Functional Safety and ISO26262 Compliance

APF-AUT-T0503

John Cotner

Field Engineer

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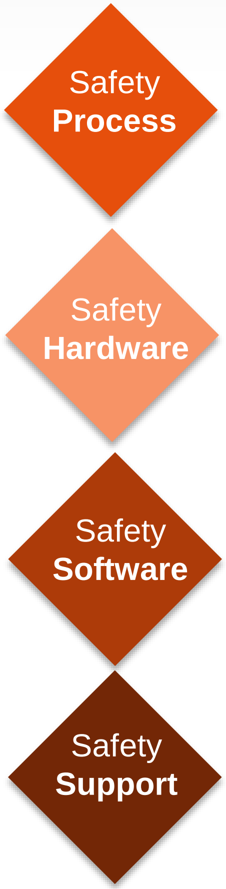
Agenda

- Introduction
  - Functional Safety Requirements
  - SafeAssure Program
- Role of the Semiconductor Supplier
  - System Challenges
  - Freescale System Solutions
- Safety Concepts of Freescale‘s Auto MCUs
  - Integrated Safety Architecture Example
- Safety Software
- Safety Support
  - Dynamic FMEDA
  - System level (beyond MCU)
- Summary



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The problem

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The World of Functional Safety Standards

	1980	1985	1990	1995	2000	2005	2010	2015
Aeronautic	DO 178 DO 178A		DO 178B ARP 4754	ARP 4761	DO 254		DO 178C ARP 4754A	
Rail Transport				EN 50155	IEC 61508 EN 5012X EN 50159			
Generic Standard IEC61508					IEC 61508		IEC 61508 Edition 2	
Industrial Automation					IEC 61508 IEC 61511 IEC 62061		IEC 61508 Edition 2	
Automotive					(IEC 61508)		ISO 26262	
Medical							IEC 60601 Edition 3	

***ISO 26262-1:9** published 15th Nov 2011*
***ISO/FDIS 26262-10** published 9th Mar 2012*

□ Select Freescale products are being defined and designed from the ground up to comply with IEC 61508 ed2.0 (2010-04) and ISO 26262 (2011-11-15)

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ISO 26262 is changing the Automotive Market

- The market trends have one thing in common: If the underlying systems fail, humans can be put at risk
- Functional Safety means “absence of unreasonable risk due to hazards caused by malfunctioning behavior of E/E systems”
- ISO 26262 is the International Standard for Functional Safety. It is applicable to safety-related automotive systems that include one or more E/E systems and that are installed in series production passenger cars with a max gross weight up to 3.5t”
- ISO 26262 addresses
  - architectural & functional aspects
  - procedural aspects (incl. safety lifecycle)
  - to avoid systematic faults and to control random faults
- Safety management is needed from the start of the product development
- Functional Safety will become a standard requirement in future RFQ’s, across most applications

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ISO 26262 Outline

The ISO 26262 standard

- provides an automotive safety lifecycle which outlines handling of safety system development and operation from project initiation to system decommission
- provides an automotive specific risk-based approach for determining risk classes based on severity, exposure (probability) and controllability of the hazard
- uses four Automotive Safety Integrity Levels (ASIL) for specifying the item’s safety requirements
  - ASIL A: the lowest ASIL level
  - ASIL B: at least 90% SPF and at least 60% latent fault (LF, a fault that isn’t detected but doesn’t lead directly to violation of a safety goal) being detected
  - ASIL C: at least 99% SPF and 90% LF detected
  - ASIL D: the highest ASIL level, at least 99.9% SPF and 99% LF detected
- provides requirements for validation and confirmation requirements to ensure the required safety level is achieved

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Determining the ASIL of an Item

Class of severity	Class of probability of exposure regarding operational situations	Classes of controllability		
		C1 (simple)	C2 (normal)	C3 (difficult, uncontrollable)
S1 (Light and moderate injuries)	E1 (very low)	QM	QM	QM
	E2 (low)	QM	QM	QM
	E3 (medium)	QM	QM	A
	E4 (high)	QM	A	B
S2 (Severe and life threatening injuries [survival probable])	E1 (very low)	QM	QM	QM
	E2 (low)	QM	QM	A
	E3 (medium)	QM	A	B
	E4 (high)	A	B	C
S3 (Life threatening injuries, fatal injuries)	E1 (very low)	QM	QM	A
	E2 (low)	QM	A	B
	E3 (medium)	A	B	C
	E4 (high)	B	C	D

(QM: “quality managed” → no requirements from standard applied explicitly)

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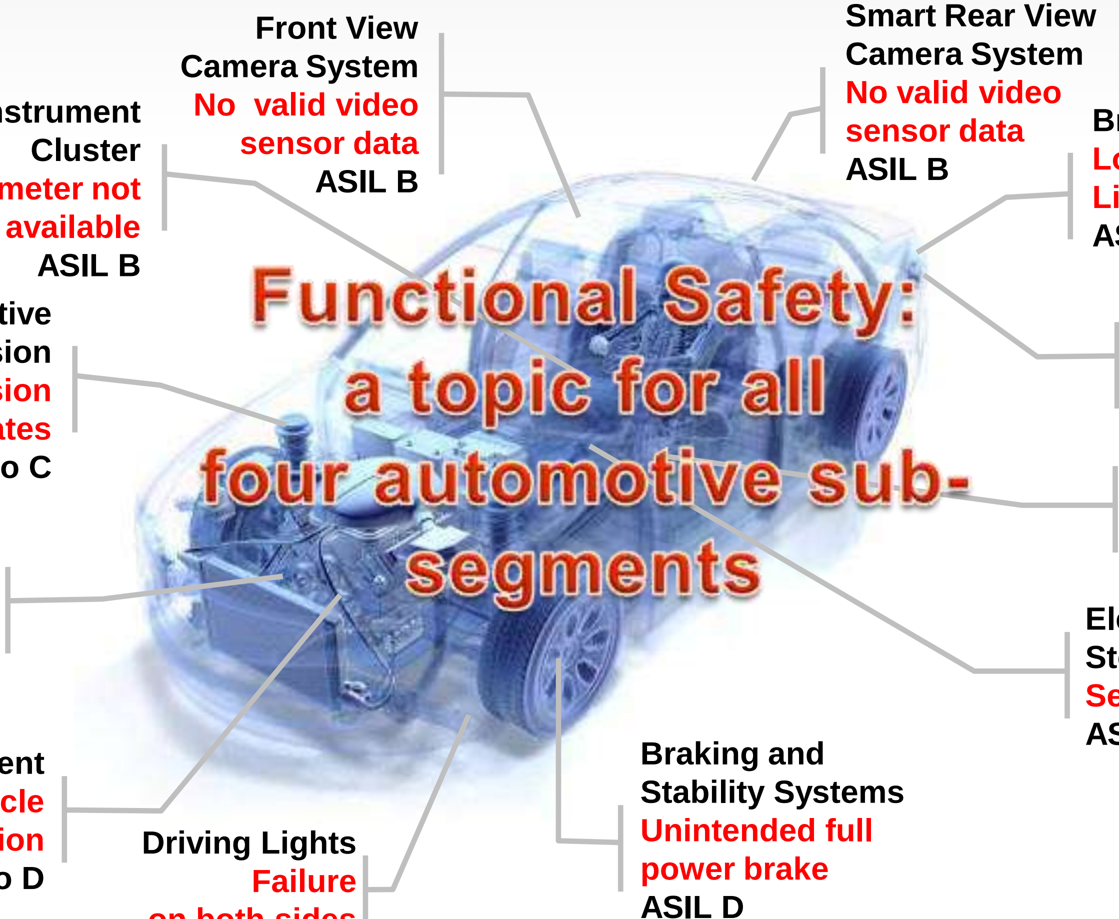
Automotive System Trends for ASIL Levels



Functional Safety: a topic for all four automotive sub-segments

Instrument Cluster
Speedometer not available
ASIL B

Front View Camera System
No valid video sensor data
ASIL B

Smart Rear View Camera System
No valid video sensor data
ASIL B

Brake Lights
Loss of Brake Lights
ASIL B

Active Suspension
Suspension oscillates
ASIL B to C

Rear Lights
Failure on both sides
ASIL A

77GHz RADAR ACC
Inadvertent Braking
ASIL C

Airbag System
Inadvertent Deployment
ASIL D

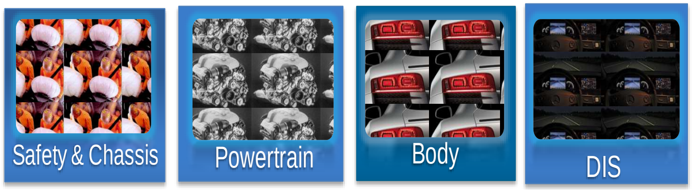
Electric Power Steering
Self-steering
ASIL D

Engine Management
Unwanted vehicle acceleration
ASIL C to D

Driving Lights
Failure on both sides
ASIL B

Braking and Stability Systems
Unintended full power brake
ASIL D

Source: Freescale: Expectations based on global customer feedback



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SafeAssure Approach: The Four Key Elements

ISO 26262
Automotive Industry standard, adaptation of IEC 61508 for electrical/electronic systems within road vehicles
Integrity levels
ASIL A, ASILB, ASIL C, ASILD
Pub date: 2011

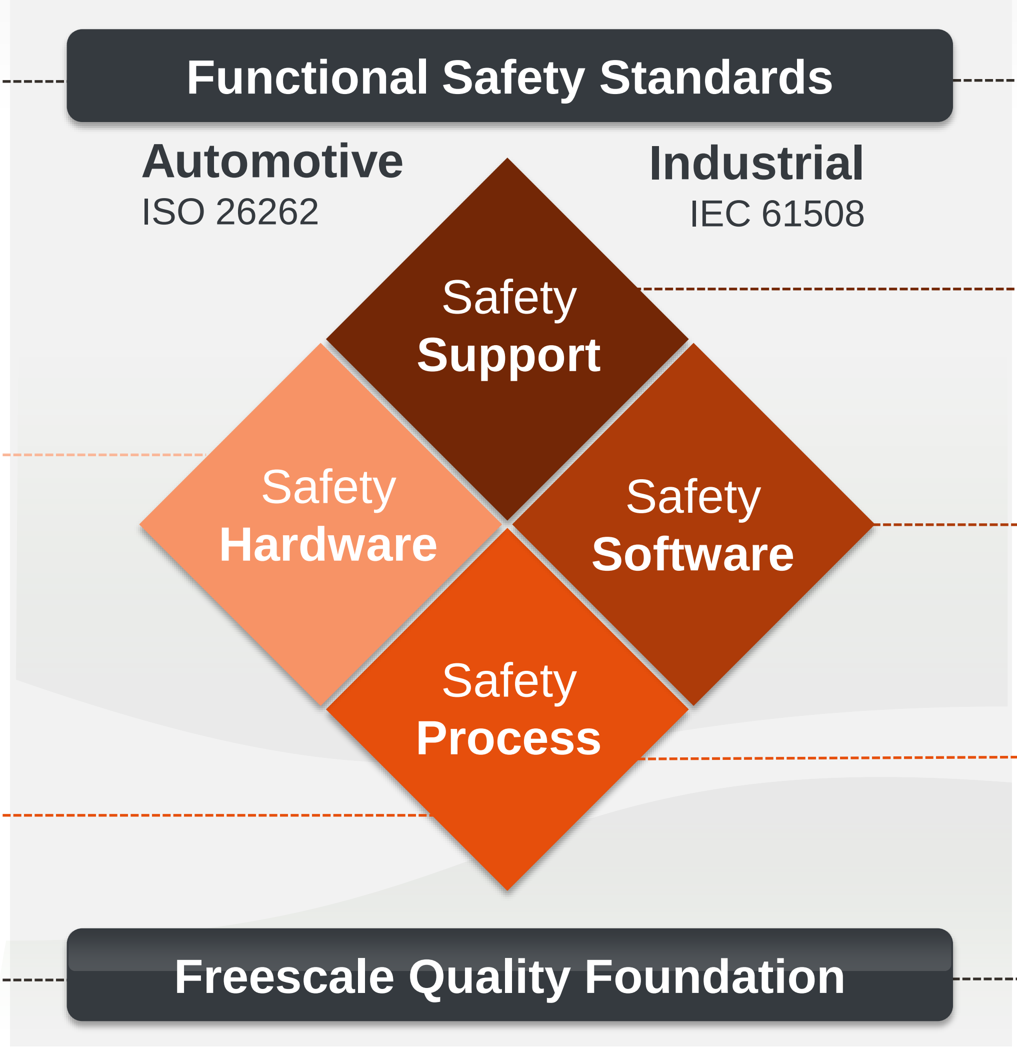
Microcontrollers
Lockstep Cores, ECC on Memories Redundant Functions, Internal Monitors, Built In Self Test, Fault Collection & Control

Analog and Power Management
Voltage Monitors, External Error Monitor, Advanced Watchdog, Built In Self Test

Sensors
Timing Checker, Digital Scan of Signal Chains, DSI3 or PSI5 Safety Data links

Organization
Safety is an integral part of the Freescale world wide organization
Project Management
Configuration & Change Management, Quality Management, Requirements Management, Architecture & Design, Verification & Validation

Quality Management
ISO TS 16949 Certified Quality Management System
Hardware - Zero Defects
Software – SPICE Level 3



Functional Safety Standards

Automotive
ISO 26262

Industrial
IEC 61508

Safety **Support**

Safety **Hardware**

Safety **Software**

Safety **Process**

Freescale Quality Foundation

IEC 61508
Generic Industry standard, applicable to electrical / electronic / programmable electronic safety-related systems.
Integrity levels
SIL 1, SIL 2, SIL 3, SIL 4
Pub date: More than 10 years ago

People
Regional functional safety experts

Documentation
Safety Application Notes / Safety Manual / FMEDA

Automotive Software
AUTOSAR OS & MCAL
Core Self Test
Device Self Test; Complex Drivers

Software Partnerships
Partnering with leading third-party software providers for automotive and industrial

Safety Analysis
Selected products defined & designed from the ground up with safety analysis being done at each step of the process
Assessments / Audits
Safety Confirmation Measures

Continuous Improvement
Process evaluation, assessments / audits and gap-analysis exist to ensure processes are continually optimized

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Role of the Semiconductor Supplier

Safety
Process

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Safety Architecture Challenge

- ISO 26262 safety lifecycle defined as top down approach
  - Next level requirements result from previous level
  - In practice also “push-back” due to availability of products with desired functionality and safety measures
- Safety architecture needs to be defined such that it is safe and can be realized in an efficient way
- Possible development options:
  - Commission custom ASICs with application specific safety measures
  - Use off-the shelf components with an integrated safety architecture
    - Many new components emerging in light of ISO 26262 adoption
  - Define major elements of safety architecture at system level
    - Use “standard” off-the shelf components → discrete (component) safety architecture
    - Traditional way of designing a functional safety system

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No “best” Safety Architecture exists!

Every embedded application has its very specifics!

Microcontroller are successful due to the general purpose nature (can be adapted to the specifics of an application)

Therefore **Freescale** provides products with **different Multi-Core safety architectures**:

- **Monolithic** integration (safety system on chip)
- Multiple device **system level integration** (multiple chip ECU)
- **Distributed** system integration (multiple ECU system)
- **…**

Customer may select their most suitable architecture!

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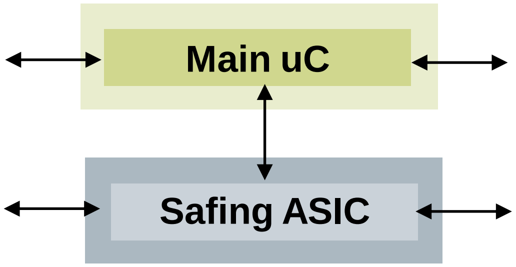
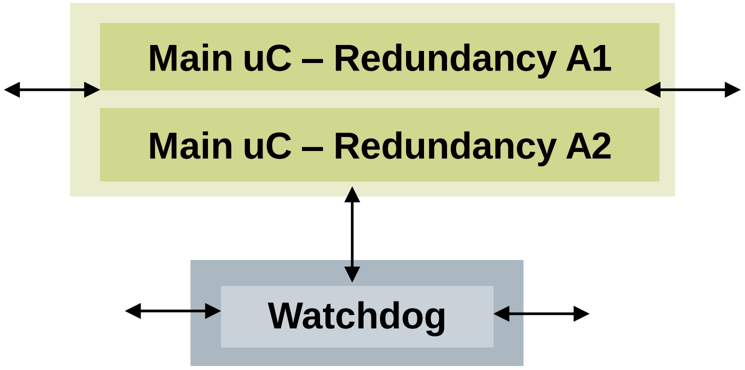
Discrete and Integrated HW Safety Architecture

- Discrete HW Safety Architecture
  - Redundancy resolved at system level by means of redundant components
  - Example: Traditional airbag system consisting of MCU and Safing ASIC
  - System designer performs dependent failure analysis

- Integrated HW Safety Architecture
  - Redundancy resolved at system level and at component level with redundant modules within a component
  - Example: Electric power steering with dual-core lock-step uC
  - Component designer performs dependent failure analysis for redundancy at module level





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From Integrated to Discrete Safety Architecture

Integrated Safety Architecture		Discrete Safety Architecture
At system level and at component level	**Safety Architecture**	Resolved at system level
One or more devices contain dedicated safety measures based on an underlying safety concept	**Device Level Safety Measures**	No underlying safety concept at device level, typically, however, measures exploitable as safety measures available
Available for integrated safety measures	**Device Level Safety Manual**	None
FMEDA, FTA for dedicated safety measures	**Device Level Safety Analysis**	None, typically general supporting information sufficient
Safety case, with complete device level argument for ISO 26262 compliance at device level	**Device Level Safety Argument**	Qualification + optional evaluation of measures in development process against systematic faults

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Quantitative ASIL Requirements for HW

	ASIL A	ASIL B	ASIL C	ASIL D
Discrete HW Safety Architecture	Feasible • Discrete safety architecture		Feasible • Discrete safety architecture using uC & separate watchdog or uC • Functional and temporal alignment between uC & 2nd channel often challenging • Fast recovery from transient faults potentially challenging	
Integrated HW Safety Architecture	Feasible • However, redundancy on component level is typically a technical overkill • Functional safety enablement simplifies demonstration of compliance		Feasible • Integrated safety architecture using dual-core lockstep uC • Functional and temporal alignment between two channels simplified • Fast recovery from transient faults more feasible	

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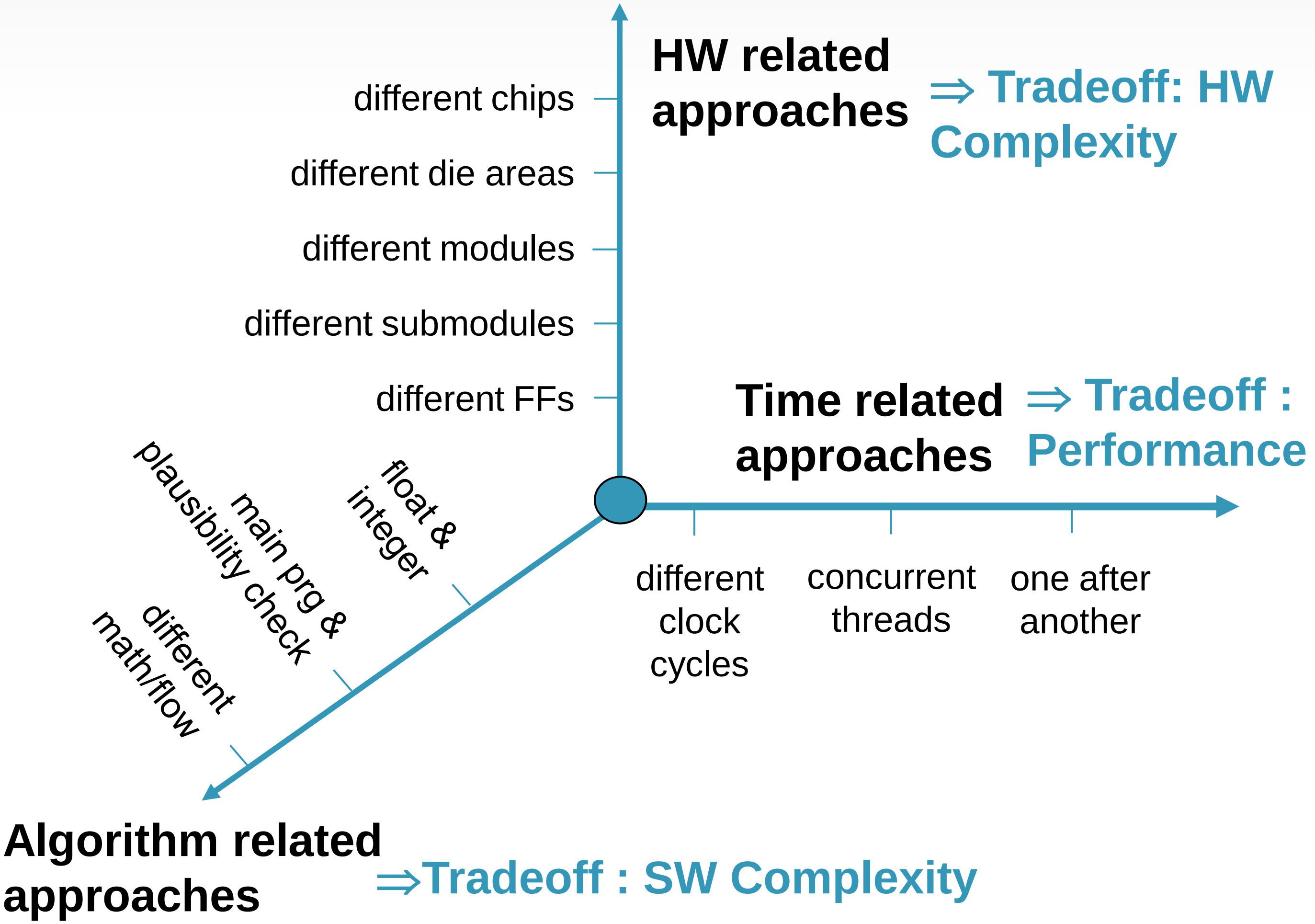
Tradeoffs of Different Redundancy Approaches



HW related approaches ⇒ **Tradeoff: HW Complexity**

different chips

different die areas

different modules

different submodules

different FFs

Time related approaches ⇒ **Tradeoff : Performance**

different clock cycles

concurrent threads

one after another

float & integer

main prg & plausibility check

different math/flow

Algorithm related approaches ⇒**Tradeoff : SW Complexity**

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From System Level to Component Level

- Functional safety is not just an issue on system level but also on component level
  - Integrated safety devices (customer has no “direct” access to details of safety functions)
- Functional safety standards explicitly address component level
  - ISO 26262: Safety Element out of Context (SEooC)
- Basic approach is to assume a system context (or several) of the component
  - Safety Application Guide (Safety Manual) specifies how the component is applied correctly in the assumed system context

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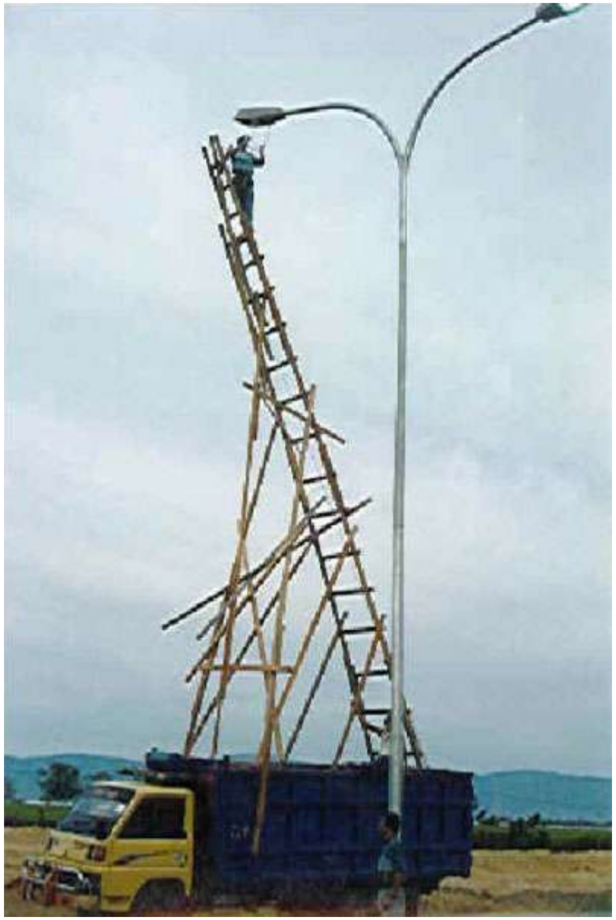
How does the system context impact safety?

Customer asks for a “safe ladder”

The “safe ladder”

The “safe ladder” in the field



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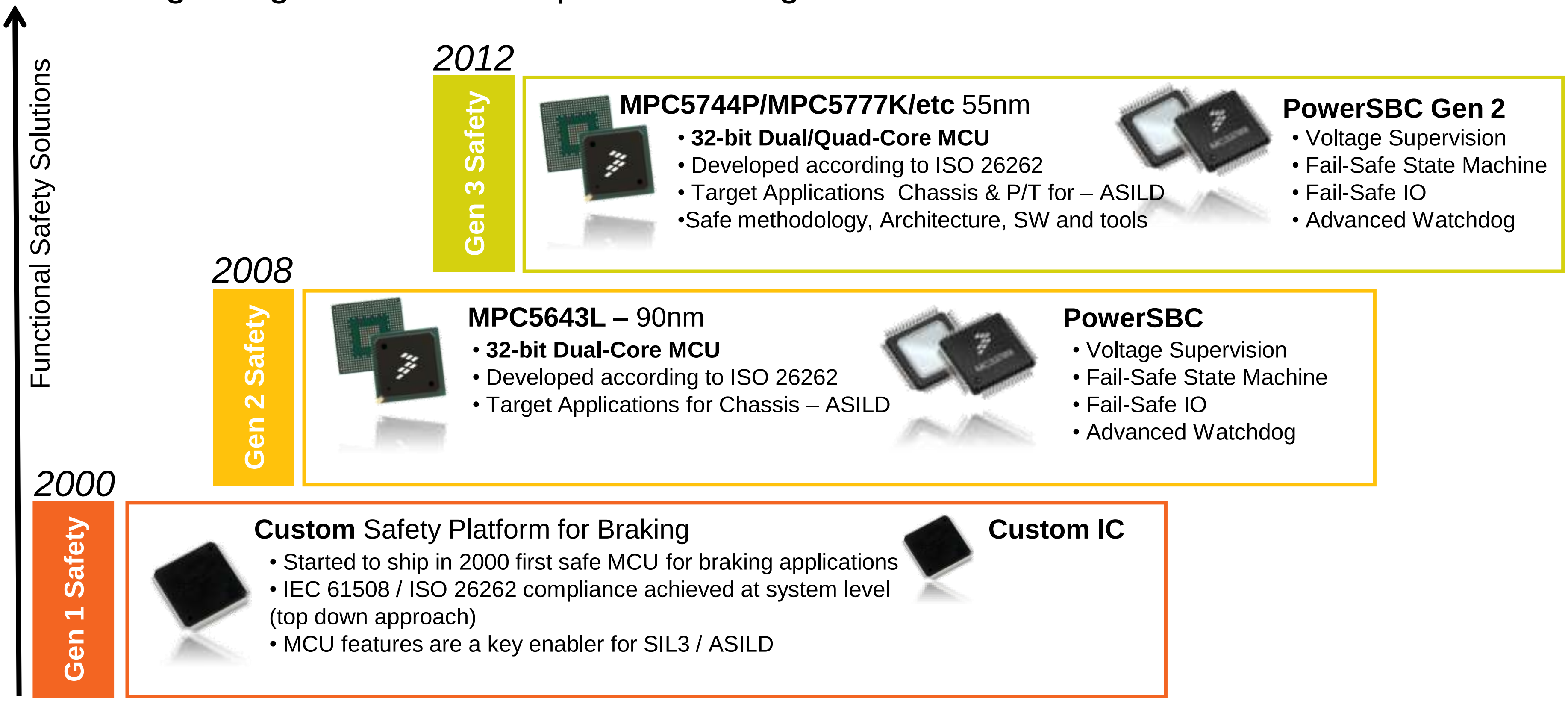
History of Auto MCU Functional Safety Solutions

- Gen 1 Safety More than 10 years experience of safety development in the area of MCU & SBC
- Gen 2 Safety First general market MCU, MPC5643L ⇒ Certified ISO 26262!
- Gen 3 Safety From 2012, multiple MCUs in Body, Chassis and Powertrain are being designed and developed according to ISO 26262



MPC5744P/MPC5777K/etc 55nm

- **32-bit Dual/Quad-Core MCU**
- Developed according to ISO 26262
- Target Applications Chassis & P/T for – ASILD
- Safe methodology, Architecture, SW and tools

PowerSBC Gen 2

- Voltage Supervision
- Fail-Safe State Machine
- Fail-Safe IO
- Advanced Watchdog

MPC5643L – 90nm

- **32-bit Dual-Core MCU**
- Developed according to ISO 26262
- Target Applications for Chassis – ASILD

PowerSBC

- Voltage Supervision
- Fail-Safe State Machine
- Fail-Safe IO
- Advanced Watchdog

Custom Safety Platform for Braking

- Started to ship in 2000 first safe MCU for braking applications
- IEC 61508 / ISO 26262 compliance achieved at system level (top down approach)
- MCU features are a key enabler for SIL3 / ASILD

Custom IC

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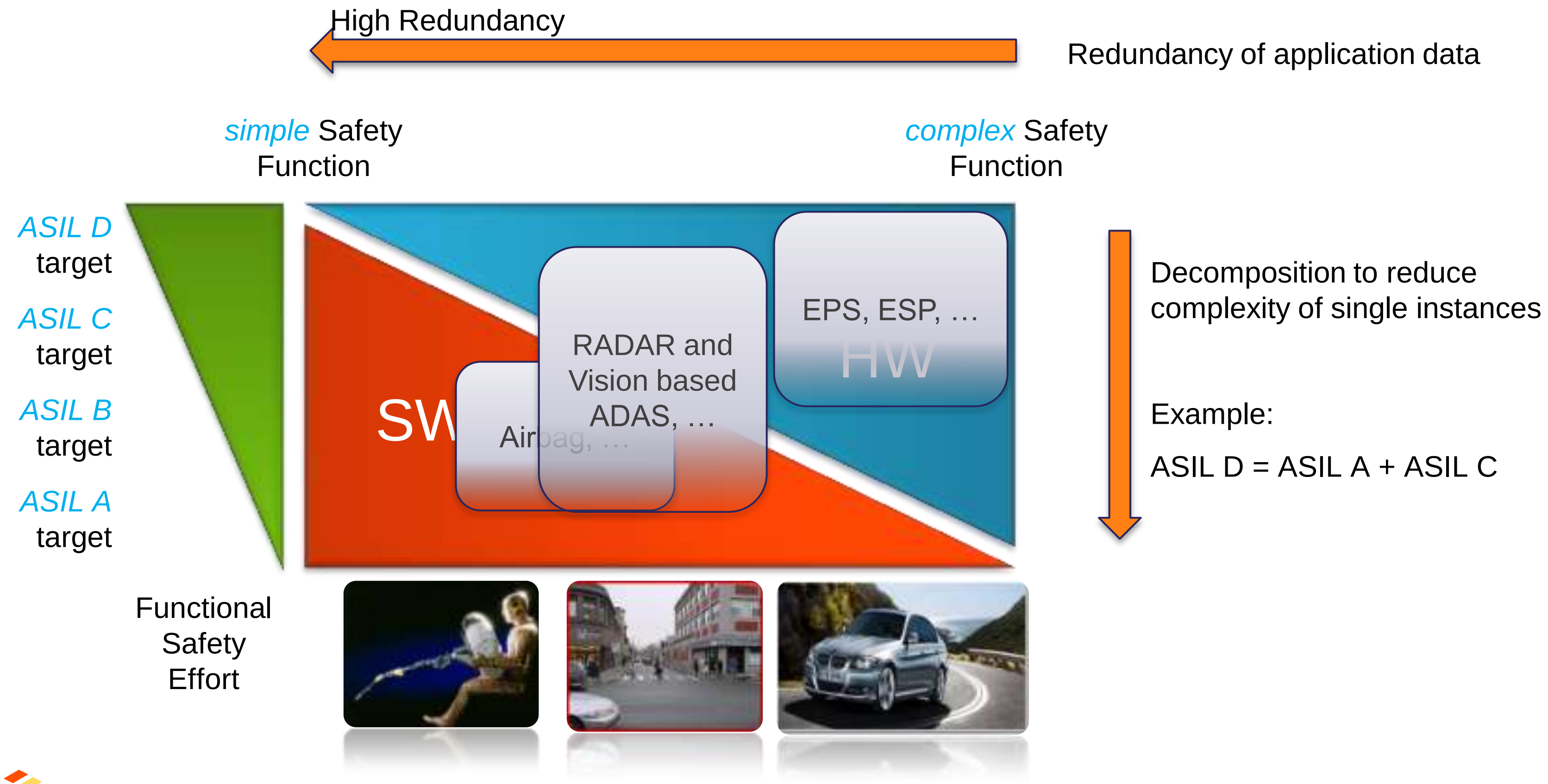
Our Vision in safety: know your context

Ideal partitioning between HW and SW measures dependant on ASIL target and complexity of safety function

Example Safety Applications …



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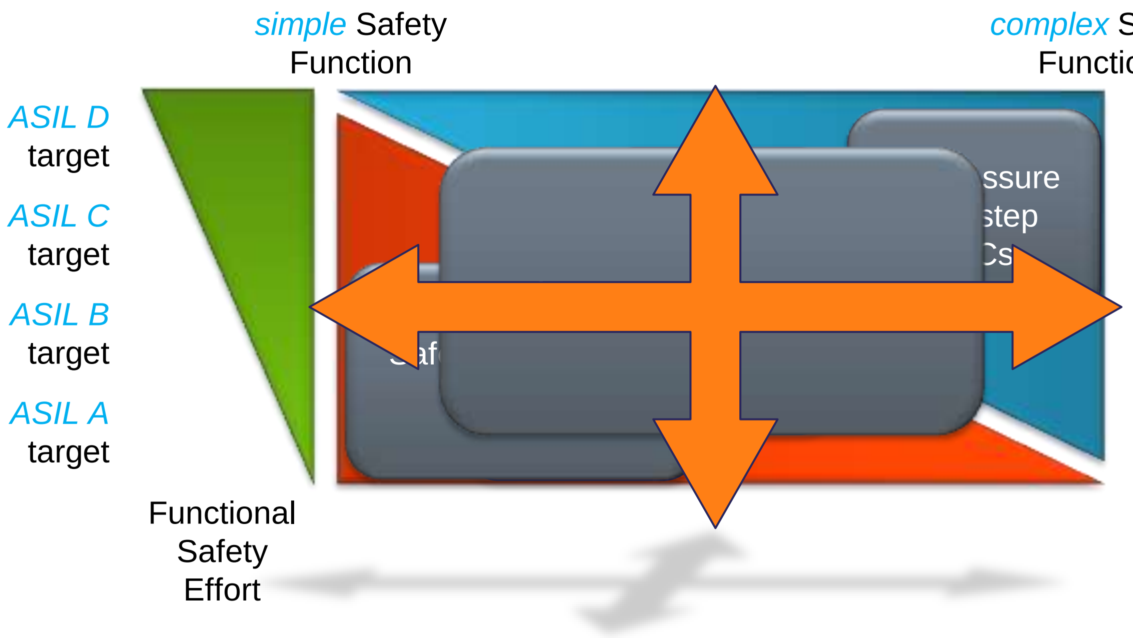
Our solution for safety: Balance and flexible

Offering products that scale to application specific safety requirements



simple Safety Function

complex Safety Function

ASIL D target

ASIL C target

ASIL B target

ASIL A target

Functional Safety Effort

SAFE ASSURE™ by Freescale

*Spanning the whole range **efficiently** …*

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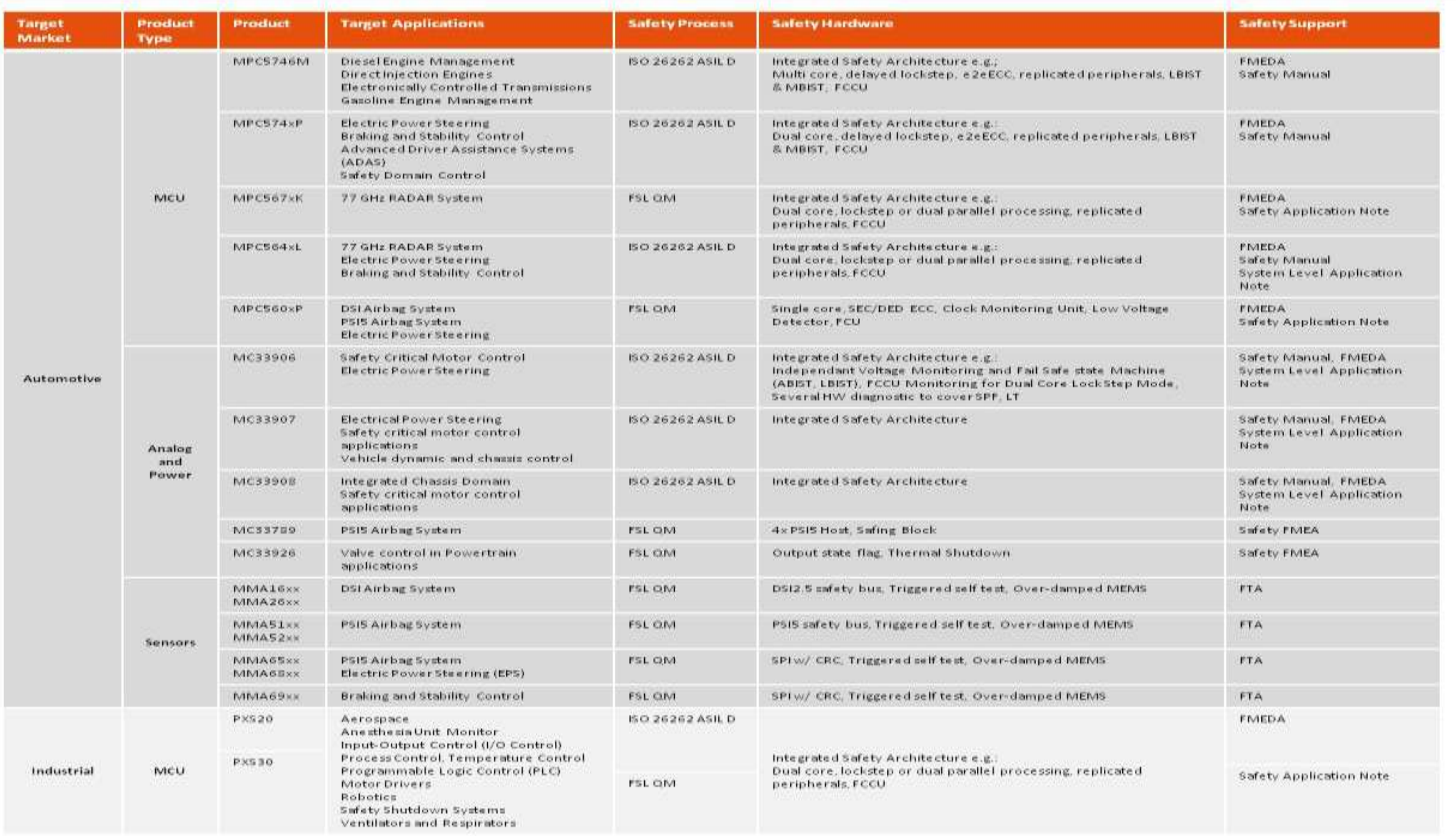
SafeAssure Products



Target Market	Product Type	Product	Target Applications	Safety Process	Safety Hardware	Safety Support
Automotive	MCU	MPC5746M	Diesel Engine Management Direct Injection Engines Electronically Controlled Transmissions Gasoline Engine Management	ISO 26262 ASIL D	Integrated Safety Architecture e.g.; Multi core, delayed lockstep, e2eECC, replicated peripherals, LBIST & MBIST, FCCU	FMEDA Safety Manual
		MPC574xP	Electric Power Steering Braking and Stability Control Advanced Driver Assistance Systems (ADAS) Safety Domain Control	ISO 26262 ASIL D	Integrated Safety Architecture e.g.: Dual core, delayed lockstep, e2eECC, replicated peripherals, LBIST & MBIST, FCCU	FMEDA Safety Manual
		MPC567xK	77 GHz RADAR System	FSL QM	Integrated Safety Architecture e.g.: Dual core, lockstep or dual parallel processing, replicated peripherals, FCCU	FMEDA Safety Application Note
		MPC564xL	77 GHz RADAR System Electric Power Steering Braking and Stability Control	ISO 26262 ASIL D	Integrated Safety Architecture e.g.: Dual core, lockstep or dual parallel processing, replicated peripherals, FCCU	FMEDA Safety Manual System Level Application Note
		MPC560xP	DSI Airbag System PSI5 Airbag System Electric Power Steering	FSL QM	Single core, SEC/DED ECC, Clock Monitoring Unit, Low Voltage Detector, FCU	FMEDA Safety Application Note
	Analog and Power	MC33906	Safety Critical Motor Control Electric Power Steering	ISO 26262 ASIL D	Integrated Safety Architecture e.g.: Independant Voltage Monitoring and Fail Safe state Machine (ABIST, LBIST), FCCU Monitoring for Dual Core LockStep Mode, Several HW diagnostic to cover SPF, LT	Safety Manual, FMEDA System Level Application Note
		MC33907	Electrical Power Steering Safety critical motor control applications Vehicle dynamic and chassis control	ISO 26262 ASIL D	Integrated Safety Architecture	Safety Manual, FMEDA System Level Application Note
		MC33908	Integrated Chassis Domain Safety critical motor control applications	ISO 26262 ASIL D	Integrated Safety Architecture	Safety Manual, FMEDA System Level Application Note
		MC33789	PSI5 Airbag System	FSL QM	4x PSI5 Host, Safing Block	Safety FMEA
		MC33926	Valve control in Powertrain applications	FSL QM	Output state flag, Thermal Shutdown	Safety FMEA
	Sensors	MMA16xx MMA26xx	DSI Airbag System	FSL QM	DSI2.5 safety bus, Triggered self test, Over-damped MEMS	FTA
		MMA51xx MMA52xx	PSI5 Airbag System	FSL QM	PSI5 safety bus, Triggered self test, Over-damped MEMS	FTA
		MMA65xx MMA68xx	PSI5 Airbag System Electric Power Steering (EPS)	FSL QM	SPI w/ CRC, Triggered self test, Over-damped MEMS	FTA
		MMA69xx	Braking and Stability Control	FSL QM	SPI w/ CRC, Triggered self test, Over-damped MEMS	FTA
Industrial	MCU	PXS20	Aerospace Anesthesia Unit Monitor Input-Output Control (I/O Control) Process Control, Temperature Control Programmable Logic Control (PLC) Motor Drivers Robotics Safety Shutdown Systems Ventilators and Respirators	ISO 26262 ASIL D	Integrated Safety Architecture e.g.: Dual core, lockstep or dual parallel processing, replicated peripherals, FCCU	FMEDA
		PXS30		FSL QM		Safety Application Note

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Safety Concept of an MCU with Integrated Safety Architecture

Safety
Hardware

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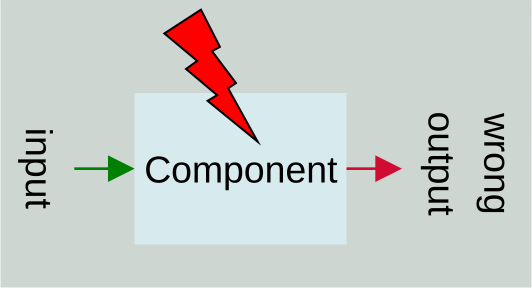
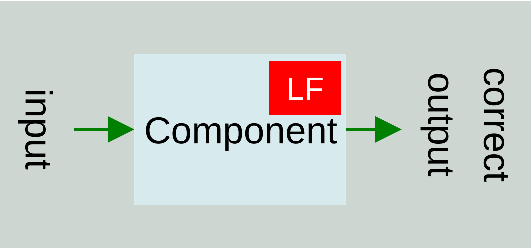
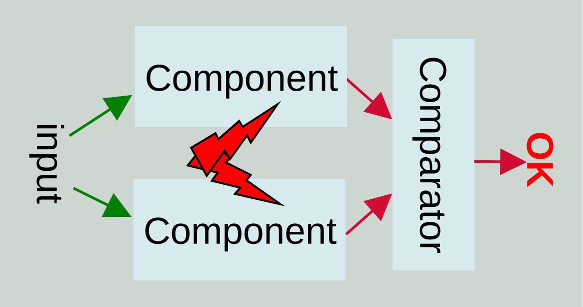
Random Failures and their Handling

- Single Point Failure (SPF)
  - Immediate potential to cause a hazard
  - Quick detection or mitigation
- Latent Failure (LF)
  - Can become dangerous in conjunction with a second fault
  - Can aggregate
  - Periodic detection
- Common Cause Failure (CCF)
  - Causes several component to fail
  - Can possibly annul redundancy-based measures
  - Mitigation or quick detection







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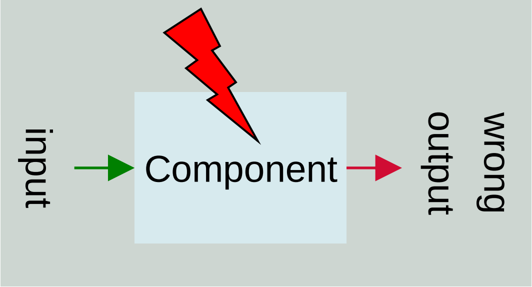
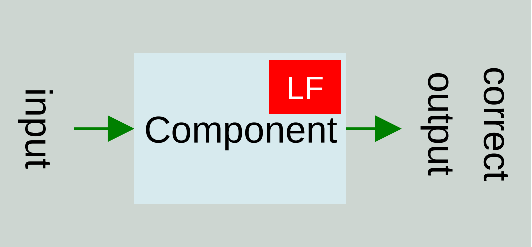
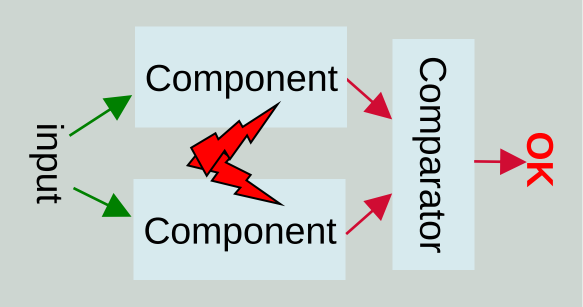
MCU Countermeasures for Failure Classes

- Single Point Failure (SPF)
  - Structural redundancy
    - Core, DMA
  - Information redundancy
    - **E2E ECC**, EDC on Cache
- Latent Failure (LF)
  - HW-Self test
    - Memory, logic
    - 90% stuck-at
- Common Cause Failure (CCF)
  - Delayed Checker Core
  - Supervision of clock, power and temperature
  - Independent safety clock
  - Independent failure signaling







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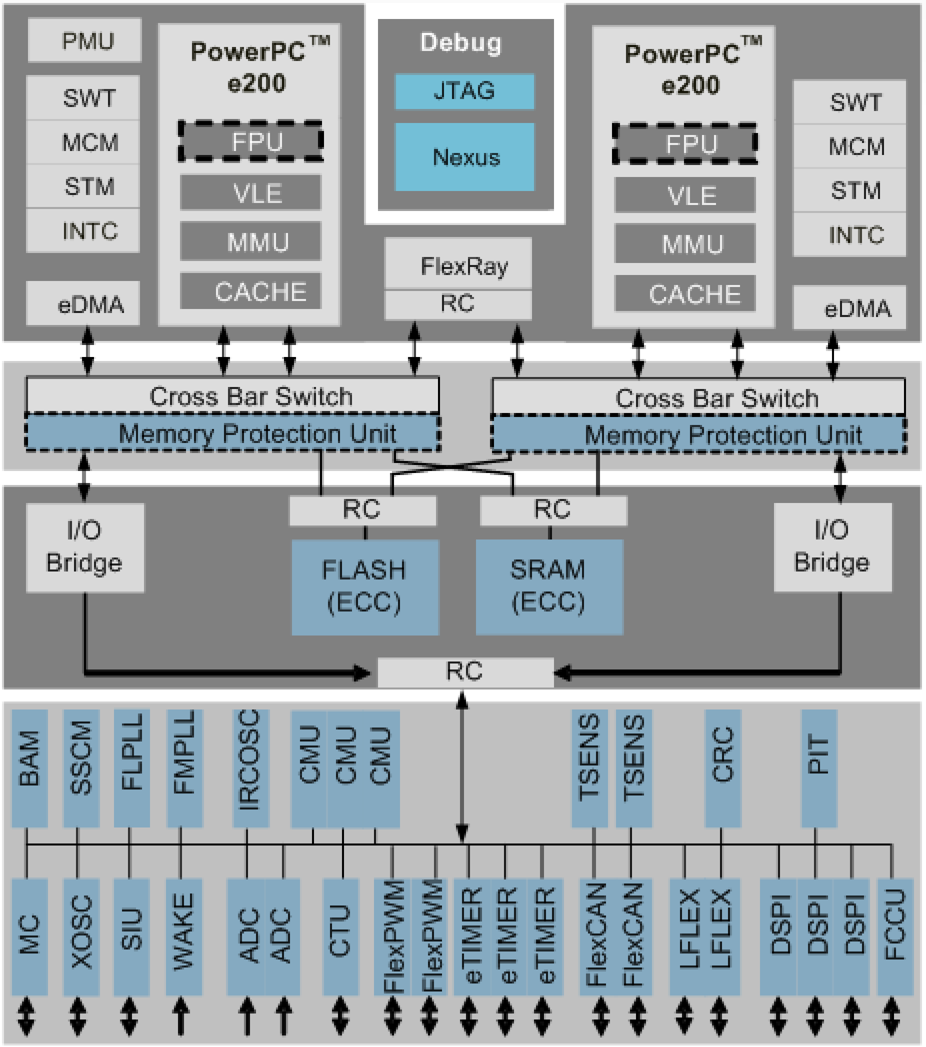
Safety Concept Example: MPC5643L (1)

- Target applications
  - Safety applications that require a high safety integrity level, such as:
    - Electric power steering
    - Electronic stability control
- Item must be in safe state for modes of (non)operation:
  - Completely unpowered
  - Reset
  - Operating correctly
  - Indicating an internal error
- Safety mechanism: technical solution to detect faults or control failures in order to achieve a safe state



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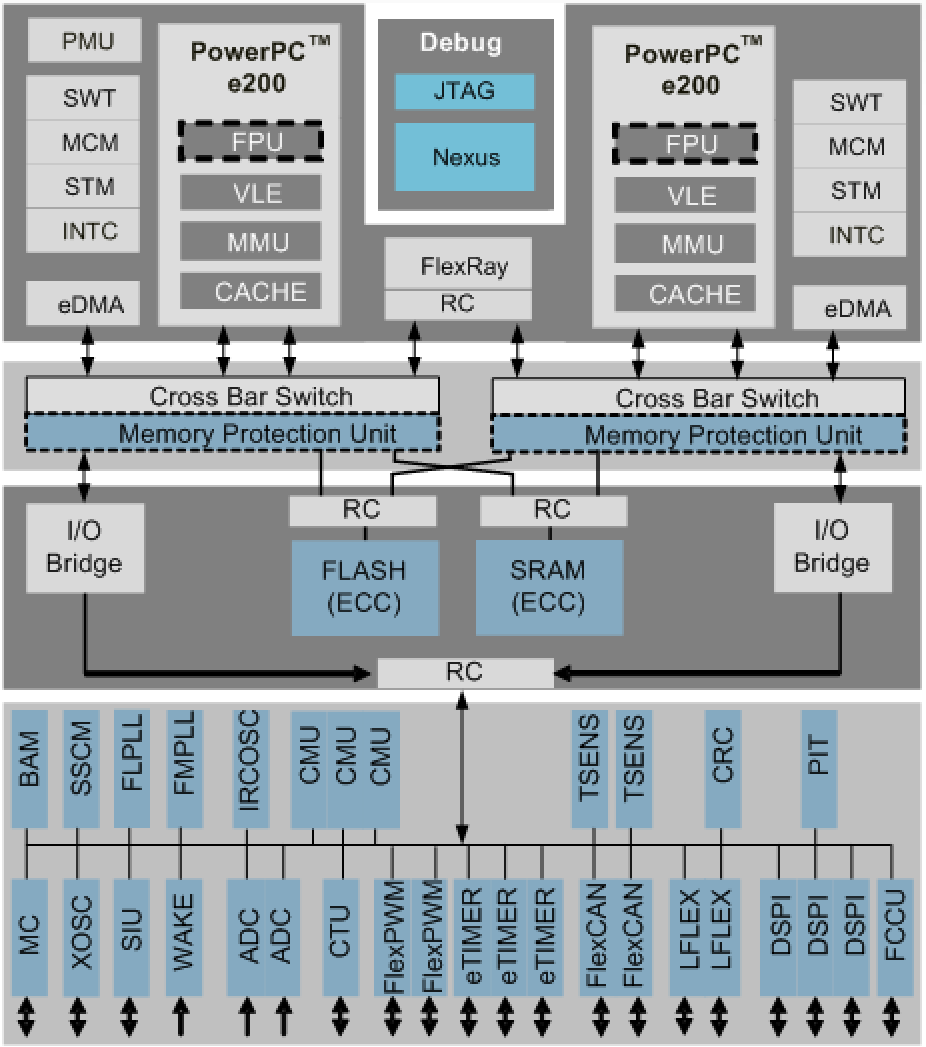
Safety Concept Example: MPC5643L (2)

- Safety mechanisms:
  - Built-in self tests (memory, logic, ADC)
  - Duplicate computational elements in lock-step
  - ECC for FLASH/SRAM
  - Temperature, clock and voltage monitors
  - Fault Collection and Control Unit (FCCU) with redundant fault notification path
  - Independent safety clock
  - eDMA and CRC
  - Access protection (MPU, register) ….



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Safety Concept Example: MPC5643L (3)

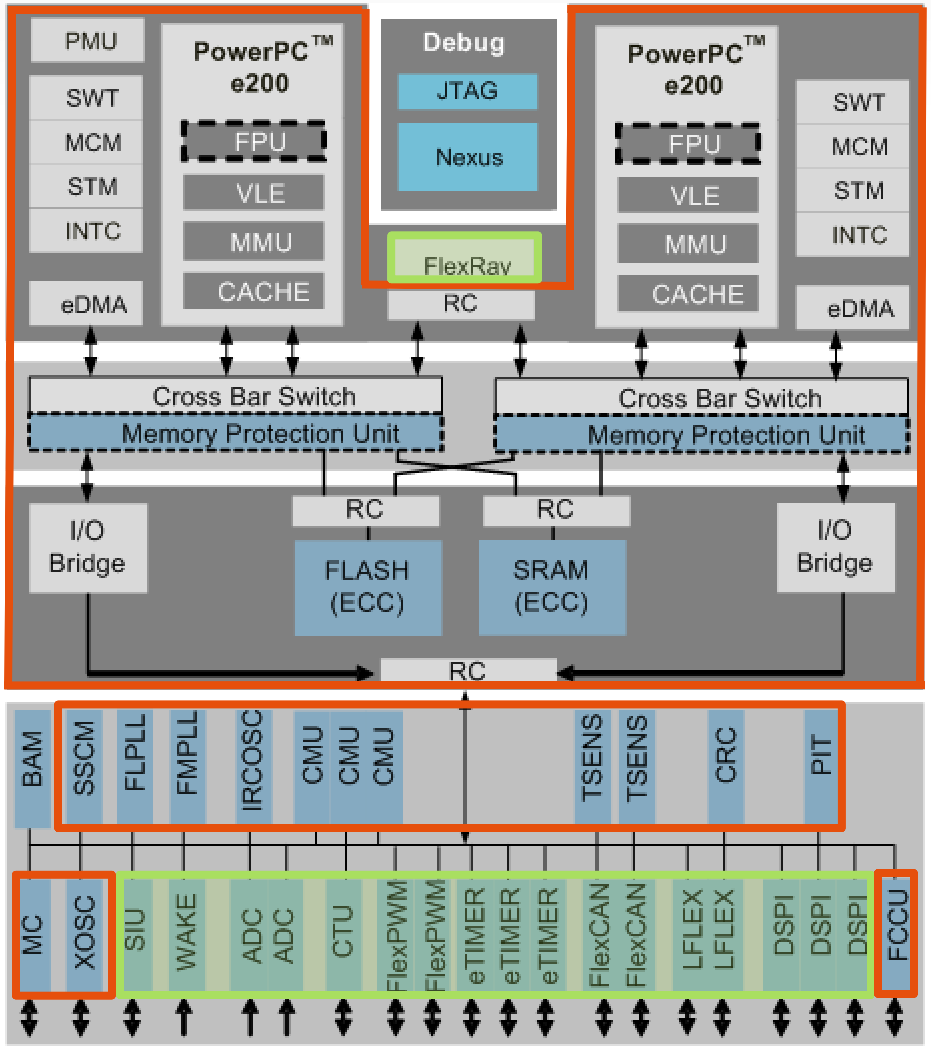
- Elements having *low* application dependency
  - Safety architecture may not interfere with application
  - Hardware driven

Computational Shell

System Safety mechanisms

- Elements having *high* application dependency
  - Functional safety of the periphery is ensured by system-level measures
  - Flexible usage within application software

I/O & Communication Peripherals



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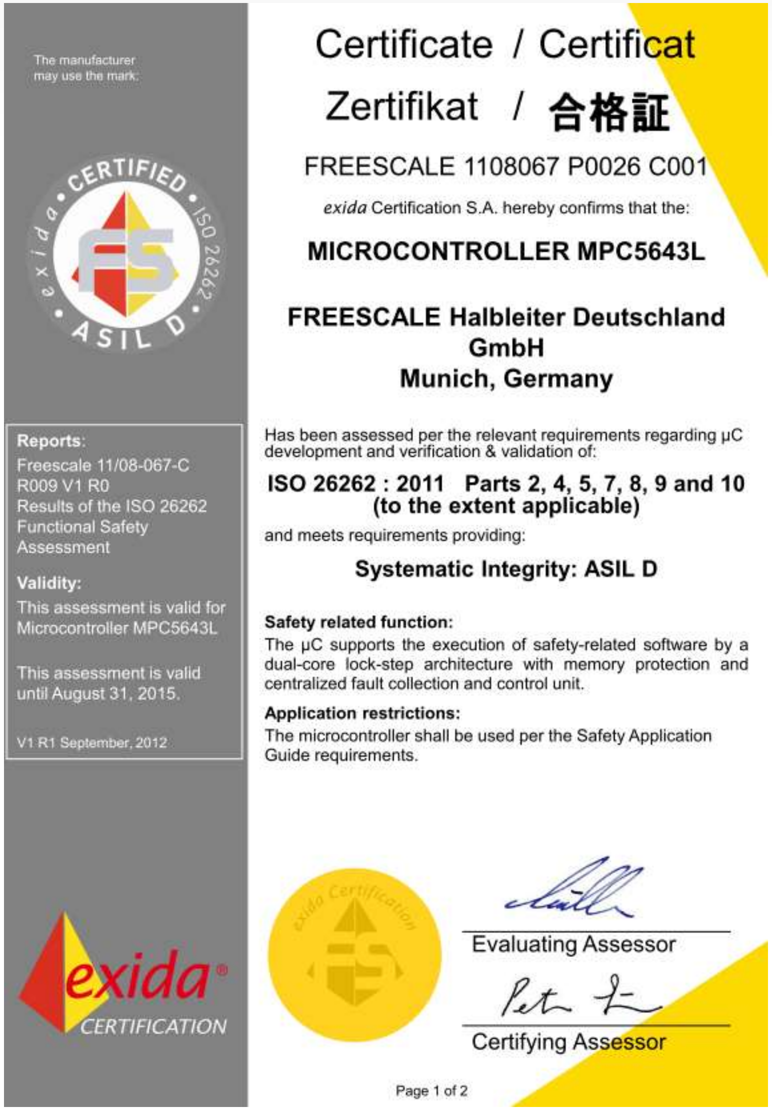
First ISO 26262 Certified MCU– Qorivva MPC5643L

- Certified by exida – an independent accredited assessor
- Certificate issued based on a successful assessment of the **product design and applied development and production processes** against all requirements and work product definitions of ISO 26262 identified as applicable to an MCU part
- **MPC5643L MCU certified for use for all Automotive Safety Integrity Levels (ASIL), up to and including the most stringent level, ASIL D**

Released on 6th September, 2012



The manufacturer may use the mark:

CERTIFIED • ISO 26262 • ASIL D • exida

Reports:
Freescale 11/08-067-C R009 V1 R0
Results of the ISO 26262 Functional Safety Assessment

Validity:
This assessment is valid for Microcontroller MPC5643L

This assessment is valid until August 31, 2015.

V1 R1 September, 2012

exida CERTIFICATION

Certificate / Certificat

Zertifikat / 合格証

FREESCALE 1108067 P0026 C001

exida Certification S.A. hereby confirms that the:

MICROCONTROLLER MPC5643L

FREESCALE Halbleiter Deutschland GmbH
Munich, Germany

Has been assessed per the relevant requirements regarding µC development and verification & validation of:

ISO 26262 : 2011 Parts 2, 4, 5, 7, 8, 9 and 10
(to the extent applicable)

and meets requirements providing:

Systematic Integrity: ASIL D

Safety related function:
The µC supports the execution of safety-related software by a dual-core lock-step architecture with memory protection and centralized fault collection and control unit.

Application restrictions:
The microcontroller shall be used per the Safety Application Guide requirements.

exida Certification

Evaluating Assessor

Peter

Certifying Assessor

Page 1 of 2

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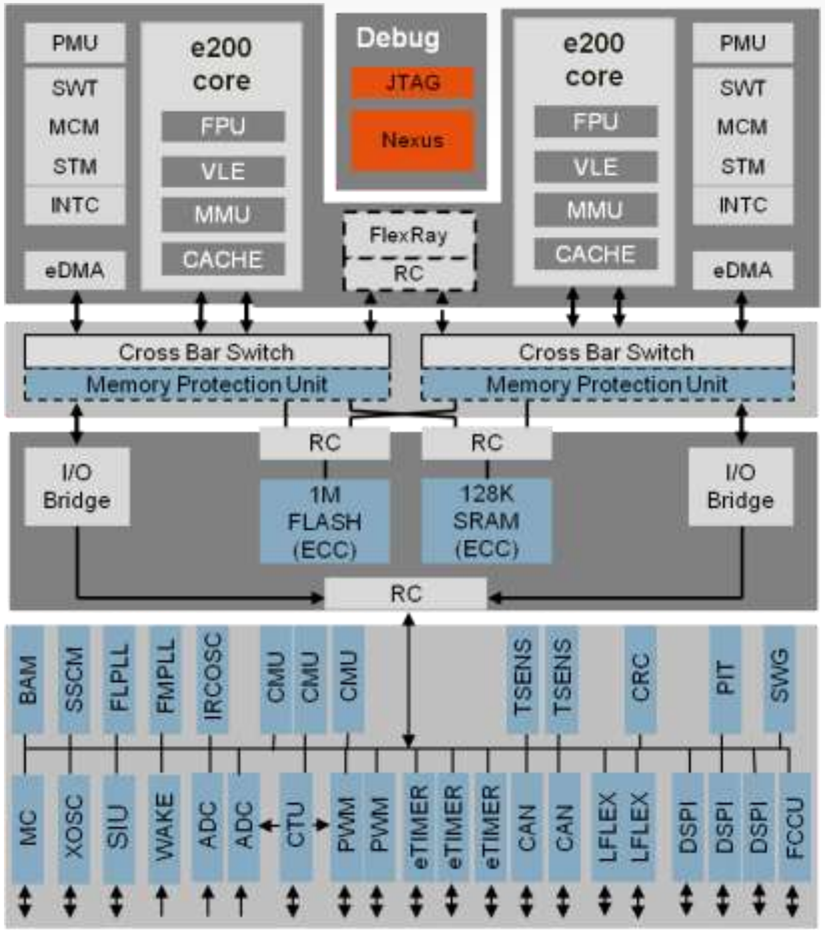
ISO 26262 Assessment and Audit Summary

- Assessment of the MPC5643L Safety Case
- Assessment and audit of Freescale's development processes used for the MPC5643L
- Assessment of the FMEDA (Failure Modes Effects and Diagnostic Analysis) of the MPC5643L to confirm it satisfies the SPFM, LFM and PMHF metrics required for ASIL D
- Assessment of the MPC5643L hardware design, implementation and verification activities
- Over 50 work products were provided to exida during the assessment and on-site audits



MPC5643L MCU

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Safety Software

Safety
Software

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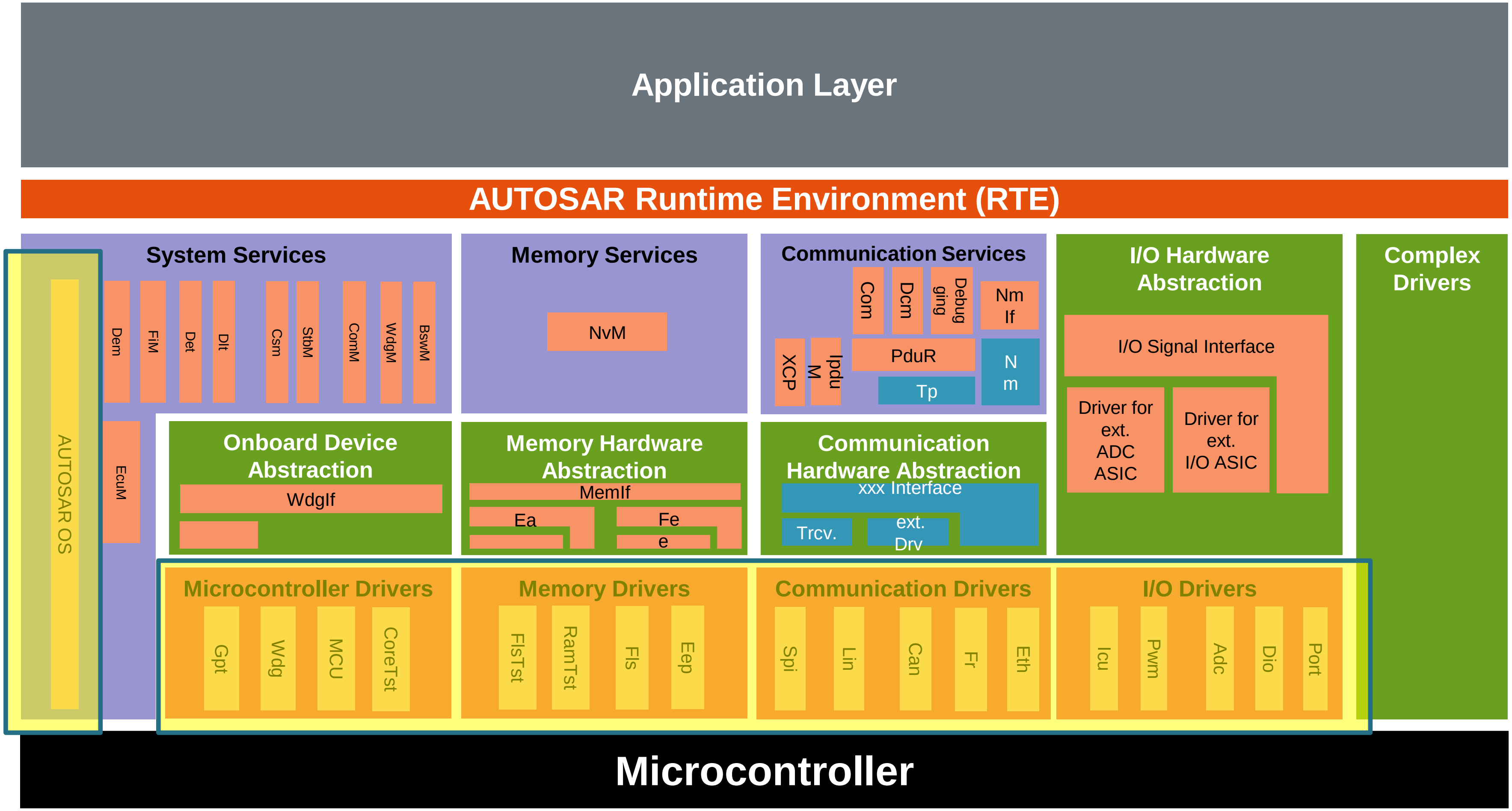
Freescale Automotive Software

- Freescale Automotive Software is mostly focused on AUTOSAR MCAL and OS

Not all modules are shown here



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Freescale Automotive Software

However, also about

- Instruction-based core self-test
- Libraries such as math library, motor control libraries, etc.
- Complex drivers such as Pulse Width Modulator (PWM) and Ethernet

ISO26262 imposes that all hardware and software elements are designed and developed to minimize the risk of causing hazardous events.

Freescale software for SafeAssure meets ISO26262

- supports hardware to meet ISO26262 requirements
  - detection of HW random faults
- supports efficient achievement of safety goals
  - detection of SW systematic faults
    - assuring freedom from interference or preventing interference
    - following ISO26262 compliant FSL SW development process
  - reaction to faults

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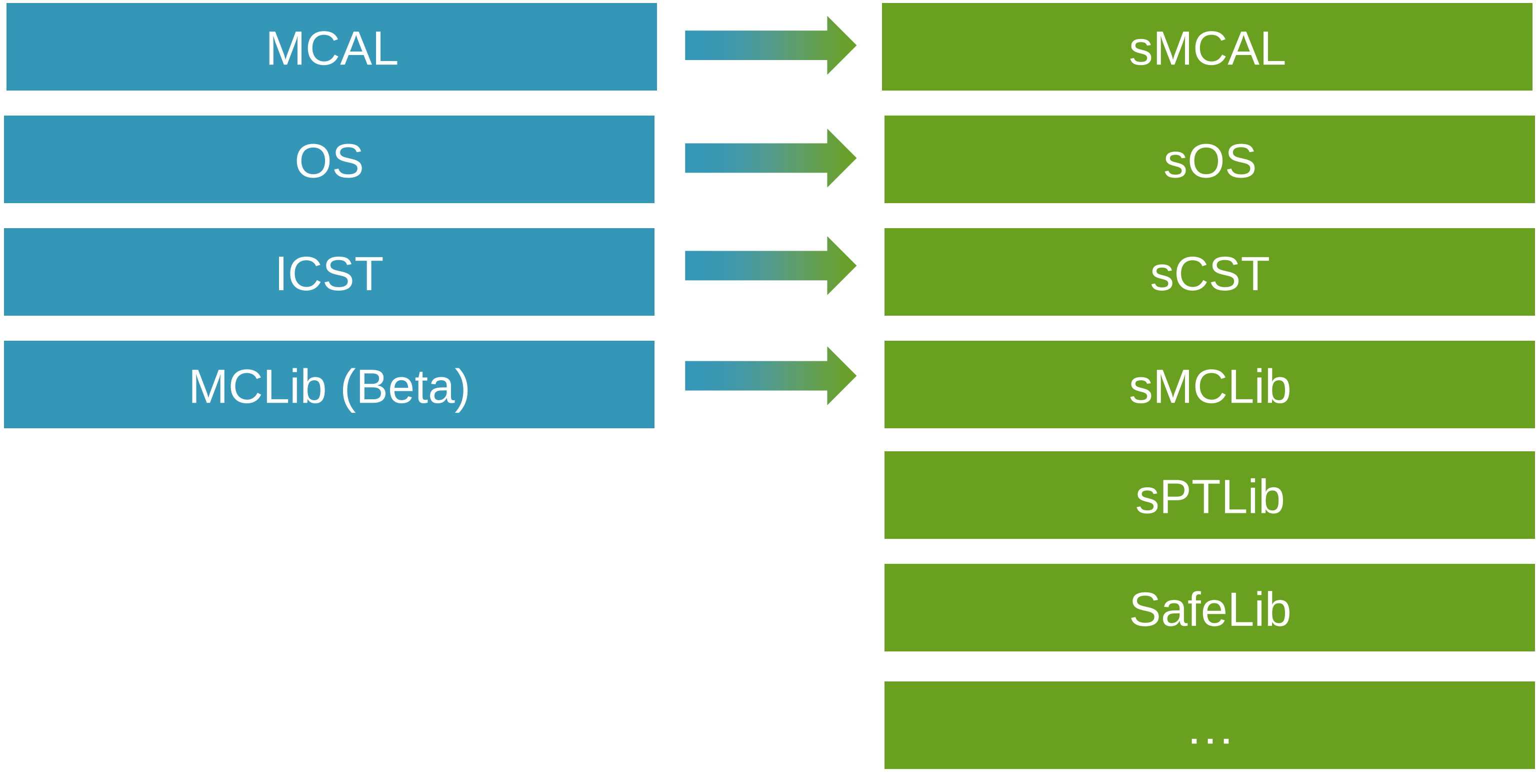
… Toward Functional Safety Software Portfolio

- Ordinary Software Offering
- SafeAssure Software Offering



MCAL → sMCAL

OS → sOS

ICST → sCST

MCLib (Beta) → sMCLib

sPTLib

SafeLib

…

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Objectives of SafeAssure Software Portfolio

- **Support efficient achievement of safety goals up to ASIL-D**
  - Safety with minimized performance degradation
  - Safety simplified for integrators
  - Cross-platform consistent architecture
- **Support achievement of hardware architectural metrics up to ASIL-D**

All products in the Software SafeAssure portfolio are Safety Element out of Context (SEooC)

- safety-related requirements are assumed
- safety-related role is assumed
- deployment is envisioned

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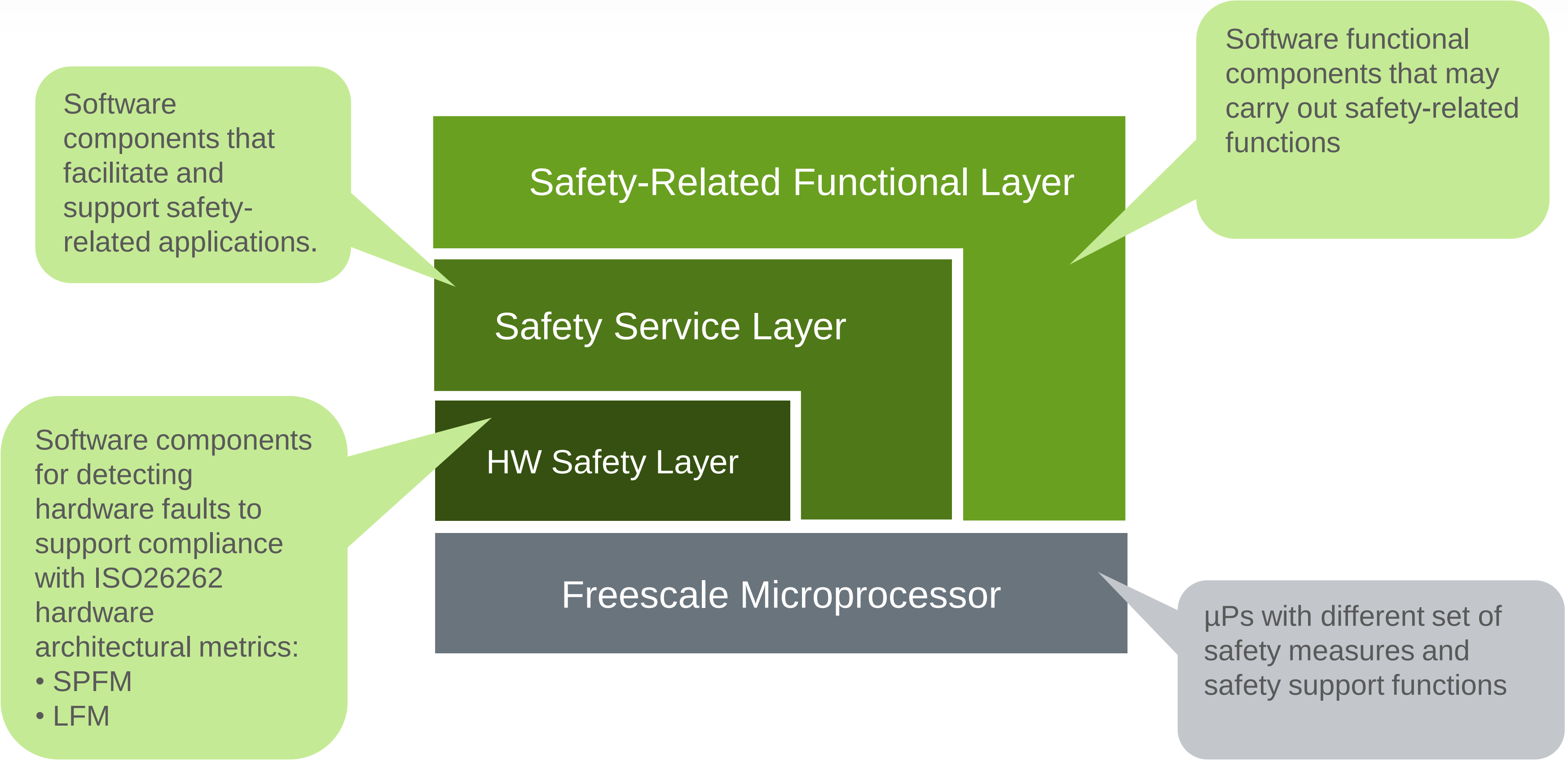
Software Portable Architecture for SafeAssure Solutions



Software components that facilitate and support safety-related applications.

Software functional components that may carry out safety-related functions

Software components for detecting hardware faults to support compliance with ISO26262 hardware architectural metrics:
- SPFM
- LFM

µPs with different set of safety measures and safety support functions

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Classes of Freescale Software Components

Freescale Software Product Class	Products
Safety-Related Functional Components	• safety MCAL (sMCAL) • safety Motor Control Lib (sMCLib)
Safety Service Components	• Safety Library (SafeLib) • Microcontroller Error Management • Software support for FCCU, MEMU, LBIST, MBIST • Hardware error collection • Safety Error Reporting and Reaction • Collect both Hardware and Software faults • Provides reaction mechanisms • Resource Manager • Manages peripheral control to enable run-time invocation of peripheral tests • CRC driver • Abstracts HW/SW implementation • DMA protection • Software Integrity Universal Checker • … tbd • safety Operating System (sOS) • FSL sOS / external sOS
HW Safety Components	• safety Core Self Test (sCST) • safety Peripheral Test Library (sPTLib)

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Safety Support

Safety
Support

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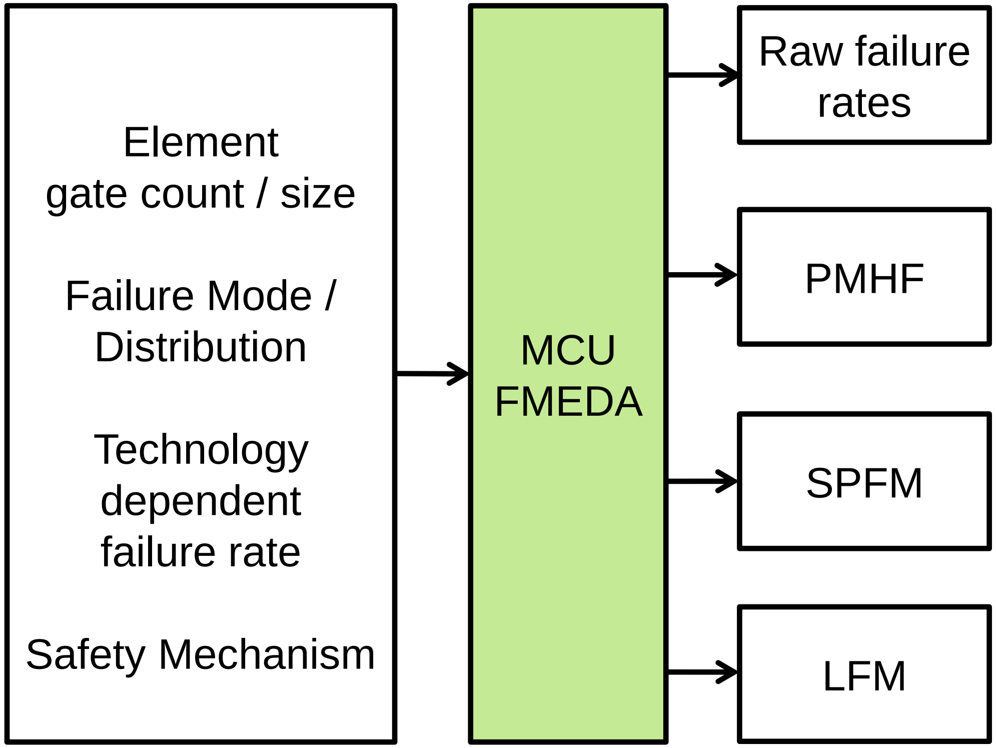
FMEDA: System-Level versus MCU

- Failure Mode, Effect and Diagnostic Analysis
- A systematic way to identify and evaluate failure modes, effects and diagnostic techniques, and to document the system.
- target values can be assigned to MCU
- FMEDA for MCU => for system-level FMEDA



Element gate count / size

Failure Mode / Distribution

Technology dependent failure rate

Safety Mechanism

MCU FMEDA

	ASIL D targets for whole item	Typical results for MCU with integr. safety architecture
Raw failure rates		
PMHF	$< 10^{-8}\,h^{-1}$	$\ll 10^{-8}\,h^{-1}$
SPFM	≥ 99%	>> 99%
LFM	≥ 90%	>> 90%

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SEooC safety assumption can be inflexible

Old SEooC assumption forces system vendors to implement **unnecessary safety measures**!

- Example: First generation safety application guide for had 68 mandatory requirements

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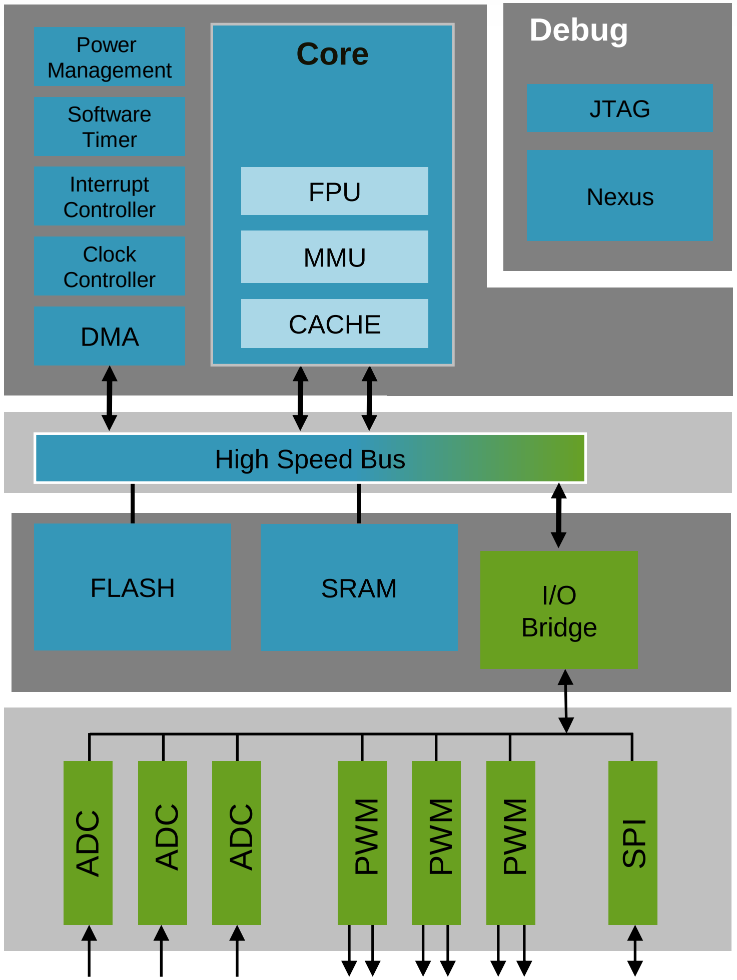
Example: Chassis Control Microcontroller

Without application context, an SEooC analysis requires safety measures for:

- PWM
- ADC
- SPI
- Core Subsystem

Consequence: over-engineering of architecture and suboptimal partitioning of software and hardware effort often



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Tailoring SEooC safety assessment

A new approach shall complement the safety measures of a context, not duplicate what the context already provides!

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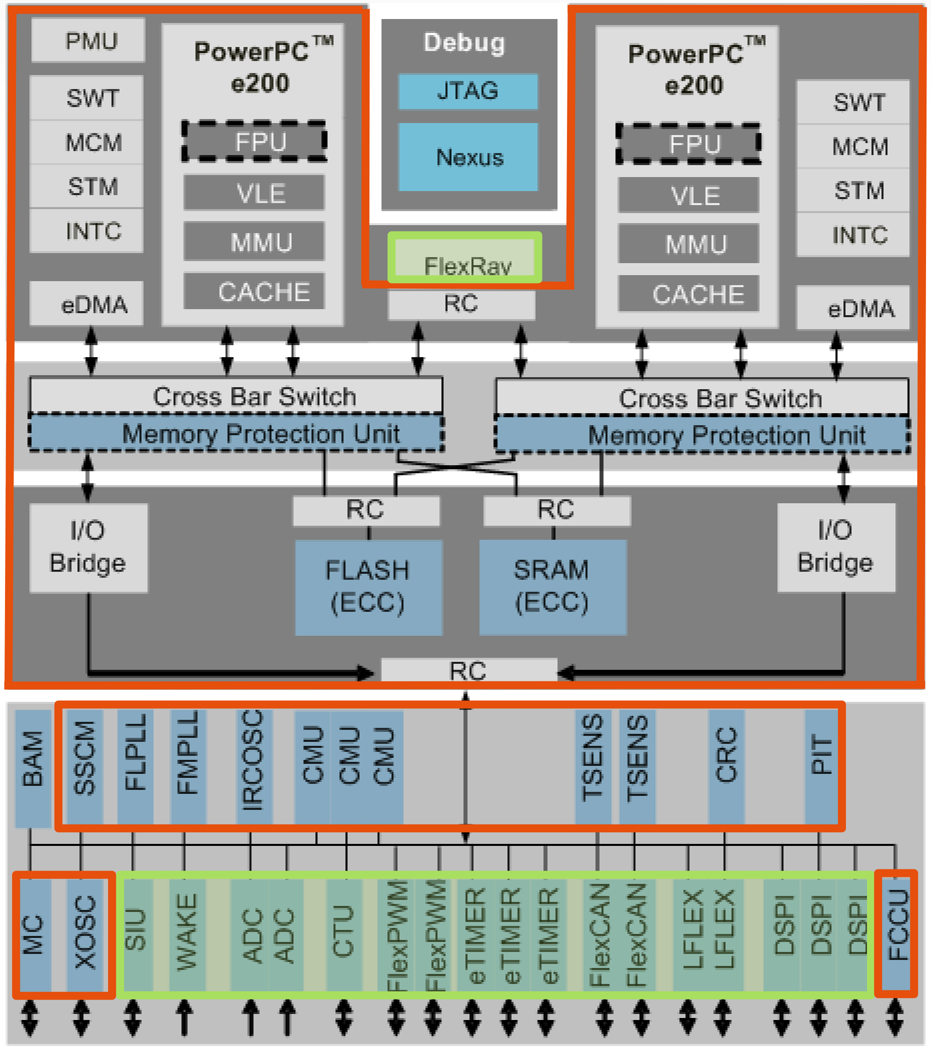
FMEDA Example: MPC5643L

- FMEDA for MPC5643L
  - Processing units (core, etc.)
  - Power supply
  - Clock
  - Non-volatile memory (FLASH)
  - Volatile memory (SRAM)
- Safety concept on system level not known
  => Raw failure rates for
  - Digital I/O
  - Analogue I/O
  - External communication



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SAFE ASSURE by Freescale

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Dynamic FMEDA

Freescale introduces dynamic FMEDA approach:

- Customer communicates implemented safety measures and Freescale delivers respective tailored FMEDA (within e.g. 1 hour)
- E.g. MPC5675K has more than >1 million different FMEDAs in data base – so truly back to the world of general purpose!
- No longer applications have to fulfill FMEDA assumption but FMEDA tailors to application

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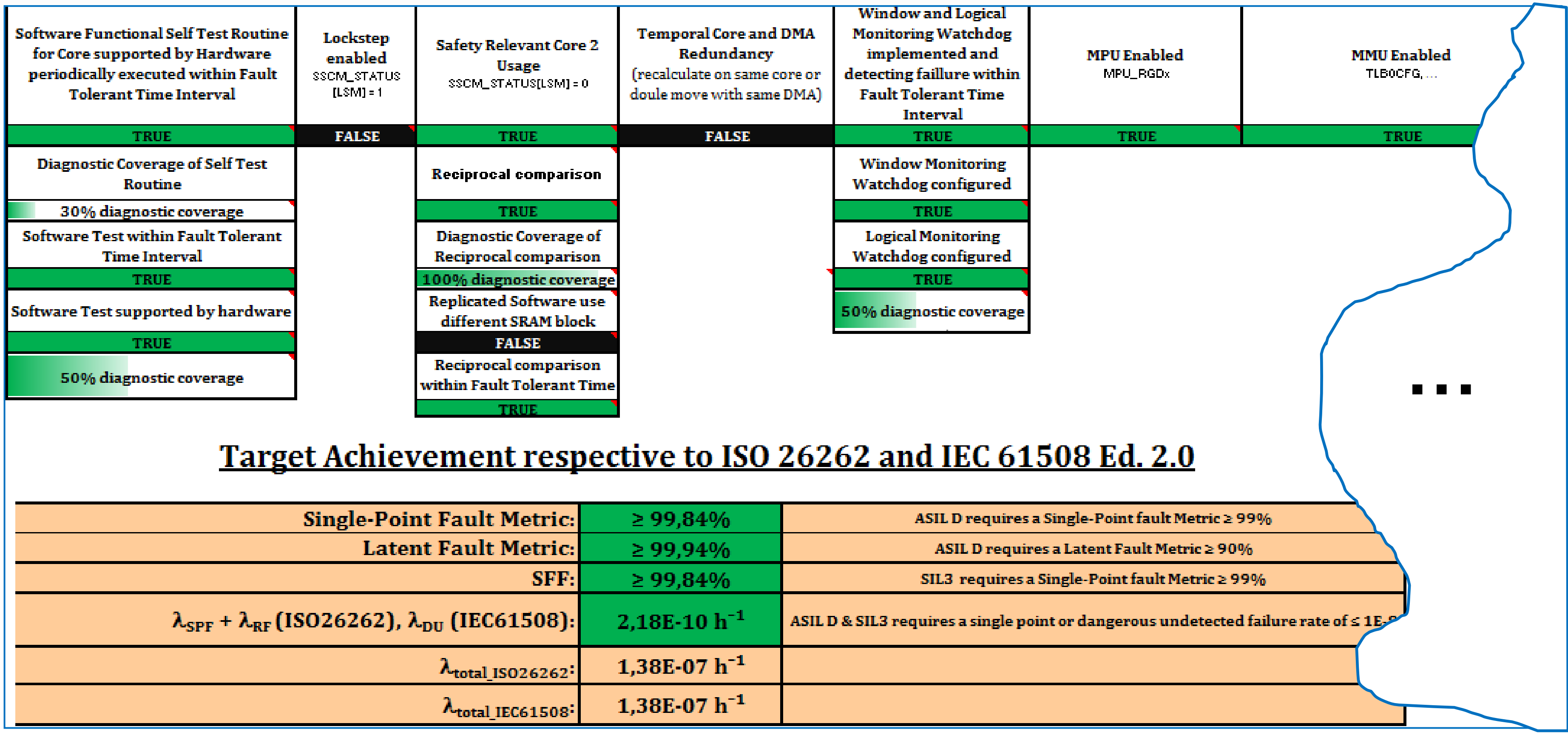
Flexible FMEDA



Software Functional Self Test Routine for Core supported by Hardware periodically executed within Fault Tolerant Time Interval

TRUE

Diagnostic Coverage of Self Test Routine

30% diagnostic coverage

Software Test within Fault Tolerant Time Interval

TRUE

Software Test supported by hardware

TRUE

50% diagnostic coverage

Lockstep enabled
SSCM_STATUS [LSM] = 1

FALSE

Safety Relevant Core 2 Usage
SSCM_STATUS[LSM] = 0

TRUE

Reciprocal comparison

TRUE

Diagnostic Coverage of Reciprocal comparison

100% diagnostic coverage

Replicated Software use different SRAM block

FALSE

Reciprocal comparison within Fault Tolerant Time

TRUE

Temporal Core and DMA Redundancy
(recalculate on same core or doule move with same DMA)

FALSE

Window and Logical Monitoring Watchdog implemented and detecting faillure within Fault Tolerant Time Interval

TRUE

Window Monitoring Watchdog configured

TRUE

Logical Monitoring Watchdog configured

TRUE

50% diagnostic coverage

MPU Enabled
MPU_RGDx

TRUE

MMU Enabled
TLB0CFG, ...

TRUE

. . .

Target Achievement respective to ISO 26262 and IEC 61508 Ed. 2.0

Single-Point Fault Metric:	≥ 99,84%	ASIL D requires a Single-Point fault Metric ≥ 99%
Latent Fault Metric:	≥ 99,94%	ASIL D requires a Latent Fault Metric ≥ 90%
SFF:	≥ 99,84%	SIL3 requires a Single-Point fault Metric ≥ 99%
$\lambda_{SPF} + \lambda_{RF}$ (ISO26262), λ_{DU} (IEC61508):	2,18E-10 h^{-1}	ASIL D & SIL3 requires a single point or dangerous undetected failure rate of ≤ 1E-
$\lambda_{total\_ISO26262}$:	1,38E-07 h^{-1}	
$\lambda_{total\_IEC61508}$:	1,38E-07 h^{-1}	

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Safety Support – FMEDA, Documentation & More

FSL QM Products - Typical Deliverables

- Safety Analysis of Architecture: Safety FMEA or FTA
- User Guide: Safety Application Note
- Development Process evidence: PPAP, Quality Plan (Mapping to ISO 26262 / IEC 61508 checklists)

ISO 26262 or IEC 61508 Products – Typical Deliverables

- Safety Analysis of Architecture: FMEDA, CCA or FTA
- User Guide: Safety Manual
- Development Process evidence: PPAP, Safety Plan, Certificates

Local Support

- Functional Safety Field Experts

Learning

- Field Training / workshops – delivered by Local Functional Safety FAE Experts

Safety Support

Safety FMEA
Safety
Application Note

FMEDA
Safety Manual (
ISO26262
compliance
eviden

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Safety Support – Dynamic FMEDA

Objective

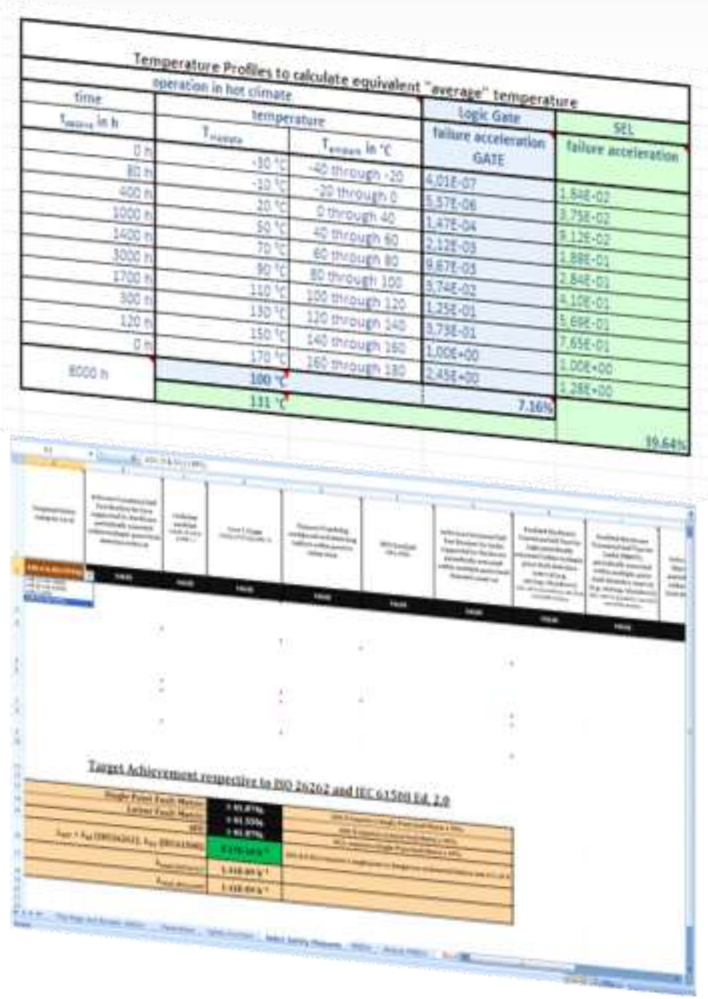
- Tailor FMEDA to match application configuration
- Enables customers, by supporting their system level architectural choices

Content

- FMEDA methods aligned with functional safety standards
  - SPFM & LFM, PMFH – ISO 26262
  - SFF & PFH- IEC 61508 ed-2.0
  - βic – IEC 61508 ed-2.0 part 2, Annex E
- Dynamic FMEDA covers elements with low application dependency: Clock, Power Supply, Flash, STM, SRAM, Processing Unit…

Work flow and result

- Customer specifies the Safety Integrity Level required by their application, and then confirms the Safety Measures that will be used
- A tailored FMEDA is then supplied to customer's for their specific application



Temperature Profiles to calculate equivalent "average" temperature

operation in hot climate

time	temperature		logic Gate	SEL
t_{device} in h	$T_{climate}$	$T_{ambient}$ in °C	failure acceleration GATE	failure acceleration
0 h	-30 °C	-40 through -20	4.01E-07	1.84E-02
80 h	-10 °C	-20 through 0	5.57E-06	3.75E-02
400 h	20 °C	0 through 40	1.47E-04	9.12E-02
1000 h	50 °C	40 through 60	2.12E-03	1.88E-01
1400 h	70 °C	60 through 80	9.67E-03	2.84E-01
3000 h	90 °C	80 through 100	3.74E-02	4.10E-01
1700 h	110 °C	100 through 120	1.25E-01	5.68E-01
300 h	130 °C	120 through 140	3.73E-01	7.65E-01
120 h	150 °C	140 through 160	1.00E+00	1.00E+00
0 h	170 °C	160 through 180	2.45E+00	1.28E+00
8000 h	100 °C			
	131 °C		7.16%	39.64%

Target Achievement respective to ISO 26262 and IEC 61508 Ed. 2.0

Single Point Fault Metric	[illegible]	[illegible]
Latent Fault Metric	[illegible]	[illegible]
SFF	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	
[illegible]	[illegible]	

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Safety Support – Safety Manual

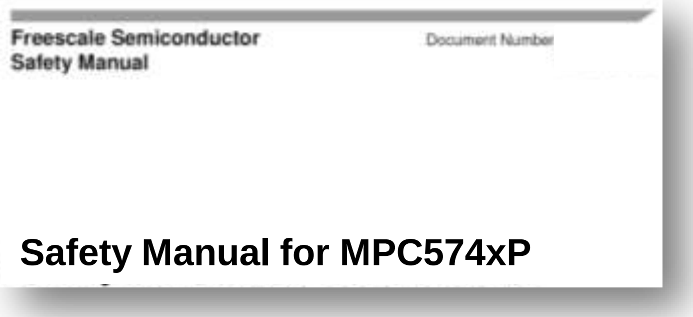
Objective

- Enables customers to extract the full value of Freescale's functional safety offering
- Simplify integration of Freescale's safety products into applications
- A comprehensible description of all information relating to FS in a single entity to ensure integrity of information and links with datasheet

Content

- SoC Safety Concept description
- System level assumptions of use (Safety specific usage considerations)
- Pseudo-code or C-Code to simplify adoption of safety application requirements
- FMEDA results
  - Latent Fault Matrix (LFM)
  - Single Point Fault Matrix (SPFM)
  - Probabilistic Metric for random Hardware Failures (PMHF)
- Provisions against Dependent Failures

Safety Manual for MCU Solution

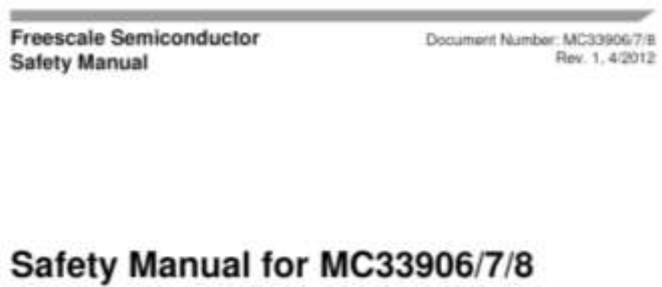


Freescale Semiconductor
Safety Manual

Document Number

Safety Manual for MPC574xP

Safety Manual for Analog Solution



Freescale Semiconductor
Safety Manual

Document Number: MC33906/7/8
Rev. 1, 4/2012

Safety Manual for MC33906/7/8

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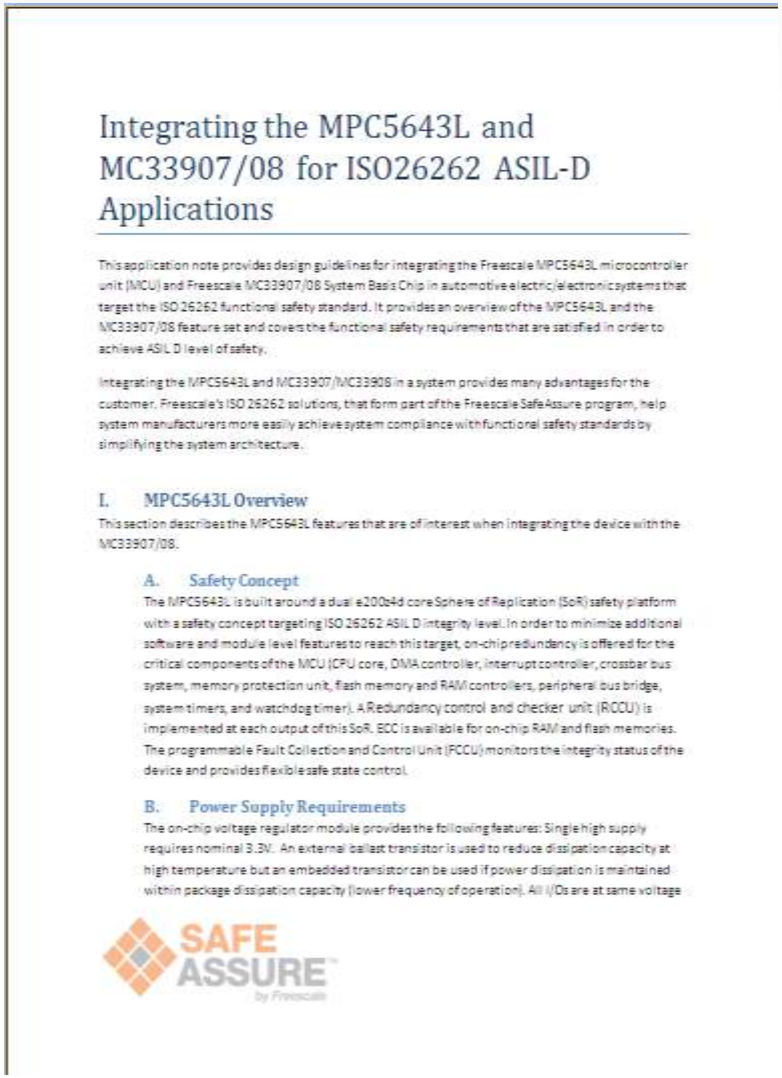
Safety Support – System Level Application Notes

Design Guidelines for

- Integration of Microcontroller and Analog & Power Management device
- Explains main individual product Safety features
- Uses a typical Electrical Power steering application to explain product alignment
- Covers the ASIL D safety requirements that are satisfied by using both products:
  - MPC5643L requires external measures to support a system level ASIL D safety level
  - MC33907/08 provides those external measures:
    - External power supply and monitor
    - External watchdog timer
    - Error output monitor



Integrating the MPC5643L and MC33907/08 for ISO26262 ASIL-D Applications

This application note provides design guidelines for integrating the Freescale MPC5643L microcontroller unit (MCU) and Freescale MC33907/08 System Basis Chip in automotive electric/electronic systems that target the ISO 26262 functional safety standard. It provides an overview of the MPC5643L and the MC33907/08 feature set and covers the functional safety requirements that are satisfied in order to achieve ASIL D level of safety.

Integrating the MPC5643L and MC33907/MC33908 in a system provides many advantages for the customer. Freescale's ISO 26262 solutions, that form part of the Freescale SafeAssure program, help system manufacturers more easily achieve system compliance with functional safety standards by simplifying the system architecture.

I. MPC5643L Overview

This section describes the MPC5643L features that are of interest when integrating the device with the MC33907/08.

A. Safety Concept

The MPC5643L is built around a dual e200z4d core Sphere of Replication (SoR) safety platform with a safety concept targeting ISO 26262 ASIL D integrity level. In order to minimize additional software and module level features to reach this target, on-chip redundancy is offered for the critical components of the MCU (CPU core, DMA controller, interrupt controller, crossbar bus system, memory protection unit, flash memory and RAM controllers, peripheral bus bridge, system timers, and watchdog timer). A Redundancy control and checker unit (RCCU) is implemented at each output of this SoR. ECC is available for on-chip RAM and flash memories. The programmable Fault Collection and Control Unit (FCCU) monitors the integrity status of the device and provides flexible safe state control.

B. Power Supply Requirements

The on-chip voltage regulator module provides the following features: Single high supply requires nominal 3.3V. An external ballast transistor is used to reduce dissipation capacity at high temperature but an embedded transistor can be used if power dissipation is maintained within package dissipation capacity (lower frequency of operation). All I/Os are at same voltage

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Functional Safety. Simplified.
Discover how we make it easier for you to attain system compliance >
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Summary

- ISO 26262 has been widely adopted for Automotive functional safety
- Systems with safety goals according to ISO 26262 are no longer an exception
- Freescale support OEMs and Tier1s to achieve their ISO 26262 safety goals
  - Discrete and integrated safety architectures
  - System level chip set solutions – beyond MCU
- Combined with a range of Safety HW products, Freescale supports customers by providing a set of differentiating collateral that enable our customers and can significantly reduce their development time
  - Dynamic FMEDA, Safety Manual, System Level Application Notes

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