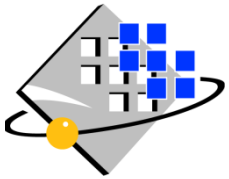

L3 Mention Informatique
Parcours Informatique et MIAGE

Génie Logiciel Avancé - Advanced Software Engineering

Standards and Legal Constraints

Burkhart Wolff
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Plan of the Chapter

- Introduction: The Role of Standards in SE
- Objectives:
  - Addressing System "Quality", "Safety", or "Security"
- Types of Standards / Norms
  - Generic Process Standards
  - Domain-specific Standards
    (Automative, Railway, Avionics, Medicine, Security)
  - Specific Standards to address phases in Processes
    (attempting assure overall "Quality", or "Tests")

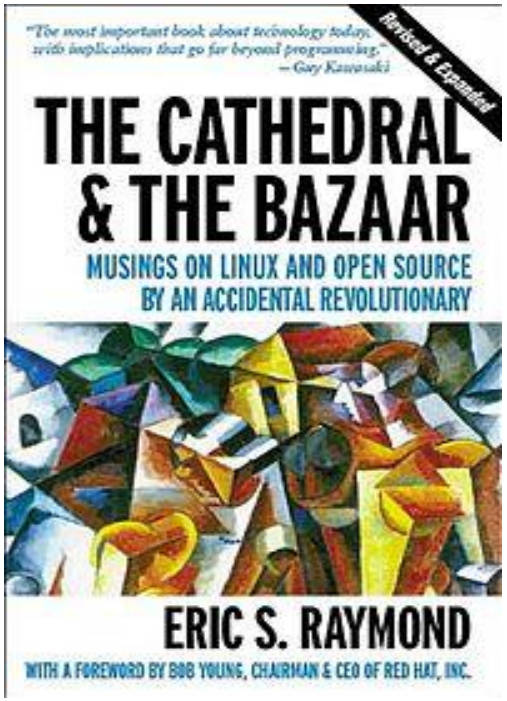
The Role of Norms and Standards in Software Engineering Processes

The Role of Norms in Software Engineering

Amusing Book: Raymonds Cathedral-Bazaar

Metaphor for (Open-Source) Processes:

- ... The *Bazaar* model, in which the code is developed over the Internet in view of the public. Raymond credits Linus Torvalds, leader of the Linux kernel project, as the inventor of this process.



contrasted to the

- ... The *Cathedral* model, in which source code is available with each software release, but code developed between releases is restricted to an exclusive group of software developers.

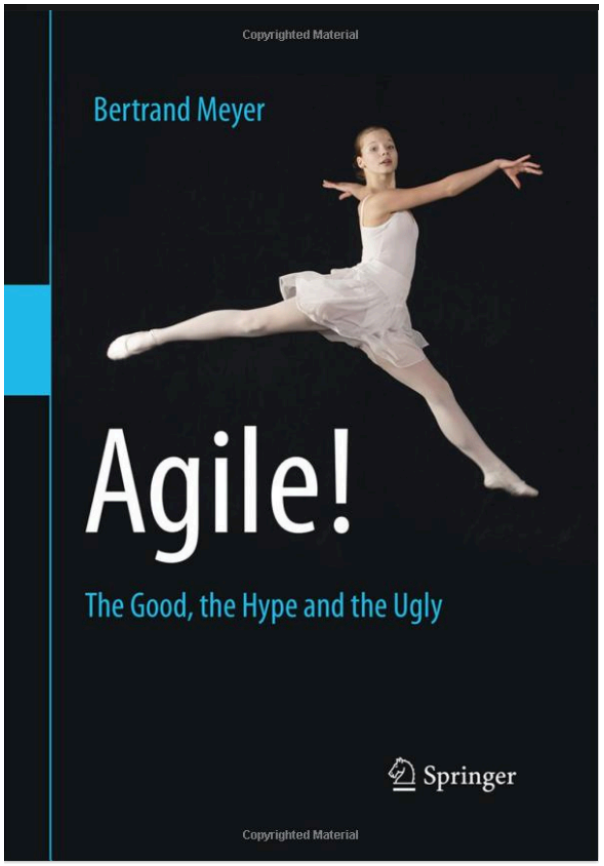
(Which is the standard case in industrial projects …)

The Role of Norms in Software Engineering

Another Amusing Book: Bertrand Meyers Book

Agile Programming

- emphasis on unit tests instead of a specification, emphasis on coding
- emphasis on scenarios (“storylines”)
- ... embrace change
- … emphasis human interaction (“pair programming”, “daily meetings”)
- widespread refuse of “Big Upfront Everything” [like requirement,analysis,design, …]
- incremental development “lasagne style”



Review: https://www.infoq.com/articles/agile-good-hype-ugly/
Summary: https://se.inf.ethz.ch/~meyer/publications/methodology/agile_software.pdf

The Role of Norms in Software Engineering

While it can be argued, if Open-Source Developments are really Bazaar-style or not, Industrial Developments follow clearly the *Cathedral* model

- ... for reasons of legal responsibility
- ... for having a contractual basis between partners in industrial developments
- ... for having a control on the timing and the investment of a development process.

Modern societies try to establish legal standards if safety, security, economic stability is concerned.

Standardisation organisations can be legal orgs (BIPM, ANSI,…) or industrial consortia (ISO, OMG, …)

The Role of Norms in Software Engineering

Some truths on Software Development Standards

- ... as such, they are usually not the beloved ones by companies and developers (exception: company intern standards to control investment risks)
- ... usually, they give an advantage over a competitor or are required by the contractor ...
- ... require an own management process (quality management, risk assessment, ..., “governance”)
- ... few empirical data over the actual improvement of a process

Objectives of Standards in Software Engineering Processes

Objectives: Safety vs. Security vs. Quality

Safety is the condition of protecting human beings against harmful conditions or events, or the control of hazards to reduce risk.

Conference of Computer Safety: … **dependable** application of computers in safety-related and safety-critical systems. SAFECOMP is an annual event covering the state-of-the- art, experience and new trends in the areas of **safety**, **…** and **reliability** of **critical computer applications**.

„Safety Critical System“:

- Energy networks, Aviation, Medicine, Nuclear Power-plants, Military
- Cars, Railway and Signalling Systems
- More and more: Networks and Telecommunication

Objectives: Safety vs. Security vs. Quality

Computer security (also known as **cybersecurity** or **IT security**) is information security as applied to computing devices such as computers and smartphones, as well as computer networks such as private and public networks, including the whole Internet.

Computer security is a branch of information technology also known as information security. It is is intended to protect computers. Computer security has three main goals:

- Confidentiality: Making sure people cannot acquire information they should not (*keeping secrets*)
- Integrity: Making sure people cannot change information they should not (*protecting data*)
- Availability: Making sure people cannot stop the computer from doing its job.

Objectives: Safety vs. Security vs. Quality

Note: Slightly different to the french definition:

La **sécurité des systèmes d'information** (**SSI**) est l'ensemble des moyens techniques, organisationnels, juridiques et humains nécessaire et mis en place pour conserver, rétablir, et garantir la sécurité du système d'information. Assurer la sécurité du système d'information est une activité du management du système d'information.)

Attention: Confusion avec l'usage en français courant:

Les différents types de sécurité correspondent aux modes de transport :

... Sécurité routière ... Sécurité ferroviaire … Sécurité aérienne ... Sécurité en mer ..

Objectives: Safety vs. Security vs. Quality

In software engineering, software quality refers to two related but distinct notions:

- Software functional quality reflects how well it complies with or conforms to a given design, based on functional requirements or specifications. That attribute can also be described as the fitness for purpose of a piece of software or how it compares to competitors in the marketplace as a worthwhile product.[1]

  It is the degree to which the correct software was produced.
- Software structural quality refers to how it meets extra-functional requirements that support the delivery of the functional requirements, such as robustness or maintainability. It has a lot more to do with the degree to which the software works as needed.

Hm, a) correctness, but also “fitness to market”

b) extra-functional requirements such as extensibility, maintainability, …

Objectives: Safety vs. Security vs. Quality

- Criticism: This classical distinction between safety and security is somewhat outdated ! Security is Safety !
- Story: Sasser Worm spreading April 30, 2004. Named Sasser because it spreads by exploiting a buffer overflow in the component known as LSASS (Local Security Authority Subsystem Service) on the affected operating systems Windows XP /2000.
- Effect: Affected within hours several million machines . . .
  - Agence France Press had all its satellite connections blocked
  - Delta Airlines cancelled Cross-Atlantic Flights
  - Insurance company *If* and *Sampo Bank* had to shut down services
  - British Coastguard had its electronic mapping service disabled
  - Lund University Hospital : no X-Rays possible
  - University of Missoury had to unplug its network
  - ... experts estimated 100 casualties world-wide ...

Objectives: Safety vs. Security vs. Quality

- Criticism: This classical distinction between safety and security is somewhat outdated !

  Security is Safety!

  - Renewed Discussion on military exploitation of Viruses after Stuxnet Virus (discovered June 2010, designed to attack the Iran Nuclear Centrifuge Program)
  - Cyber-Warfare developed in the Armies of many Countries

Still, you will find a lot of people disputing over this difference …

Objectives of Standards in Software Engineering Processes

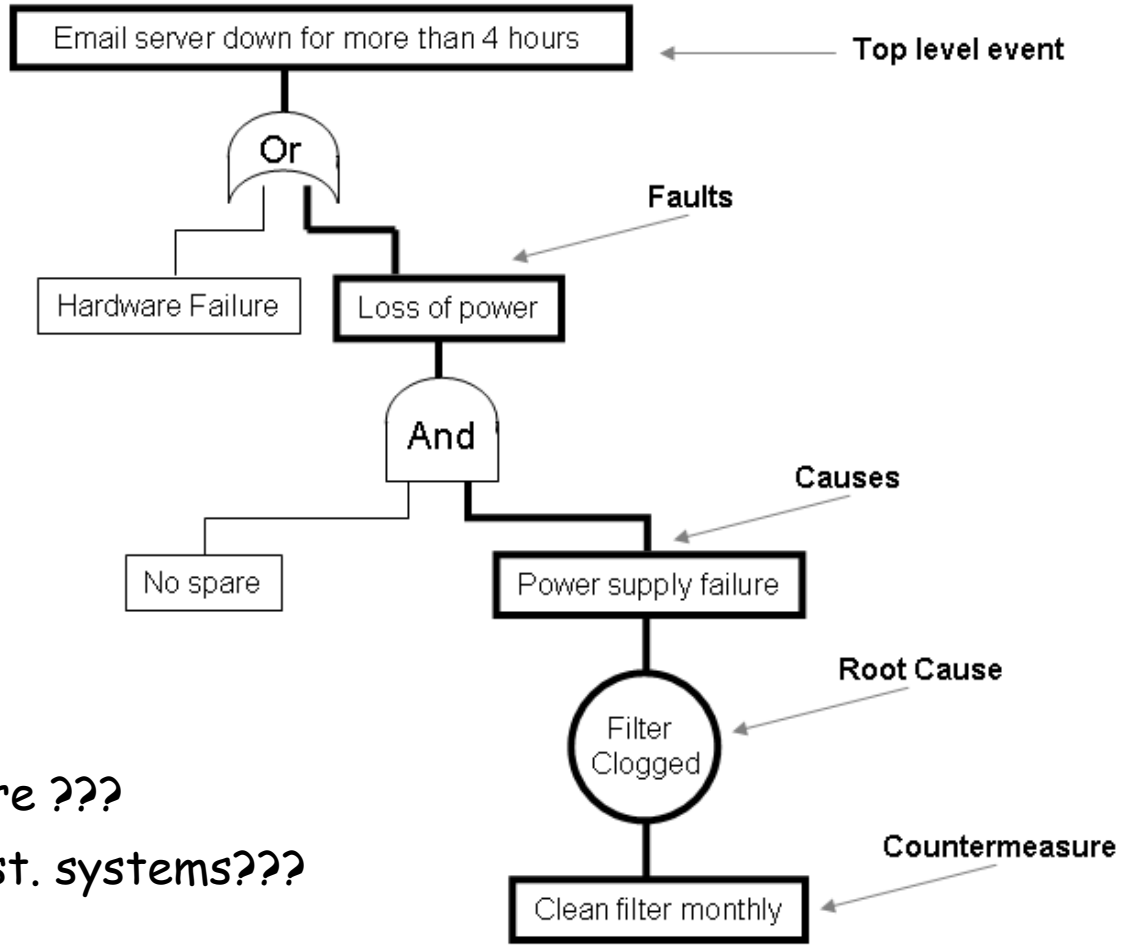
Domain Specific Safety Standards

- A bunch of Safety Standards have their roots in hardware - and systems design, and are therefore centred around probabilistic notions:
  - PFD Probability of Failure on Demand
    PFH Probability of Failure per Hour (Cont. Service)
  - Risk Analysis
- A Certifications must provide:
  - A rigorous definition of 'dangerous failure' for the system in question,
  - Fault Tree Models
  - Likelyhood of Demand, Complexity of Device

Domain Specific Safety Standards

- Example: A Fault-Tree Model

- Criticism:
  - Models and probabilities difficult to justify (risks independent?)
  - Applicable to software ??? To digital, determinist. systems???



Domain Specific Safety Standards

- Core notion:

MTBF (Mean Time Between Failures)

RRF (risk reduction factor)

Safety Integrity Level (SIL)

PFH (Probability of failure per hour)

PFD (probability of failure on demand)

SIL	PFD	PFD (power)	RRF
1	0.1-0.01	10^{-1} - 10^{-2}	10-100
2	0.01-0.001	10^{-2} - 10^{-3}	100-1000
3	0.001-0.0001	10^{-3} - 10^{-4}	1000-10,000
4	0.0001-0.00001	10^{-4} - 10^{-5}	10,000-100,000

SIL	PFH	PFH (power)	RRF
1	0.00001-0.000001	10^{-5} - 10^{-6}	100,000-1,000,000
2	0.000001-0.0000001	10^{-6} - 10^{-7}	1,000,000-10,000,000
3	0.0000001-0.00000001	10^{-7} - 10^{-8}	10,000,000-100,000,000
4	0.00000001-0.000000001	10^{-8} - 10^{-9}	100,000,000-1,000,000,000

SIL in Safety Standards

D. Smith, K. Simpson, "Safety Critical Systems Handbook - A Straightforward Guide to Functional Safety, IEC 61508 (2010 Edition) and Related Standards" (3rd Edition, ISBN 978-0-08-096781-3, 270 Pages).

Domain Specific Safety Standards

- The following standards use SIL as a measure of reliability and/or risk reduction
  - ANSI/ISA S84 (Functional safety of safety instrumented systems for the process industry sector)
  - IEC EN 61508 (Functional safety of electrical/electronic/programmable electronic safety related systems)
  - IEC 61511 (Safety instrumented systems for the process industry sector)
  - IEC 61513 (Nuclear Industry)
  - IEC 62061 (Safety of machinery)
  - EN 50128 (Railway applications - Software for railway control and protection)
  - EN 50129 (Railway applications - Safety related electronic systems for signalling
  - EN 50402 (Fixed gas detection systems)

Domain Specific Safety Standards

- The following standards use SIL as a measure of reliability and/or risk reduction
  - ...
  - EN 50402 (Fixed gas detection systems)
  - ISO 26262 (Automotive industry)
  - MISRA, various (Guidelines for safety analysis, modelling, and programming in automotive applications)
  - Defence Standard 00-56 Issue 2 - accident consequence

  The use of a SIL in specific safety standards may apply different number sequences or definitions to those in IEC EN 61508.

Domain Specific Safety Standards

- Even from these «soft» probabilistic models, hard «digital» requirements arise:

  The international standard on functional safety for software development of road vehicles ISO26262-6 requires the

  freedom from interference by software partitioning

- Thus it is aimed at providing a trusted embedded real-time operating system, which is oriented to ECUs (Electronic Control Units) in automotive industry. (avionics similarly)

Domain Specific Safety Standards

- A quite typical Example:

  CENELEC 50128 Software Standard

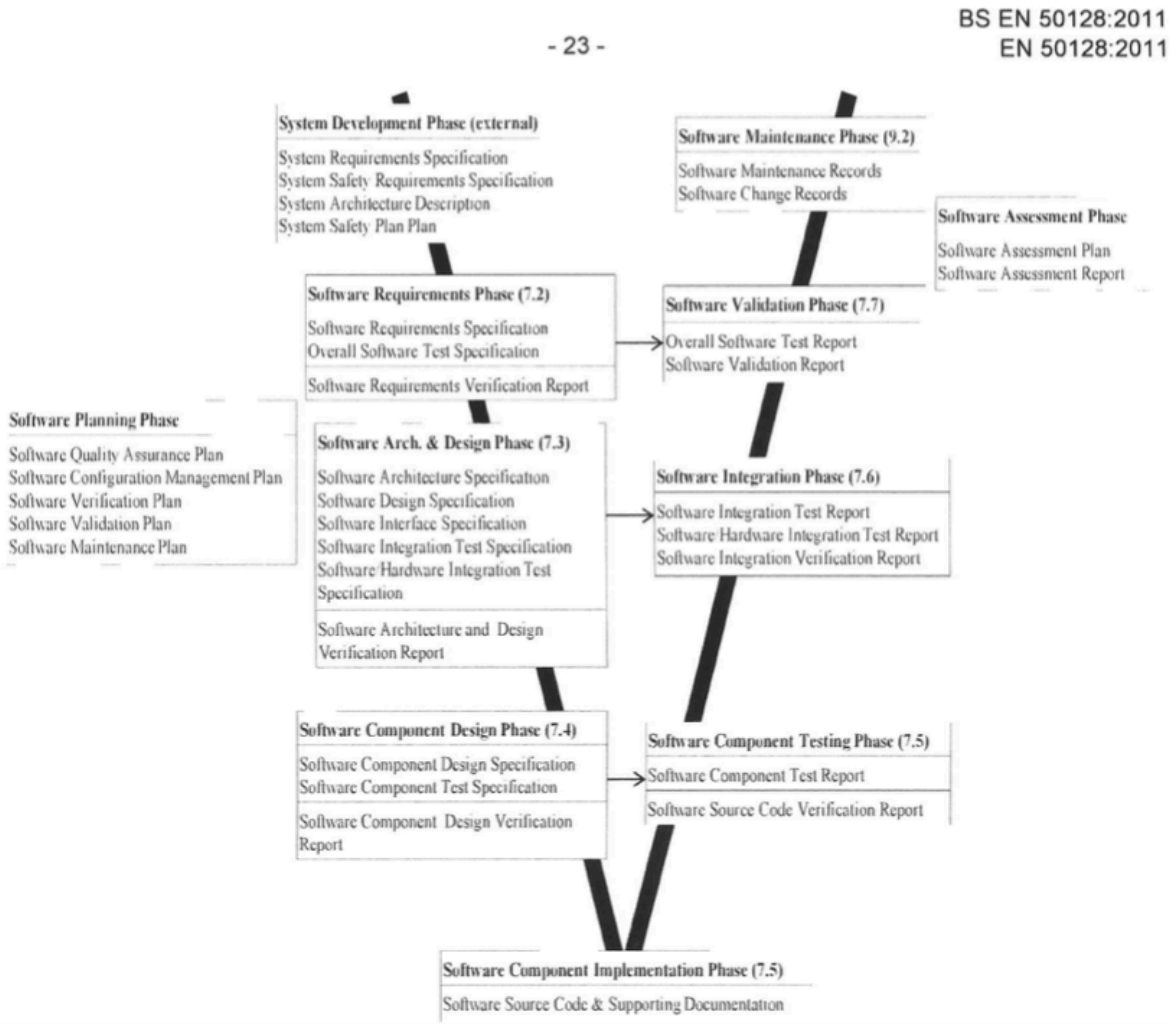
  (complementing the CENELEC 50126 Railway Systems Standard on Safety)

- It defines
  - a vocabulary
  - a process with phases, roles, and organisational constraints
  - a number of milestone documents
  - quality levels (SIL 1 .. 4)
  - a bunch of techniques and measures

  (rather than statistic approaches)

Domain Specific Safety Standards

- Phases and Milestones



Domain Specific Safety Standards

- Techniques and Measures

Table A.2 – Software Requirements Specification (7.2)

TECHNIQUE/MEASURE	Ref	SIL 0	SIL 1	SIL 2	SIL 3	SIL 4
1. Formal Methods (based on a mathematical approach)	D.28	-	R	R	HR	HR
2. Modelling	Table A.17	R	R	R	HR	HR
3. Structured methodology	D.52	R	R	R	HR	HR
4. Decision Tables	D.13	R	R	R	HR	HR

Requirements:

1) The Software Requirements Specification shall include a description of the problem in natural language and any necessary formal or semiformal notation.

2) The table reflects additional requirements for defining the specification clearly and precisely. One or more of these techniques shall be selected to satisfy the Software Safety Integrity Level being used.

Table A.5 – Verification and Testing (6.2 and 7.3)

TECHNIQUE/MEASURE	Ref	SIL 0	SIL 1	SIL 2	SIL 3	SIL 4
1. Formal Proof	D.29	-	R	R	HR	HR
2. Static Analysis	Table A.19	-	HR	HR	HR	HR
3. Dynamic Analysis and Testing	Table A.13	-	HR	HR	HR	HR
4. Metrics	D.37	-	R	R	R	R
5. Traceability	D.58	R	HR	HR	M	M
6. Software Error Effect Analysis	D.25	-	R	R	HR	HR
7. Test Coverage for code	Table A.21	R	HR	HR	HR	HR
8. Functional/ Black-box Testing	Table A.14	HR	HR	HR	M	M

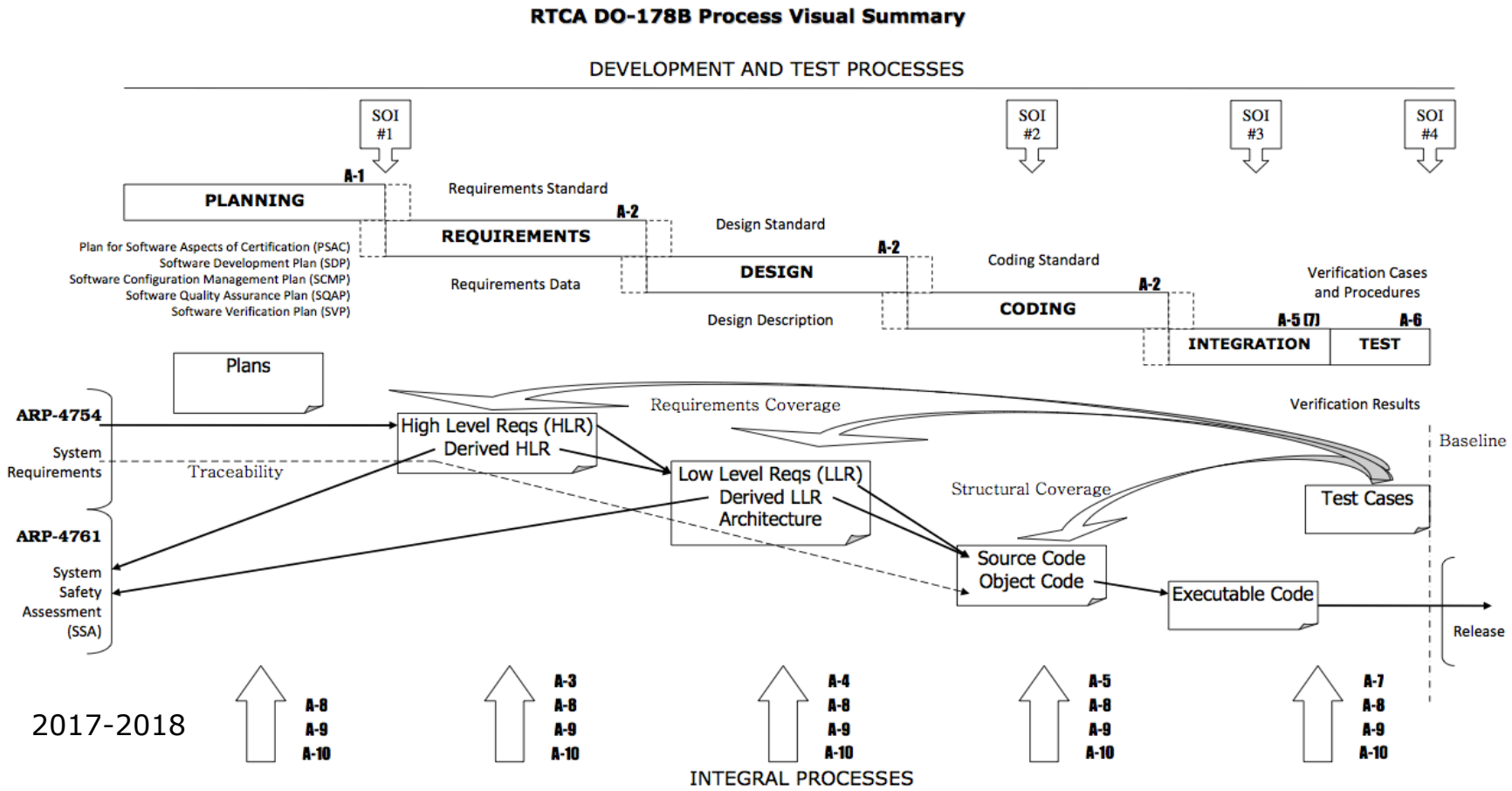
In-between Generic and Specific SE Standards : DO 178B/C

- … stems from the Avionics Context (FAA certifications)
- … but adresses explicitly the needs of software:

The FAA applies DO-178B as the document it uses for guidance to determine if the software will perform reliably in an airborne environment,[1] when specified by the Technical Standard Order (TSO) for which certification is sought. The introduction of TSOs into the airworthiness certification process, and by extension DO-178B, is explicitly established in 14 Code of Federal Regulations (CFR) Part 21, Subpart O.

In-between Generic and Specific SE Standards : DO 178B

- DO 178B makes explicit requirements
  - on the SE Development process and its documentation

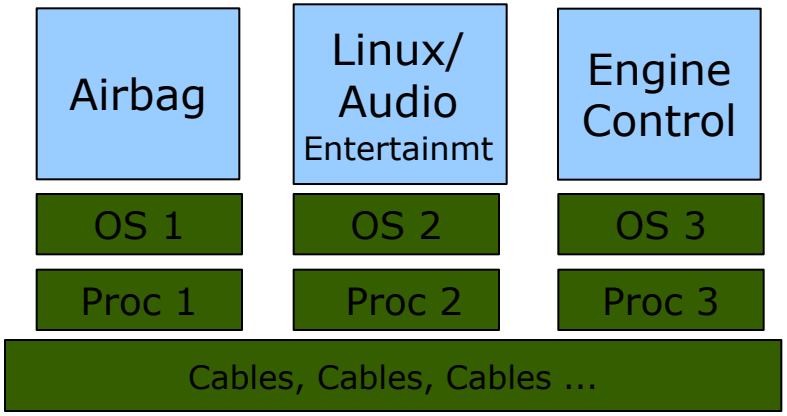


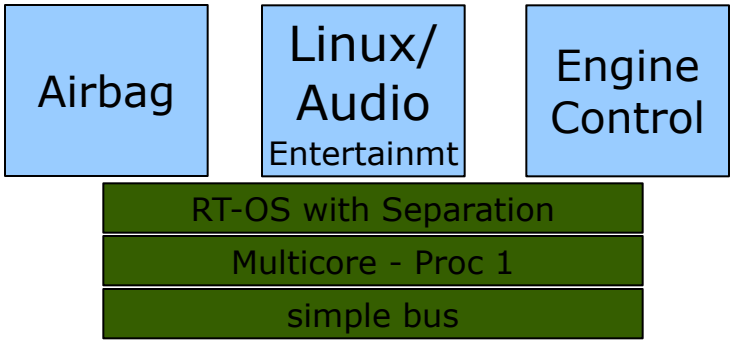
2017-2018

Security Standards : Consequences

- Example: A current industrial challenge resulting from the requirement «Freedom of interference»
  - Real-time Operating System Kernels assuring not only memory protection, but « Non-interference »

    (PikeOS, Sel4, INTEGRITY-178B, RTOS Wind River Systems…)

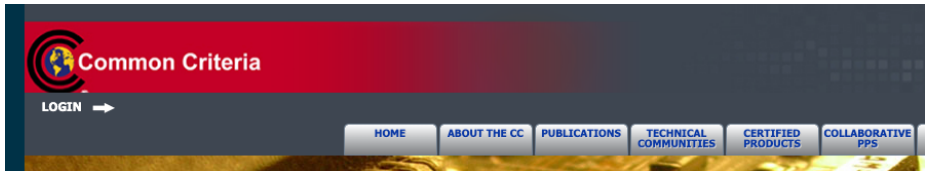




Generic Software Engineering Standards

ISO/IEC/IEEE 15408 for computer security certification:

«Common Criteria» (CC)



- Framework where users can specify security functional and assurance requirements (SFR and SAR) by *Protection Profiles* (PP)
- Vendors/Developers can implement and/or claim security attributes of their products
- Evaluators (usually test labs) evaluate the products and determine if they actually meet the claims.
- A certification authority (France: ANSI, Germany: BSI) issues certificate

Common criteria provides assurance that the process of specification, implementation and evaluation of a computer security product has been conducted in a rigorous and repeatable manner.

Source: https://www.commoncriteriaportal.org/

Generic Software Engineering Standards

ISO/IEC/IEEE 15408 for computer security certification:

«Common Criteria» (CC)

- Evolved Terminology:
  - EAL: Evaluation Assurance Level
  - PP: Protection Profile
  - SAR: Security Assurance Requirement
  - SF: Security Function
  - SFR: Security Functional Requirement
  - SFP: Security Function Policy
  - SOF: Strength of Function
  - ST: Security Target
  - TOE: Target of Evaluation
  - TSP: TOE Security Policy
  - TSF: TOE Security Functionality
  - TSC: TSF Scope of Control
  - TSFI: TSF Interface

Generic Software Engineering Standards

ISO/IEC/IEEE 15408 for computer security certification:

«Common Criteria» (CC)

Documentation process and assurance levels:

- EAL1: Functionally Tested
- EAL2: Structurally Tested
- EAL3: Methodically Tested and Checked
- EAL4: Methodically Designed, Tested and Reviewed
- EAL5: Semi-formally Designed and Tested
  (Smart-Cards, Tenix Interactive Link, XTS-400 (an OS))
- EAL6: Semi-formally Verified Design and Tested
  (Green Hills INTEGRITY-178 RTOS)
- EAL7: Formally Verified Design and Tested
  (Fox Data Diode, Gemplus Smart Card).

Generic Software Engineering Standards

ISO/IEC/IEEE 15408 for computer security certification:

«Common Criteria» (CC)

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Generic Software Engineering Standards

Excerpt from the https://www.commoncriteriaportal.org/products/ - database:

Network and Network-Related Devices and Systems – 230 Certified Products

Operating Systems – 52 Certified Products

Product	Vendor	Product Certificate	Date Certificate Issued	Certificate Validity Expiration Date	Compliance	Scheme
IBM RACF for z/OS Version 2 Release 4 Certification Report Security Target	IBM Corporation	CCRA Certificate	2022-09-22	2027-09-22	EAL5+ ALC_FLR.3	IT
PikeOS Separation Kernel, Version 5.1.3 Certification Report Security Target	SYSGO GmbH	CCRA Certificate	2022-09-20	2027-09-19	EAL5+ ADV_IMP.2 ALC_CMC.5 AVA_VAN.5 ALC_DVS.2 ALC_FLR.3	DE

The "security target" in this public data-base describes what security function has actually been certified, the EAL level the depth of the acquired guarantees.

Conclusion

- Attempts to control development processes and software products by standards (norms)
- Attempts to assure and certify software quality.
- Most serious and relevant standards (in France):
  - DO 178B (Avionics)
  - CENELEC 50128 (Avionics)
  - ISO 9000 (Processes)
  - **ISO/IEC/IEEE** 29119 (Software Test)
  - **ISO/IEC/IEEE** 15408 «Common Criteria» for computer security certification requiring formal models as well as proof techniques for EAL 6 and EAL 7.