An Overview of Functional Safety for Automotive

November 2015

kVA
1708-C Augusta Street, STE 3
Greenville, SC 29605
training@kvausa.com
www.kvausa.com

Presenter Background

Jody J. Nelson

Jody Nelson is Managing Partner of kVA and a Functional Safety Certified Automotive Engineer (FSCAE) and Functional Safety Certified Engineer – Development (FSCED).

He received the B.S. and M.S. degrees in electrical engineering from the University of Wisconsin, Madison, in 2000 and 2002, respectively, where his studies focused on power electronics.

From 2002 until 2009 he worked for Daimler AG in Stuttgart, Germany and Troy, Michigan, developing hybrid and electric vehicle powertrains, power electronic systems, motor control hardware and software, high-voltage safety, and diagnostic systems. Since 2009 he has been consulting in automotive safety-related fields, including application of the ISO 26262 to automotive platforms.

TÜV NORD
TÜV NORD Systems
GmbH & Co.KG
FSCAE
A031
0123/11

TÜV NORD
TÜV NORD Systems
GmbH & Co. KG
FSCED
Functional Safety
Certified Engineer
Development
A031_0227/13

Unintentional Air Bag Deployment

Chevy recalls 2013 Malibu Eco over unintended airbag deployment fears

General Motors has announced the automaker is recalling certain 2013 Chevrolet Malibu models for a potential sensor failure. Under hard braking, the vehicle's sensing and diagnostic module may reset itself, and if that occurs just before an abrupt turn, the vehicle could trick itself into sensing a rollover. In that event, **the roof rail airbag could deploy outside of a crash situation. What's more, the seat belt pretensioners could then fail during a severe crash.** Needless to say, it could be a dangerous situation. The recall covers a total of **4,304 units** manufactured between October 24, 2011 and March 31, 2012.

Unintended Air-Bag Deployments Lead to Recall of 144,000 Ford F-150s

Ford is recalling about **144,000 F-150 pickups** from the 2005-6 model years because the driver's side **air bag might deploy without the vehicle being in a crash**, a Ford spokesman said Wednesday. The number represents a small fraction of the total F-150s that the National Highway Traffic Safety Administration was initially concerned about.

A defect investigation by the safety agency, which began late in 2009, grew eventually to cover about 1.3 million F-150s from the 2004-6 model years.

As a result of that investigation, the agency said it received 238 reports of "inadvertent deployment," of which **77 resulted in injuries like abrasions, cuts, a broken tooth and, for two owners, loss of consciousness.**

An air-bag wire in the truck's steering wheel might have chafed against the horn plate's metal edges, which could expose a bare copper wire "and create the potential for a short circuit that would illuminate the warning lamp," Mr. Sherwood said. Left unfixed, the wire could, under "unique circumstances," prompt the driver's air bag to deploy.

Toyota Recalls RAV4 and Highlanders for faulty airbag sensors

Toyota announced a voluntary recall for almost **308,000 sport utility vehicles** (SUV), more than three years after the auto maker learned that its curtain shield airbags **could deploy without a crash.**

Toyota has admitted to learning of the problem in 2007 and determined the cause to be a short circuit in two sensors. According to Toyota, the sensor design was changed in 2008.

Despite the change, Toyota continued to receive reports of premature airbag deployments. Toyota did not consider the problem recall worthy because for the curtain shield airbag to deploy without a crash, it would require two short circuits to "occur nearly simultaneously after the initial air bag check."

According to Toyota, they continued to monitor the situation. In March, Toyota change its position after a consumer was injured in a premature curtain shield deployment.

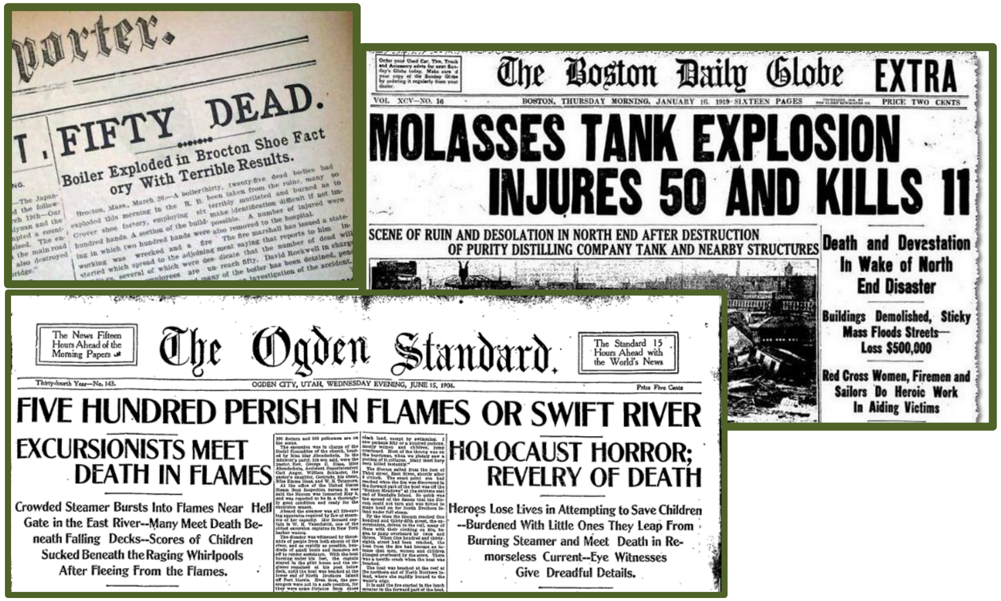
In 2010, Toyota was fined almost $49 million, the maximum allowed, from allegations by the National Highway Traffic Safety Administration (NHTSA) that the automaker had not reported safety problems in a timely manner.

Hackers Remotely Kill a Jeep on the Highway

Hackers send commands through the Jeep's ***entertainment system*** *to its dashboard functions,* ***steering, brakes****, and transmission, all from a laptop:*

- *the vents in the Jeep Cherokee* ***started blasting cold air*** *at the maximum setting*
- *Next the* ***radio switched to the local hip hop station*** *and began blaring Skee-lo at full volume*
- *windshield* ***wipers turned on****, and wiper fluid blurred the glass*
- *my* ***accelerator stopped working***
- *functions that at lower speeds fully* ***kill the engine****,* ***abruptly engage the brakes****, or disable them altogether*
- *they* ***cut the Jeep's brakes****, leaving me frantically pumping the pedal as the 2-ton SUV slid uncontrollably into a ditch*

Safety Standards: Background



porter.

FIFTY DEAD.

Boiler Exploded in Brocton Shoe Factory With Terrible Results.

Brocton, Mass., March 20.—A boiler exploded this morning in the R. B. Grover shoe factory, employing hundred hands. A section of the building in which two hundred hands were working was wrecked and a fire started which spread to the adjoining buildings, several of which were des[illegible] employees are un[illegible] thirty, twenty-five dead bodies had been taken from the ruins, many so terribly mutilated and burned as to make identification difficult if not impossible. A number of injured were also removed to the hospital. The fire marshall has issued a statement saying that reports to him indicate that the number of dead will reach fifty. David Rockwell in charge of the boiler has been detained, pending investigation of the accident.

The Boston Daily Globe EXTRA

Order your Used Car, Tire, Truck and Accessory advts for next Sunday's Globe today. Make sure of your copy of the Sunday Globe by ordering it regularly from your dealer.

VOL. XCV—NO. 16 BOSTON, THURSDAY MORNING, JANUARY 16, 1919—SIXTEEN PAGES PRICE TWO CENTS

MOLASSES TANK EXPLOSION INJURES 50 AND KILLS 11

SCENE OF RUIN AND DESOLATION IN NORTH END AFTER DESTRUCTION OF PURITY DISTILLING COMPANY TANK AND NEARBY STRUCTURES

Death and Devestation In Wake of North End Disaster

Buildings Demolished, Sticky Mass Floods Streets—Loss $500,000

Red Cross Women, Firemen and Sailors Do Heroic Work In Aiding Victims

The News Fifteen Hours Ahead of the Morning Papers

The Ogden Standard.

The Standard 15 Hours Ahead with the World's News

Thirty-fourth Year—No. 143. OGDEN CITY, UTAH, WEDNESDAY EVENING, JUNE 15, 1904. Price Five Cents

FIVE HUNDRED PERISH IN FLAMES OR SWIFT RIVER

EXCURSIONISTS MEET DEATH IN FLAMES

Crowded Steamer Bursts Into Flames Near Hell Gate in the East River--Many Meet Death Beneath Falling Decks--Scores of Children Sucked Beneath the Raging Whirlpools After Fleeing From the Flames.

HOLOCAUST HORROR; REVELRY OF DEATH

Heroes Lose Lives in Attempting to Save Children --Burdened With Little Ones They Leap From Burning Steamer and Meet Death in Remorseless Current--Eye Witnesses Give Dreadful Details.

- The original designation of “engineer” was driven by safety
- The first role of an engineer was to ensure dangerous equipment (e.g., boilers, engines) would **not fail with catastrophic results**
- engineers followed **technical standards for safe design** of equipment

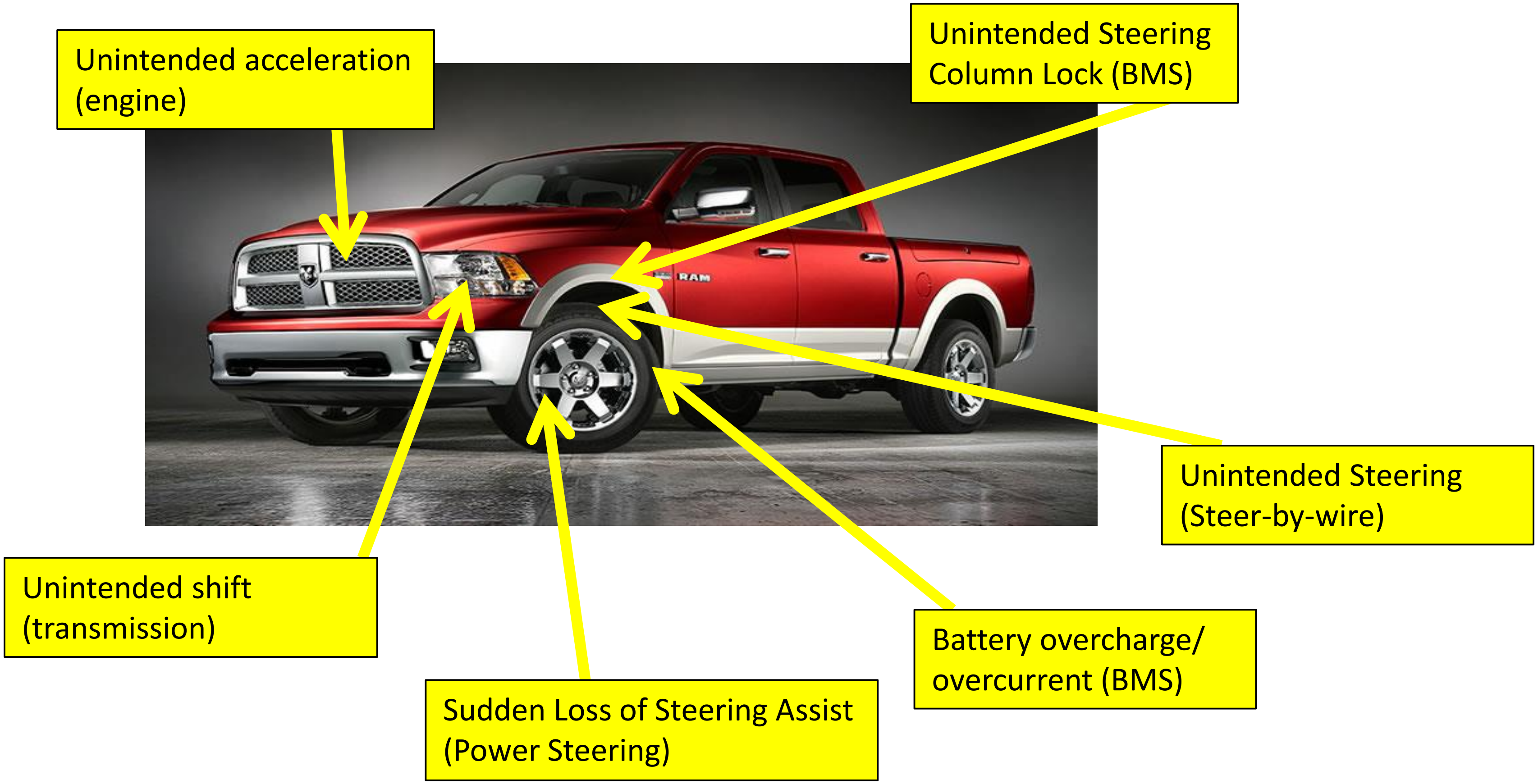
- Electronic controls in automobiles now perform safety-related functions
- Engineers must ensure electronic systems do **not fail with catastrophic results**
- **ISO 26262** is the **technical standard for safe design of such systems**

What is ISO 26262?

- **ISO 26262 is the *state of the art* standard for functional safety of E/E systems for passenger vehicles**
  - Strongly intertwined with product development
  - Strong emphasis on functional safety management
  - Strong emphasis on the early phases of development
  - Requires traceability throughout entire lifecycle
  - ***Not*** a reliability standard
    - failures are allowed...
    - ...but prevention of a ***safe state*** **is not**

What is Automotive Functional Safety?

Layman's Terms: Automotive functional safety is the desire to ensure that **malfunctions** of automotive **electronics and software** will not increase the risk of **injury or a fatality** above natural risks.



Unintended acceleration (engine)

Unintended Steering Column Lock (BMS)

Unintended Steering (Steer-by-wire)

Unintended shift (transmission)

Sudden Loss of Steering Assist (Power Steering)

Battery overcharge/ overcurrent (BMS)

The Need for ISO 26262

Vehicle’s E/E systems are complex and are growing rapidly

Platform Golf IV (1998)	Platform Golf V (2003)	Platform Golf VI (2010)
17 ECUs 2 CANs 147 CAN-Messages 434 CAN signals	Central Gateway 35 ECUs 5 CANs, 3 LINs 307 CAN-Messages 2669 CAN signals	Central Gateway 49 ECUs 5 CANs, 7 LINs 704 CAN-Messages 6516 CAN signals

Source: Lisa Whalen, *Making Products and Systems Functionally Safe*, 2012 CTi Conference on ISO 26262, Troy, MI

The Need for ISO 26262

Complex Vehicle Software Size (lines of code)

F-22 Raptor
1.7 Million

F-35 Joint Strike Fighter
5.7 Million

Boeing 787 Dreamliner
6.5 Million

2009 MB S-Class
20 Million[1] (radio and navigation only)

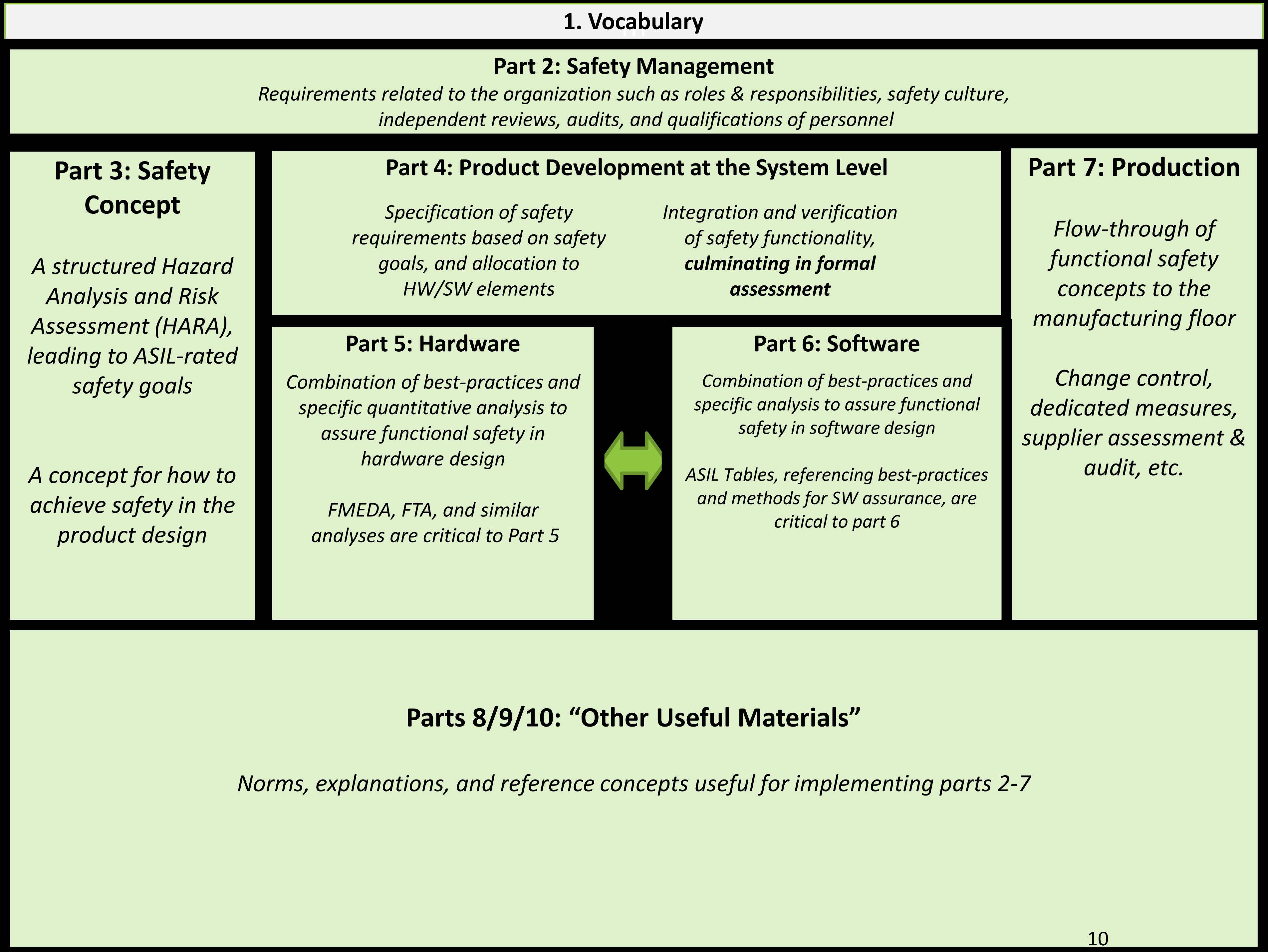
Technische Universität München

~100 Million (today)
~70-100 ECUs

FROST & SULLIVAN

~200-300 Million
(predicted future)

[1] Source: Robert Charette, *This Car Runs on Code*, IEEE Spectrum, February 2009



1. Vocabulary

Part 2: Safety Management

Requirements related to the organization such as roles & responsibilities, safety culture, independent reviews, audits, and qualifications of personnel

Part 3: Safety Concept

A structured Hazard Analysis and Risk Assessment (HARA), leading to ASIL-rated safety goals

A concept for how to achieve safety in the product design

Part 4: Product Development at the System Level

Specification of safety requirements based on safety goals, and allocation to HW/SW elements

Integration and verification of safety functionality, ***culminating in formal assessment***

Part 5: Hardware

Combination of best-practices and specific quantitative analysis to assure functional safety in hardware design

FMEDA, FTA, and similar analyses are critical to Part 5

Part 6: Software

Combination of best-practices and specific analysis to assure functional safety in software design

ASIL Tables, referencing best-practices and methods for SW assurance, are critical to part 6

Part 7: Production

Flow-through of functional safety concepts to the manufacturing floor

Change control, dedicated measures, supplier assessment & audit, etc.

Parts 8/9/10: “Other Useful Materials”

Norms, explanations, and reference concepts useful for implementing parts 2-7

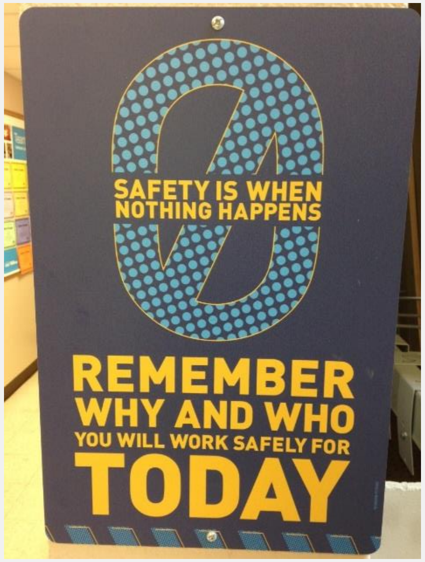
ISO 26262 Vocabulary

tolerable risk → **Risk (1.99)** which is accepted in a given context based on the current moral concept of society.

unreasonable risk → **Risk** (1.99) judged to be unacceptable in a certain context according to valid societal moral concepts

ISO 26262 Vocabulary

safety → The absence of **unreasonable risk (1.136)**.


SAFETY IS WHEN NOTHING HAPPENS
REMEMBER WHY AND WHO YOU WILL WORK SAFELY FOR TODAY

functional safety → Absence of unreasonable risk due to hazards caused by malfunctioning behaviour of E/E systems.

Legal Aspect

Product liability puts the burden of proof for acting with due care **on the manufacturer**. Therefore manufacturers **must be able to provide evidence** by appropriate documentation that they **ensured the safety** of its product with due care.

Reference: CTi ‘15, Functional safety new questions arise; Andreas Reuter

Legal Aspect

Trials deal with what you did 10 or 15 years ago…

- What can save you are:
  - Well defined processes **that were followed**
  - **Good documentation**

> “The dullest pencil is better than the sharpest memory.”
>
> - Mark Twain

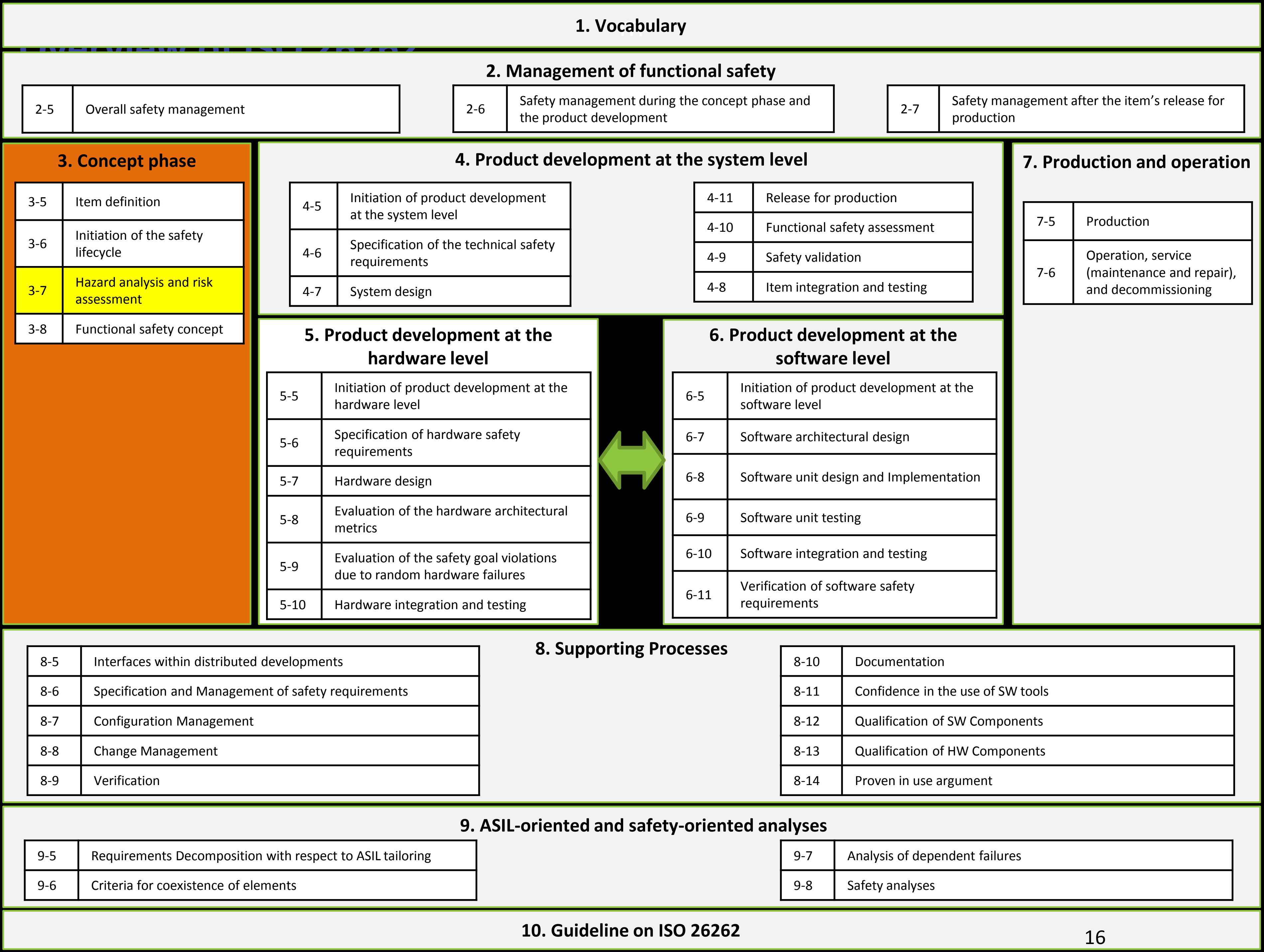
Reference: CTi ‘15, U.S. Legal Issues – Overview and Practical Considerations; Clay Guise

Legal Aspect

How a standard can be used in U.S. Law

- Product **meets the standard**
- Standard applies but it **was not met**
- If standard had been met, product **would be “better”**
- Others do it “better” or “differently”

Reference: CTi ‘15, U.S. Legal Issues – Overview and Practical Considerations; Clay Guise



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

4-11	Release for production
4-10	Functional safety assessment
4-9	Safety validation
4-8	Item integration and testing

7. Production and operation

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

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

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 SW tools
8-12	Qualification of SW Components
8-13	Qualification of HW 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

ISO 26262 Part 3 Clause 7:
Classification of Hazardous Events

Step 2 – For each hazard, what is the probability of the event?

Probability of Exposure

7.4.3.2 - The probability of exposure of each operational situation shall be estimated based on a defined rationale for each hazardous event. The probability of exposure shall be assigned to one of the probability classes, E0, E1, E2, E3 and E4, in accordance with Table 2.

Table 2 — Classes of probability of exposure regarding operational situations

	Class				
	E0	**E1**	**E2**	**E3**	**E4**
Description	Incredible	Very low probability	Low probability	Medium probability	High probability

ISO 26262 Part 3 Clause 7:
Classification of Hazardous Events

Step 3 – For each hazard occurrence, how severe is the damage?

Severity

7.4.3.2 - The severity of potential harm shall be estimated based on a defined rationale for each hazardous event. The severity shall be assigned to one of the severity classes S0, S1, S2 or S3.

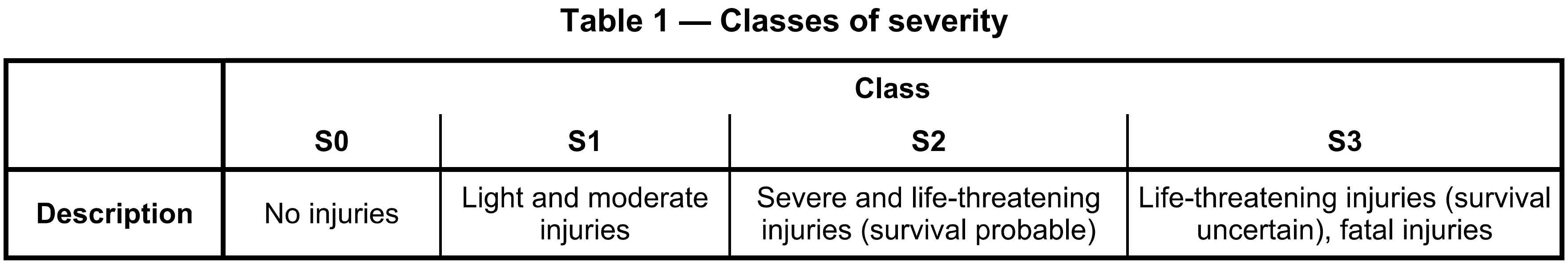


Table 1 — Classes of severity

	Class			
	S0	**S1**	**S2**	**S3**
Description	No injuries	Light and moderate injuries	Severe and life-threatening injuries (survival probable)	Life-threatening injuries (survival uncertain), fatal injuries

ISO 26262 Part 3 Clause 7:
Classification of Hazardous Events

Step 4 – For each hazard occurrence, to what degree can the situation be controlled, e.g. by the driver?

Controllability

7.4.3.2 - The controllability of each hazardous event, by the driver or other persons potentially at risk, shall be estimated based on a defined rationale for each hazardous event. The controllability shall be assigned to one of the controllability classes C0, C1, C2, and C3 in accordance with Table 3.

Table 3 — Classes of controllability

	Class			
	C0	**C1**	**C2**	**C3**
Description	Controllable in general	Simply controllable	Normally controllable	Difficult to control or uncontrollable

ISO 26262 Part 3 Clause 7:
ASIL Determination

- Based on the Hazard Assessment and Risk Analysis (HARA), each hazard is assigned an "**A**utomotive **S**afety **I**ntegrity **L**evel" or **ASIL**
  - Range from **ASIL A** (least stringent) to **ASIL D** (most stringent)
  - QM (Quality Management) follows normal development process
  - SAE J2980 released in May 2015 to harmonize levels

Difficulty to Control

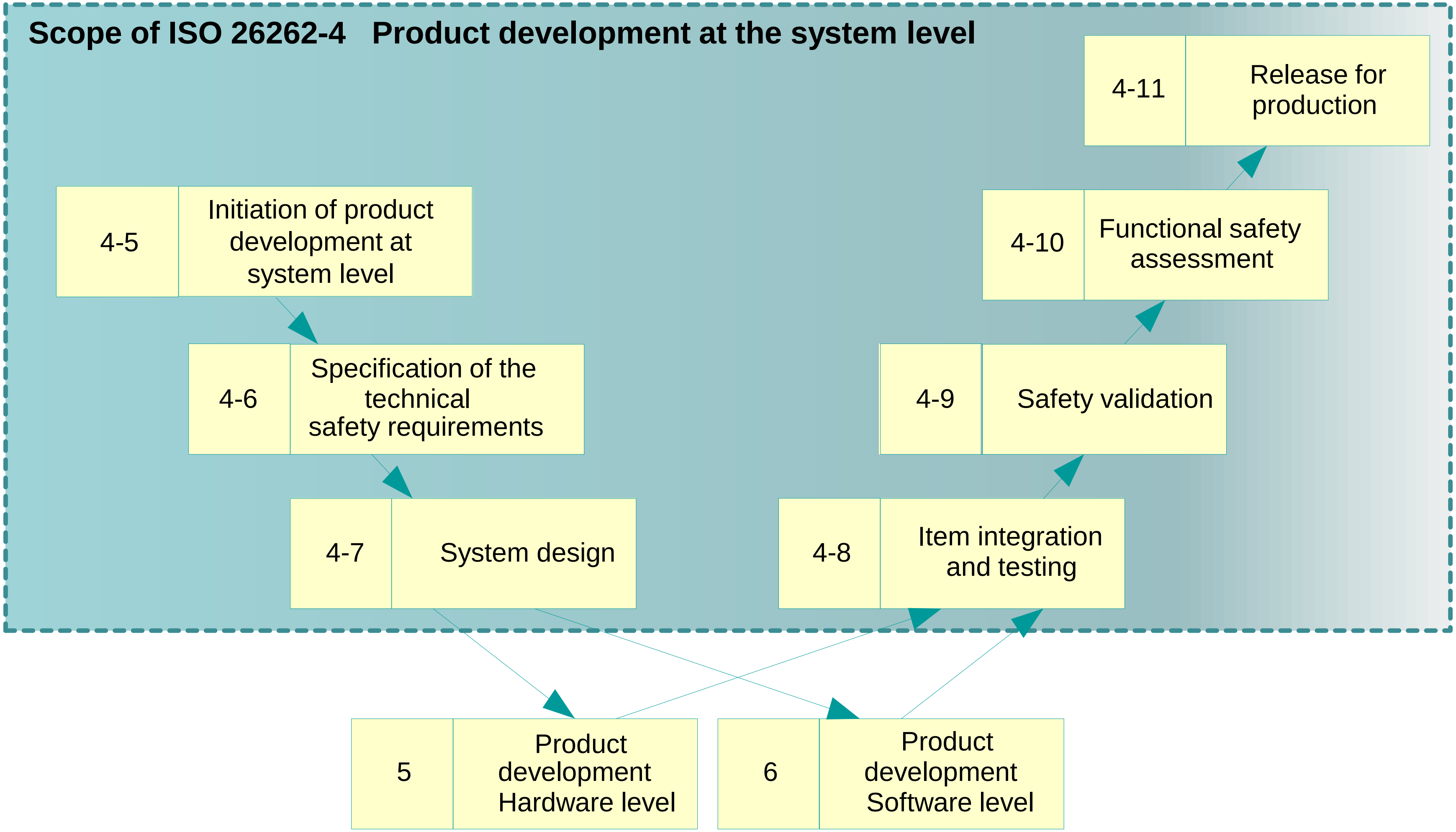
Greater Severity

Higher Probability Of Exposure

Severity Class	Exposure Class	Controllability Class		
		C1	C2	C3
S1	E1	QM	QM	QM
	E2	QM	QM	QM
	E3	QM	QM	A
	E4	QM	A	B
S2	E1	QM	QM	QM
	E2	QM	QM	A
	E3	QM	A	B
	E4	A	B	C
S3	E1	QM	QM	A
	E2	QM	A	B
	E3	A	B	C
	E4	B	C	D

ASIL RATING

Scope of Part 4



Scope of ISO 26262-4 Product development at the system level

4-5 Initiation of product development at 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 Hardware level

6 Product development Software level

kVA = engineered safety

ISO 26262 Part 4 Clause 7.4.3:

Measures for the avoidance of systematic failures

systematic failure (1.130) → **failure (1.39)**, related in a deterministic way to a certain cause, that can only be eliminated by a change of the design or of the manufacturing process, operational procedures, documentation or other relevant factors

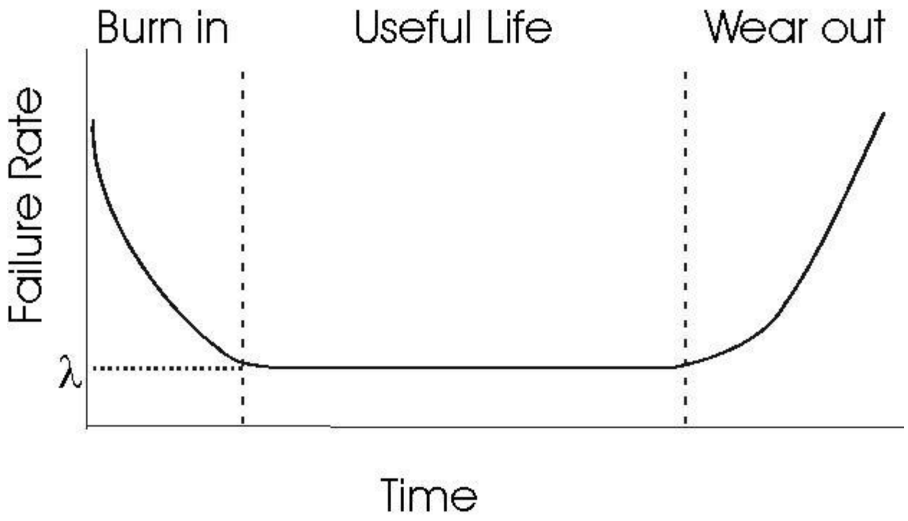
Systematic failure represents a design oversight or **mistake**

General methods to avoid systematic failure are called out by ISO 26262

ISO 26262 Part 4 Clause 7.4.4:

Measures for control of random hardware failures

random hardware failure (1.192) → **failure (1.39)** that can occur unpredictably during the lifetime of a hardware **element (1.32)** and that follows a probability distribution



ISO 26262 Part 5 Clauses 8 and 9:
Random Hardware Failures & HW Architectural Metrics

ISO 26262-5:8 and **ISO 26262-5:9** require specific metrics to be calculated, to demonstrate robustness of hardware against safety goal violation arising from random failure as follows:

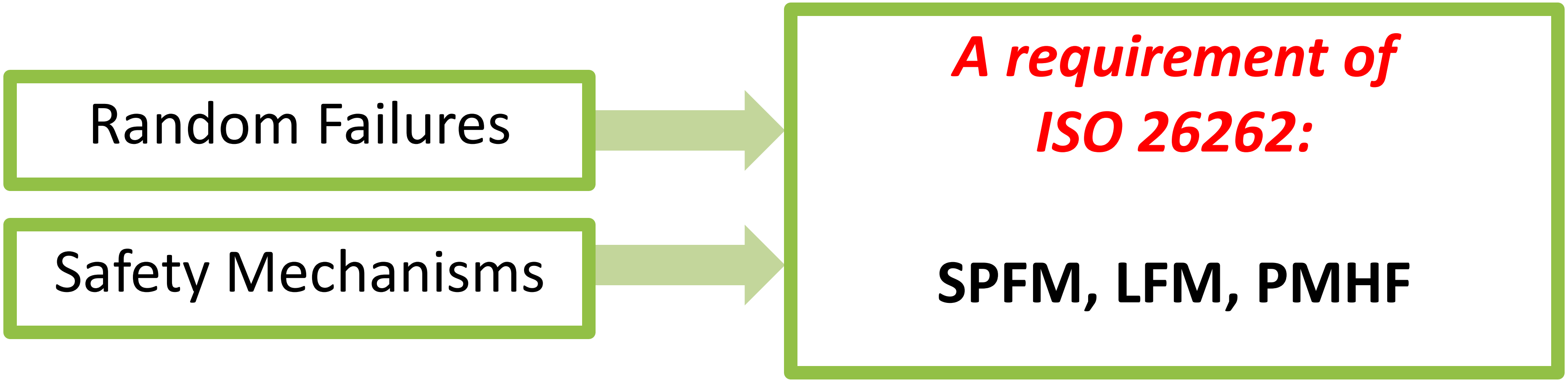
		ASIL RATING			
source	Requirement:	**A**	**B**	**C**	**D**
ISO 26262-5, Table 4	**Single-point fault metric**	**-**	**≥90%**	**≥97%**	**≥99%**
ISO 26262-5, Table 5	**Latent-fault metric**	**-**	**≥60%**	**≥80%**	**≥90%**
ISO 26262-5, Table 6	**Probabilistic Metric for HW Failure**	**-**	**<10-7 /h**	**<10-7 /h**	**<10-8 /h**

One of several tools available to calculate these metrics:

FMEDA - Failure Modes, Effects, and Diagnostics Analysis

ISO 26262 Part 5 Clauses 8 and 9:

Random Hardware Failures & HW Architectural Metrics



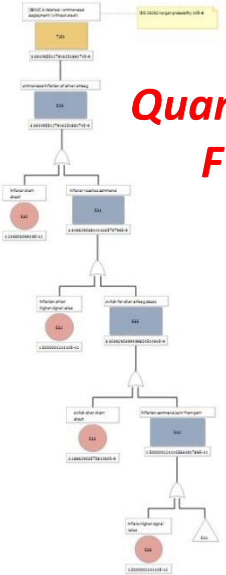
Random Failures

Safety Mechanisms

A requirement of ISO 26262:

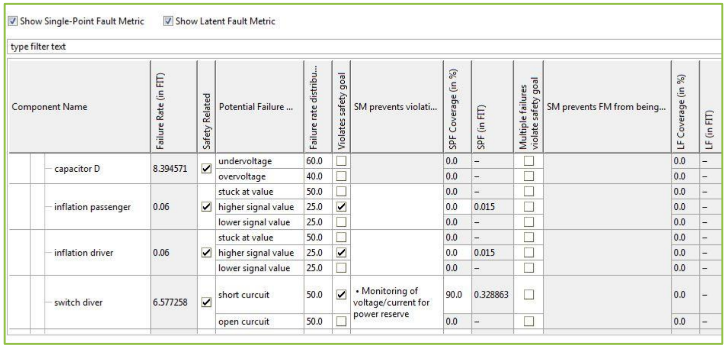
SPFM, LFM, PMHF

Several alternate approaches can meet the requirement:



Quantified FTA

failure rate classes (FRC) approach



☑ Show Single-Point Fault Metric ☑ Show Latent Fault Metric

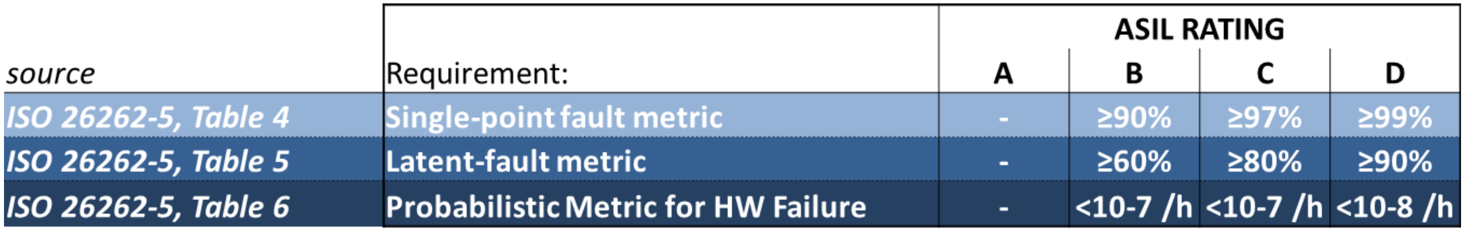
type filter text

Component Name	Failure Rate (in FIT)	Safety Related	Potential Failure ...	Failure rate distribu...	Violates safety goal	SM prevents violati...	SPF Coverage (in %)	SPF (in FIT)	Multiple failures violate safety goal	SM prevents FM from being...	LF Coverage (in %)	LF (in FIT)
capacitor D	8.394571	☑	undervoltage	60.0	☐		0.0	–	☐		0.0	–
			overvoltage	40.0	☐		0.0	–	☐		0.0	–
inflation passenger	0.06	☑	stuck at value	50.0	☐		0.0	–	☐		0.0	–
			higher signal value	25.0	☑		0.0	0.015	☐		0.0	–
			lower signal value	25.0	☐		0.0	–	☐		0.0	–
inflation driver	0.06	☑	stuck at value	50.0	☐		0.0	–	☐		0.0	–
			higher signal value	25.0	☑		0.0	0.015	☐		0.0	–
			lower signal value	25.0	☐		0.0	–	☐		0.0	–
switch diver	6.577258	☑	short curcuit	50.0	☑	• Monitoring of voltage/current for power reserve	90.0	0.328863	☐		0.0	–
			open curcuit	50.0	☐		0.0	–	☐		0.0	–

FMEdA

Notes on Hardware Metrics and Targets

- The demands of ISO 26262-5, clauses 8 and 9 are **severe**, especially for ASIL C and ASIL D systems



		ASIL RATING			
source	Requirement:	A	B	C	D
ISO 26262-5, Table 4	**Single-point fault metric**	**-**	**≥90%**	**≥97%**	**≥99%**
ISO 26262-5, Table 5	**Latent-fault metric**	**-**	**≥60%**	**≥80%**	**≥90%**
ISO 26262-5, Table 6	**Probabilistic Metric for HW Failure**	**-**	**<10-7 /h**	**<10-7 /h**	**<10-8 /h**

- Extensive hardware and software measures are typically required to achieve these challenging targets, such as
  - Lockstep processing
  - Memory partitioning and Intensive memory checking
  - CAN end-to-end protection
  - I/O monitoring
  - Plausibility checks

- **Management Requirement:** Assign responsibility for the safety analysis to determine these metrics, and ensure it is carried out

Software Development under ISO 26262

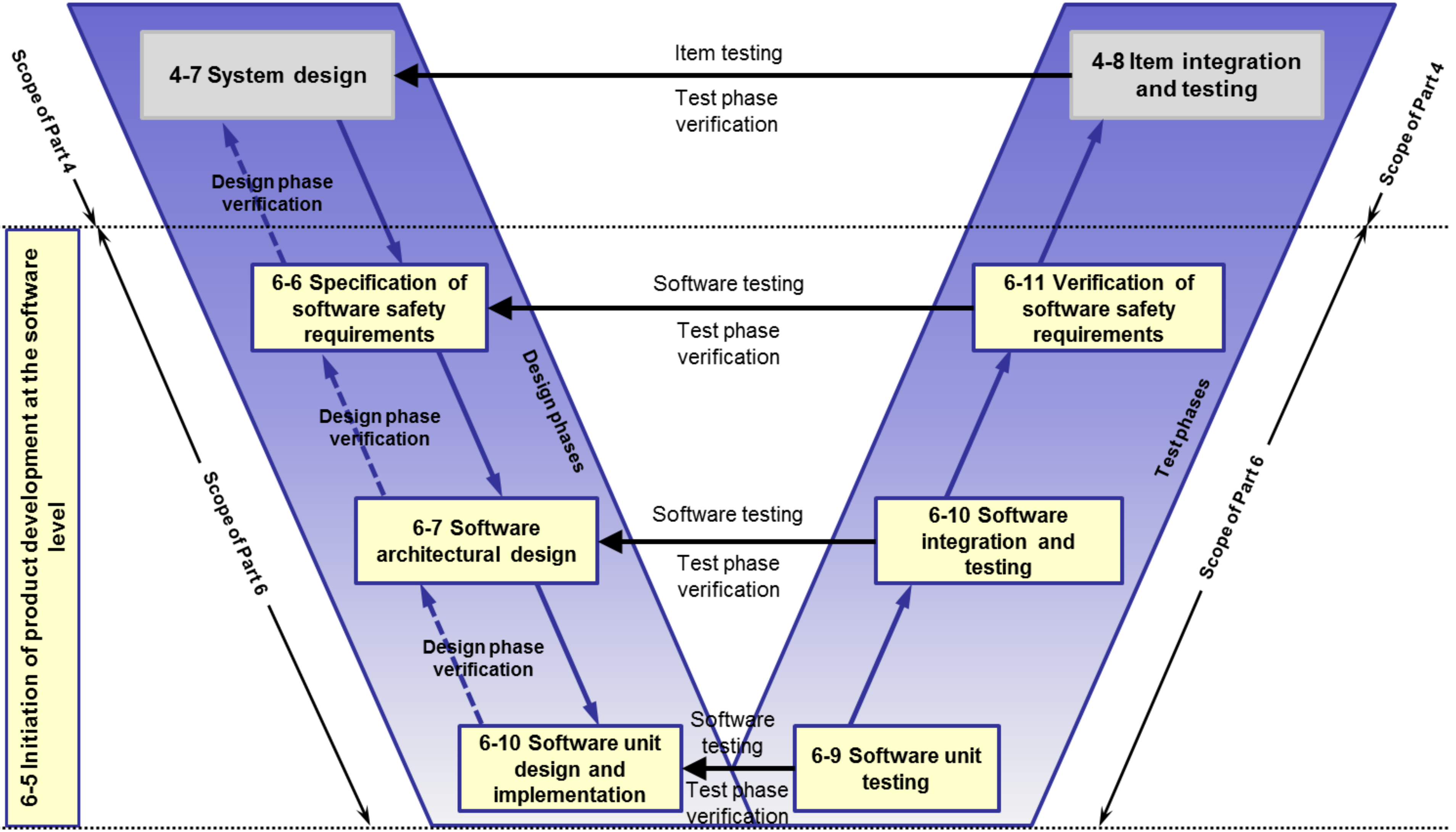
- Software failure is systematic by nature
  - Implication: failures are reduced, and safety is achieved, **by careful and rigorous software process implementation**

- A long list of methods are called out in ISO 26262, for all aspects of software development

- Most requirements are contained in so-called "ASIL Tables"
  - Provides lists of best practices for software development

ISO 26262 Part 6 :

Product Development at the software level



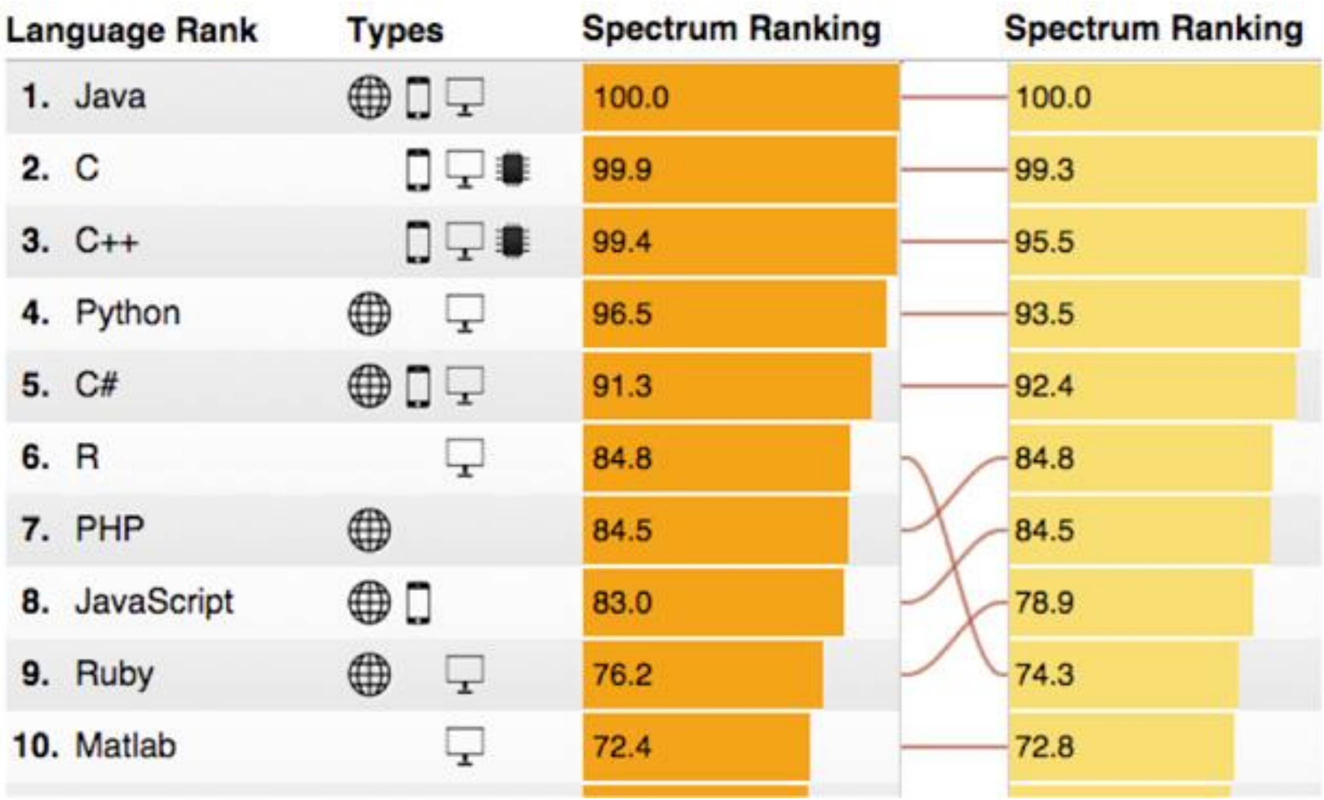
4-7 System design
Item testing
Test phase verification
4-8 Item integration and testing
Scope of Part 4
Design phase verification
6-6 Specification of software safety requirements
Software testing
Test phase verification
6-11 Verification of software safety requirements
Design phases
Test phases
6-5 Initiation of product development at the software level
Design phase verification
6-7 Software architectural design
Software testing
Test phase verification
6-10 Software integration and testing
Scope of Part 6
Design phase verification
6-10 Software unit design and implementation
Software testing
Test phase verification
6-9 Software unit testing
Scope of Part 6
Scope of Part 4

kVA = engineered safety

ISO 26262 Part 6 Clause 5:

Initiation of product development at the software level

Top Ten Programming Languages According to IEEE



IEC 61508 Recommendations:	Language Rank	Types	2015 Spectrum Ranking	2014 Spectrum Ranking
Not Recommended	1. Java	🌐 📱 🖥	100.0	100.0
Highly Recommended with subset	2. C	📱 🖥 ▪	99.9	99.3
	3. C++	📱 🖥 ▪	99.4	95.5
Not listed	4. Python	🌐 🖥	96.5	93.5
	5. C#	🌐 📱 🖥	91.3	92.4
	6. R	🖥	84.8	84.8
	7. PHP	🌐	84.5	84.5
	8. JavaScript	🌐 📱	83.0	78.9
	9. Ruby	🌐 🖥	76.2	74.3
Highly Recommended with subset	10. Matlab	🖥	72.4	72.8

Posted July 20, 2015 by Stephen Cass on IEEE Spectrum

Who is kVA?

- kVA is a technical consulting group based in the U.S., focused on **functional safety standards implementation,** with 3 U.S. locations:
  - **Greensboro, NC**
  - Greenville, SC
  - Royal Oak, MI
- kVA's mission is to lead the implementation of functional safety standardization (**ISO 26262, IEC 61508, ISO 13849, + others**), in the U.S. and abroad
- kVA provides **training services**, **consulting and contract engineering services**, **audits and assessments**, **gap analysis**, and **engineering software** to enable functional safety at major automotive and industrial companies

Introduction to kVA

kVA serves clients' needs in:

- Functional Safety
- High Voltage Safety
- Electromagnetic Compatibility (EMC)
- Mechanical / Electrical Systems Integration
- Vehicle Architecture / Vehicle Design
- EV, PHEV, HEV, and ICE powertrains
- Diagnostics
- Regulatory Standards for Safety and Emissions

kVA is a Thought Leader in Vehicle Safety

- Served on the Safety Panel as functional safety expert at the IEEE International Electric Vehicle Conference in Greenville, April 2012
- Technical paper on functional safety of battery management systems at 2012 IEEE Product Safety Engineering Society Conference in Portland, November 2012
- Presented two technical papers on the topic of ISO 26262, related to BMS safety and EMC, at the 2013 SAE World Congress and Exposition in Detroit, April 2013.
- Two papers to be presented at the 2015 SAE World Congress
- CTI ISO 26262 Conference, Detroit
    - Conference Sponsor in June 2012
    - Conference Sponsor and Author in May 2013
    - Conference Sponsor in May 2014
- IQPC 26262 Conference, Ann Arbor
    - Conference Sponsor in September 2014

IEEE

PSES

Product Safety Engineering Society

SAE®

CTi

Car Training Institute

IQPC

International Quality & Productivity Center

Training and Certification for Safe Vehicle Design and Development

- **kVA** has a partnership with **TÜV-Nord**, a leading German safety organization, to provide **functional safety training and certification** in the English language.

TÜV NORD

- **kVA** staff have all achieved the **Functional Safety Certified Automotive Engineer (FSCAE)**, a designation conferred by **TÜV-Nord** and recognized internationally.

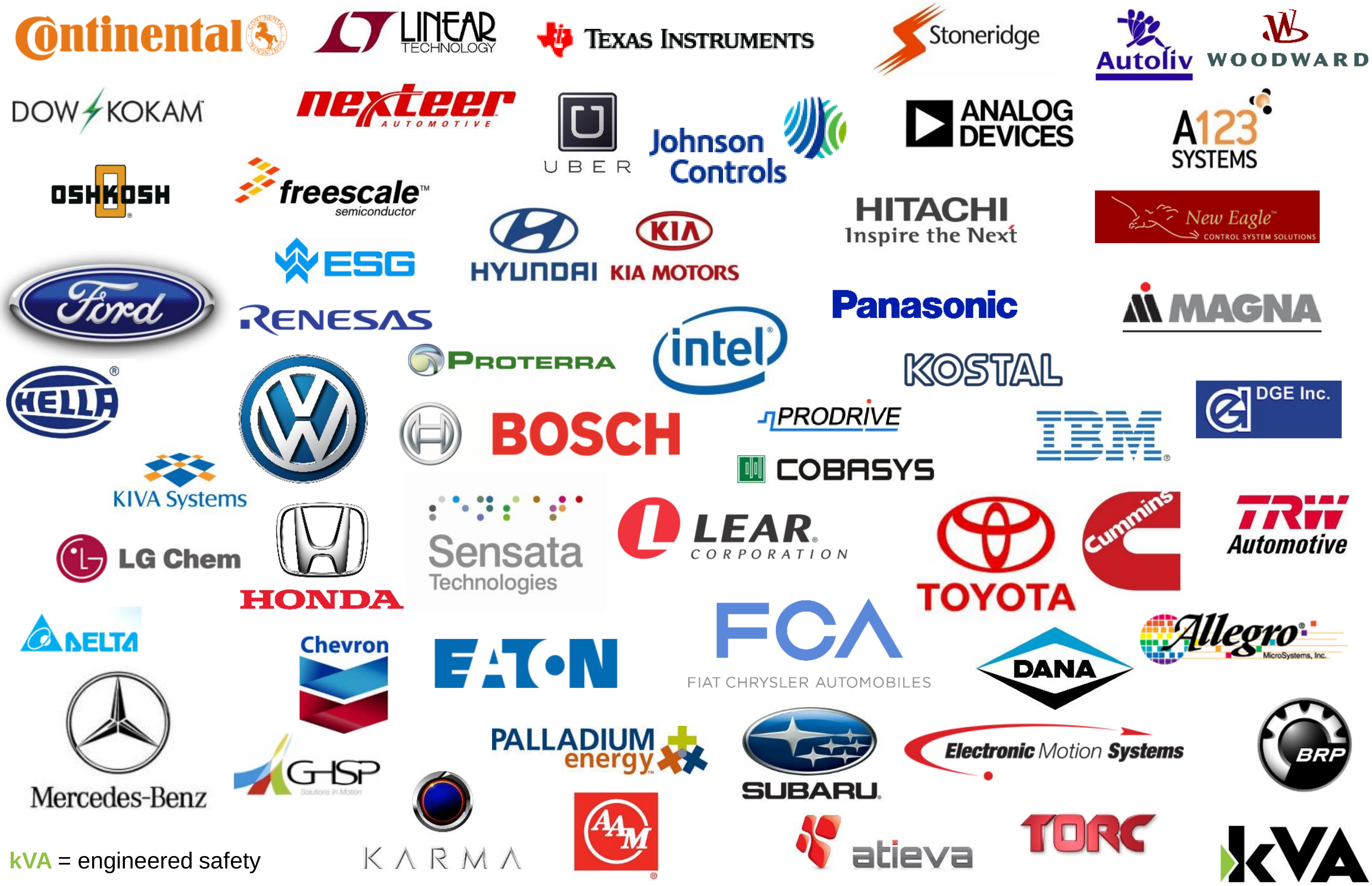
TÜV NORD
TÜV NORD Systems
GmbH & Co.KG
FSCAE
A031
0123/11

TÜV NORD
TÜV NORD Systems
GmbH & Co.KG
FSCAE
A031
0127/11

registered certification stamps for kVA managing partners B. Taylor and J. Nelson

- **kVA trains and certifies** the industry in functional safety standards and processes
  - **ISO 26262**
  - **IEC 61508**

kVA's Clients



kVA = engineered safety

Contact

Jody J. Nelson
Managing Partner, kVA

Located in Greensboro, NC

jody.nelson@kvausa.com
786.999.8264

www.kvausa.com