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SAFURE

Safety and Security – Towards a Combined Approach for Mixed-Critical Cyber-Physical Systems

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HiPEAC
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SAFety and secURity by dEsign for interconnected mixed-critical cyber-physical systems

Agenda: Safety & Security

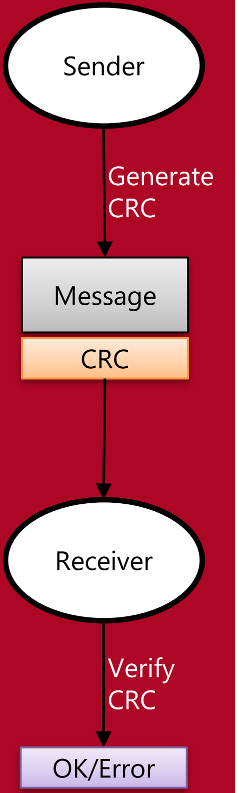
- Definition
- Synergies and conflicts
- Combined analysis
- Safety + security by design in development

Definition

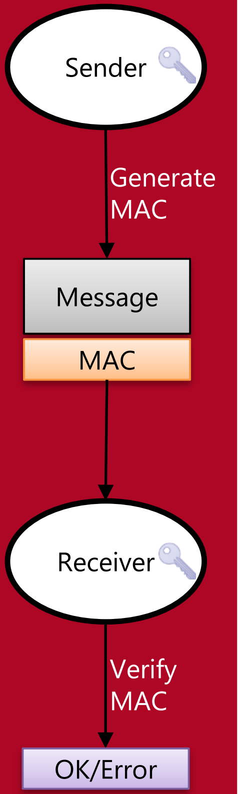
- Safety:
  - Random hardware faults
  - Systematic failures during design
    - Design failures
    - Software bugs

- Security:
  - Intentional manipulation by attackers
    - Vulnerabilities in hardware/software systems
    - Security is determined by weakest link in the system

Example 1: Data Integrity



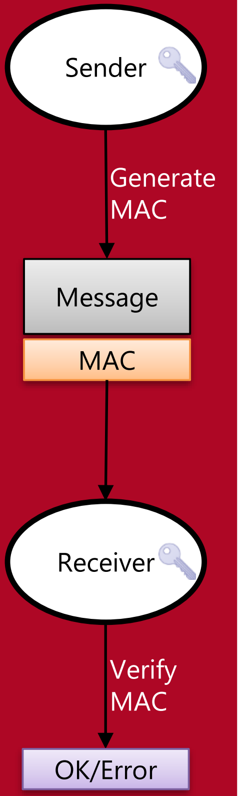
- Safety: Cyclic Redundancy Check (CRC)
  - Detect randomly distributed errors
  - Uses additional redundant data generated by binary polynomial division
  - Polynomial usually optimized at single bit errors
  - Easy to implement in SW and HW
  - Widely used in communication (e.g. CAN bus protocol)



Example 1: Data Integrity

- Security: Message Authentication Code (MAC)
  - Fixed-length keyed code representing a message
  - Uses cryptographic primitives (Hashes or block ciphers)
  - Generation and verification uses secret key
  - Infeasible for attacker to create a valid MAC without knowing the secret key
  - MAC value can be truncated
  - Error detection probability $2^{-len(MAC)}$

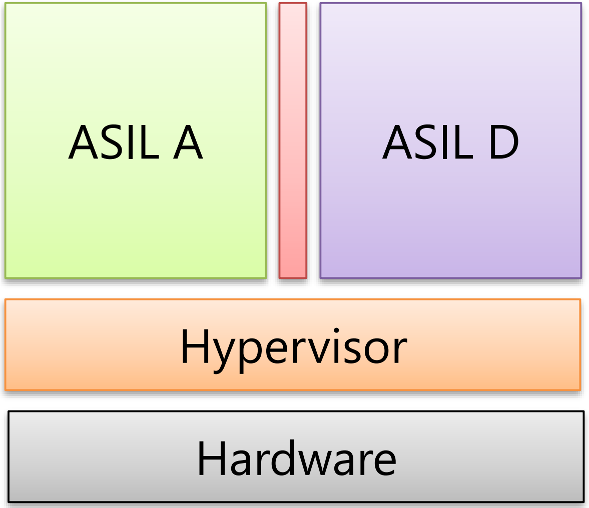
Example 1: Data Integrity



- Safety + Security:
  - CRCs can be replaced by (truncated) MACs in many systems
  - Better integrity protection (multi-bit errors are detected)
  - Authenticity: MAC calculation requires secret key
  - However: Additional complexity
    - MAC calculation more complex than CRC
    - Truncated MAC (64-128 bits) larger than CRC (16-32 bits)
    - Key Management

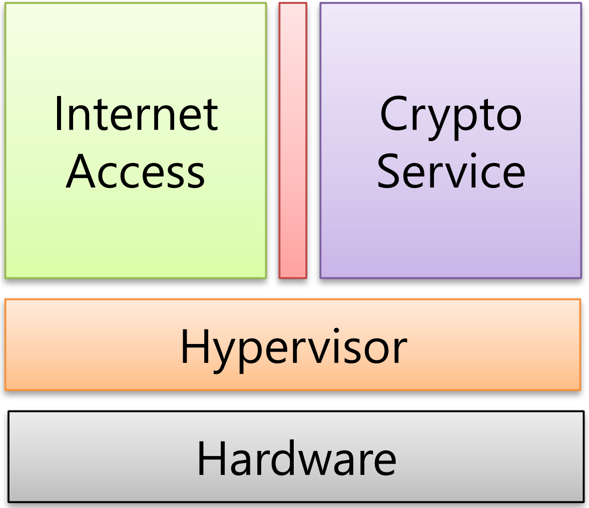
Example 2: Virtualization for CPS

- Virtualization as a Safety Measure:
  - Minimize hazards and risks
  - Separation of different criticality levels
    (e.g. ASIL A vs. ASIL D)
  - Freedom in interference



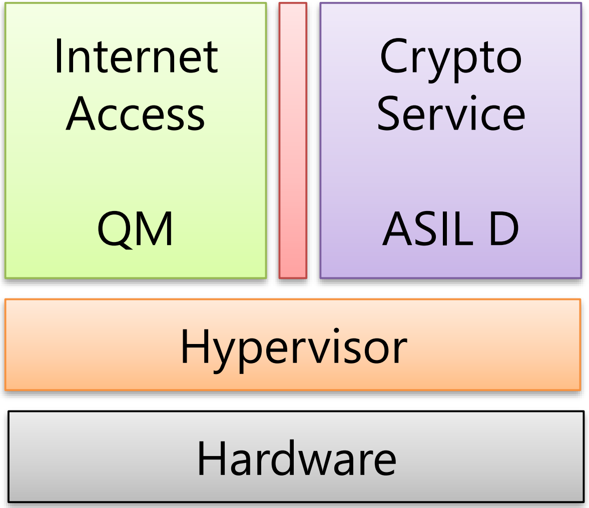
Example 2: Virtualization for CPS

- Virtualization as a Security Measure:
  - Strong separation of security-critical from non-critical services
  - Security attack on one VM (e.g. Internet Access) does not affect other VMs
  - Small trusted code base (hypervisor and crypto service)



Example 2: Virtualization for CPS

- Virtualization as Security and Security Measure:
  - Separation of different criticality levels
  - Strong separation of security-critical from non-critical services



Further Synergies

- Analysis
  - Safety: Hazard Analysis & Risk Assessment
  - Security: Security Risks Analysis
- Availability
  - Safety: Reliability, Robustness
  - Security: Absence of Denial-of-Service attacks
- Event of damage:
  - Safety: Producer’s liability
  - Security: Liability (attack on safety function), Reputation

Conflicts: Power Window

- Safety:
  - Protection against injury
  - Behavior on obstacle detection (normal car):
    - Prevent hazard
    - Stop and move window down a bit
- Security:
  - Protection against manipulation
  - Behavior on obstacle detection (high-security car):
    - Prevent access
    - Close window

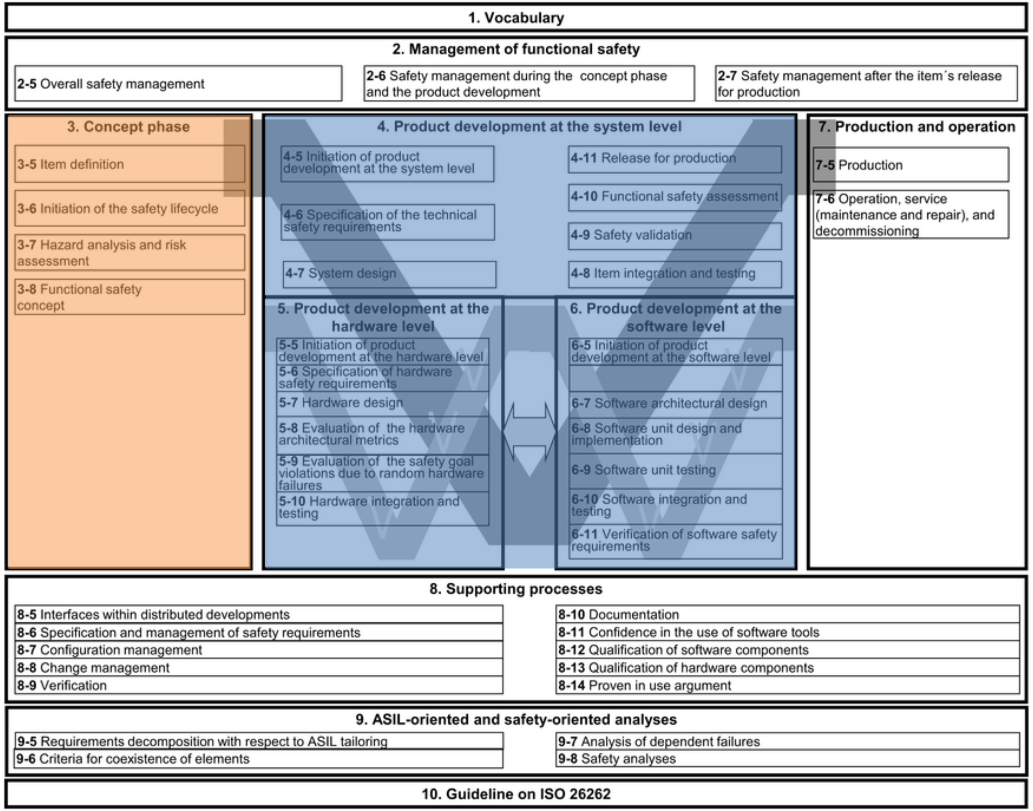
Source: Hyundai

Further Conflicts

- Safety:
  - (Hard) Real-time requirem

- Security:
  - Crypto algorithms take itional time
  -

Development Process



1. Vocabulary

2. Management of functional safety
- 2-5 Overall safety management
- 2-6 Safety management during the concept phase and the product development
- 2-7 Safety management after the item´s release for production

3. Concept phase
- 3-5 Item definition
- 3-6 Initiation of the safety lifecycle
- 3-7 Hazard analysis and risk assessment
- 3-8 Functional safety concept

4. Product development at the system level
- 4-5 Initiation of product development at the system level
- 4-6 Specification of the technical safety requirements
- 4-7 System design
- 4-8 Item integration and testing
- 4-9 Safety validation
- 4-10 Functional safety assessment
- 4-11 Release for production

5. Product development at the hardware level
- 5-5 Initiation of product development at the hardware level
- 5-6 Specification of hardware safety requirements
- 5-7 Hardware design
- 5-8 Evaluation of the hardware architectural metrics
- 5-9 Evaluation of the safety goal violations due to random hardware failures
- 5-10 Hardware integration and testing

6. Product development at the software level
- 6-5 Initiation of product development at the software level
- 6-7 Software architectural design
- 6-8 Software unit design and implementation
- 6-9 Software unit testing
- 6-10 Software integration and testing
- 6-11 Verification of software safety requirements

7. Production and operation
- 7-5 Production
- 7-6 Operation, service (maintenance and repair), and decommissioning

8. Supporting processes
- 8-5 Interfaces within distributed developments
- 8-6 Specification and management of safety requirements
- 8-7 Configuration management
- 8-8 Change management
- 8-9 Verification
- 8-10 Documentation
- 8-11 Confidence in the use of software tools
- 8-12 Qualification of software components
- 8-13 Qualification of hardware components
- 8-14 Proven in use argument

9. ASIL-oriented and safety-oriented analyses
- 9-5 Requirements decomposition with respect to ASIL tailoring
- 9-6 Criteria for coexistence of elements
- 9-7 Analysis of dependent failures
- 9-8 Safety analyses

10. Guideline on ISO 26262

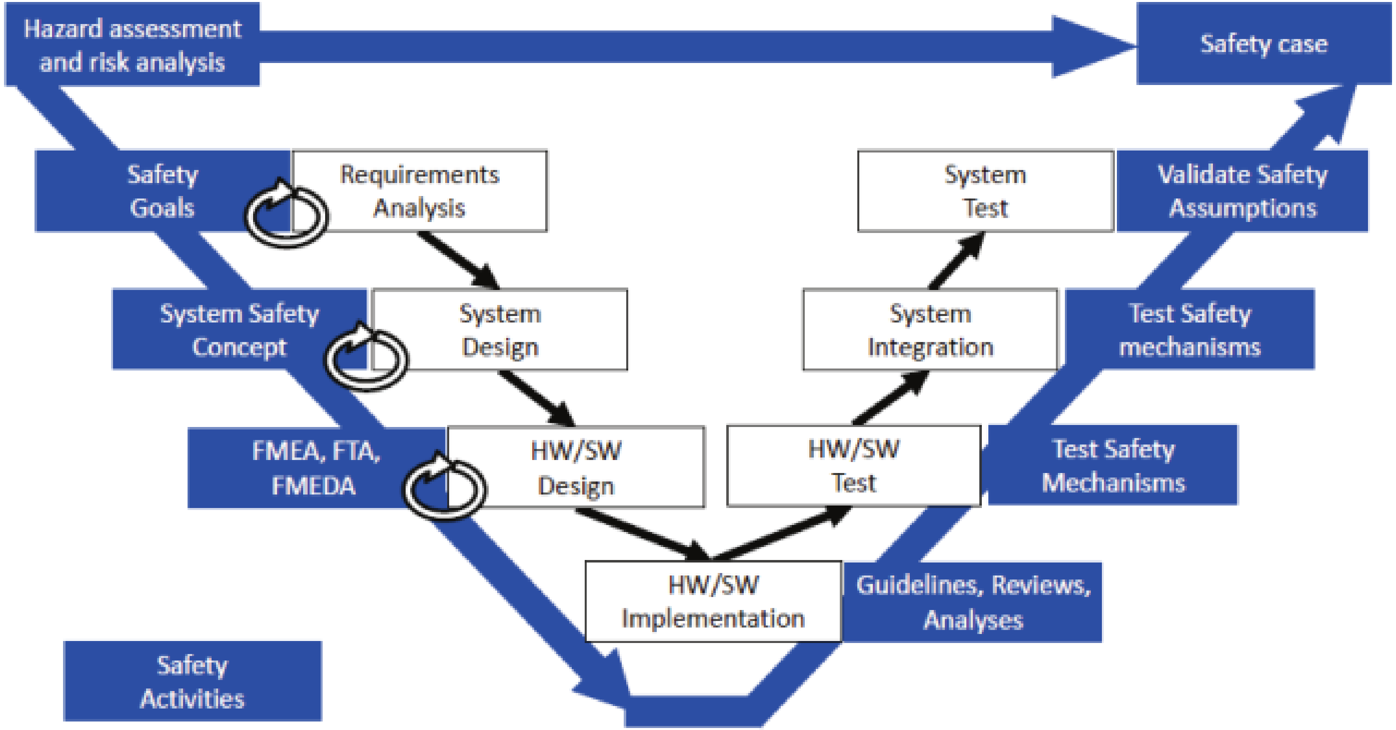
Source: ISO 26262: „Road Vehicles – Functional Safety"

Concept Phase

- Safety:
  - Analysis at design/implementation
    - Hazard analysis
    - FMEA, FTA, FMEDA
  - Included in development process
  - Stable, established, standardized

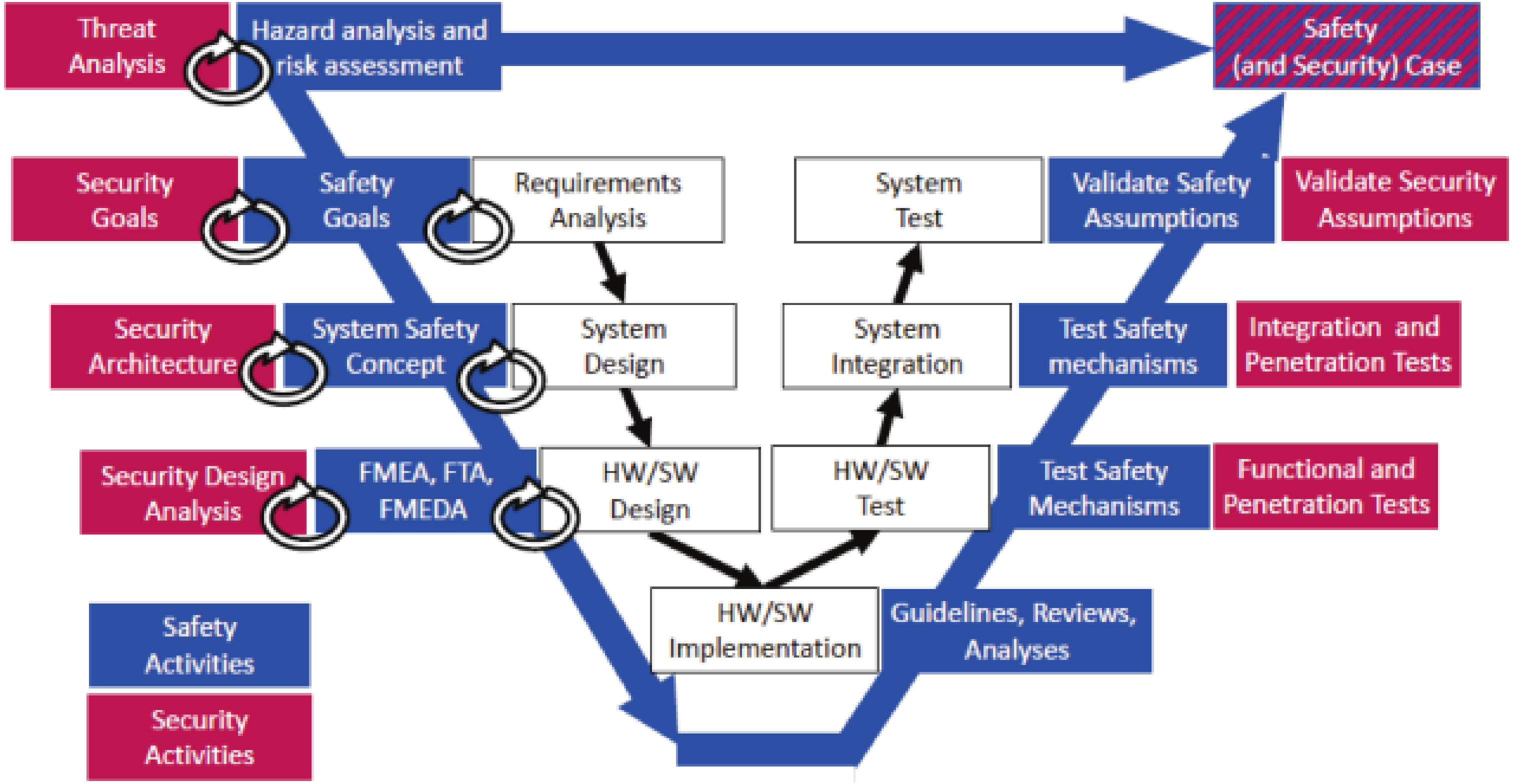
- Security:
  - Security and Risk Analysis
    - Threat and damage analysis
  - Countermeasures
    - Cryptography, HSMs, side-channel elimination
  - Moving target
    - New vulnerabilities and attacks
  - Relatively new, standards not fully established

Safety Process



Source: „ Automotive Functional Safety = Safety + Security“, Simon Burton, *Jürgen Likkei, Priyamvadha Vembar, Marko Wolf*

Safety + Security Process



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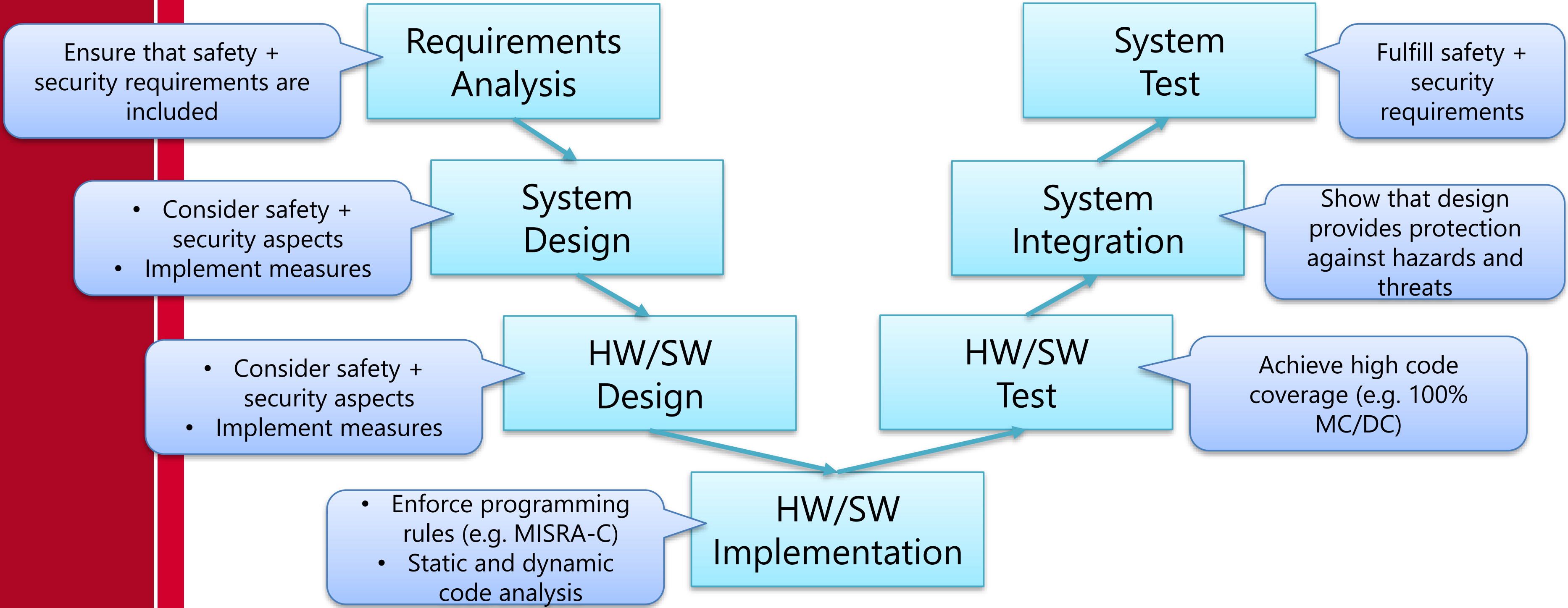
Product Development Phase: Safety + Security by Design



Ensure that safety + security requirements are included

- Consider safety + security aspects
- Implement measures

- Consider safety + security aspects
- Implement measures

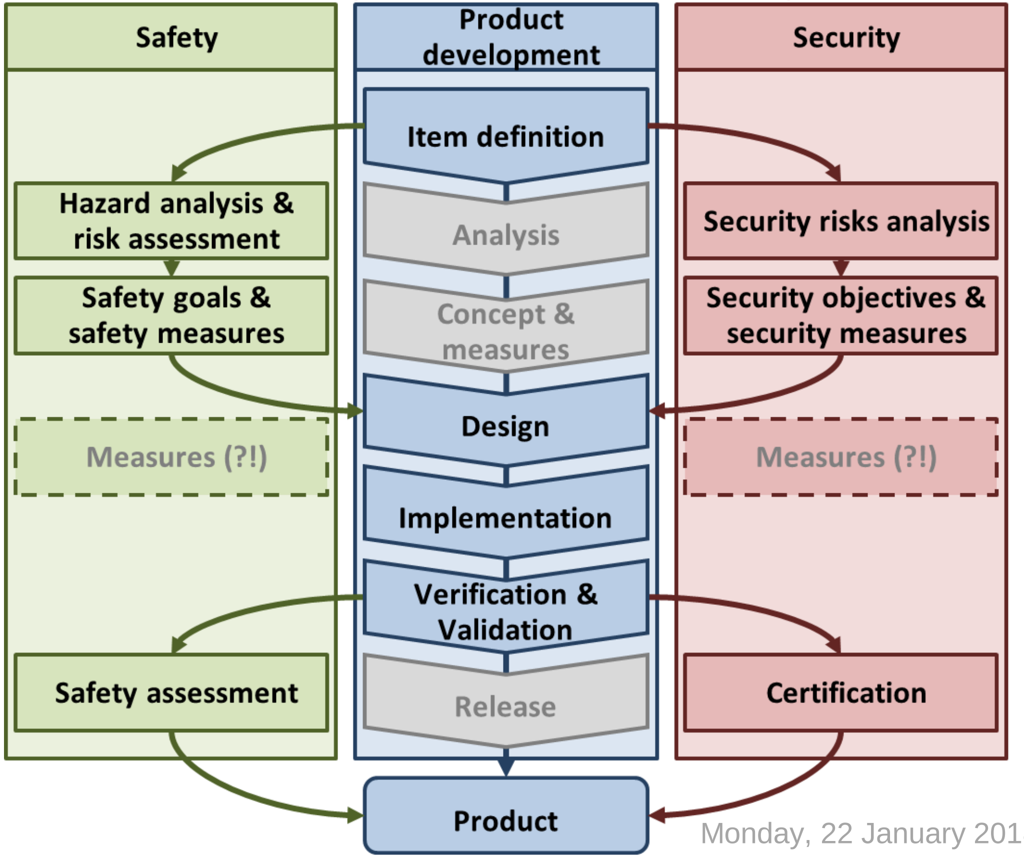
- Enforce programming rules (e.g. MISRA-C)
- Static and dynamic code analysis

Achieve high code coverage (e.g. 100% MC/DC)

Show that design provides protection against hazards and threats

Fulfill safety + security requirements

Combined Safety + Security Process



Source: „ Synergetic Safety and Security Engineering“, *Dr. Christian Eherer , Dr. Henrik J. Putzer, Franz Strasser, Dr. Marko Wolf*

Conclusion

- Combined process
  - Assists to identify synergies and potential conflicts at an early design phase
    - Synergies can then simplify development process
    - Conflicts can then be addressed separately
  - Similarities also in analyses (HARA & SRA)
  - Implementation & tests: measures from one domain also increase confidence in other (e.g. code coverage)
  - Security certification and safety assessment: achieved levels can be compared

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