Software Architecture for Secure ECUs

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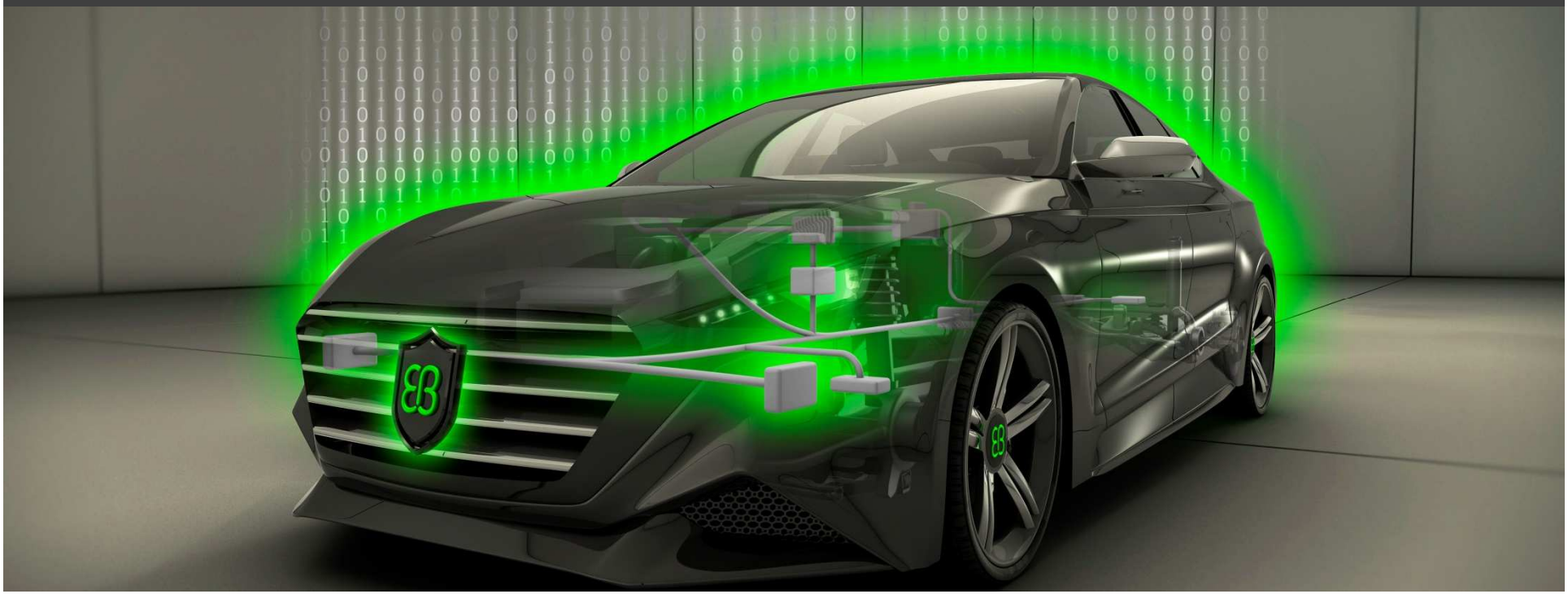
EB TechDay - June 2015



Agenda

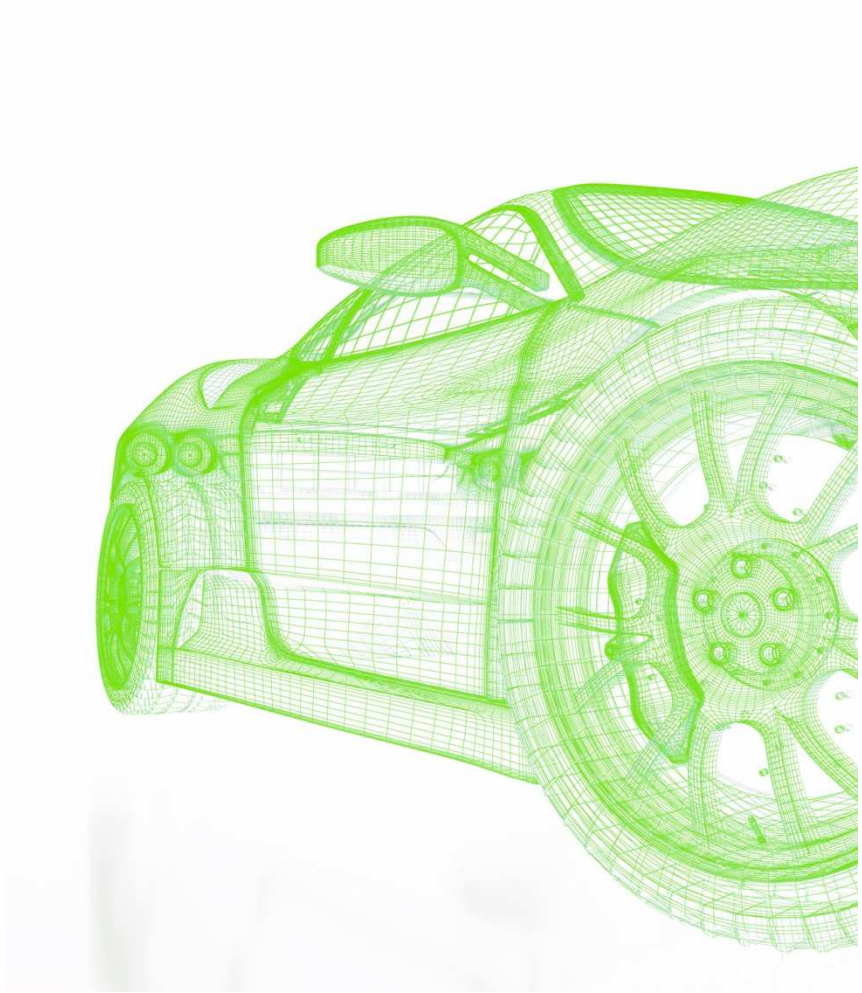
"No safety without security and vice versa"

Established Safety Concepts

Safety Analysis Methods for Security Analysis

Secure Software Architecture Extensions

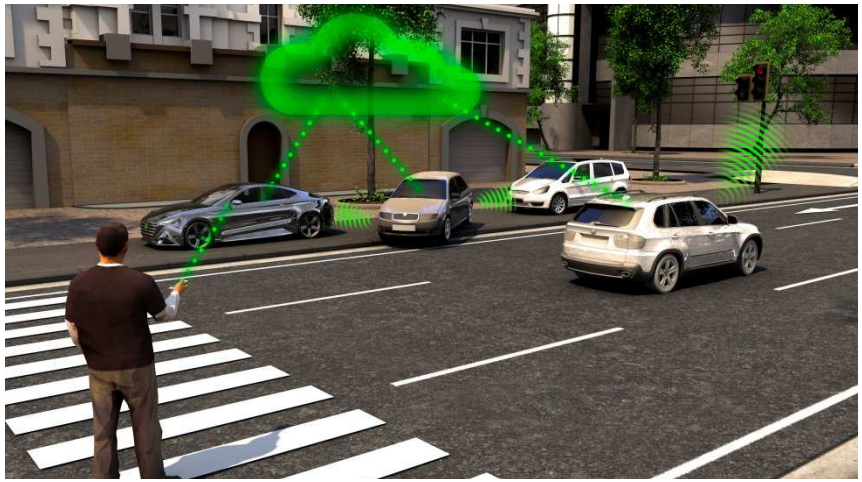
Summary



The Car of the Future:
Increased comfort – Increased potential for damage

- **Autonomous Driving**
  - Highly safety-critical
  - Requires latest data from the “cloud”

- **Car-2-X Communication**
  - Communication with
    - other cars
    - infrastructure
    - mobile phone or other devices
  - ECUs have access to the on-board network



Recent security breaches

OpenSSL “Heartbleed” vulnerability

- Sensitive data accessible via maintenance function
- Encryption and maintenance functions are technically unrelated
- Cause: implementation error

Remote door unlock

- Attacker could open cars with fake SMS
- Various vulnerabilities:
  - Partially unencrypted communication
  - Provision of sensitive data
  - Missing integrity checks
  - Weak or identical encryption keys
  - Replay attacks possible

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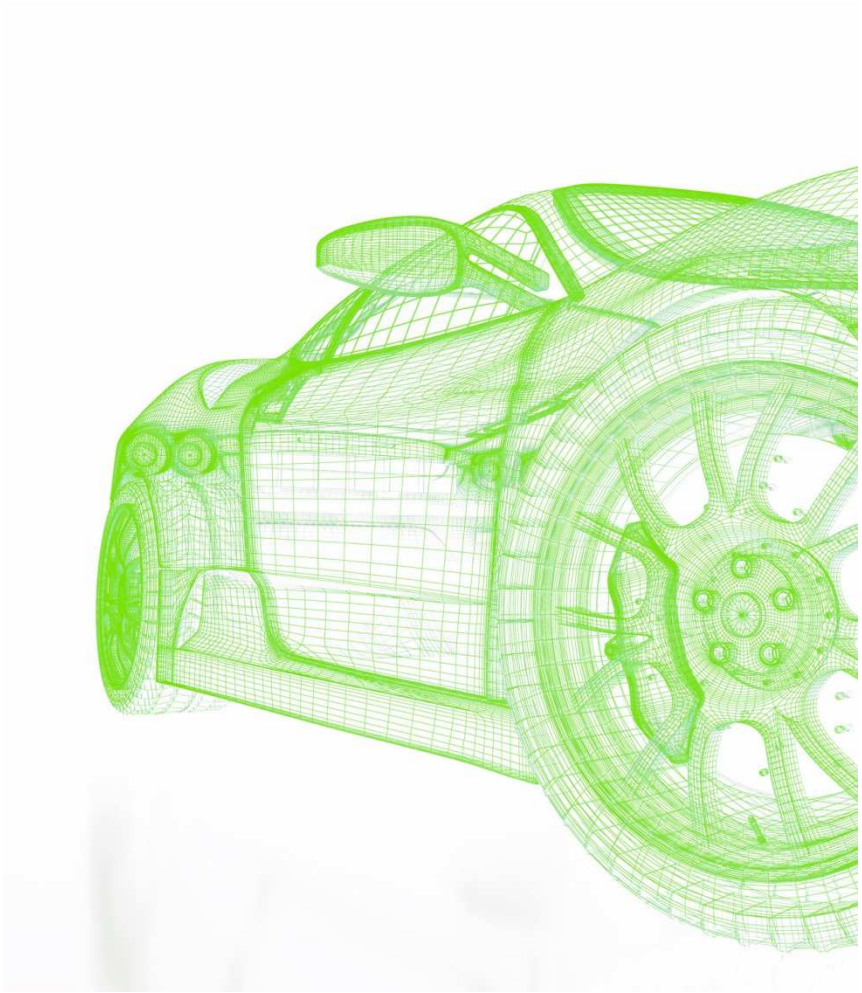
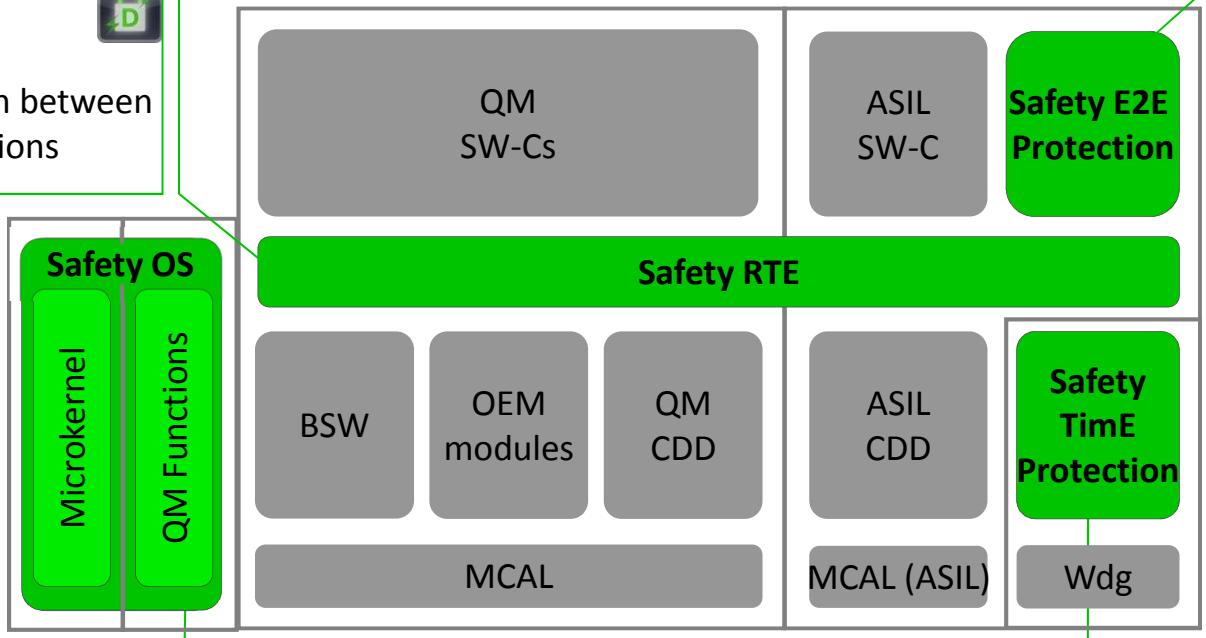


Memory Partitioning

Safety RTE
Protected communication between Memory Partitions

Safety E2E Protection
Safe communication to other ECUs

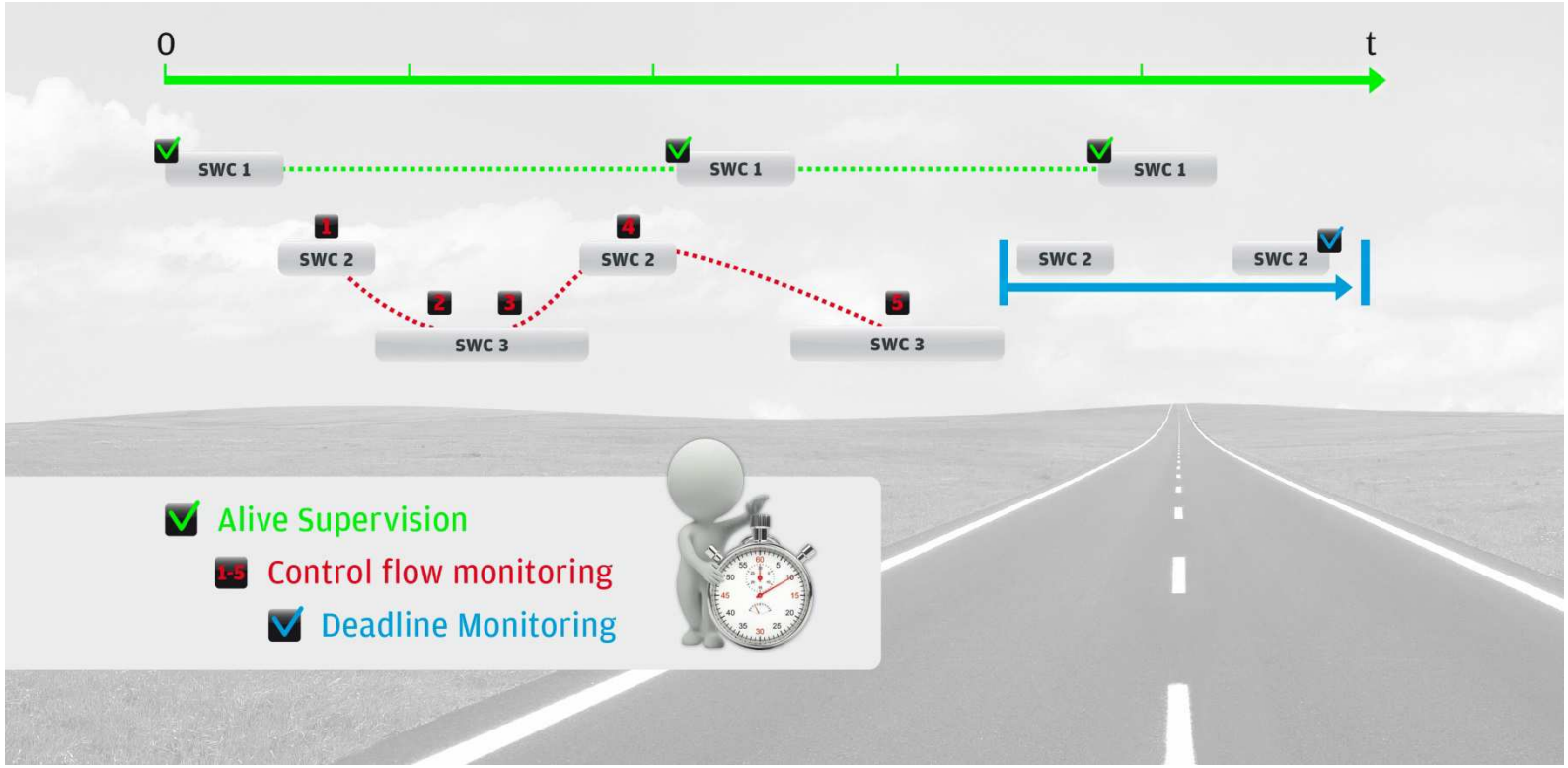


Memory Partitions

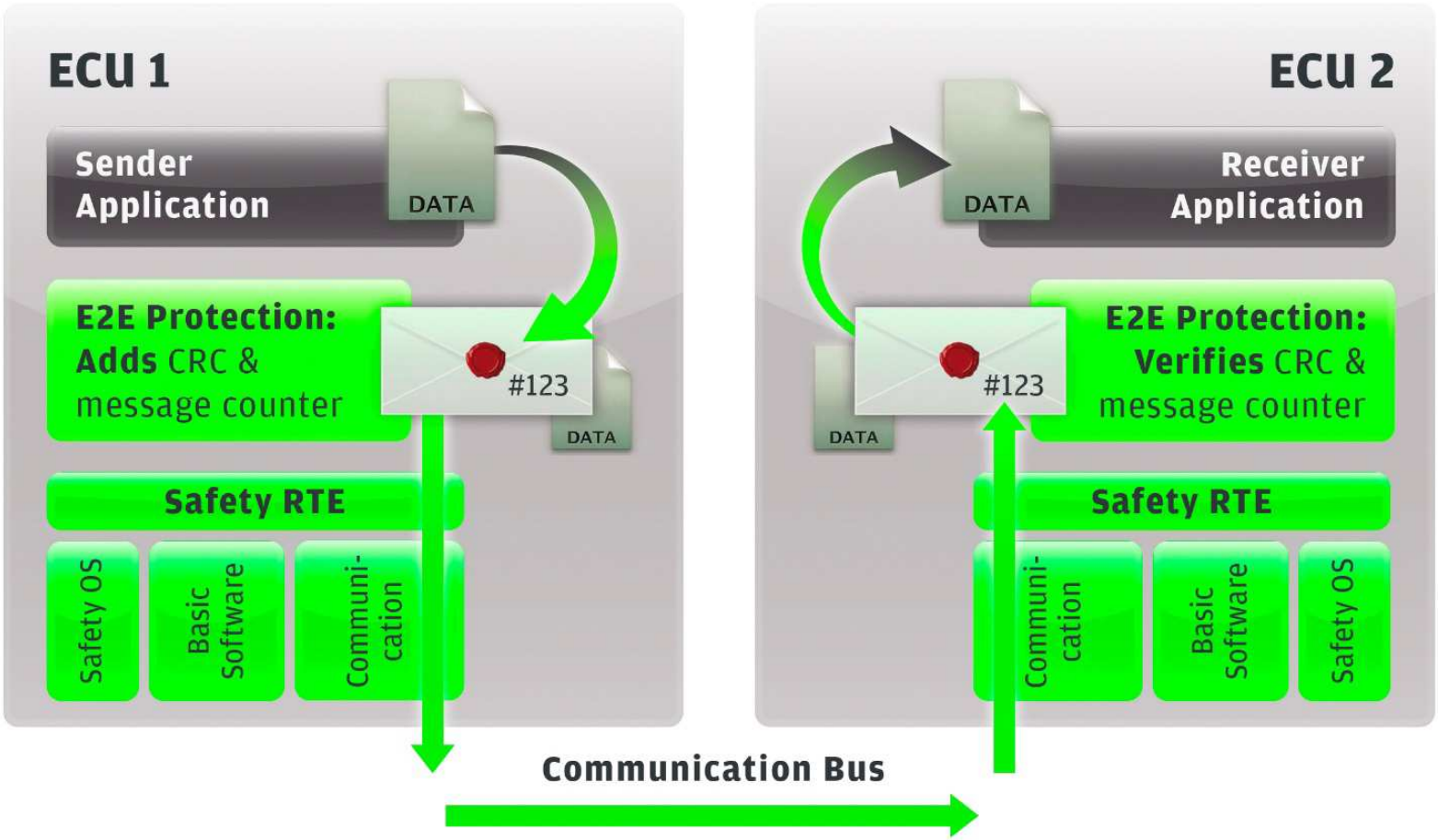
Safety OS
- Data Protection
- Stack Protection
- Context Protection
- OS Protection
- Hardware Error management

Safety TimE Protection
- Alive supervision
- Deadline Monitoring
- Control flow monitoring

Time and Execution Protection



Communication Protection



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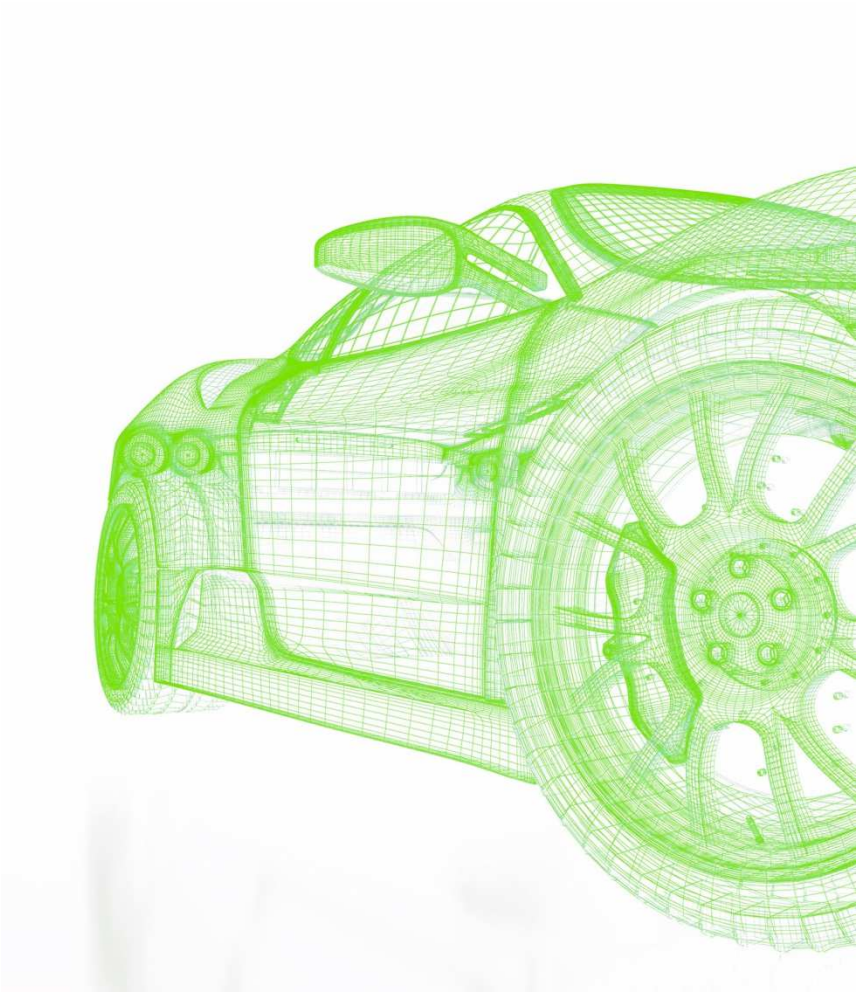


Static vs. Dynamic Threat Model

Safety: static threat model

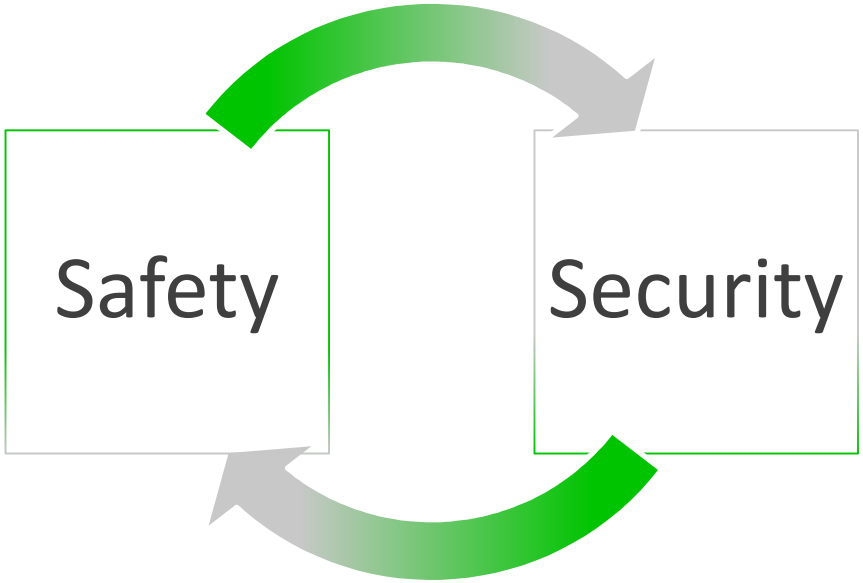
- Threats are known at system design
- Threats are internal, e.g. random or systematic faults
- Iterations improve existing model with new knowledge

Security: dynamic threat model

- New threats can emerge during system operation
- Threats are external
- Intelligent opponent has to be considered

Extending Safety Analysis to Security Analysis

- Safety and security rely on **risk models**
- It´s crucial to recognize and **use synergies**
- Extend hazard and risk analysis with **malicious attacker**
  - Attacker has access to all communication channels
  - Extend safety requirements with security requirements



Searching for security vulnerabilities brings new safety exposures to light and vice versa

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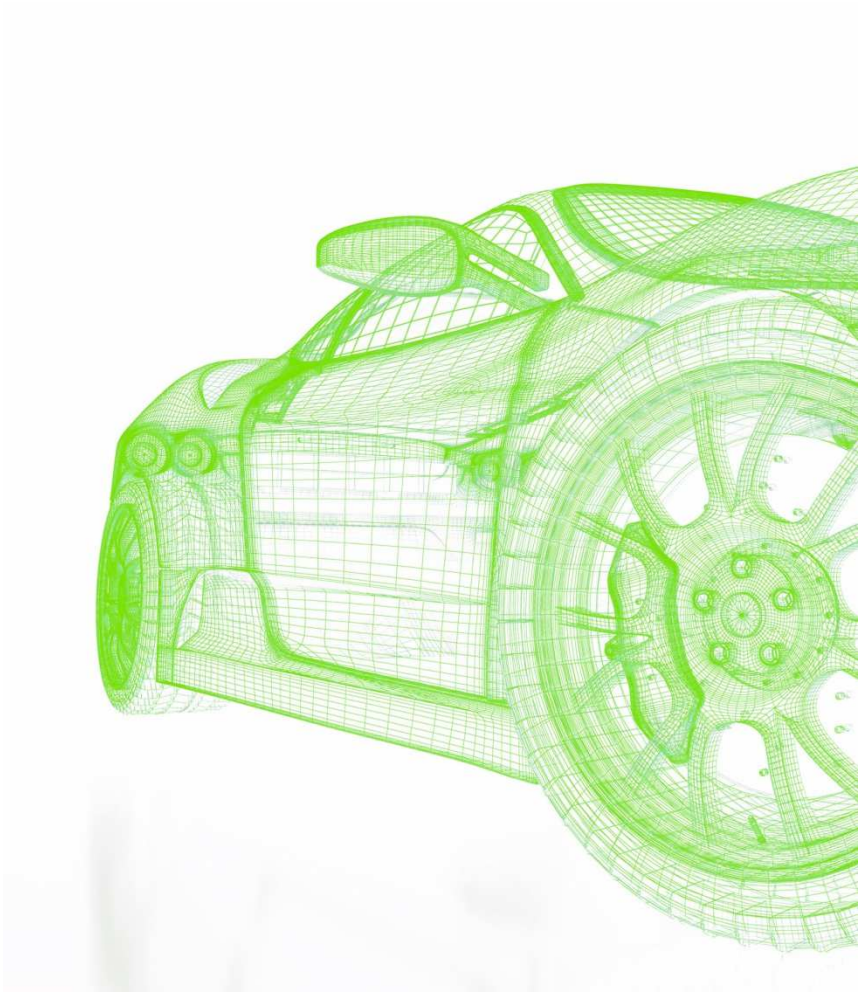


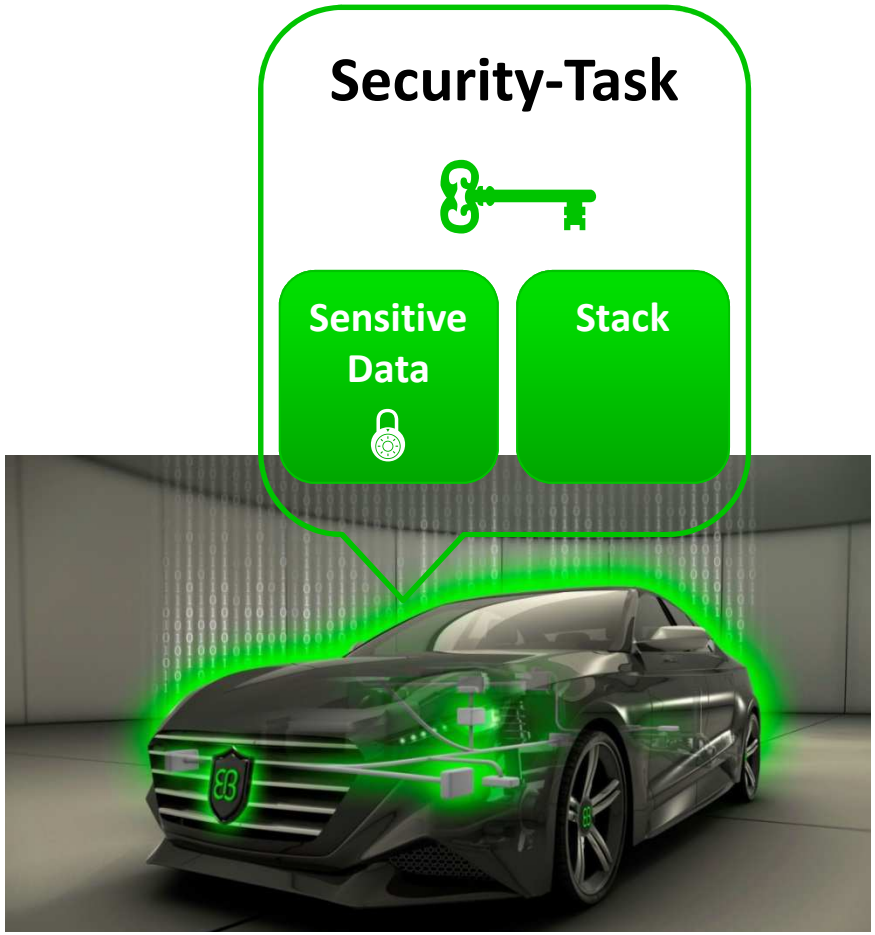
Using Partitioning to Protect Data

- **Memory Partitioning**
  - Read protection
  - Execution protection

⇒ Allow access to sensitive data only for authorized tasks

- **Stack Protection**
  - Stack protected via MPU

⇒ Prevention against stack-overflow attacks



Message Integrity

Threats → **Countermeasures**

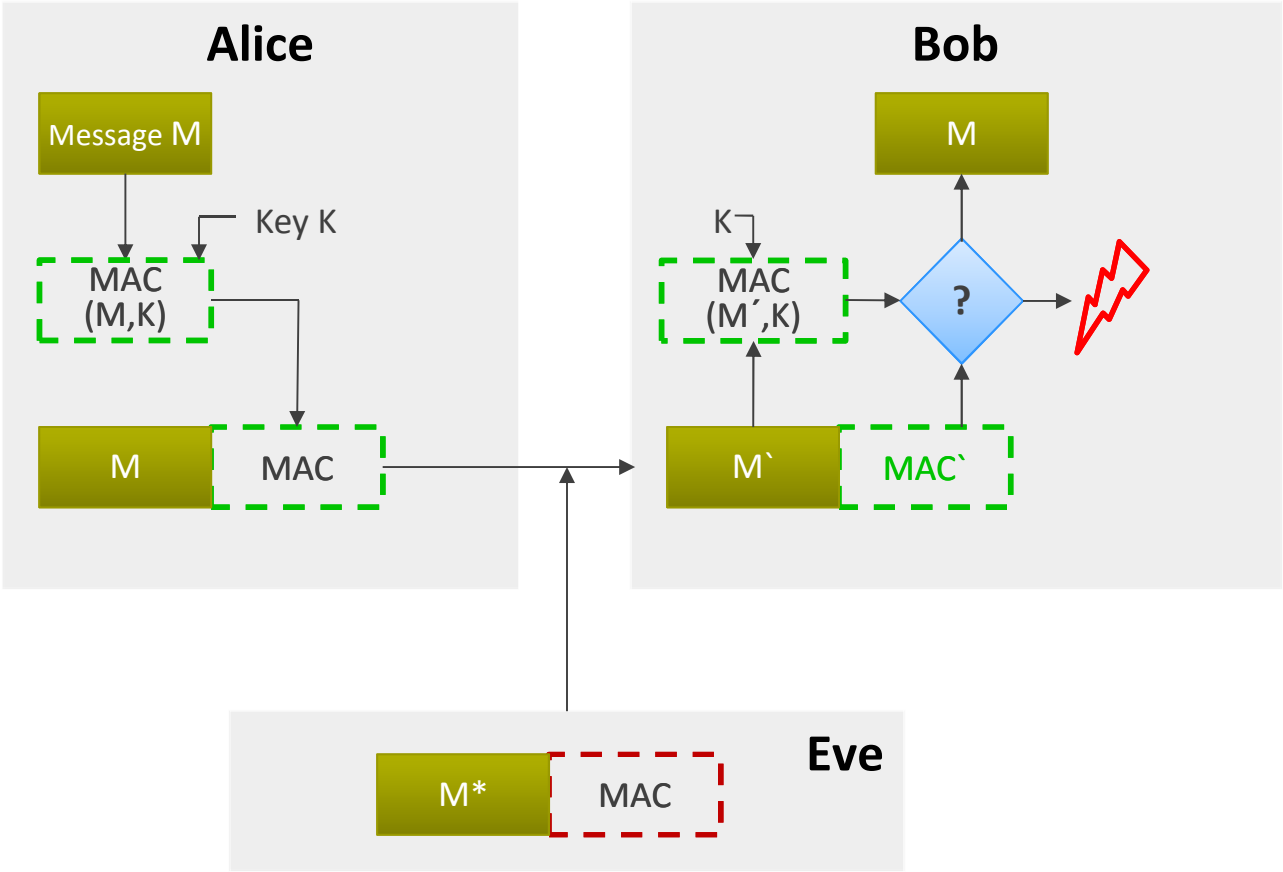
1. **Unauthorized message access**
   - Read, Modify, Delete
2. **Impersonate other user**
   - Initiate communication
3. **Temporal attacks**
   - Replay, Delay

1. **Encryption**
   - Unauthorized read, modification, Impersonation of other user
2. **Signatures**
   - Modification, Impersonation of other user
3. **Integrity Checksums**
   - Modification
4. **Message counters and timestamps**
   - Replay, Delay

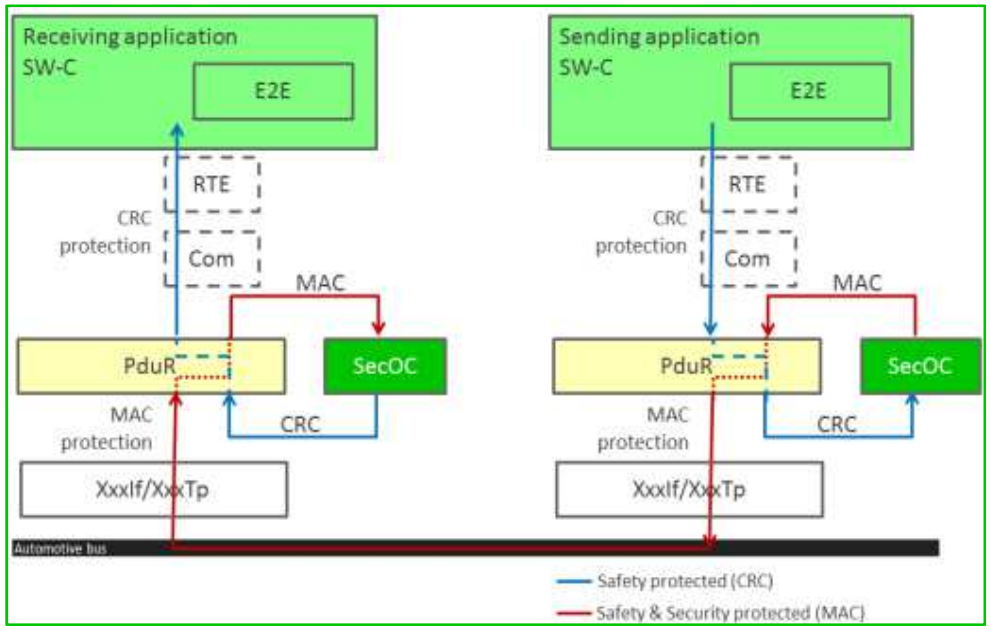
MACs containing signatures and freshness values eliminate most threads

Message Authentication

- MAC with key K is appended to message M
- Key is known to sender and receiver
- Alterations from Eve are detected by Bob



AUTOSAR: E2E and SecOC



Sender

- Unsafe channel between application and SecOC module
  - Protect message with CRC from E2E in application
  - Safe transport between ECUs
- SecOC transforms CRC to MAC
  - Safe and secure transport between ECUs

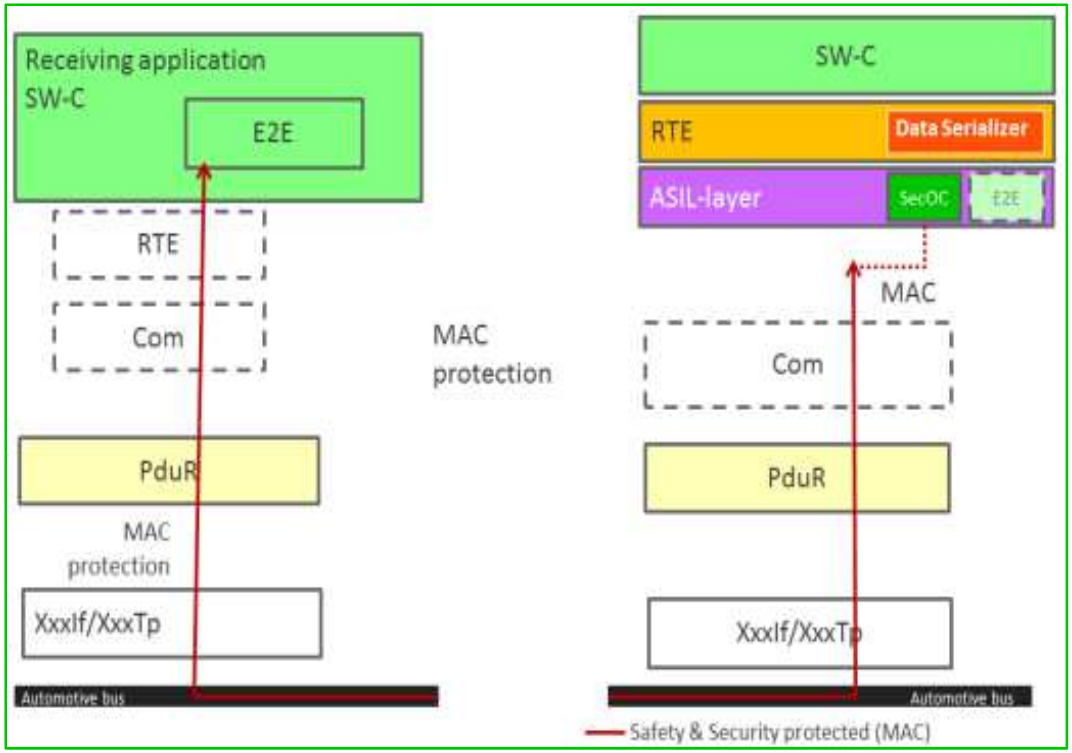
Receiver

- SecOC transforms MAC to CRC
- Application checks CRC

End-to-end protection with SecOC

Single SecOC approach

- Use MAC algorithm also for message integrity
- Place ASIL developed SecOC in highest AUTOSAR layer
- Omit overhead for additional end-to-end protection



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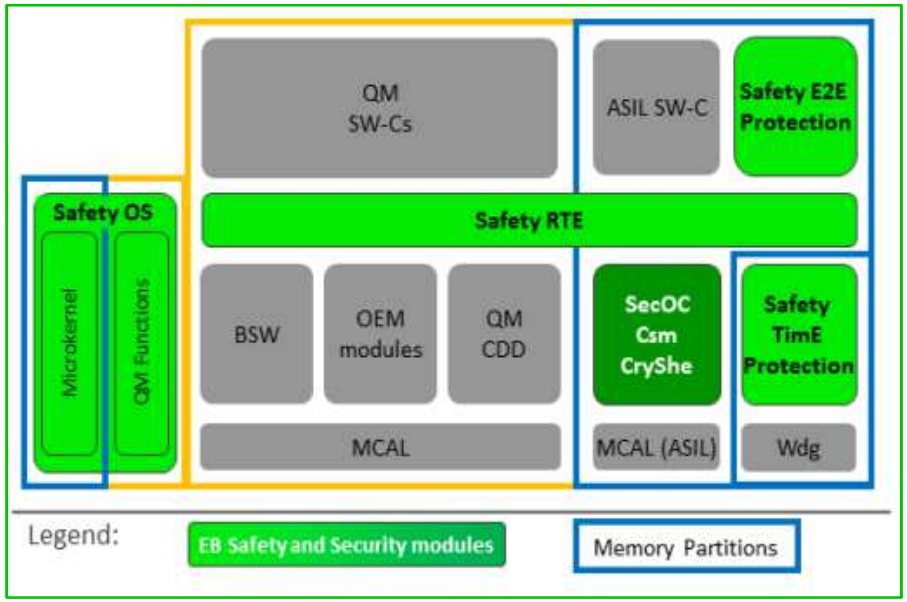
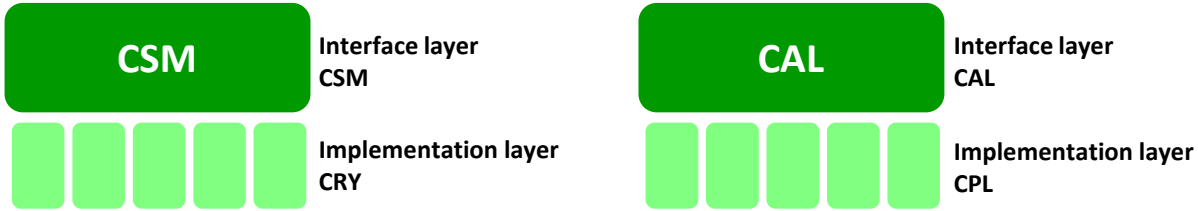
AUTOSAR safety and security architecture



- **Safety OS**
  - Memory write (**safety**), read and execution (**security**) protection
- **TimE Protection**
  - Control flow monitoring (**safety**)
- **E2E protection and SecOC**
  - Data integrity (**safety**, **security**)
  - Authentication (**security**)
- **Csm, CryShe**
  - Data encryption (**security**)

Csm, Cry, CryShe, Cal, Cpl,…

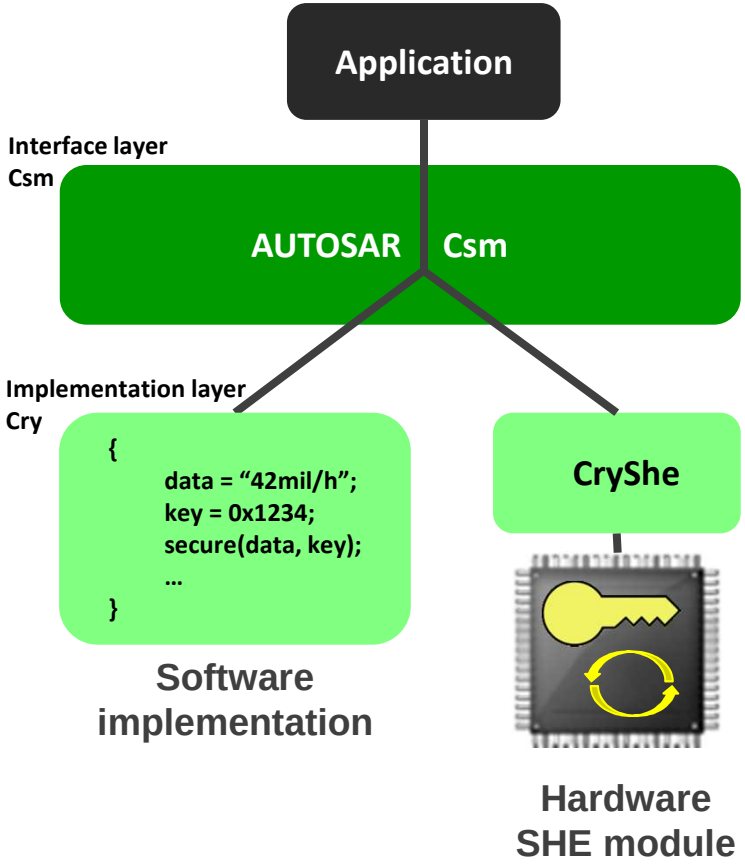
- AUTOSAR defines two sets of crypto routines
  - Crypto **service** manager (CSM/CRY)
  - Crypto abstraction **library** (CAL/CPL)
- Both AUTOSAR specifications subdivide crypto modules into two layers
  - Interface layer
    SERVICES
  - Implementation layer
    PRIMITIVES



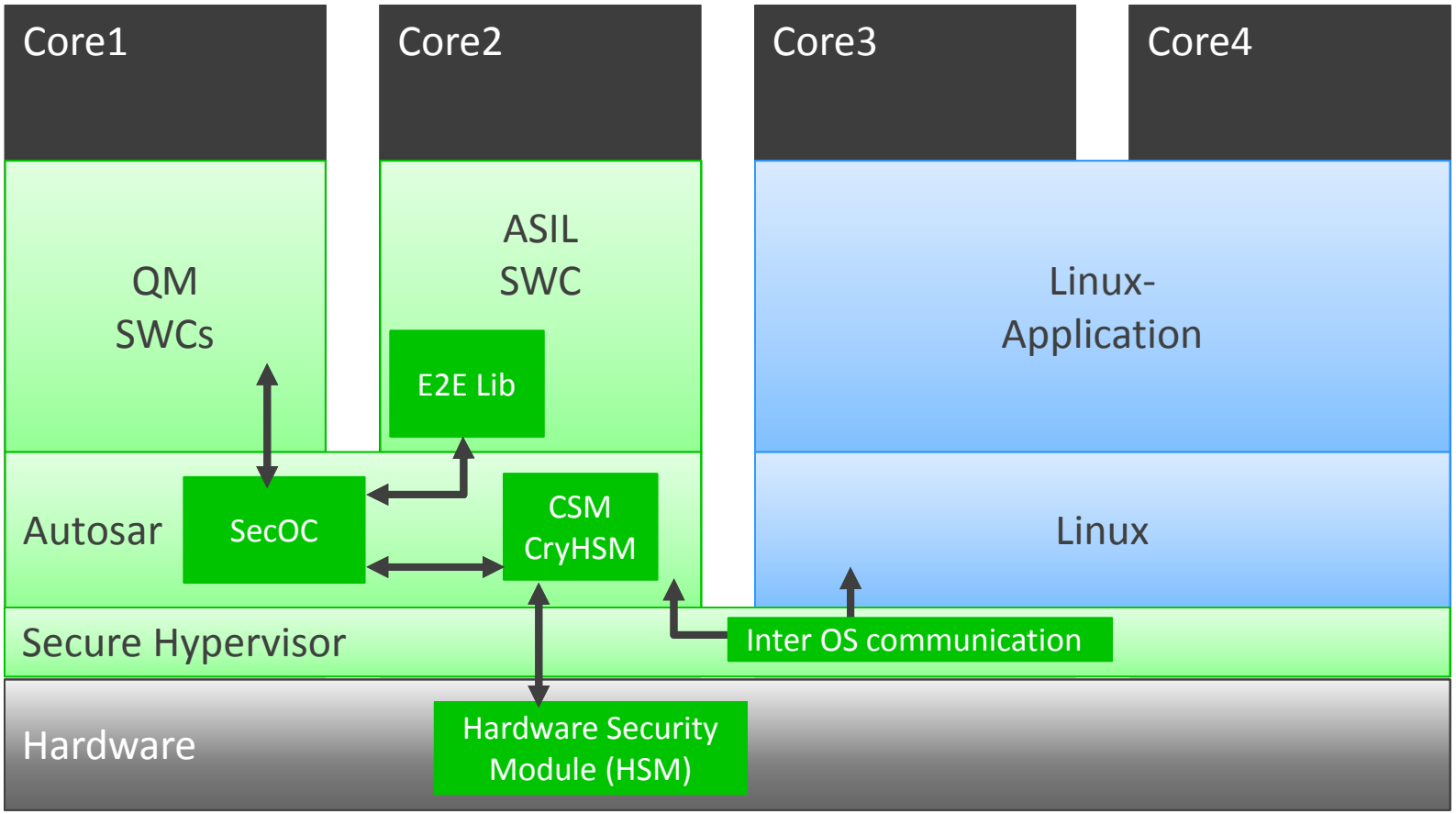
- Only the interface layer is properly specified in AUTOSAR
  - This layer is completely standardized
- Contents of the implementation layer are left open for customer options
  - This layer implements customer specific solutions with a standardized interface to the interface layer

Use case examples – Secure Hardware Extension

- Attainable security level in software is limited.
- New automotive ECUs offer a 'Secure Hardware Extension (SHE)' module.
  - E.g. freescale Bolero 3M/Calypso, Infineon TC179x, Fujitsu Atlas-L family, Renesas RH850
- EB integrates the new hardware module with standard software.
- Development of drivers for SHE.
- Integration with AUTOSAR cryptographic module (Csm/CryShe).
- Tool driven configuration.
- We enable customers to easily switch between cryptographic routines in software and hardware.



Outlook: Hypervisor setup



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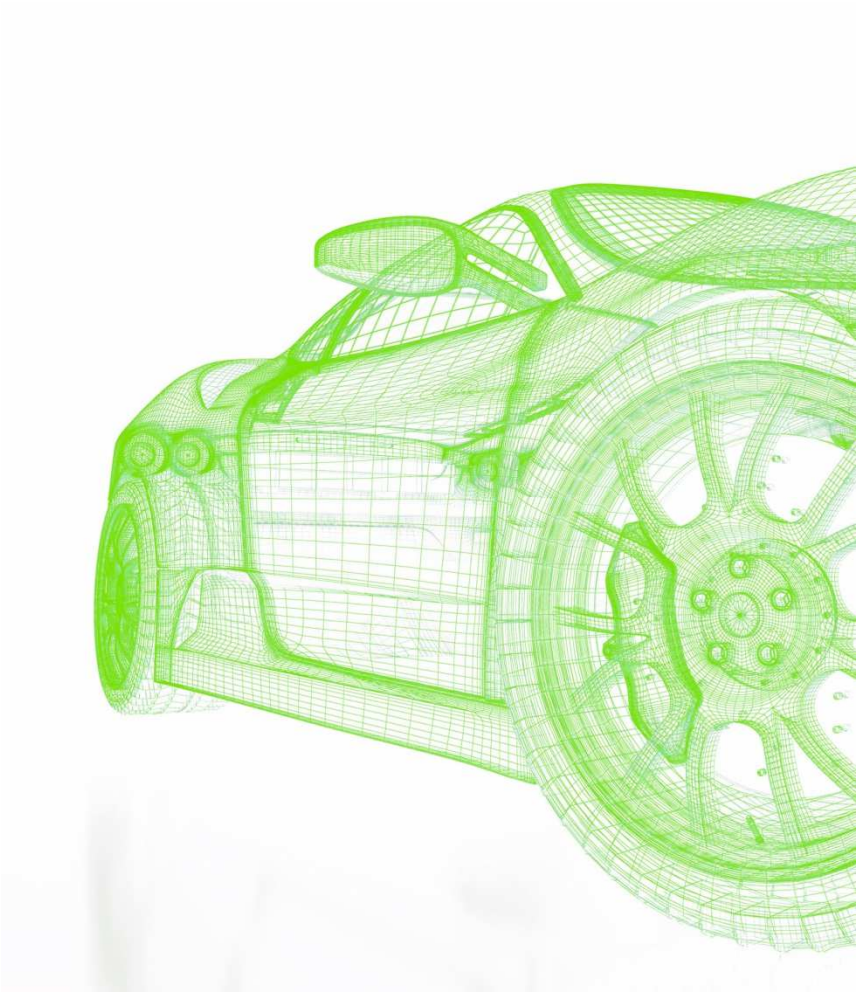

Summary

- **Extend safety analyses with security aspects**
  - Safety and security complement each other
  - Employed methods are quite similar
- **Safe and secure software architectures**
  - Use partitioning mechanisms for protection mechanisms
  - Use secure authentication and integrity mechanisms for safe communication
- **Hypervisors combines two worlds**
  - Access to board net via AUTOSAR
  - Applications on e.g. Linux
  - Protected communication through Firewall

Thank you!

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