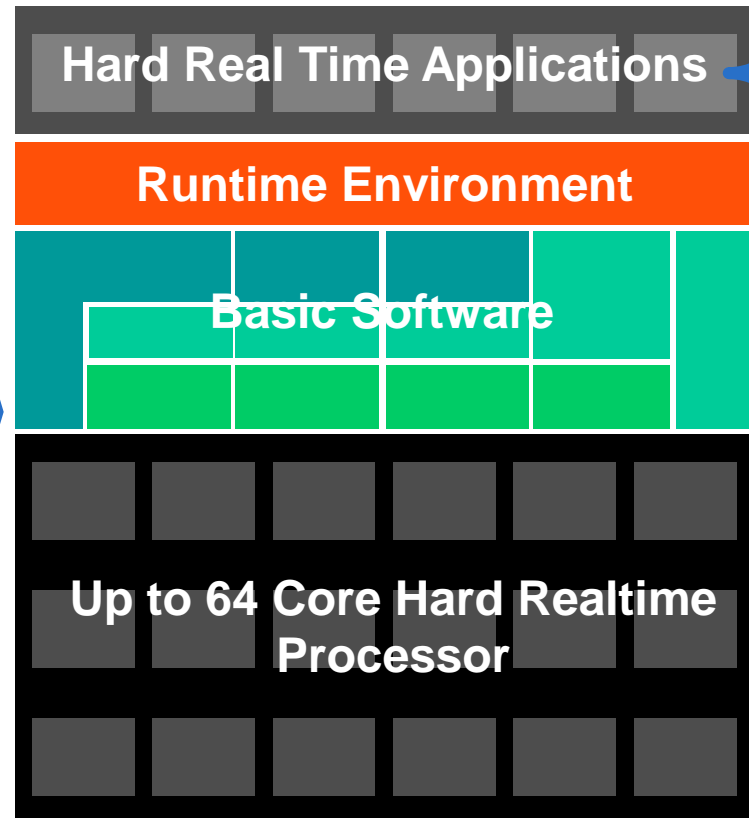
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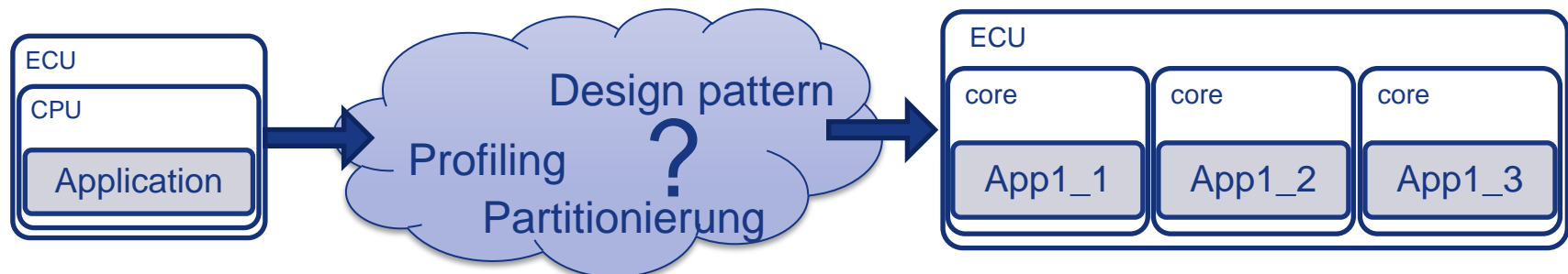
## parMERASA Scope

Analysis & Parallelization Support Tools

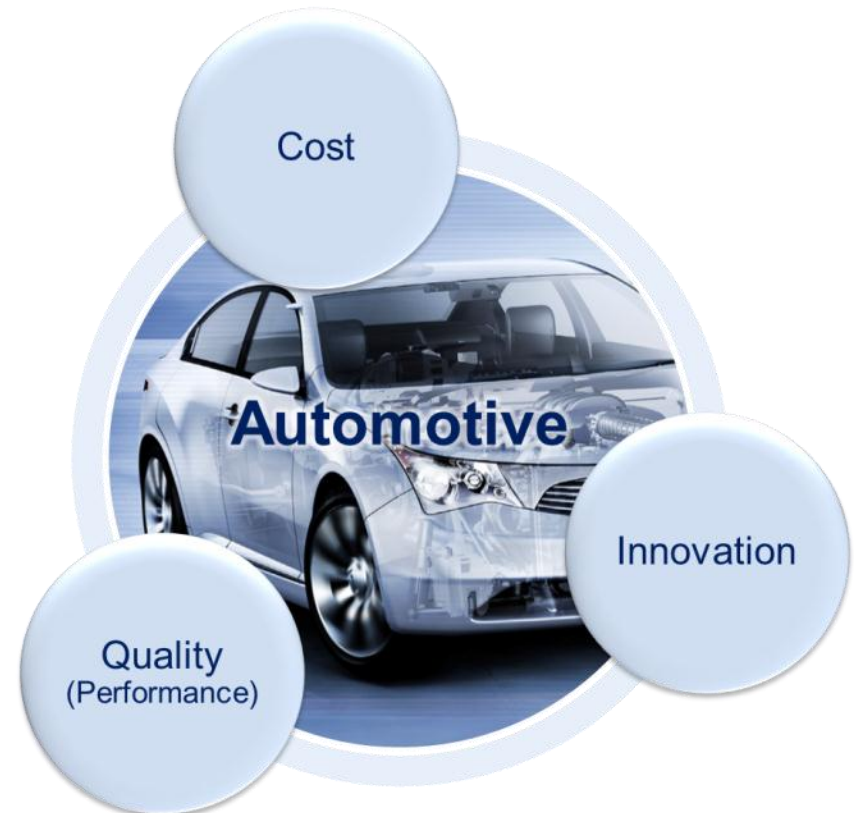


## parMERASA relevance for automotive

- How to parallelize automotive applications while preserving the real time properties?
- Safe scheduling (not only in multi core ECUs)
- Where are the limits for parallelization of automotive applications?
- Use cases
  - Fuel efficient engine control
  - Vehicle internal router
  - High integration - compound ECU

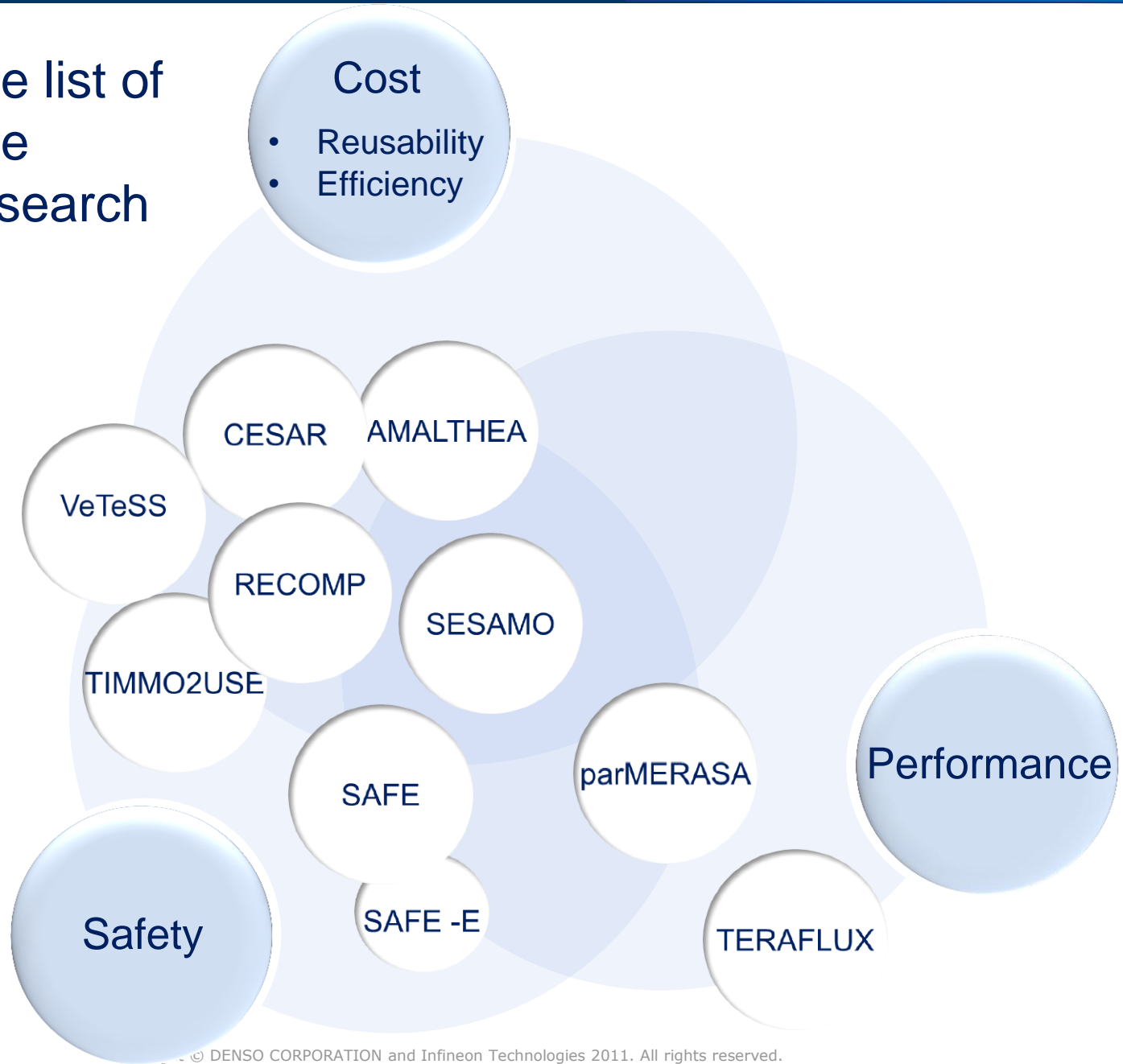


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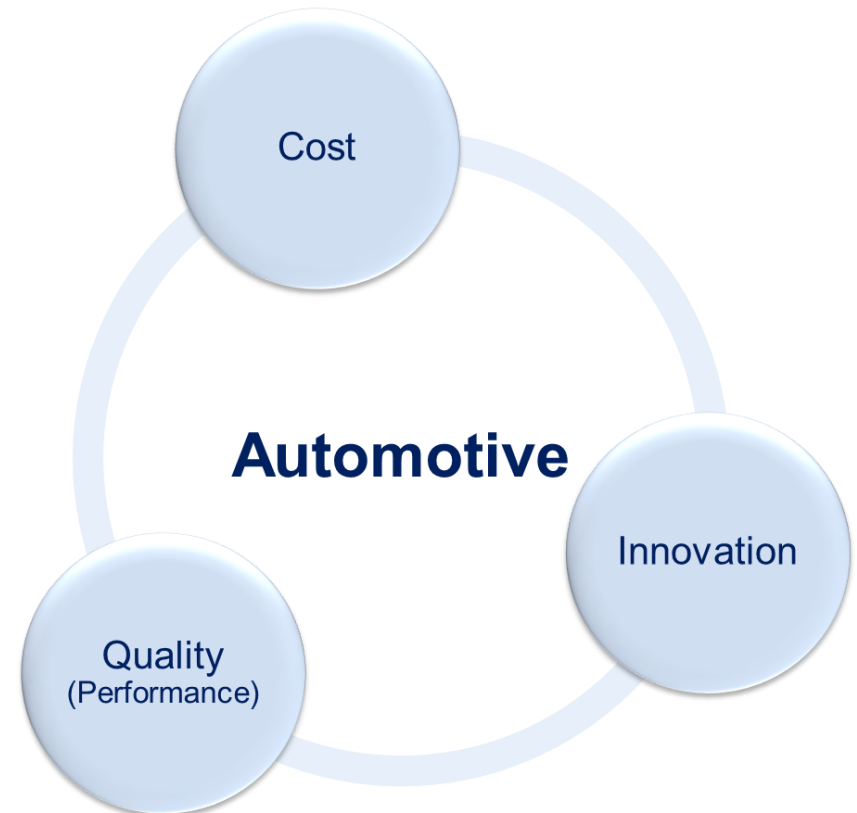


# Public Research Landscape

Incomplete list of automotive related research projects



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- AUTOSAR is a key enabler of future electronics and SW for automotive industry!
  
- Public research → important source of innovation!
  
- Future concerns of AUTOSAR:
  - **Fragmentation**: How to master different releases, how to prevent cherry picking and simplified subsets in BRICS?
  - **Speed**: Consumer standards evolution (integration)

# Questions