AUTOSAR and Functional Safety

Simon Fürst, BMW Group

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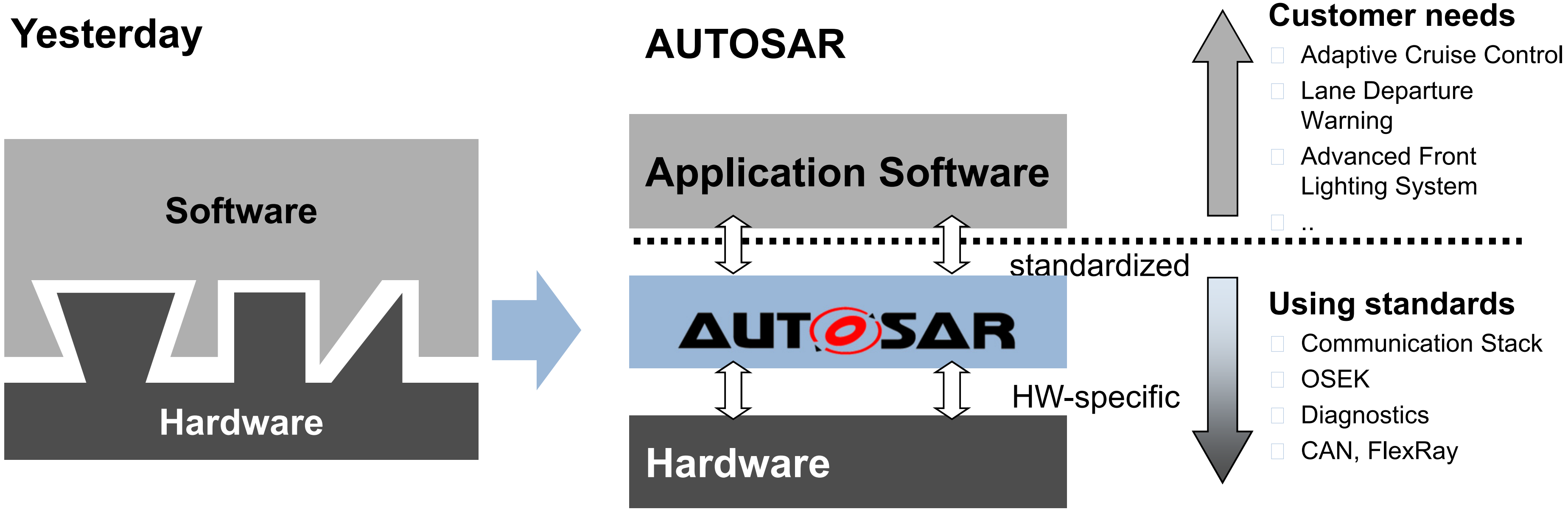
AUTOSAR and Functional Safety
Overview

Basic aspects of AUTOSAR architecture and methodology

- Safety mechanisms supported by AUTOSAR
- Technical safety concepts supported by AUTOSAR
- Relationship to ISO 26262 and Conclusion

AUTOSAR and Functional Safety
AUTOSAR Vision

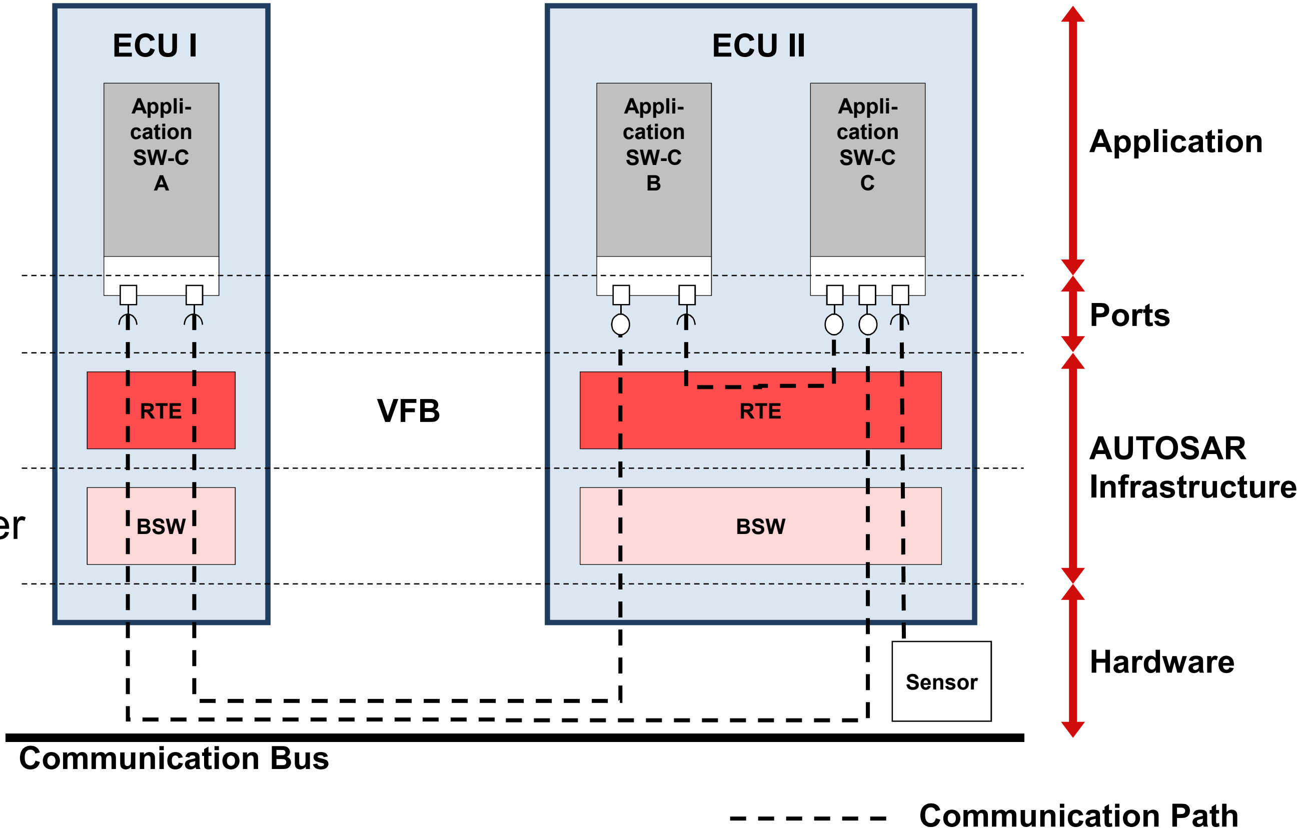
AUTOSAR aims to standardize the software architecture of ECUs.
AUTOSAR paves the way for innovative electronic systems that further improve performance, safety and environmental friendliness.



- Hardware and software will be widely independent of each other.
- Development can be de-coupled by horizontal layers. This reduces development time and costs.
- The reuse of software increases at OEM as well as at suppliers. This enhances quality and efficiency.

AUTOSAR and Functional Safety
Intra- and Inter-ECU Communication

- Ports implement the interface according to the communication paradigm (here client-server based).
- Ports are the interaction points of software components.
- The communication is channeled via the RTE.
- The communication layer in the basic software is encapsulated and not visible at the application layer.



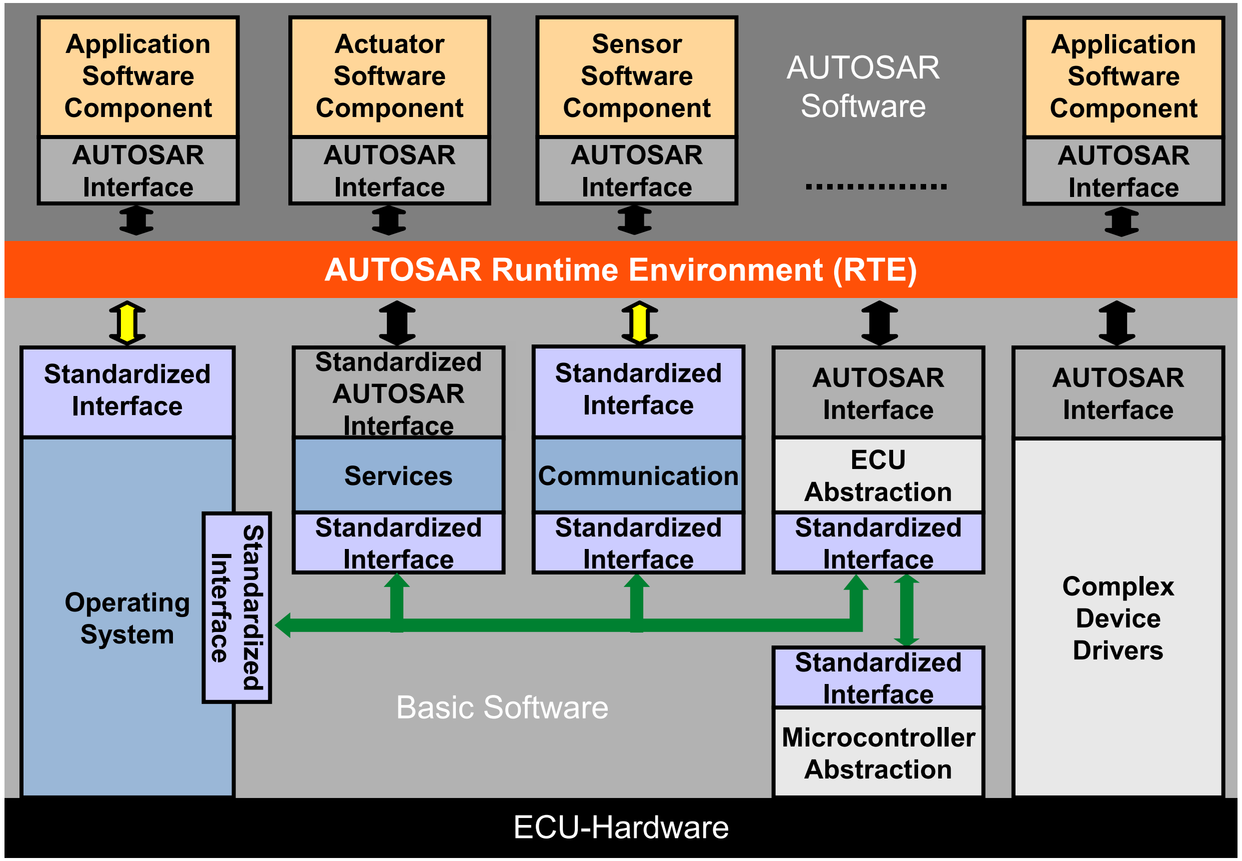
AUTOSAR and Functional Safety
Software Architecture – AutOSAR Defined Interfaces

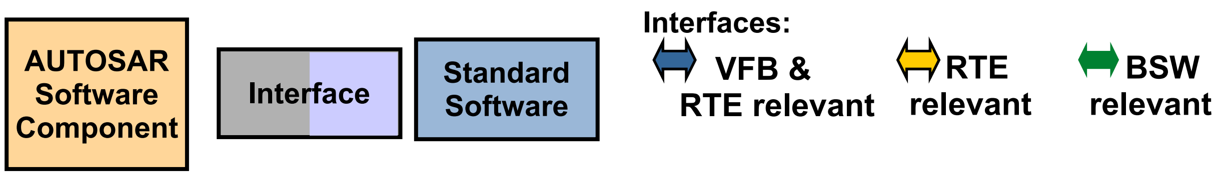
Automotive Open System Architecture (AUTOSAR):

- Standardized, openly disclosed interfaces
- HW independent SW layer
- Transferability of functions
- Redundancy activation

AUTOSAR RTE:

by specifying interfaces and their communication mechanisms, the applications are decoupled from the underlying HW and Basic SW by the RTE. This enables the realization of re-usable application software components.





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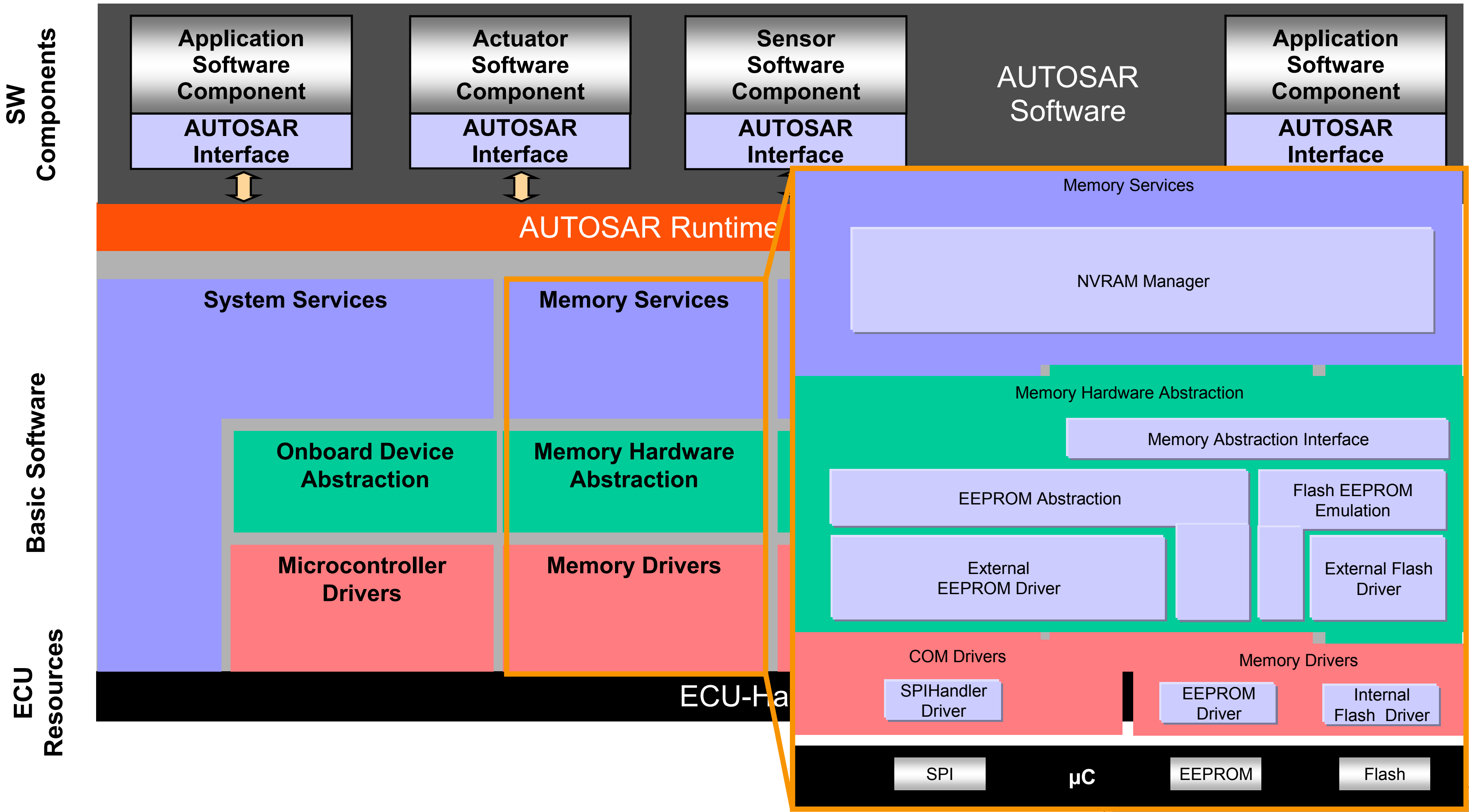
Software Architecture: Software Abstraction inside the Infrastructure Architecture

The Basic Software Layers are further divided into functional groups.
Each functional group consist of multiple basic software modules.



Methodology and Templates: The AUTOSAR Meta Model

The AUTOSAR Meta Model

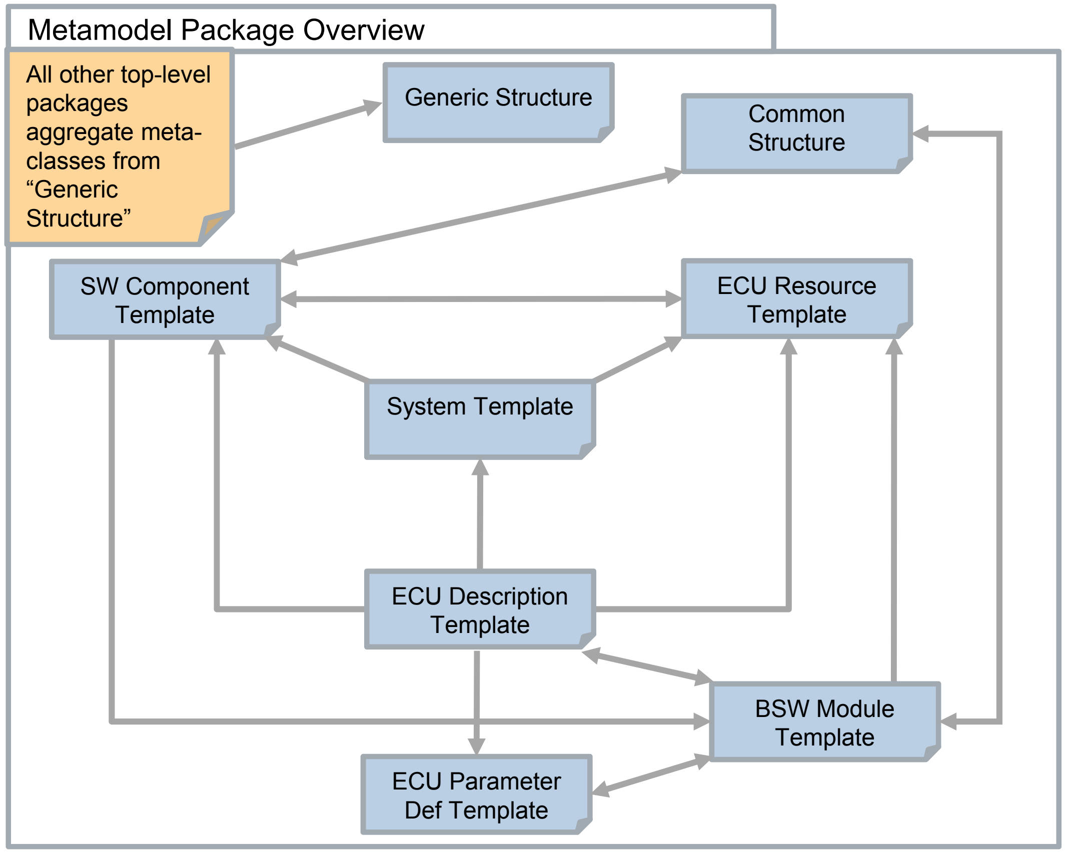
- is the backbone of the AUTOSAR architecture definition
- contains complete specification, how to model AUTOSAR systems

M3: Model of the Meta Model (Meta-Meta Model) (Defines UML Modeling Elements)

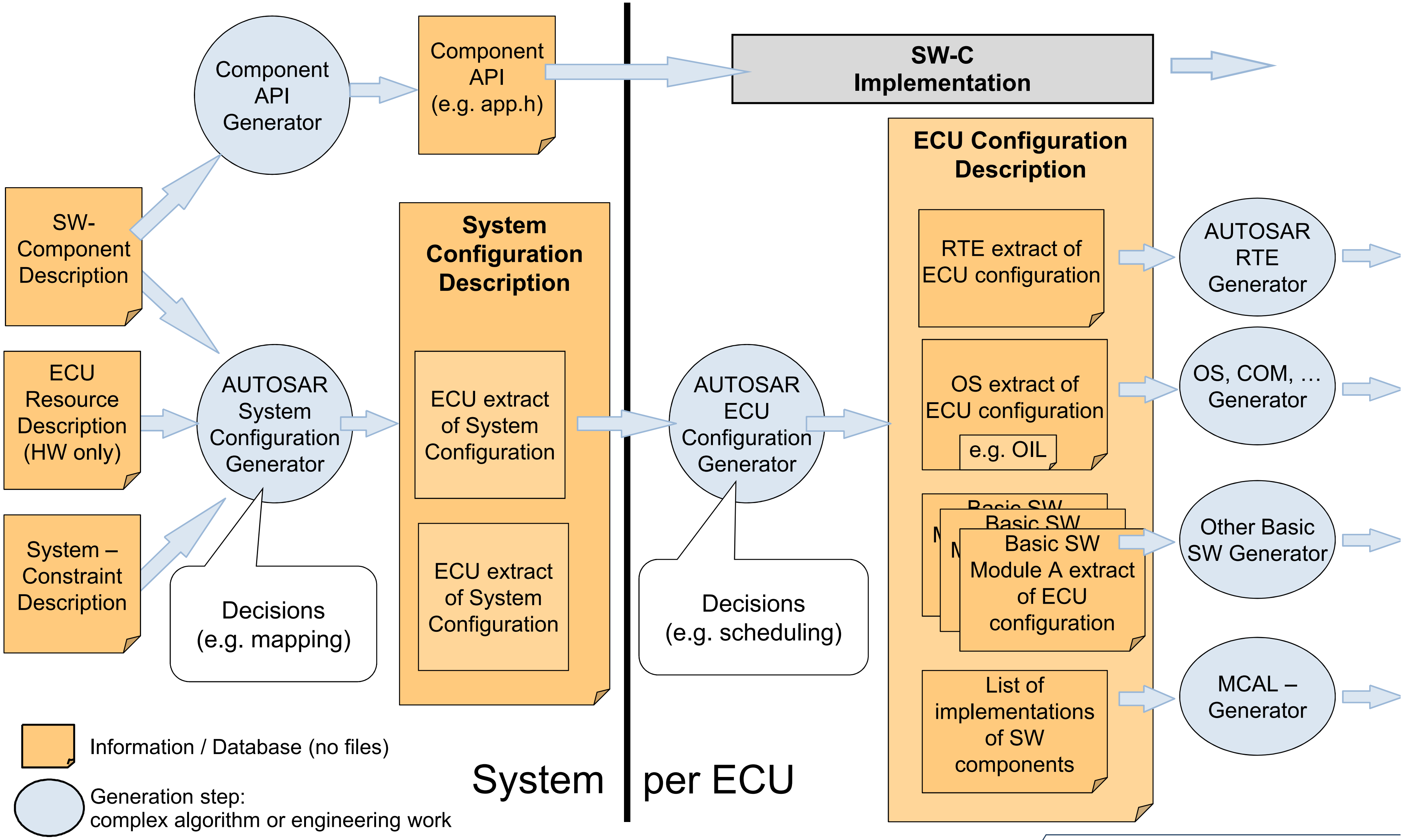
M2: Model of the model (Meta Model) (Defines AUTOSAR Modeling Elements)

M1: Model of the system (Defines a real system)

M0: Realized System in the car (Implements a real system)



AUTOSAR and Functional Safety
AUTOSAR Methodology – Alternative Visualization



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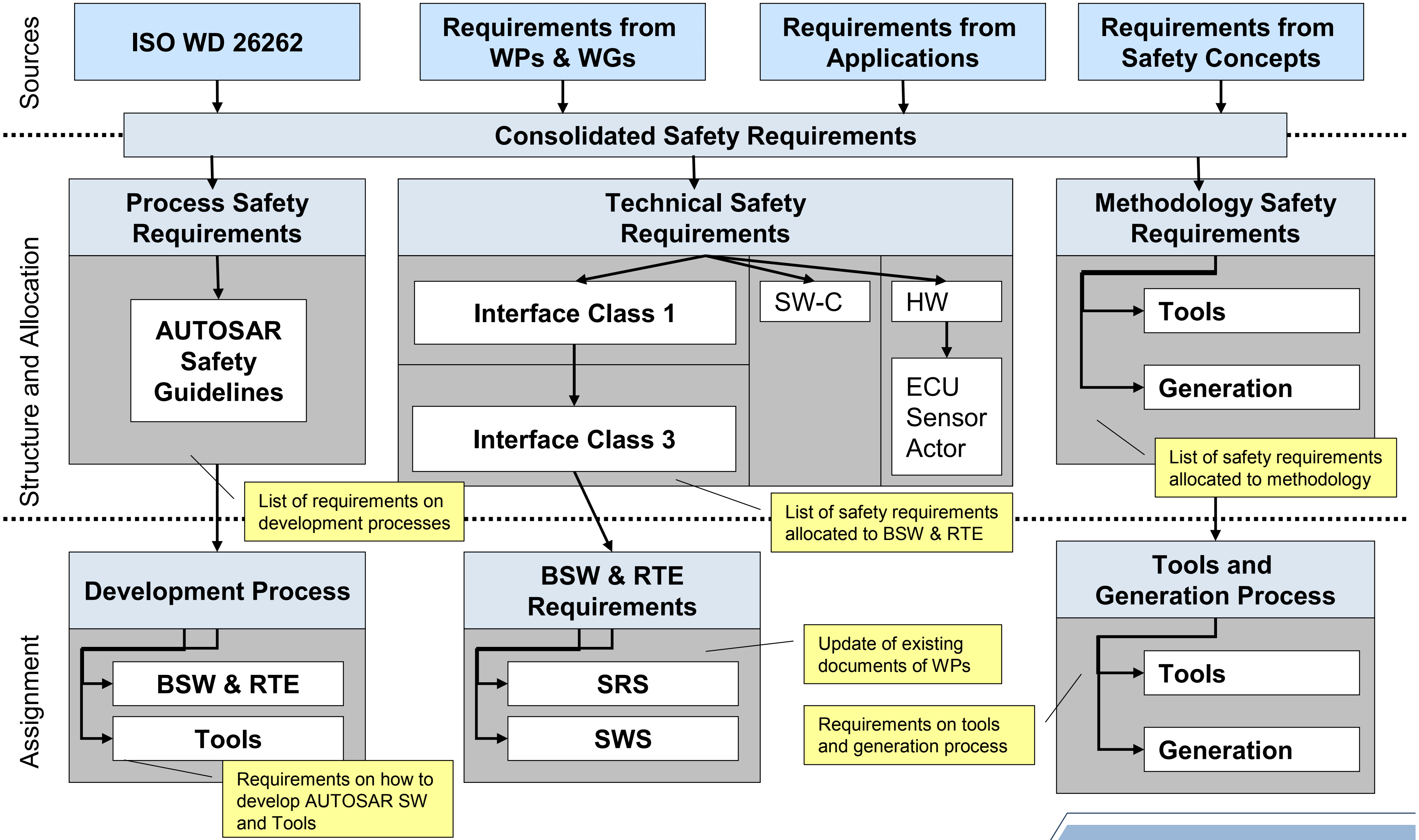
AUTOSAR and Functional Safety
Approach of AUTOSAR with regard to Functional Safety.



AUTOSAR and Functional Safety
Overview on Safety Mechanisms Supported by AUTOSAR

- Built-in self test mechanisms for detecting hardware faults (testing and monitoring)

- Run-time mechanisms for detecting software faults during the execution of software
  - Program flow monitoring

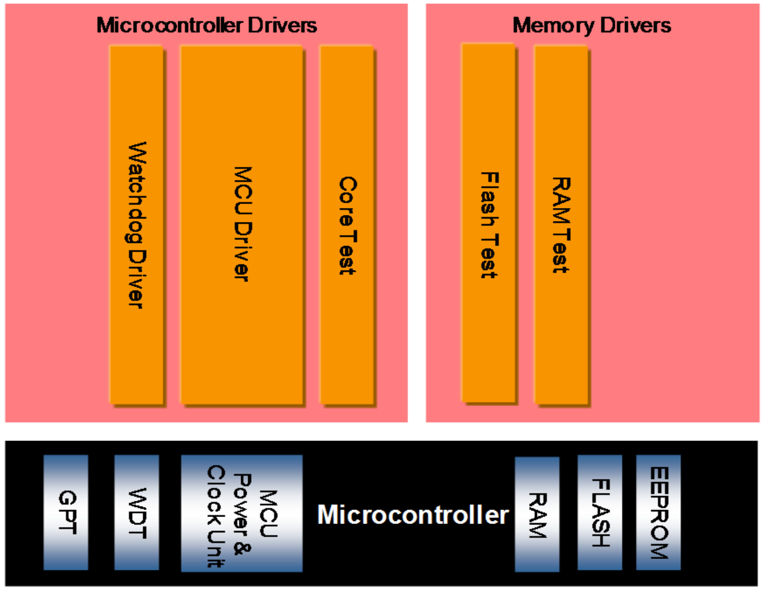
- Run-time mechanisms for preventing fault interference
  - Memory partitioning for SW-Cs
  - Time partitioning for applications

- Run-time mechanisms for protecting the communication
  - End-to-end (E2E) communication protection for SW-Cs

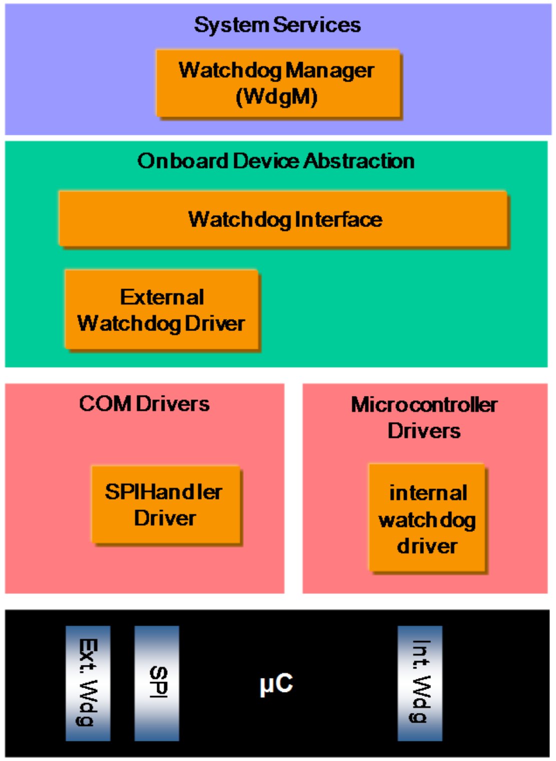
- Run-time mechanisms for error handling

AUTOSAR and Functional Safety
Safety mechanisms for detecting errors.

- Memory:
  - RAM Test
  - Flash Test
  - Support for ECC memory
- Core:
  - Core Test



- Watch Dog
  - Logical and temporal program flow monitoring



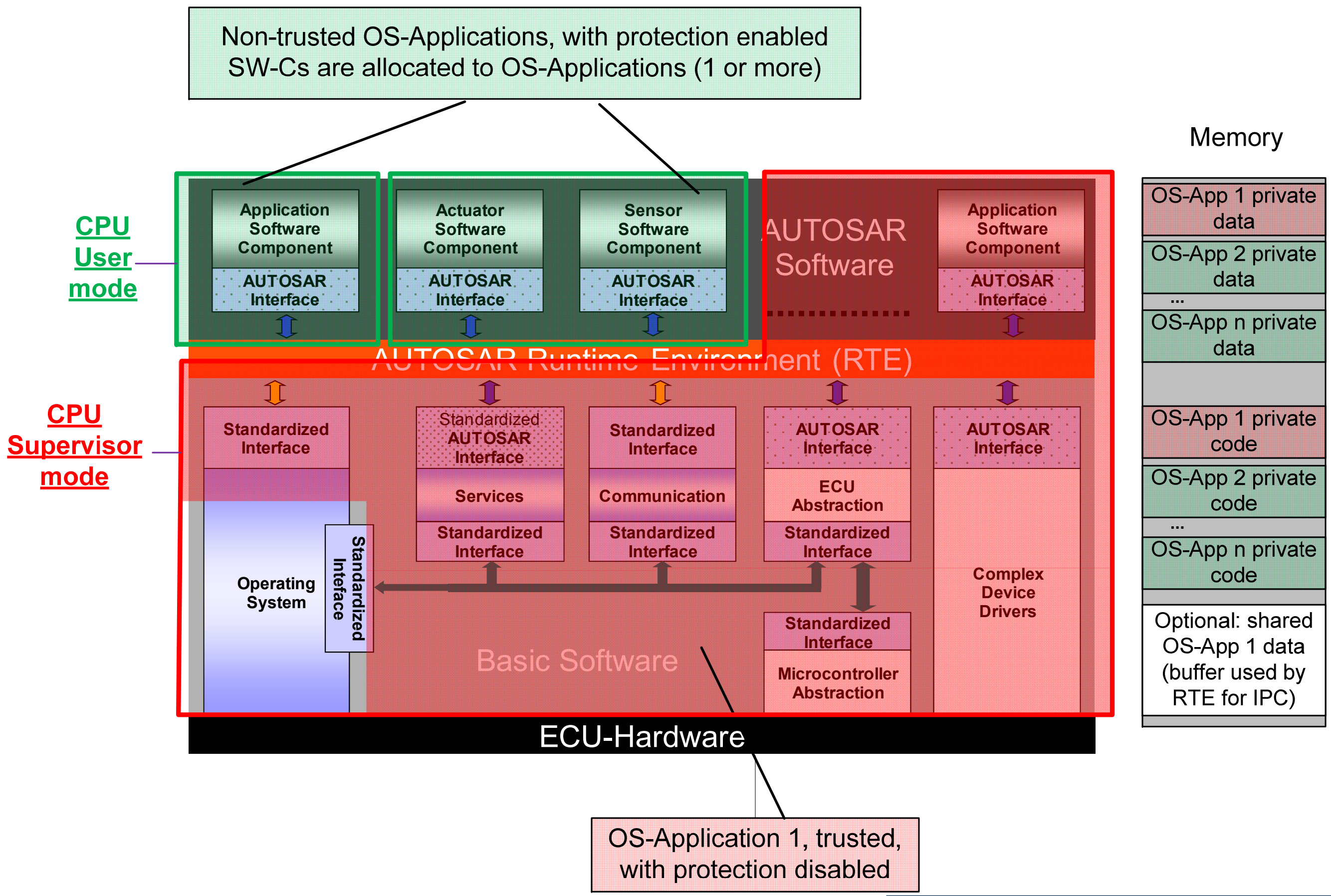
AUTOSAR and Functional Safety
Run-time mechanisms for error handling

- Detected errors in the basic software:
  - Are reported through DEM to SW-Cs. SW-Cs then executes application-specific actions
  - Are reported to FIM, which permits to disable some functions of SW-C

- Detected hardware errors:
  - Arithmetic exceptions (e.g. division by 0): handled by OS callouts (small error handling routines in the context of basic software). Typical reaction – ECU reset
  - HW errors detected by HW testing: handled by callouts. Typical reaction – ECU reset
  - Errors detected my MMU/MPU (memory and time partitioning). It will shut down or restart the faulty SW-C partition

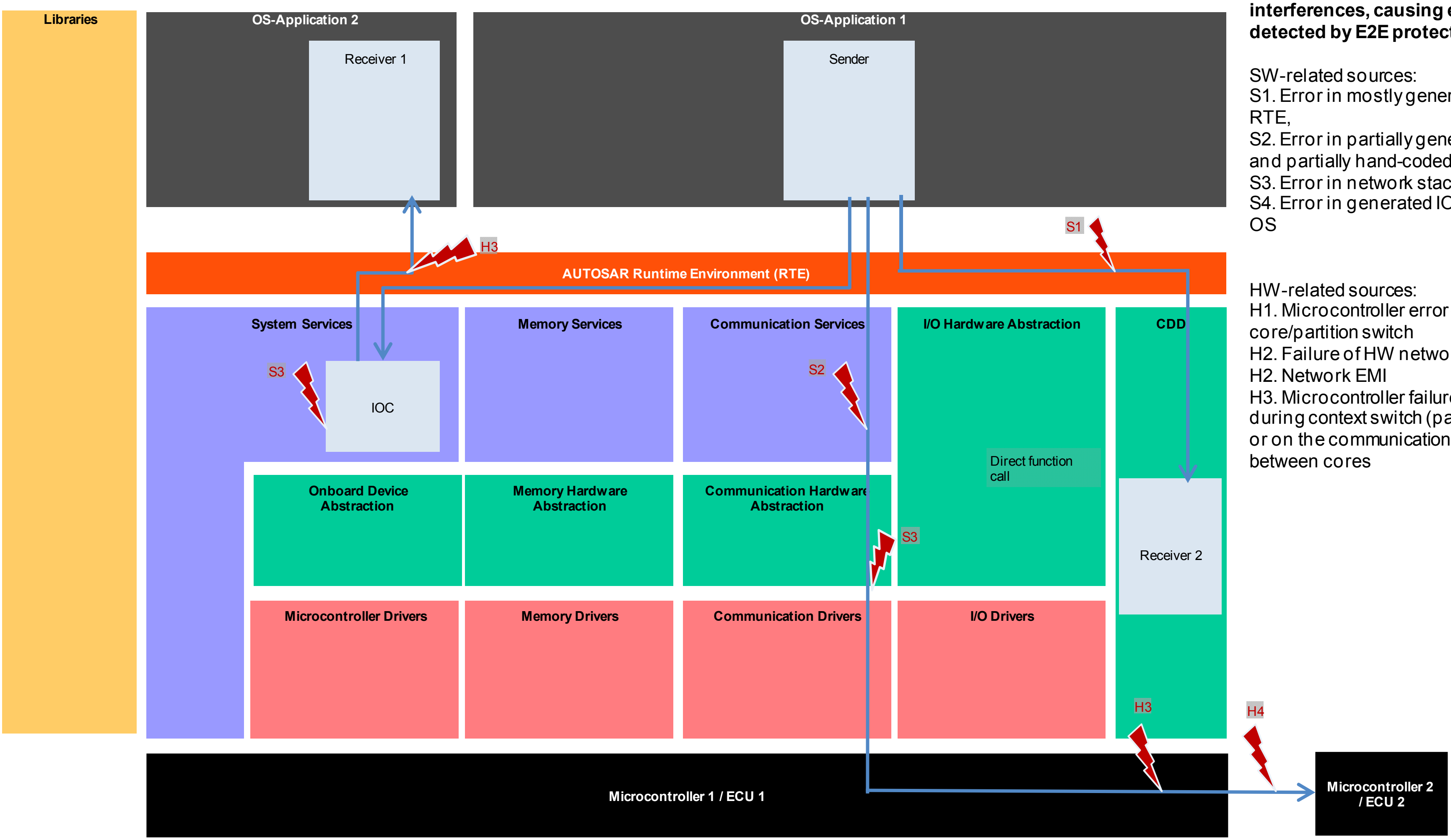
AUTOSAR and Functional Safety
Memory partitioning for Software-Components

- Enables create protection boundaries around groups of SW-Cs
- This is realized by user-mode/non-trusted memory partitions (for groups of SW-Cs)
- This protects from interference:
  (1) basic software and
  (2) SW-Cs in other partitions
- Basic software is not partitioned. It runs with in CPU super-visor mode with full access to memory, CPU and all other hard-ware resources



AUTOSAR and Functional Safety
End-to-End communication protection (1/4)

- E2E protection detects faults in data caused by both hardware and in software



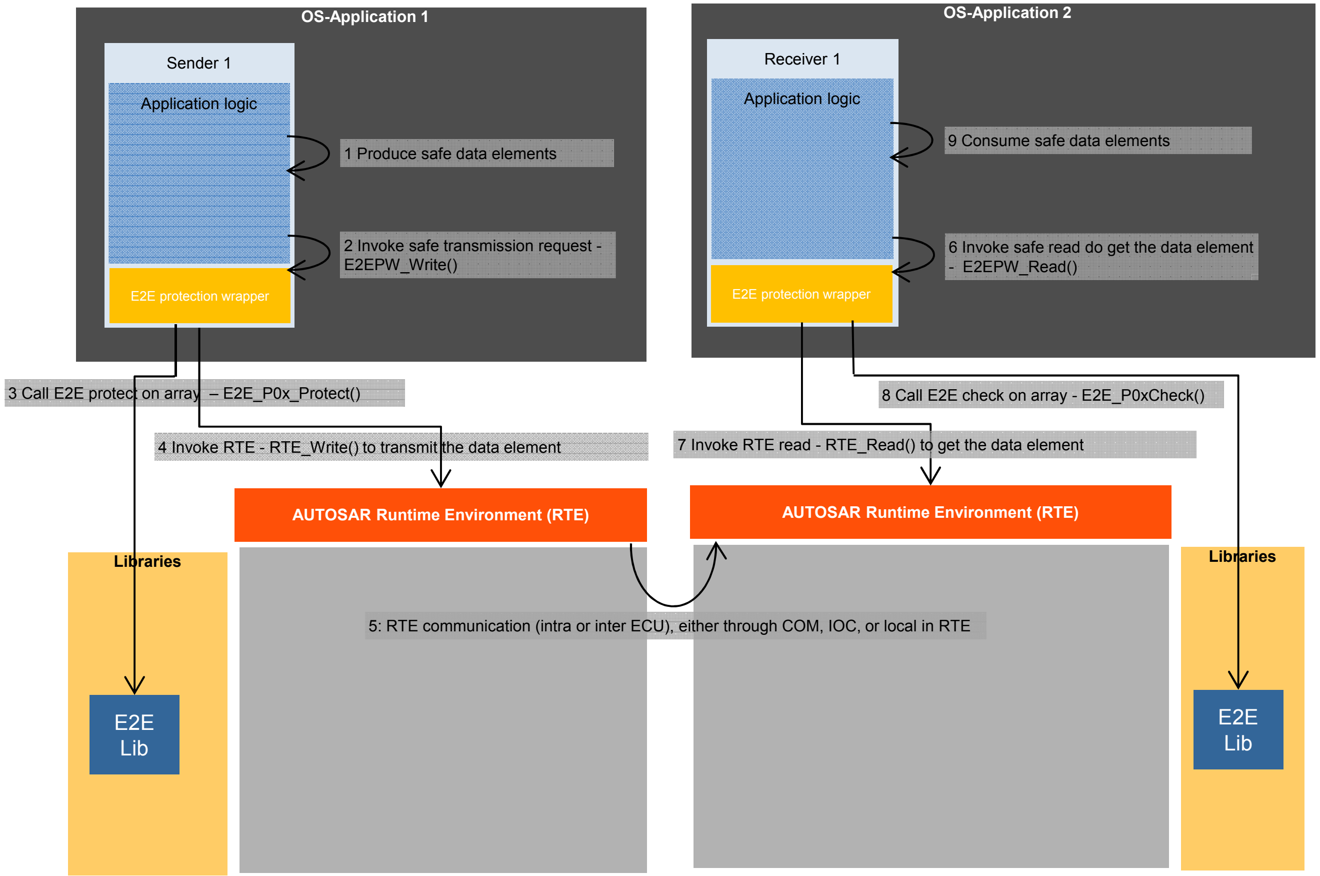
Typical sources of interferences, causing errors detected by E2E protection:

SW-related sources:
S1. Error in mostly generated RTE,
S2. Error in partially generated and partially hand-coded COM
S3. Error in network stack
S4. Error in generated IOC or OS

HW-related sources:
H1. Microcontroller error during core/partition switch
H2. Failure of HW network
H2. Network EMI
H3. Microcontroller failure during context switch (partition) or on the communication between cores

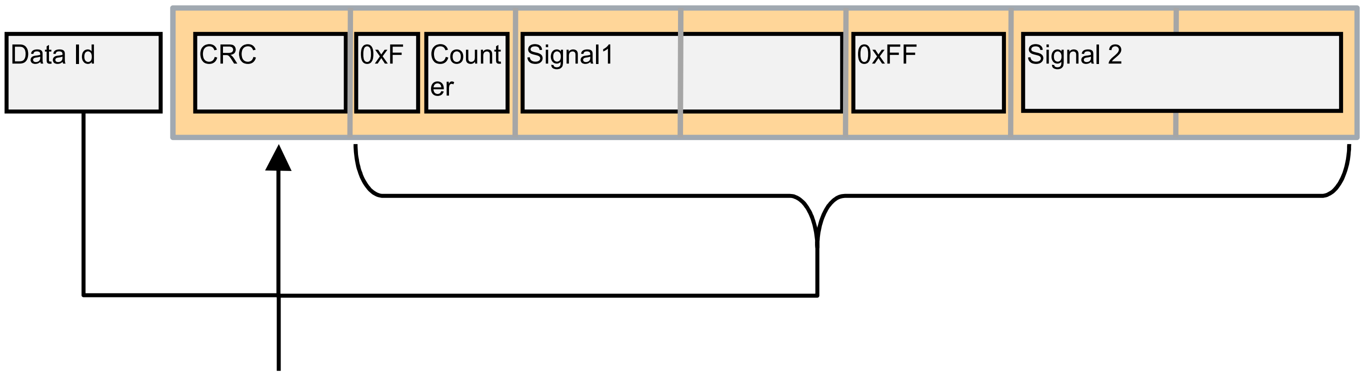
AUTOSAR and Functional Safety
End-to-End communication protection (2/4)

- Application is almost un-impacted by the introduction of end-to-end protection wrapper
- End-to-End protection wrapper protects/checks the communication on behalf of application, i.e. SW-Cs
- End-to-End Protection wrapper encapsulates the data protection and also invokes RTE



AUTOSAR and Functional Safety
End-to-End communication protection (3/4)

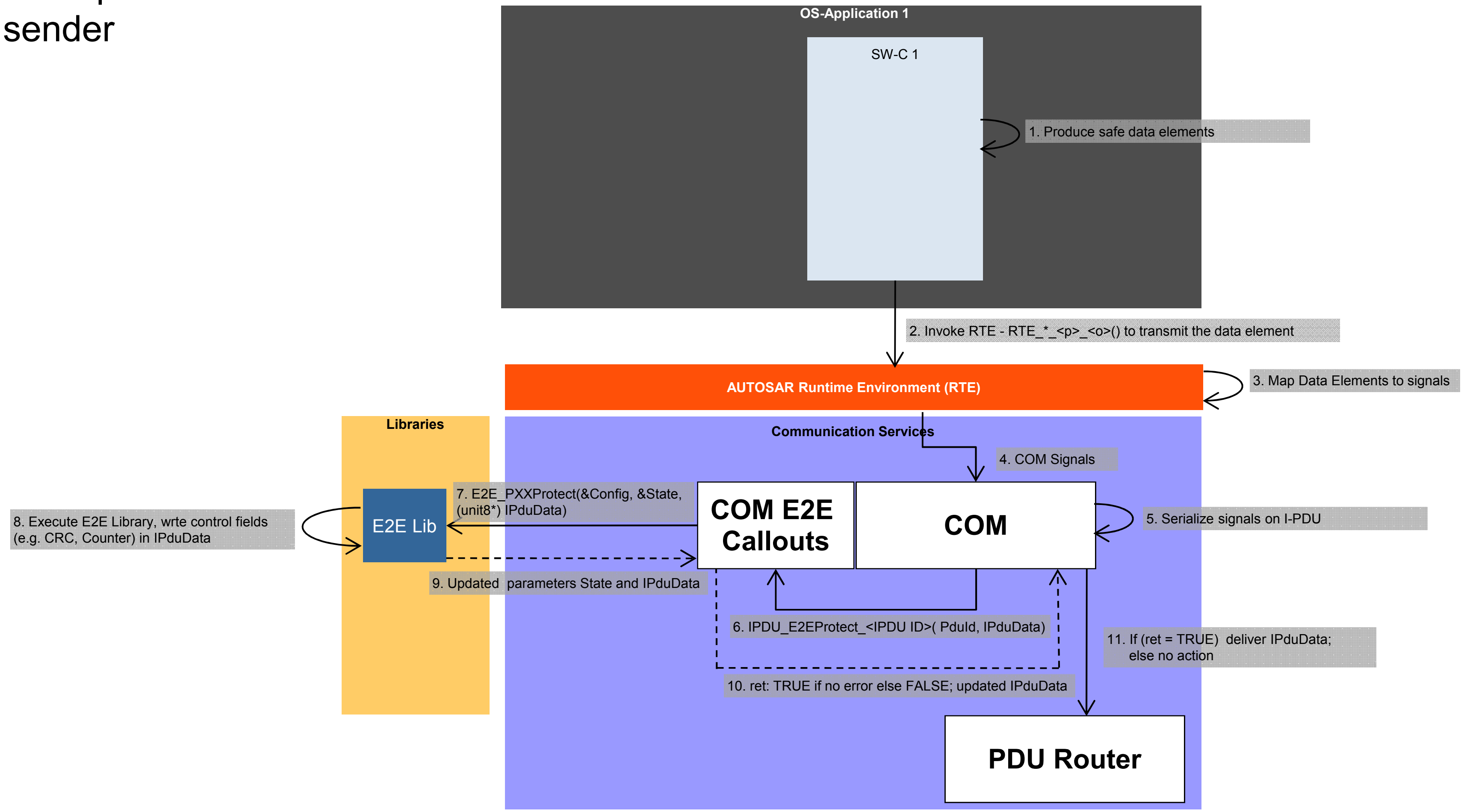
- Protection of data exchanged over communication channels like FlexRay and CAN
- Failure modes addressed as defined by ISO DIS 26262 for communication (repetition, deletion, insertion, incorrect sequence, corruption, timing faults, addressing faults, inconsistency, masquerading)
- Three different protection mechanisms for data are used
  - CRC, counter, Data ID, timeout detection
  - Data ID included in to calculated CRC, but not sent



CRC := CRC8 over
(1) Data Id,
(2) all serialized signal (including empty areas, excluding CRC byte itself)

AUTOSAR and Functional Safety
End-to-End communication protection: future considerations (4/4)

- Fully AUTOSAR compliant design with major impact on ASIL inheritance
  - Example: overall flow at sender



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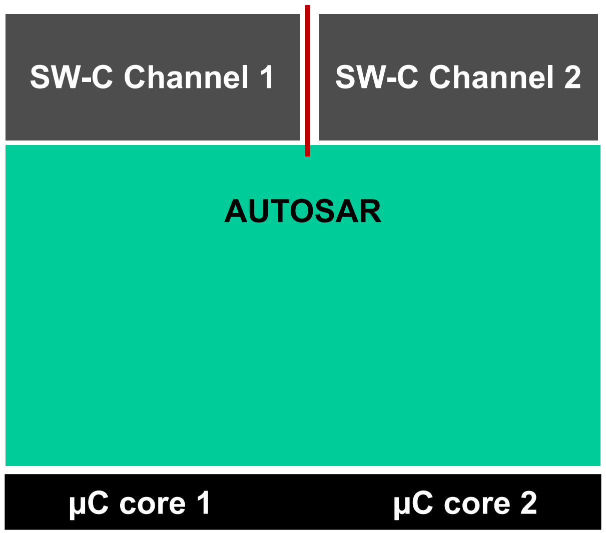
AUTOSAR and Functional Safety
Technical safety concepts supported by AUTOSAR

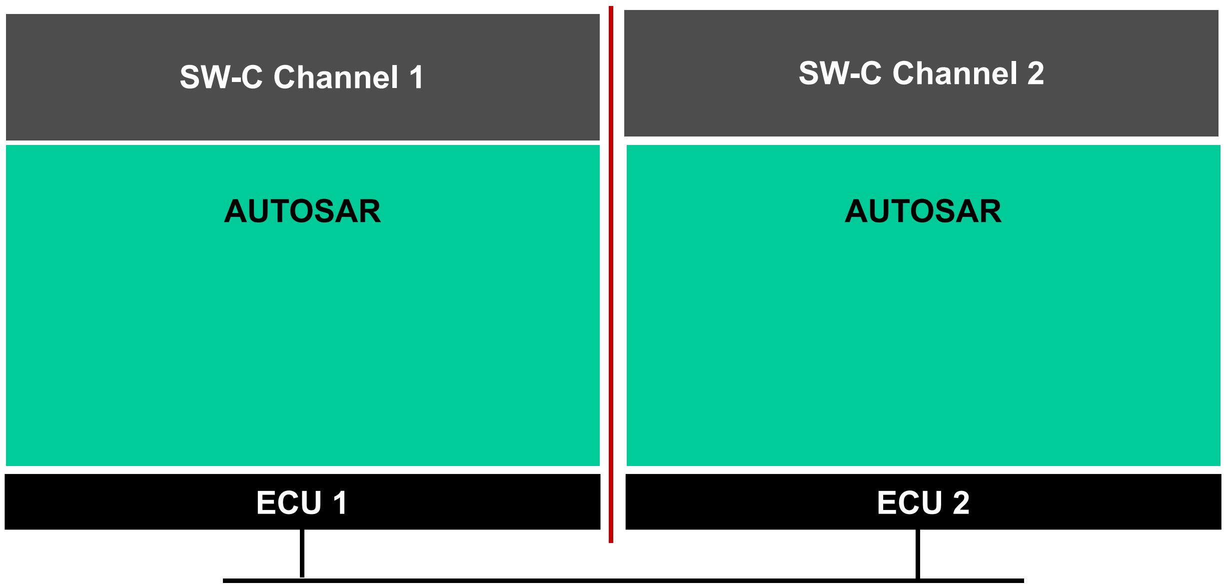
- Implementation of typical safety concepts in the automotive domain
  - Intelligent HW watchdog (ASIC) / 3-level safety concept
  - Monitored channel (2 µCs, the second is a simple µC monitoring the first µC)
  - Dual channel (2 AUTOSAR µCs)

- Application redundancy (on the same or different µCs)
- Basic Software redundancy inside one ECU

AUTOSAR and Functional Safety
Application redundancy

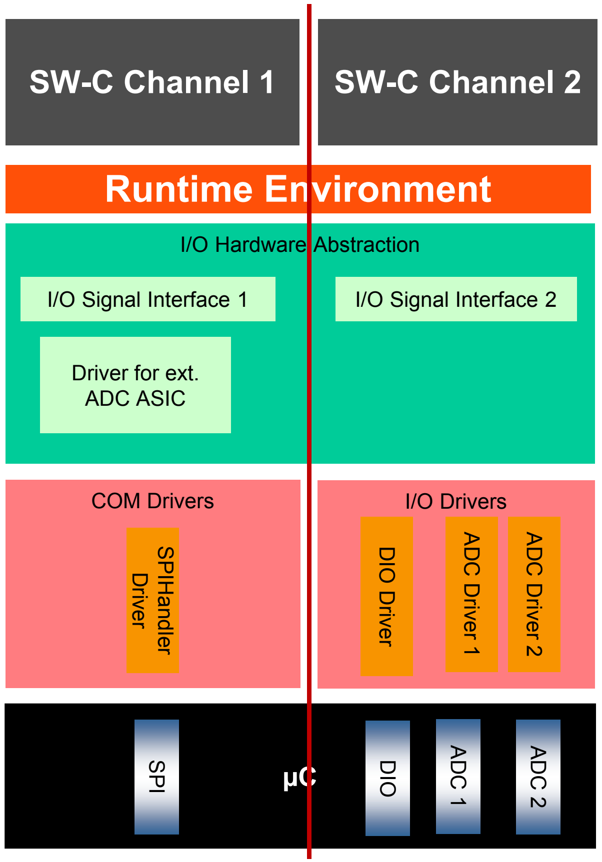
- Assuming integrity of HW/ECU and AUTOSAR basic software implementation, software redundancy with ASIL decomposition can be used within the same ECU.
- Distribution of SW channels across ECUs is also possible..

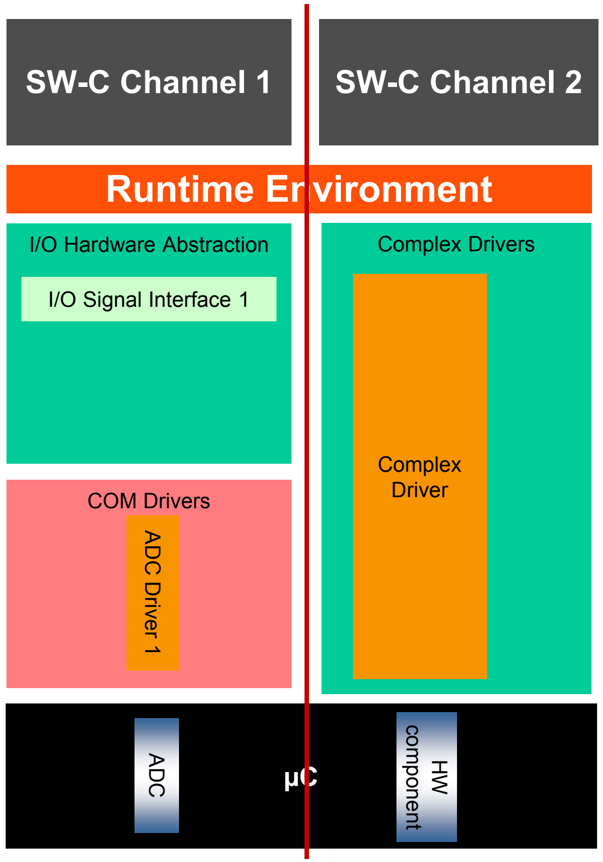




AUTOSAR and Functional Safety
Basic Software redundancy inside one ECU

- Redundancy inside AUTOSAR e.g. double input/output data paths through
  - Redundant IO hardware abstraction and IO drivers
  - Redundant and diverse (e.g. ADC + DIO, internal ADC + external ADC)
- Redundancy through integration of complex drivers running on the same µC offering a redundant data path





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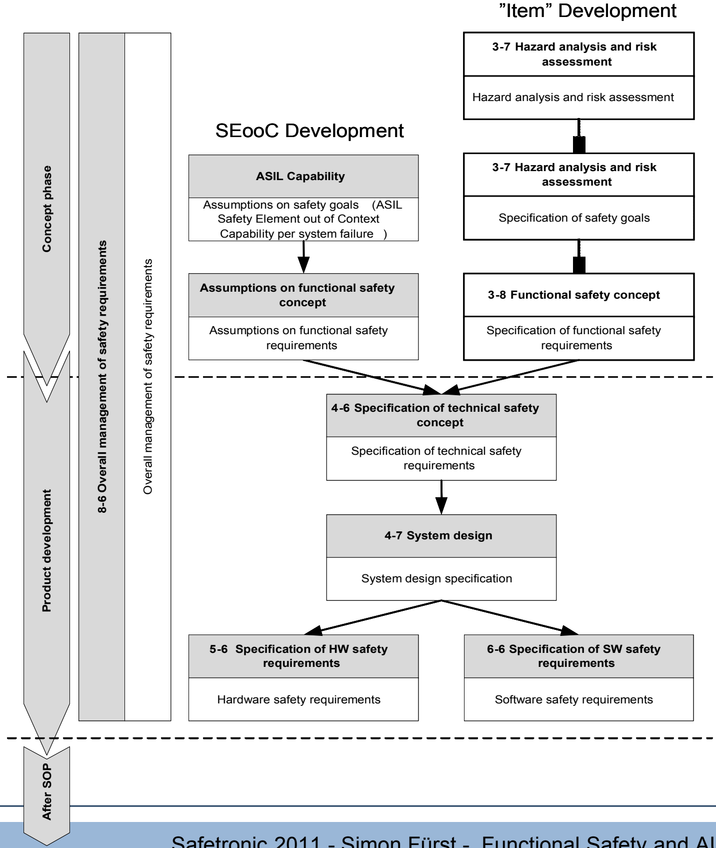
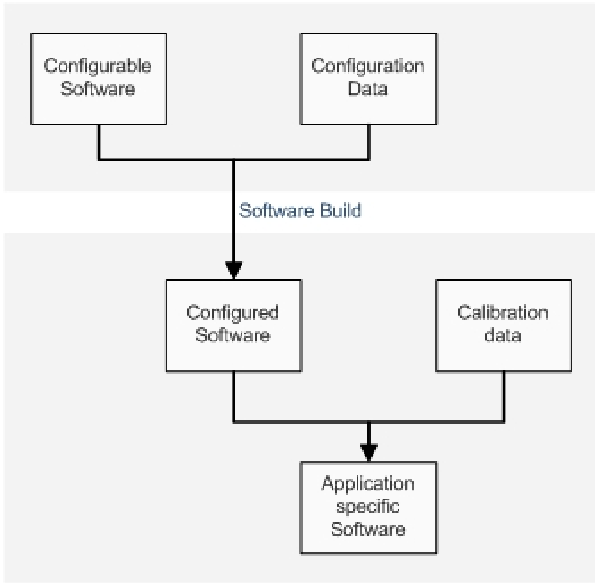
AUTOSAR and Functional Safety
Relationship to ISO 26262

- Essential concepts of ISO 26262 have been developed in sync with AUTOSAR
  - Software configuration — Part 6, Chapter 7 and Annex C
  - Freedom of interference by partitioning — Part 6, Chapter 7 and Annex D
  - Safety Element out of Context (SEooC) — Part 10, Chapter 9
  - Qualification of software tools — Part 8, Chapter 10



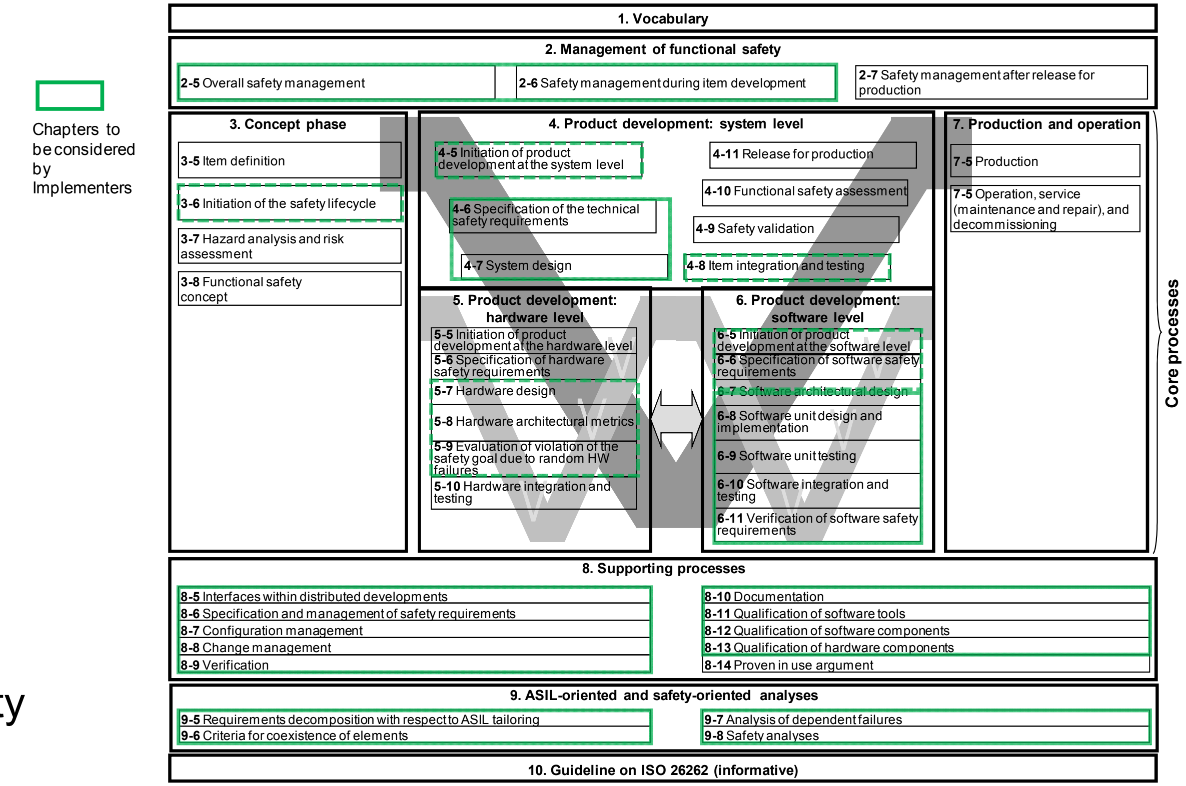


AUTOSAR and Functional Safety Relationship to ISO 26262

- Due to rules on ASIL inheritance defined in ISO 26262 the AUTOSAR basic software and RTE inherits safety relevance.
  - Either implement complete AUTOSAR basic software according to max. ASIL of application software or
  - demonstrate freedom of inference in basic software by appropriate mechanisms

- Implementers have to tailor ISO 26262 according to their activities in the safety-lifecycle

- For all implemented safety mechanisms a safety manual is needed containing
  - The fault model according to which the safety mechanism was developed
  - The constraints that must be fulfilled when applying a safety mechanism



AUTOSAR and Functional Safety
Conclusion

- AUTOSAR systematically derived safety mechanisms supported in release 4.0
- AUTOSAR provides support for dedicated safety mechanisms with generic fault models
- AUTOSAR supports typical technical safety concepts
- During system and software design the safety manual is considered to appropriately use the safety mechanisms of an AUTOSAR implementation.

AUTOSAR provides essential support for building of safety related systems