Ensuring Reliable Networks TTTech

From AUTOSAR Adaptive to a Safe Level 4 ADAS Platform

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- ADAS ECU - TTIntegration Platform Approach and Validation Support
- Experience from Level 3 series projects
- TTIntegration and AUTOSAR Adaptive
- The fail-operational Level 4 challenge
- Putting it all together

ADAS Domain ECU Architecture – Scalable and Flexible Architecture

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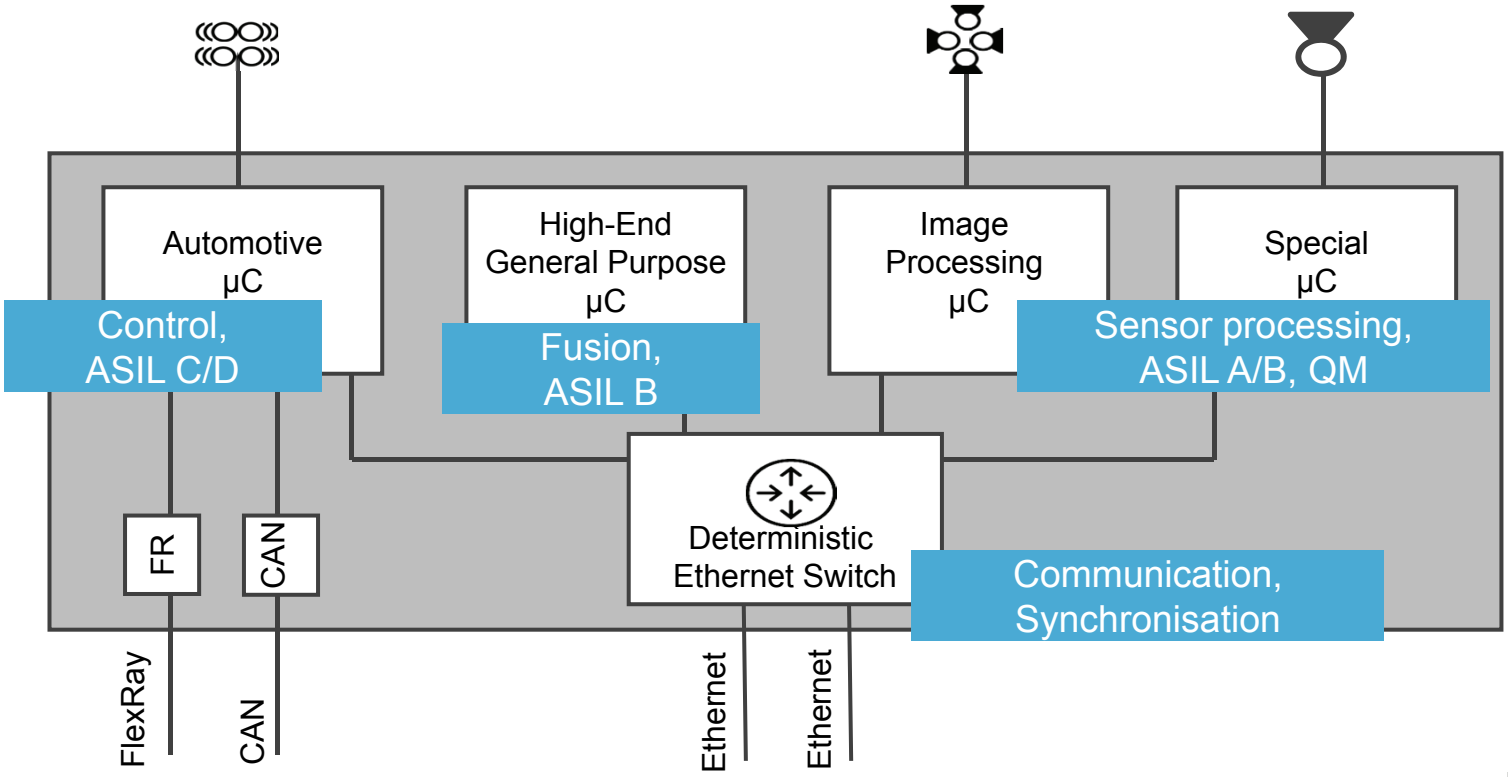

Ad Hoc Software Architecture

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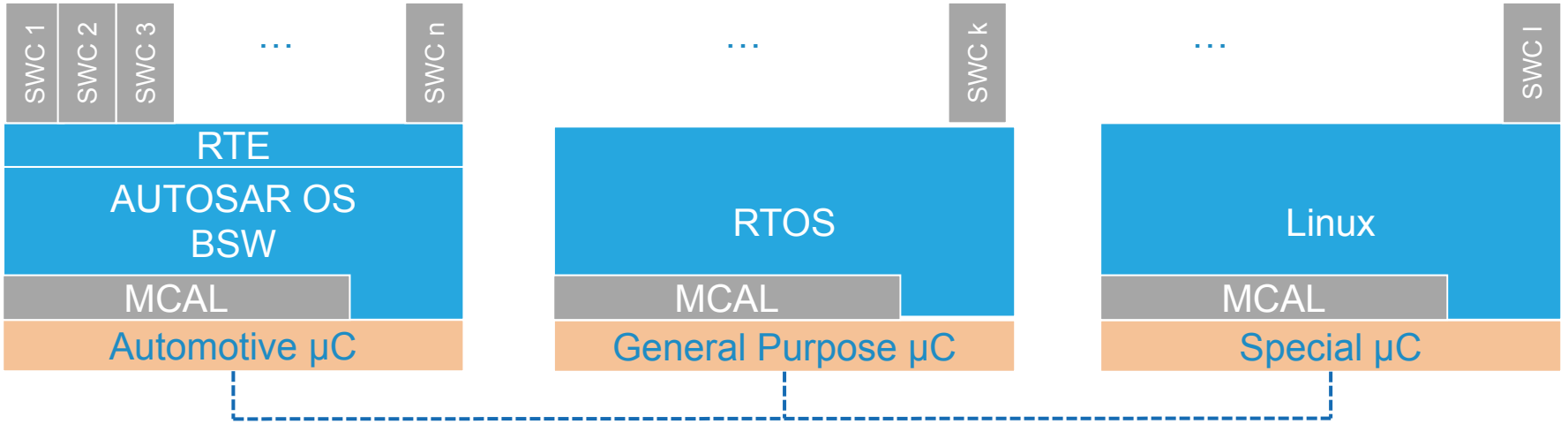

- Different APIs, no SWC portability
- Inhomogeneous basic services, tool and integration landscape
- „Manual“ interface adaptation between SWCs

Integrated Software Architecture – Integration and Validation Support

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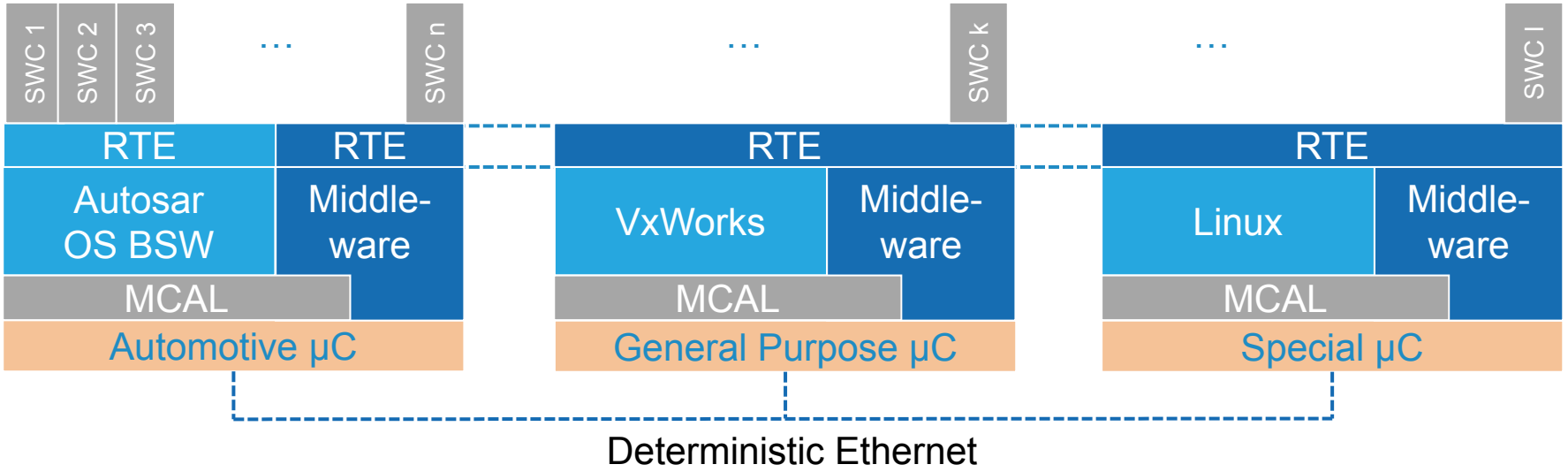

- Uniform basic services on all Hosts
- SWCs can be moved between Hosts
- Integrated Tooling and SWC integration process

PC-based SW-in-the-Loop Simulation (SIL)

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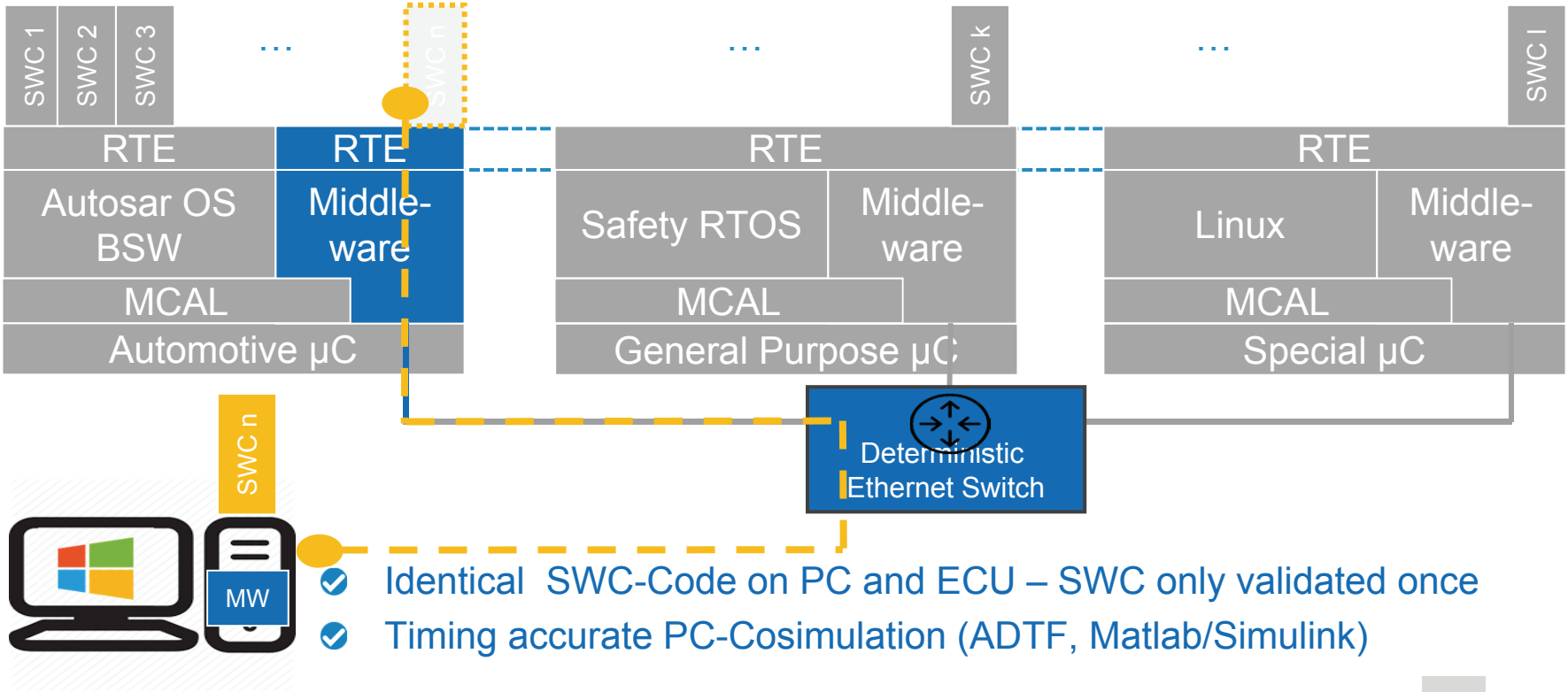

- Identical SWC-Code on PC and ECU – SWC only validated once
- Timing accurate PC-Cosimulation (ADTF, Matlab/Simulink)

Debugging & Tracing – Validation Support using Open Standards

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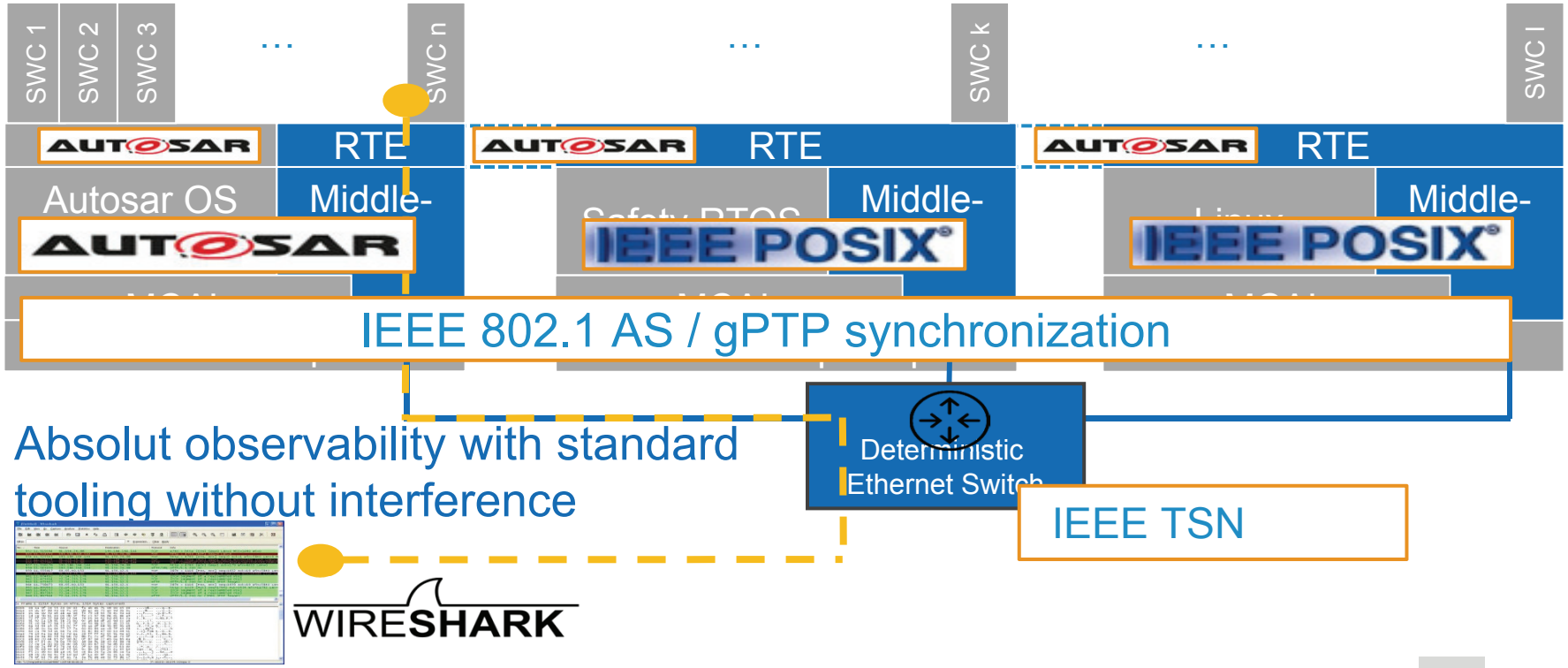

Software Integration of Complex Real-Time Systems

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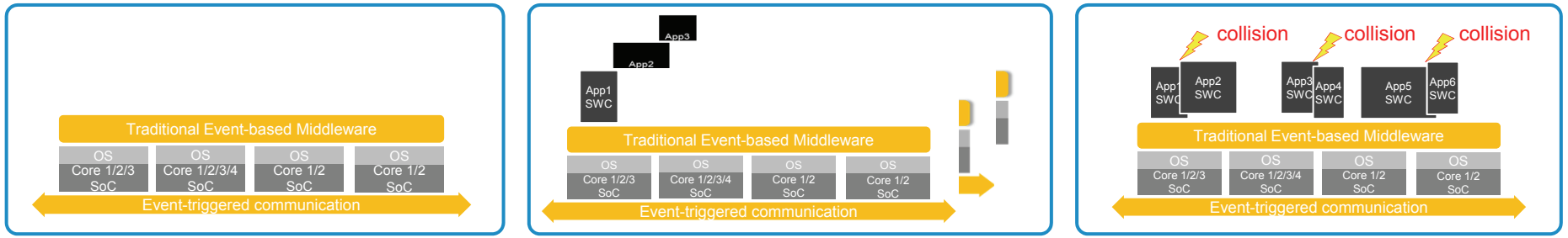
1. Integration of platform without configuring execution frames

2. Applications are integrated and tested individually by SWC suppliers without any timing restrictions

3. All applications are integrated by the SW-integrator on the platform; conflicts start immediately as it is not clear who is causing problems and why



4. Conflicts are reported back to function SW suppliers, applications have to be modified to meet the system‘s timing restrictions

Modular Platform - Reduced Integration and Validation Efforts

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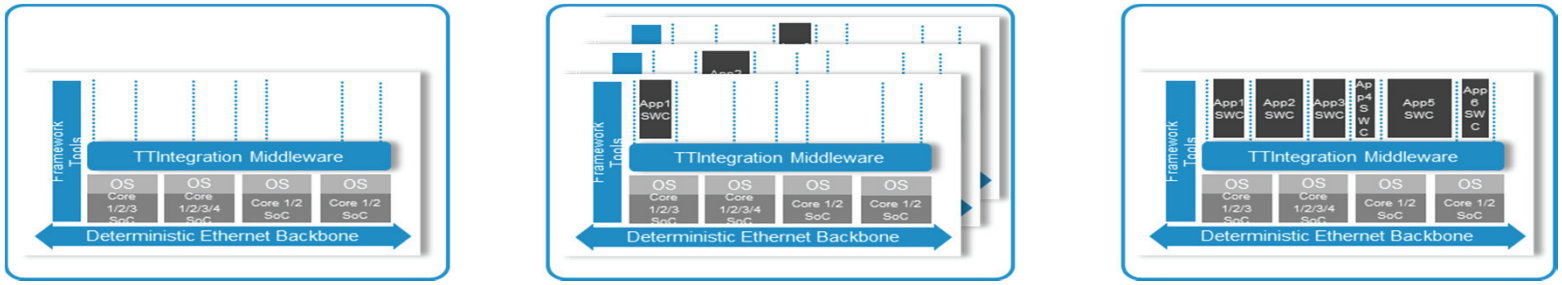
Integration process massively accelerated

Iterations are avoided



1. Platform configuration and application scheduling
2. Single SWC test within configured schedule
3. SWCs are instantly running together (“composability”)

Insights from Serial Development

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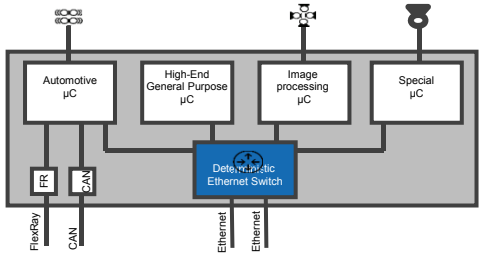
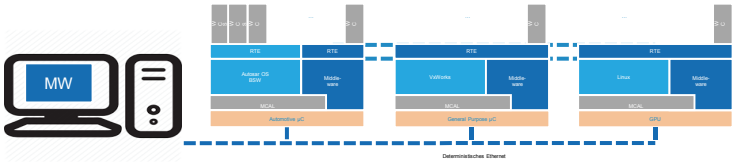
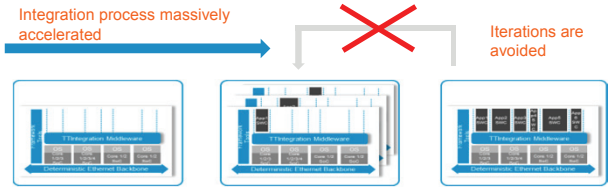
Providing a clean platform architecture requires only very little HW-Overhead (Switch)



Middleware features are intensively used (flexible SW allocation, PC co-simulation, debug features)



A clearly defined integration process is very helpful for the work spilt between suppliers, dependencies and release organization



Next Generation – Diverse Application Interfaces with AUTOSAR Adaptive

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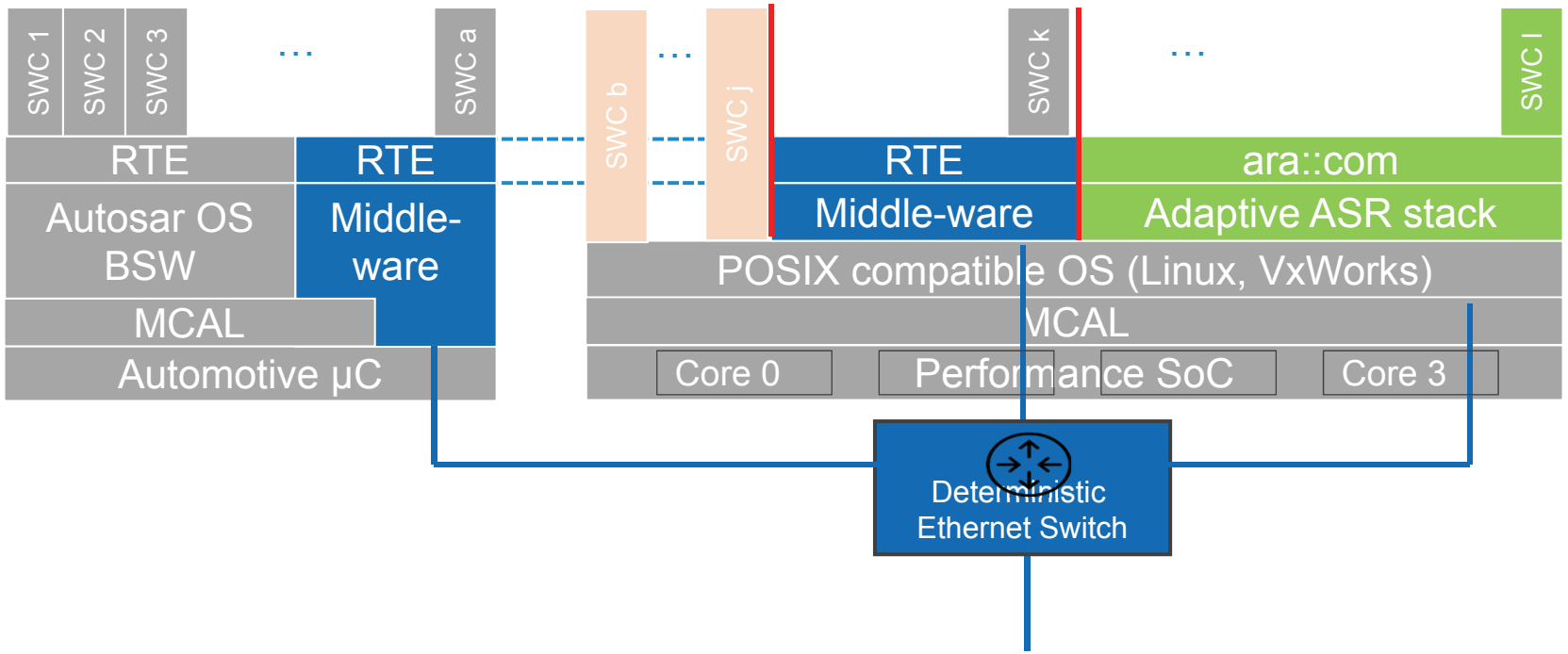

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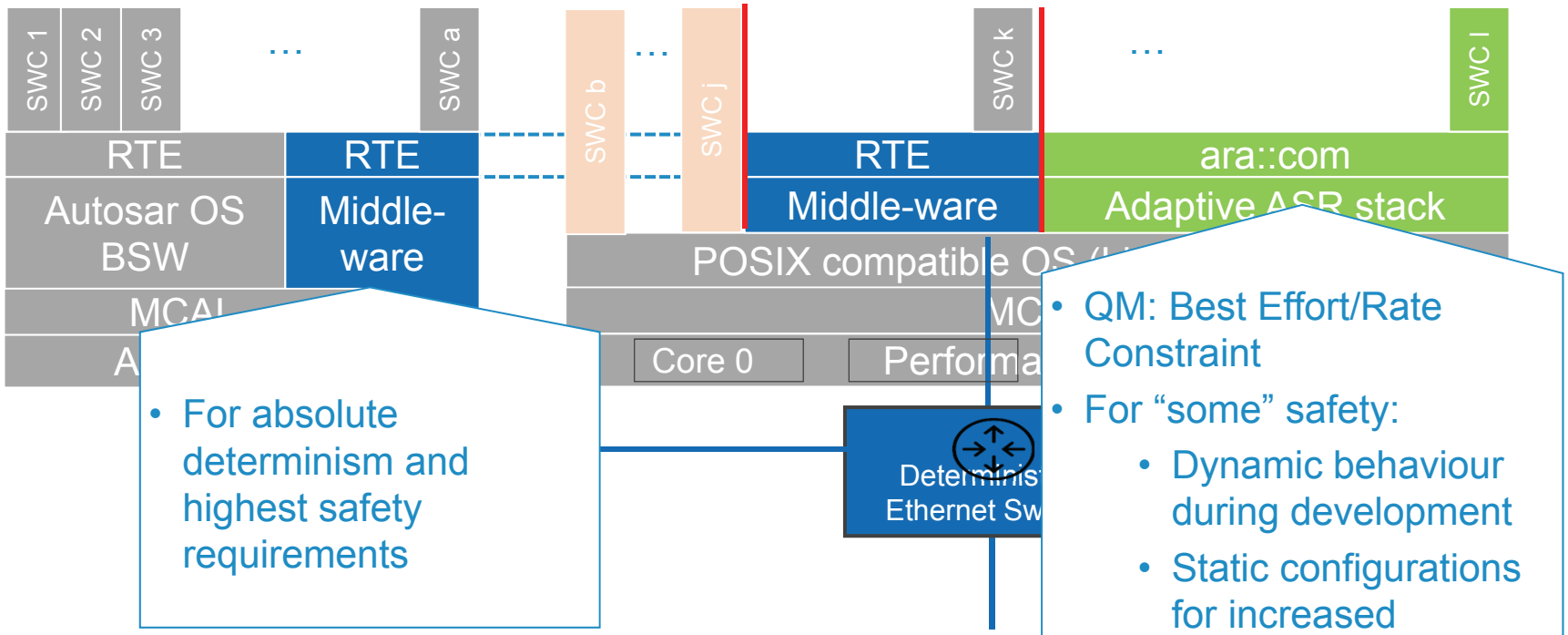

Next Generation – Diverse Application Interfaces with AUTOSAR Adaptive

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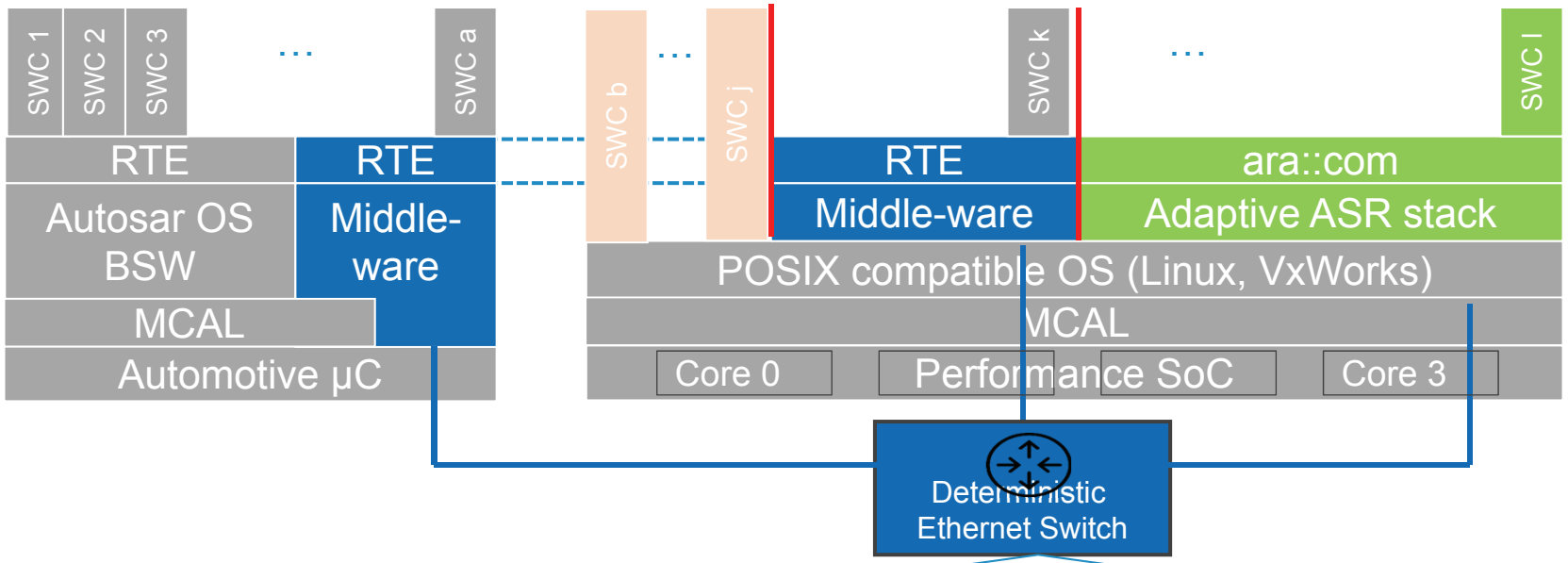
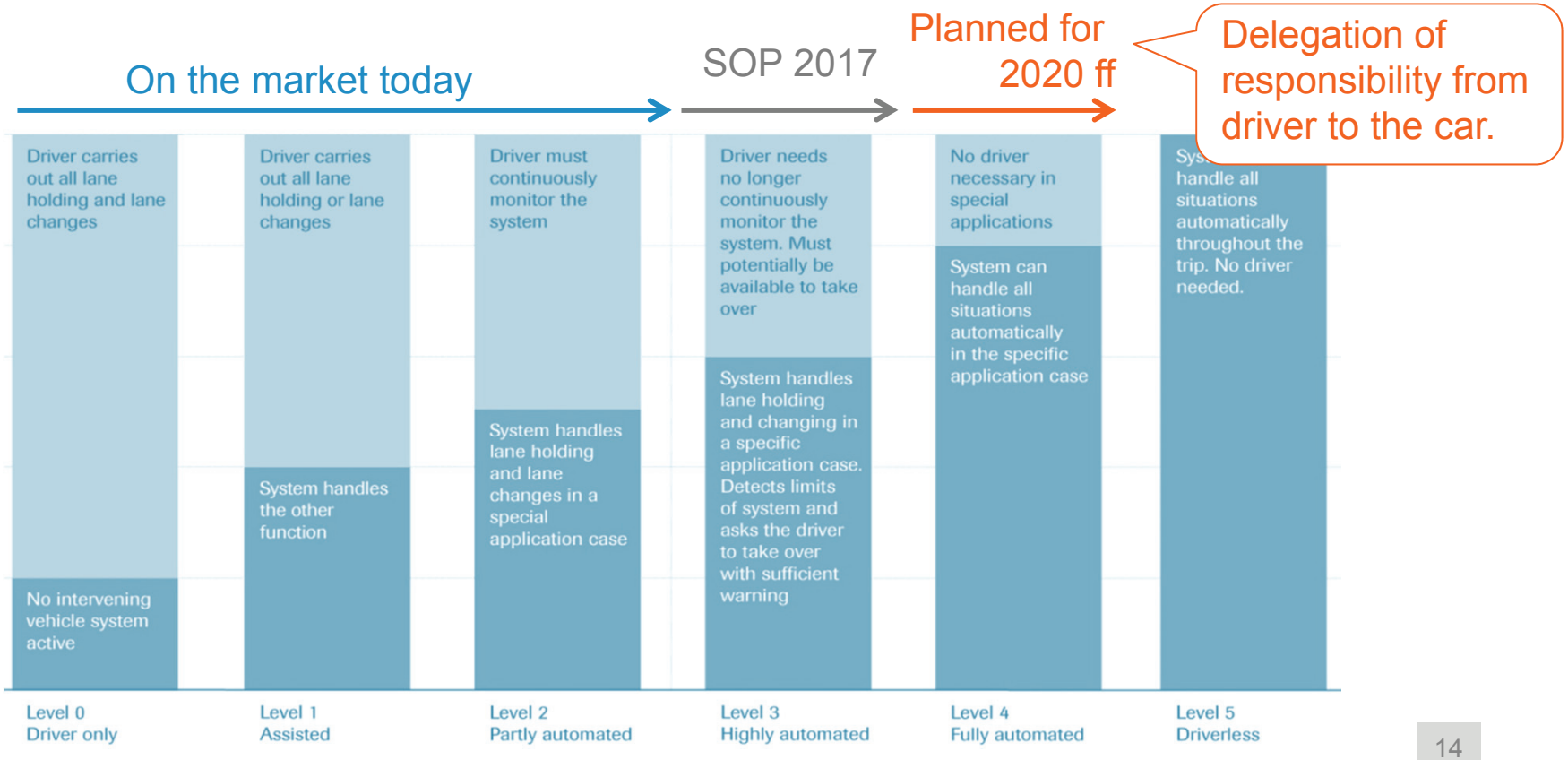


- Enables mixed criticality network traffic (coexistence of best effort and safety related traffic)

Automated Driving - System Classification by VDA



Level 4 - Safety Requirements

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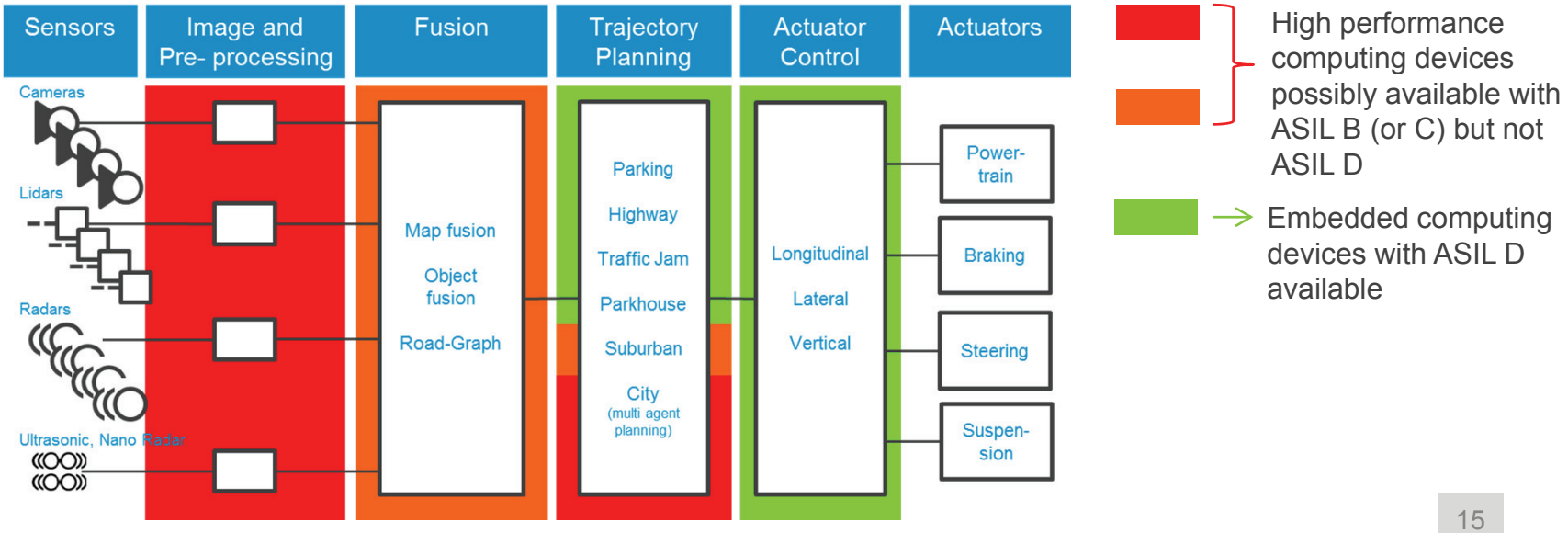
- Level 4 automated driving requires ASIL D
- No high performance compute chips available for ASIL D
- High speed Level 4 automated driving required fault tolerance ASIL D



The Fail-Operational Requirement

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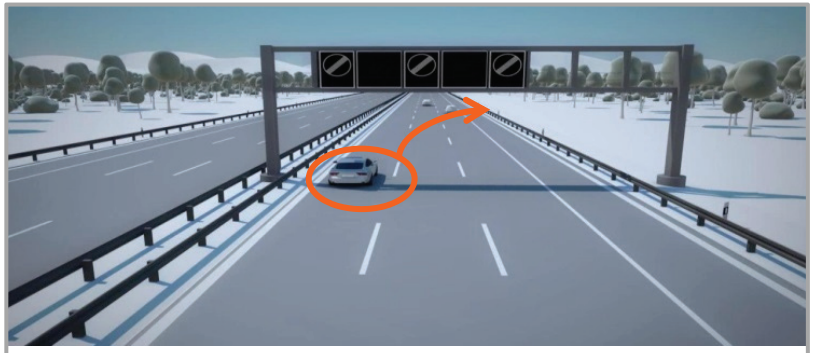
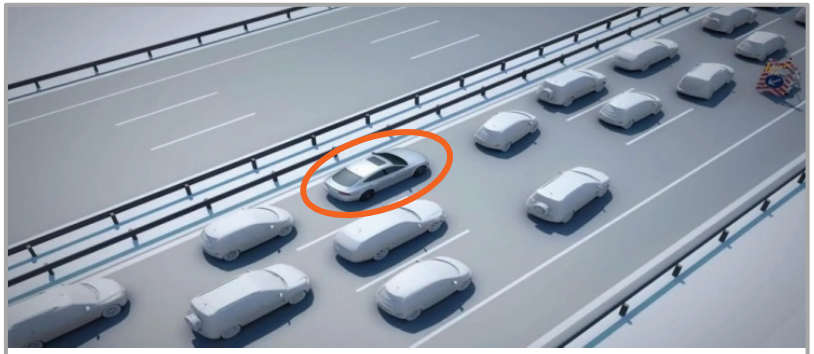
Level 4: “System can handle all situations automatically in the specific application case” [VDA] → Even in the case of component failures!



- Autonomous lane change to the side and stopping



- Or Stop the car (avoiding obstacles)

Why is it Difficult?

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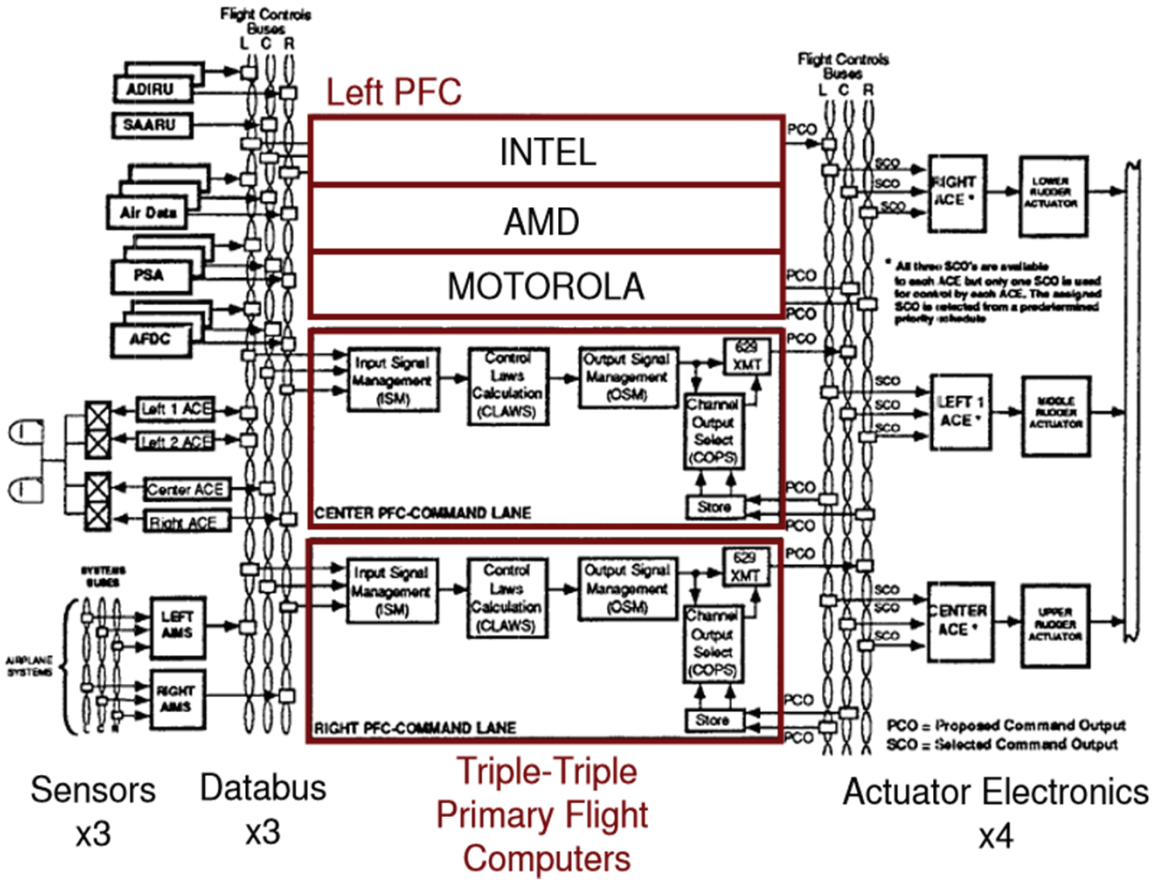
Airplanes are fly-by-wire and fail-operational …

… but they use triple or quad redundant diverse electronics

And they have very strict software development requirements

TTTech provides the fly-by-wire network for Embraer E-Jet E2 Family

777 Triple-Triple Architecture [Yeh, 96]



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- Boeing 777 Flight Computer
- 3 x 3 Architecture
- Hardware diversity
- „Perfect“ Software – No ASIL decomposition like mechanisms

ISO 26262 Approach

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Fault avoidance according to ASIL

Systematic Faults

Software
- Processes more strict for higher ASIL

Examples
- Strict traceability
- MC/DC test coverage
- Formal methods

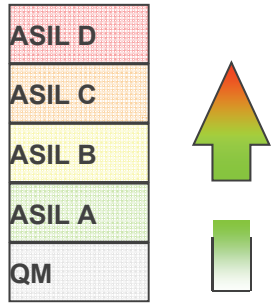
Hardware
- Processes more strict for higher ASIL

Examples
- Formal reviews
- Fault injection tests
- Analysis

Random Faults

Hardware
- Lower fault probability for higher ASIL

Examples - self checking design
- Dual core lockstep
- ECC
- Clock supervision



ASIL: Automotive Safety Integrity Level

Design Corners For Random Hardware Faults

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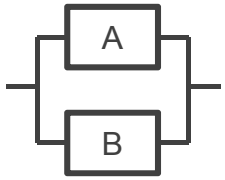
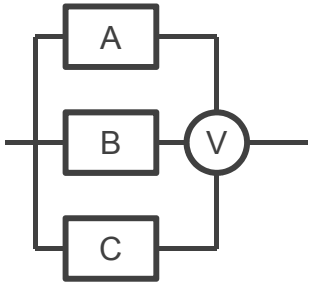
1oo2
one out of two



- Components need to be fail-silent or self-checking (i.e., deliver correct result or no result at all)

2oo3
two out of three



- Components can fail arbitrarily
- The voter becomes the critical element and a single point of failure
- Components can be ASIL B (high performance) but the voter becomes ASIL D (embedded safety)

Solution Sketch Systematic Faults – Fail-operational ASIL-D and Diversity

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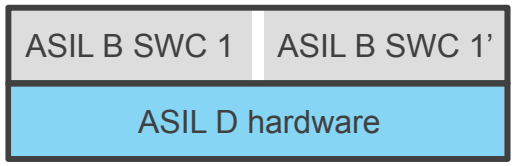
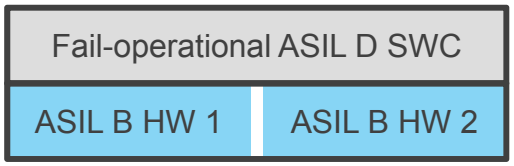
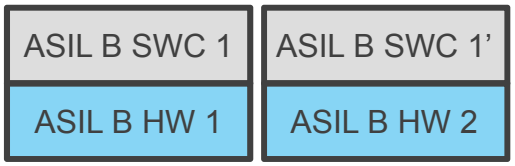
diverse software
single hardware



single software
diverse hardware



diverse software
diverse hardware



- In most cases diversity is more costly and more effort compared to a single version with a higher ASIL level
- Unfortunately many COTS SW/HW components are not available as ASIL D
- But many COTS components are available from multiple suppliers (Operating Systems, SoCs etc.)
  → No need to raise to fail-operational ASIL D due to diversity opportunity
- The “right” compromise is clearly application specific

The New Problem for fail-operational Architectures : Example insufficient ASIL D Decomposition

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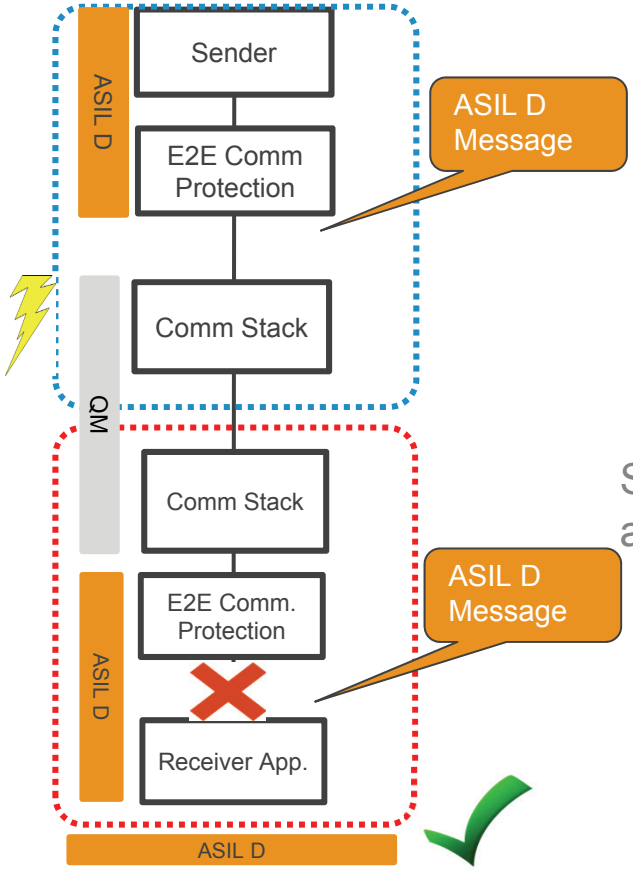
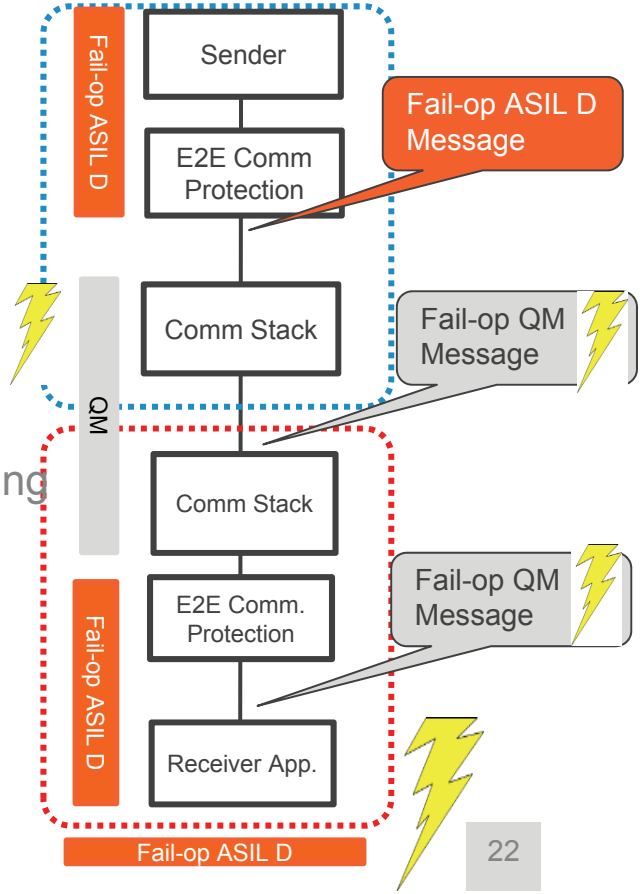


Bugs in QM components are detected but message is still unusable

System is only “QM” concerning availability of the software



The Fail-Operational Challenge

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- Find the optimal architectural compromise for cost, safety and performance by selecting
  - the best suited hardware fault-tolerance mechanisms,
  - the most appropriate ASIL decomposition
  - considering diversity where necessary or beneficial
  - based on the best suited set of sensor and SoCs
  - considering scalability

Fail-operational Redundancy Integration: Fail-operational as a Simple Add-in (1)

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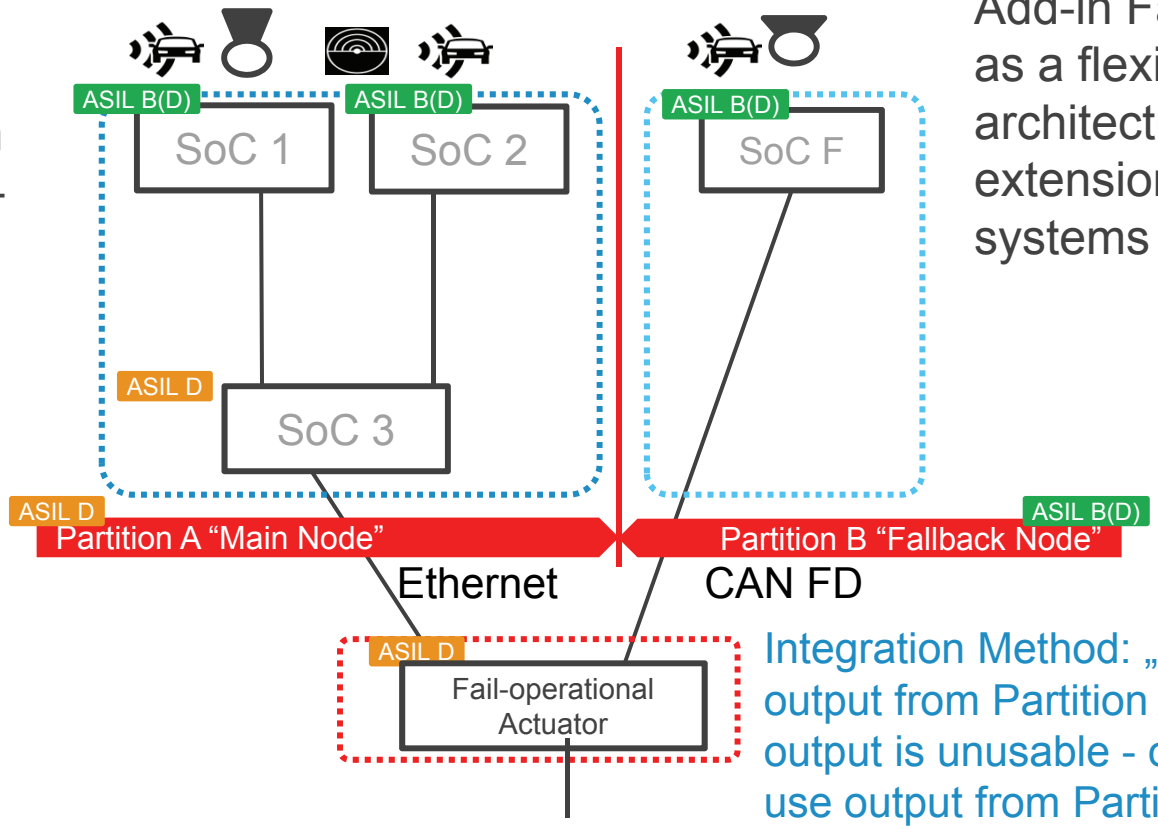
Sensors

High Integrity Main Node enables (fail-silent) ASIL D commands



Add-in Fallback Node as a flexible low cost architecture extension for fail-op systems

Integration Method: „Apply output from Partition A unless output is unusable - only then use output from Partition B“

Random/Systematic HW Fault Solution: Partition Independence (1)

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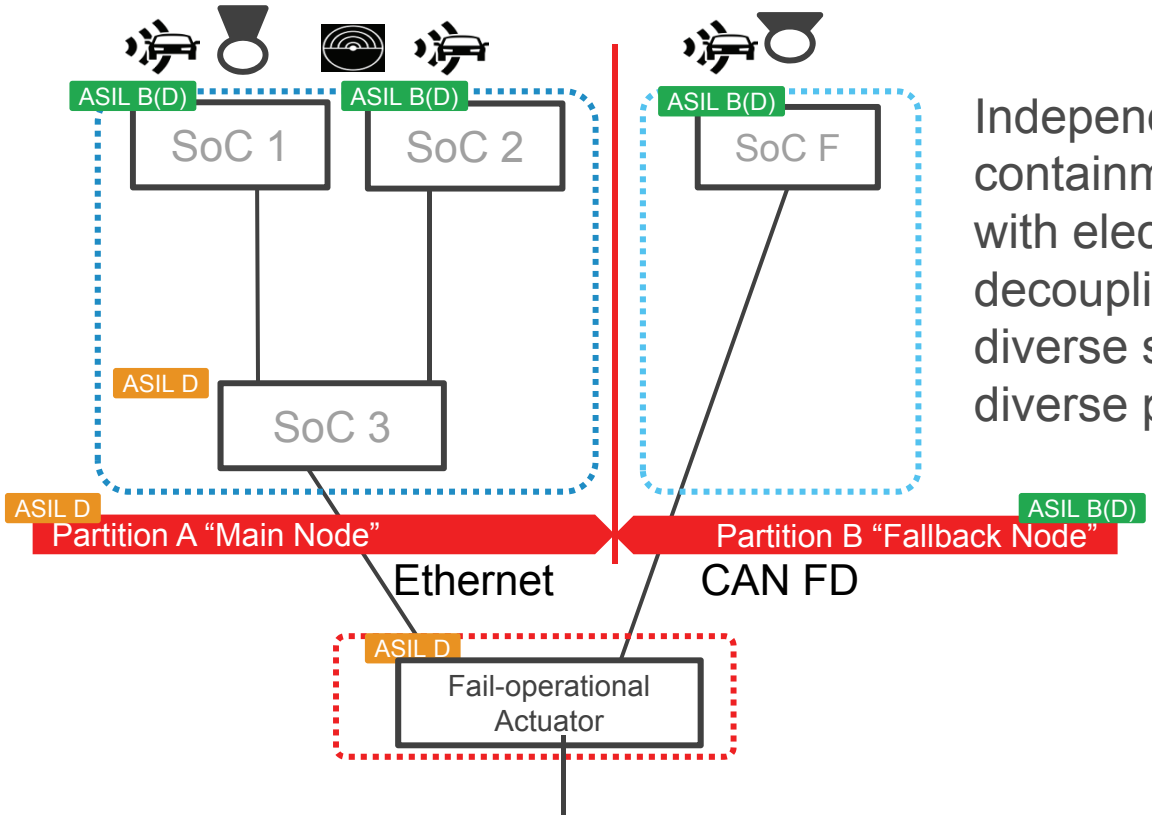
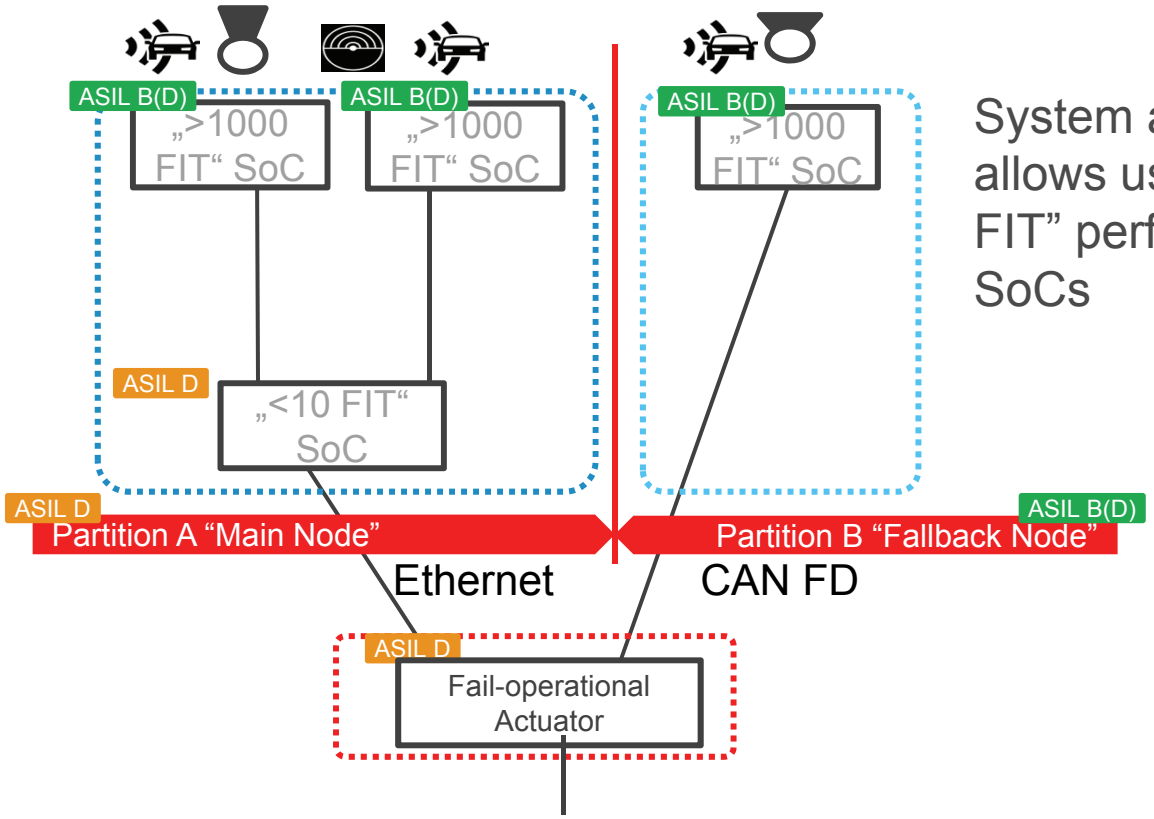
Sensors



Independent Fault-containment regions with electrical decoupling, diverse sensors and diverse power supply

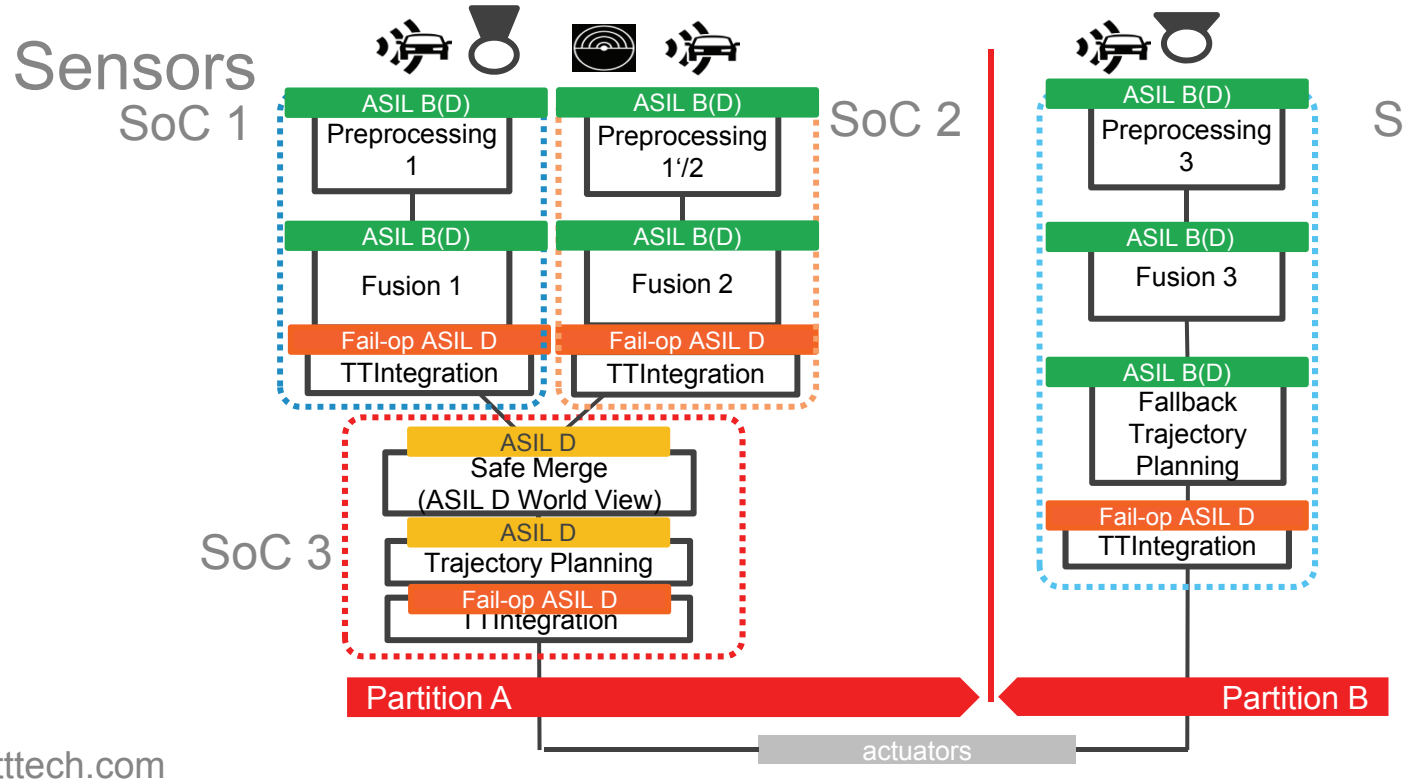
Random HW Fault Solution: Partition Independence (1)

Sensors



System architecture allows use of “high FIT” performance SoCs

Systematic Software Faults – Example Application Architecture Solution



Platform Architecture for Level 4 Automated Driving (1)

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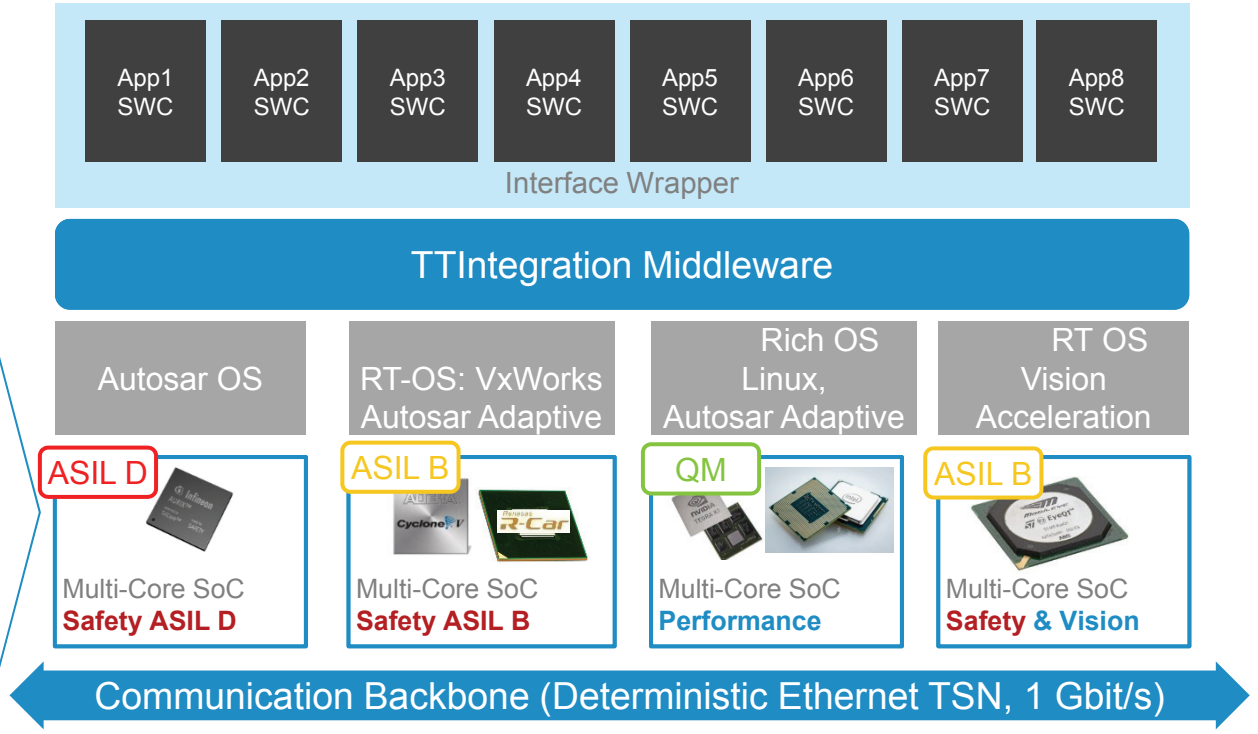
- Flexible combination of SoCs according to the necessary performance and ASIL level
- Flexibility to support different redundancy, and diversity schemes



Platform Architecture for Level 4 Automated Driving (2)

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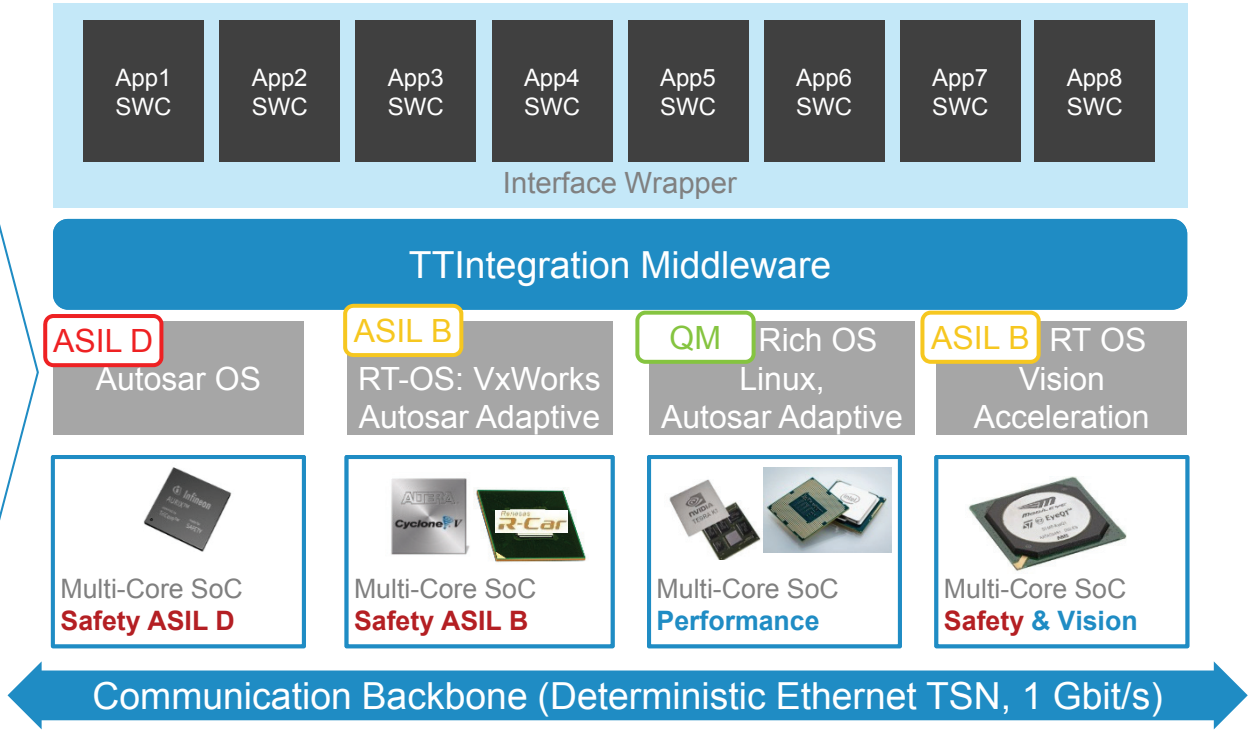
- Flexible combination of different operating systems according to needed features and ASIL level
- Possibility for diverse operating systems use



Next Generation Platform Architecture (3)

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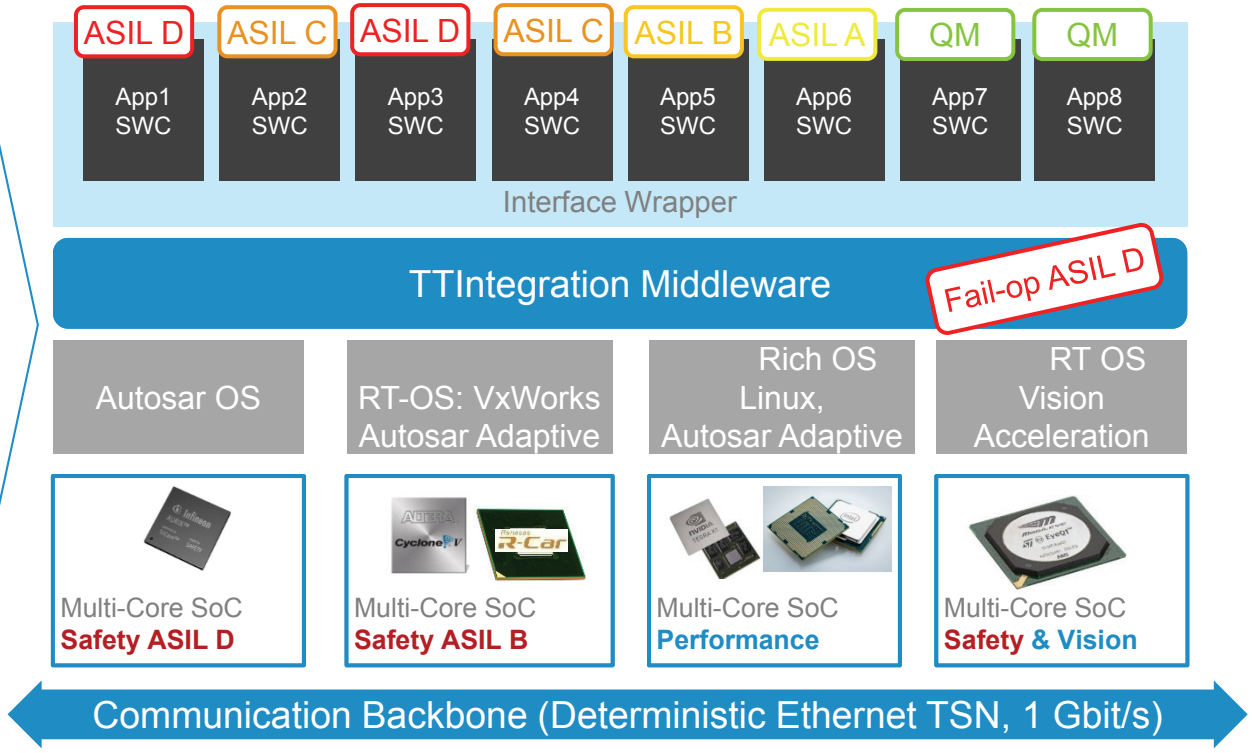
- Flexible combination of SWCs with different ASIL levels
- Coexistence of fail-silent and fail-op SWCs without interference
- Diverse application interfaces (POSIX, AUTOSAR (Classic, Adaptive)
- Diverse and replicated SWCs will be supported
- Middleware will fulfill fail-op ASIL D



TTIntegration for fail-operational Level 4 Autonomous Driving

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- We do not know what the OEM's Level 4 application will look like - But the next generation TTIntegration will support it by providing a flexible fail-operational ASIL D execution environment

- Thank you for your attention

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