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Approaches to meet Certification Requirements for Mission-Critical Domains

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Content

- Certification in Mission-Critical Domains
  Elements, Requirements
- Compliance with safety standards
- V&V techniques used in OOO Siemens CT SE
  Static Analysis, Code Coverage Analysis: Examples
- Our experience makes the case
  Evidence Improvement for Certification
- Conclusions
  Our vision on further perspectives

Certification: Elements of Software Certification

Elements of Software Certification

- Product
  - Evaluation, measurement of the product
  - Uncertainty reduced by reference, measurement methods
- Process
  - Standards to define what must be performed to build software systems
  - Assessment of organizations for conformance
- People
  - Skilled people to get processes right
  - People with knowledge beyond computer science/swe
  - Licensing “software engineers” by state examinations

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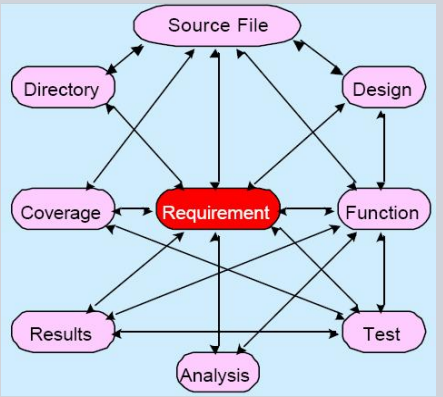
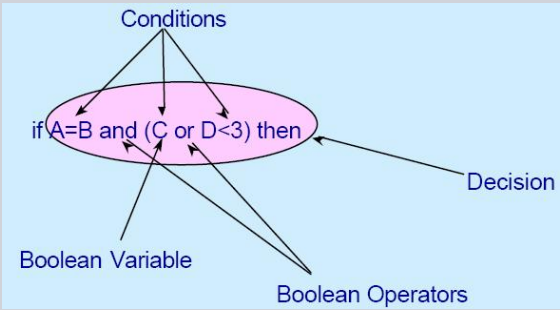
Certification Requirements: Examples

At development process level



- Focus on Requirements, Test, Traceability
- Use of Tools to manage process
  - Requirements captured electronically
  - Traceability information added (or conjured by system)
  - Checklists, documents, test templates generated automatically
- Application of Design and Coding Policy
  - Reviews

At software product level



- Definition of components integrity levels
- Traditional V&V intensified with a combination of diverse development techniques
- Application of advanced assurance techniques

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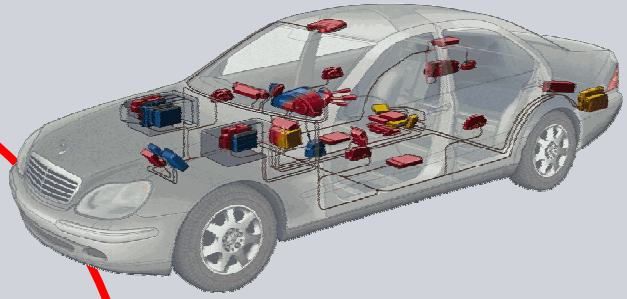
Dependability in Siemens products



Integrity

Safety

Maintainability

Dependability in Siemens Products

Availability

Reliability

Confidentiality

Almost all Siemens Business Units develop and sell products that perform safety-critical operations. Most of these products nowadays contain an ever increasing software part.

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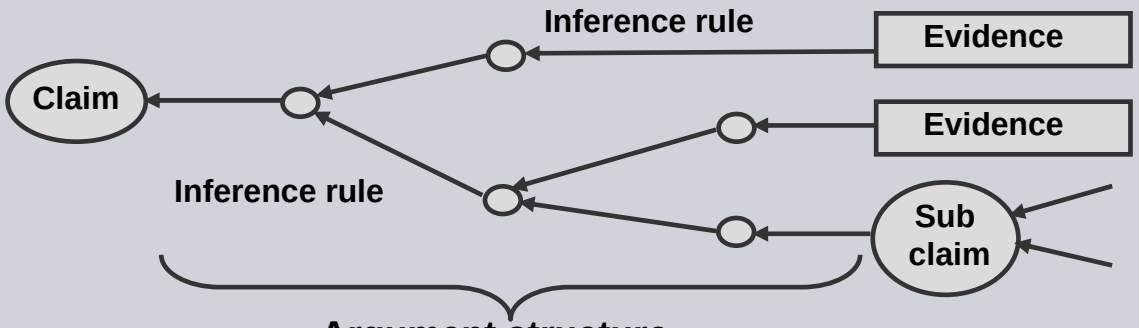
Evidence Improvement for Certification

Claims Proving Structure from Safety Cases (UK) ADELARD



Claims	Argumentation	Product & Process Evidence
- functional properties - non-functional - safety - reliability - availability - maintainability - security	- static code analysis - formal proofs - MTTF, reliability testing - compliance to safety standards - coverage analysis	- design documentation - testing evidence - COTS product evaluations - …

Compliance to safety standards

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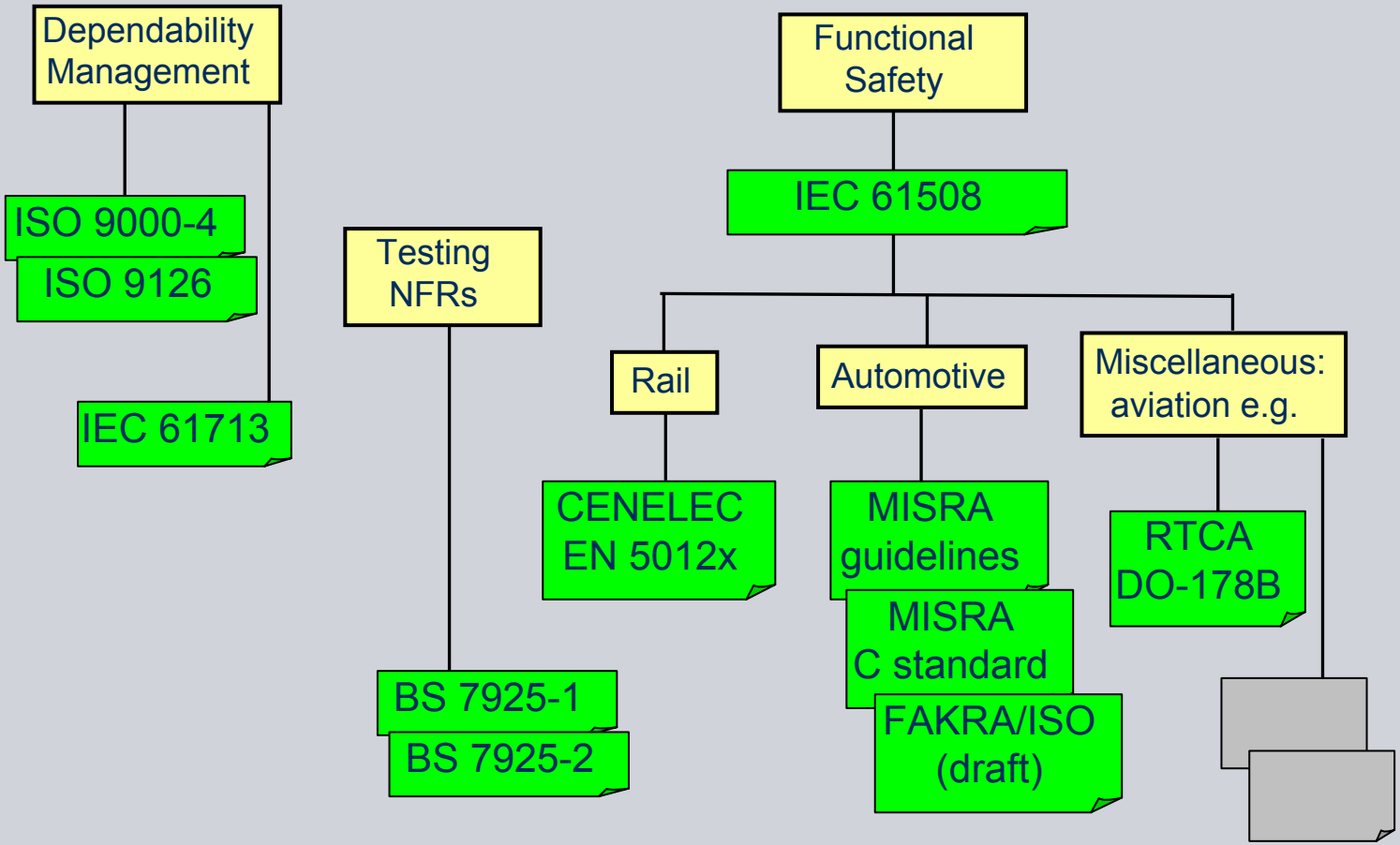
Compliance to Safety Standards and Guidelines



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Compliance to Safety Standards and Guidelines

IEC 61508, DO-178B

- Sound basis for certification
- One of the ways to gain software ‘approval for use’
- Product and Process Examination
  - Six processes to be performed (Planning, Development, QA, etc.)
  - Traceability between requirements, design, code, tests, etc.
  - Independence of some activities performed (IV&V)
  - Product evaluation tasks determined by integrity level
- Integrity levels
  - Task selection, degree of task performance
- Uses an overall safety lifecycle model as the technical framework for the activities necessary for ensuring safety

We mean to use standards recommendations for not safety-related software

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Application of Static Code Analysis

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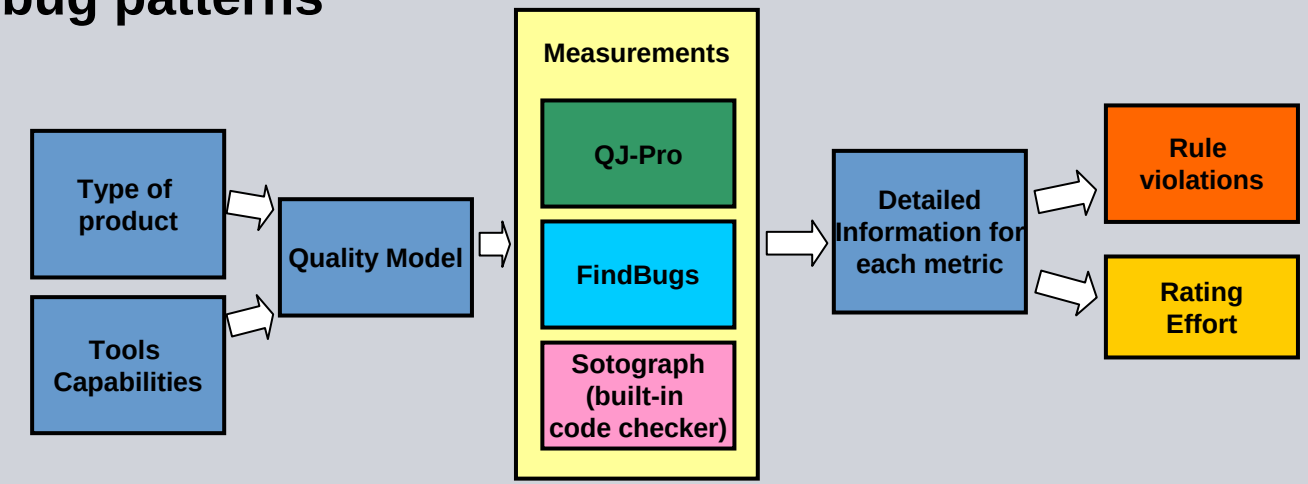
Static Code Analysis (tool-based)

- **Subjects** program texts to scrutiny and review in order to detect inconsistencies and omissions
- **Checks**
  - conformance to coding standards
  - misuse of programming language
  - best practices (e.g. defensive programming)
  - code structure
- **Identifies bug patterns**

- How could we improve/ supplement it?
- Add software structure assessment →



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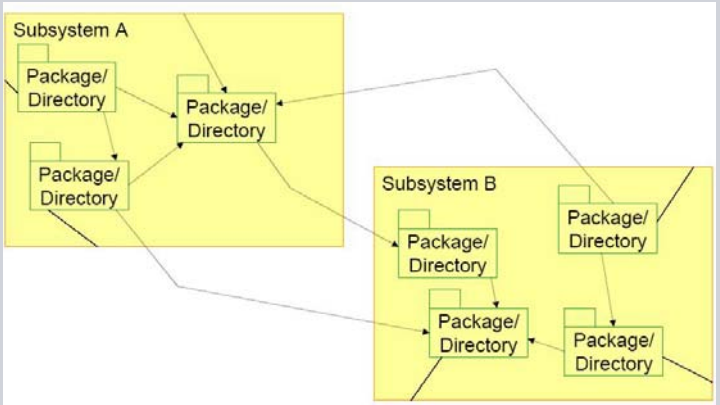
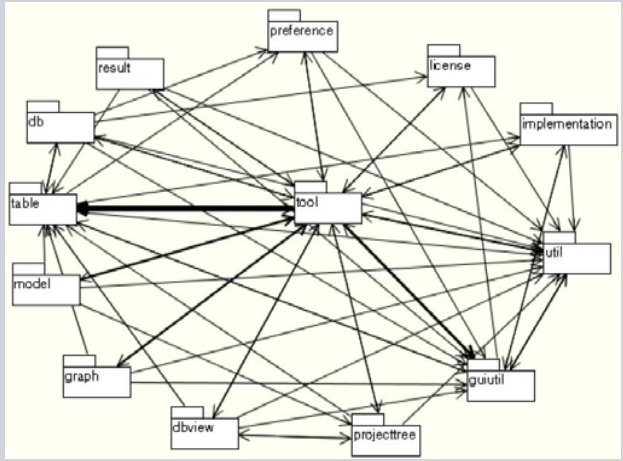
Software Structure Assessment

- **Goals**
  - Identify architecture violations on the source code level
  - Evaluate maintainability and understandability of software under analysis
  - Supplement traditional static analysis



- **Means**
  - Aggregation of fine-grained source code artifacts to subsystems
  - Definition and check of rules how subsystems are allowed to interact (call-references, attribute usage, inheritance etc.)
  - Cycles based analysis
    - How many cycles?
    - How large is a cycle?
    - Which are high cyclically coupled artifacts?
  - Graphs for visualization



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Static Analysis: Sample project results

Static Analysis

- By applying code analyzers with various capabilities there were identified:
  - Code structures with potential side-effects
    - missing ‘default’ statements,
    - usage of deprecated classes and methods,
    - methods fail to close streams etc.
  - Maintainability issues
    - high complexity expressions, dummy comments, confusing class/method names

Cycle-based analysis

- On package level there were found 3 cycle groups
  - One of subsystems is considered not maintainable in case of further evolutions due to chaotic relationships between members

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Lessons learned

- **High level view based on Quality Model**
- **Detailed rating information**
  - Risk assessment (based on expert evaluation)
  - Effort (to fix findings)
- **Identified places in code with potential side-effects**
  - Inappropriate objects comparison
  - Unhandled states of the system (missing ‘default’ statements)
  - Software misbehavior

- **Conclusions**
  - Might include elements of code review technique (safety standards requirement)
  - Difficult to implement large sized software system without considerably breaking the planned architecture
  - Necessity of tool based regular architecture conformance checking

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Application of Code Coverage Analysis

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Coverage Analysis – Rigorous V&V Technique

It is the process of

- Finding areas of a program not exercised by a set of test cases
- Creating additional test cases to increase coverage
- Determining a quantitative measure of code coverage, which is an indirect measure of quality

Condition/Decision coverage

- All decisions must be executed
- All decisions with possible outcomes
- All conditions with all possible outcomes

If A=0 and B<2 and C>5 then P; …

A=0	B<2	C>5	P
T	T	T	T
F	T	T	F
T	F	T	F
T	T	F	F

Each outcome must be tested once

As a result

- We are able to show that each condition has its intended effect on the outcome of a decision

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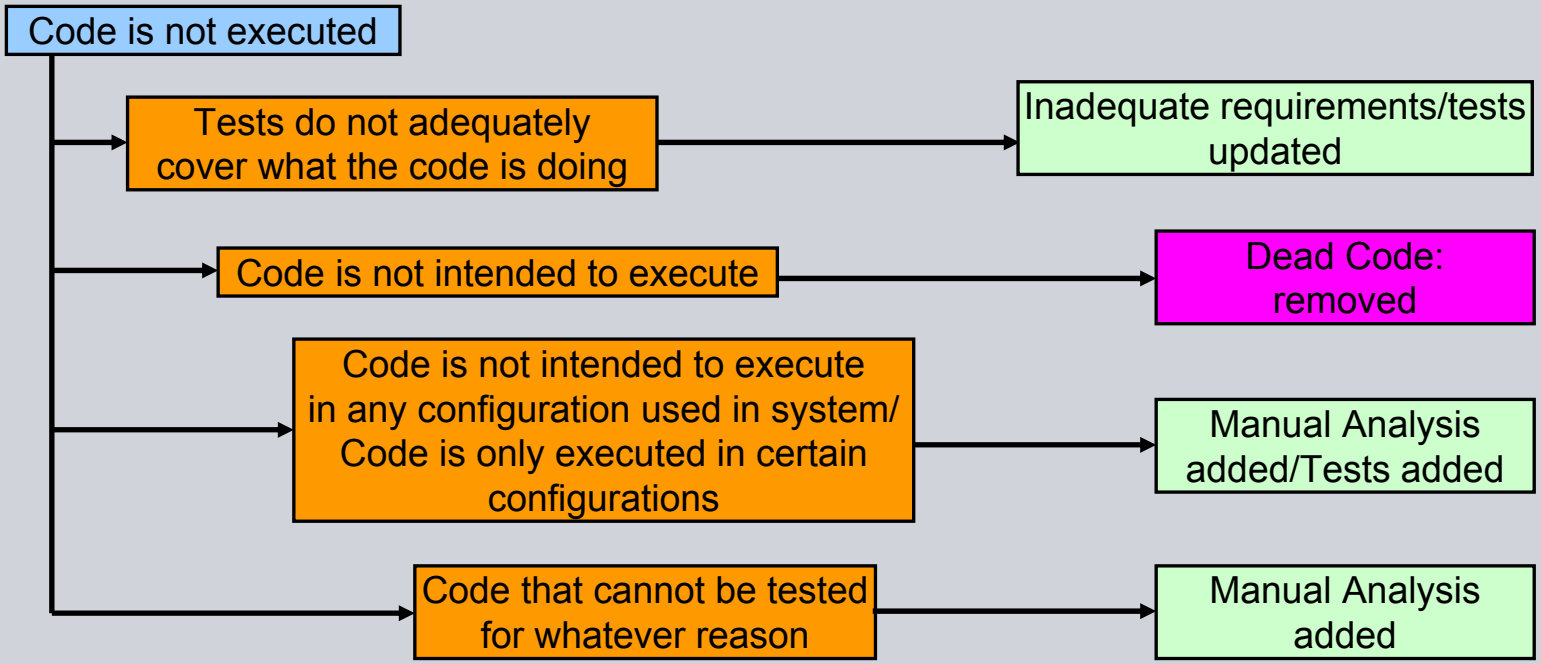
Coverage Analysis – Targets

- Mission-critical software has the highest target – 100% coverage, revealed not exercised code structure is processed in the following way:



- The lowest targets assume having another testing strategy
  - E.g. attain some coverage through the entire test program
  - Strive for high coverage in any particular area.

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MCDC Coverage Analysis – Example

Report before analysis:

```
decision line 57: if statement
        if( (channel>=0) && (channel<NUM_ADC_CHAN) )
        T       F
    1: *tt      fx   ((channel>=0)) &&    PARTIALLY covered
```

Report after analysis:

```
decision line 57: if statement
        if( (channel>=0) && (channel<NUM_ADC_CHAN) )
        T       F
    1: *tt      fx   ((channel>=0)) &&    PARTIALLY covered
```

#ANALYSIS:

- **Functions invoked with project defined constant parameters**
- **Many functions are called and configured with sets of constant data that have been defined for the project**
- **These configuration parameters prevent many functions from covering all paths**
- **These paths are not traversed at any time and can be shown that they will never be traversed within context of this project.**

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Lessons learned

- Coverage analysis (MC/DC) is the recommended mean to support certification materials
- Coverage analysis is a rigorous testing technique that helps:
  - Eliminate gaps in a test suite
  - Most in the absence of a detailed, up-to-date requirements specification
- Multiple condition/decision coverage is very useful general-purpose measure for C, C++, and Java
- Setting right target of coverage can increase testing productivity
- Programmers have to think more about testability of their code

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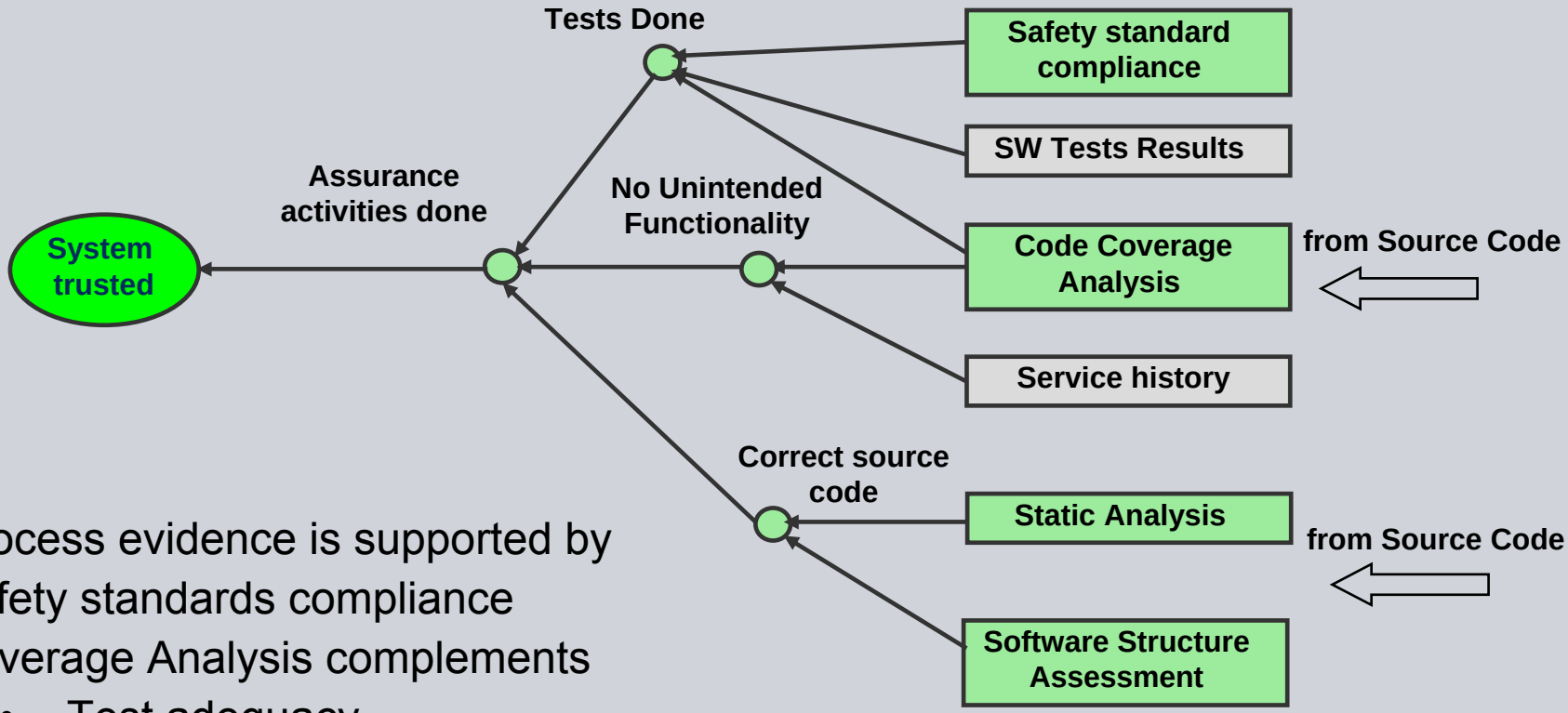
Our experience makes the case …



- Process evidence is supported by safety standards compliance
- Coverage Analysis complements
  - Test adequacy
  - Service history
- Software Structure Assessment provides additional confidence in source code thoroughness

We continue removing remaining uncertainty required for certification…

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Conclusions

- Assurance of mission-critical software quality required by **certification** cannot be provided by only one technique

- Still important to have trusted engineering processes to produce software artifacts which:
  - can be measured
  - analyzed during the lifecycle

- Application of V&V techniques complementing each other like
  - static code analysis supported by software structure assessment
  - coverage analysis assuring quality of set of tests

- Outlook
  - Choice of methods has to depend on the required level of dependability inline with the target domain
  - We are looking forward for application of promising techniques such as model checking, advanced static code analysis, in-depth testing for software safety

THANK YOU!

QUESTIONS?