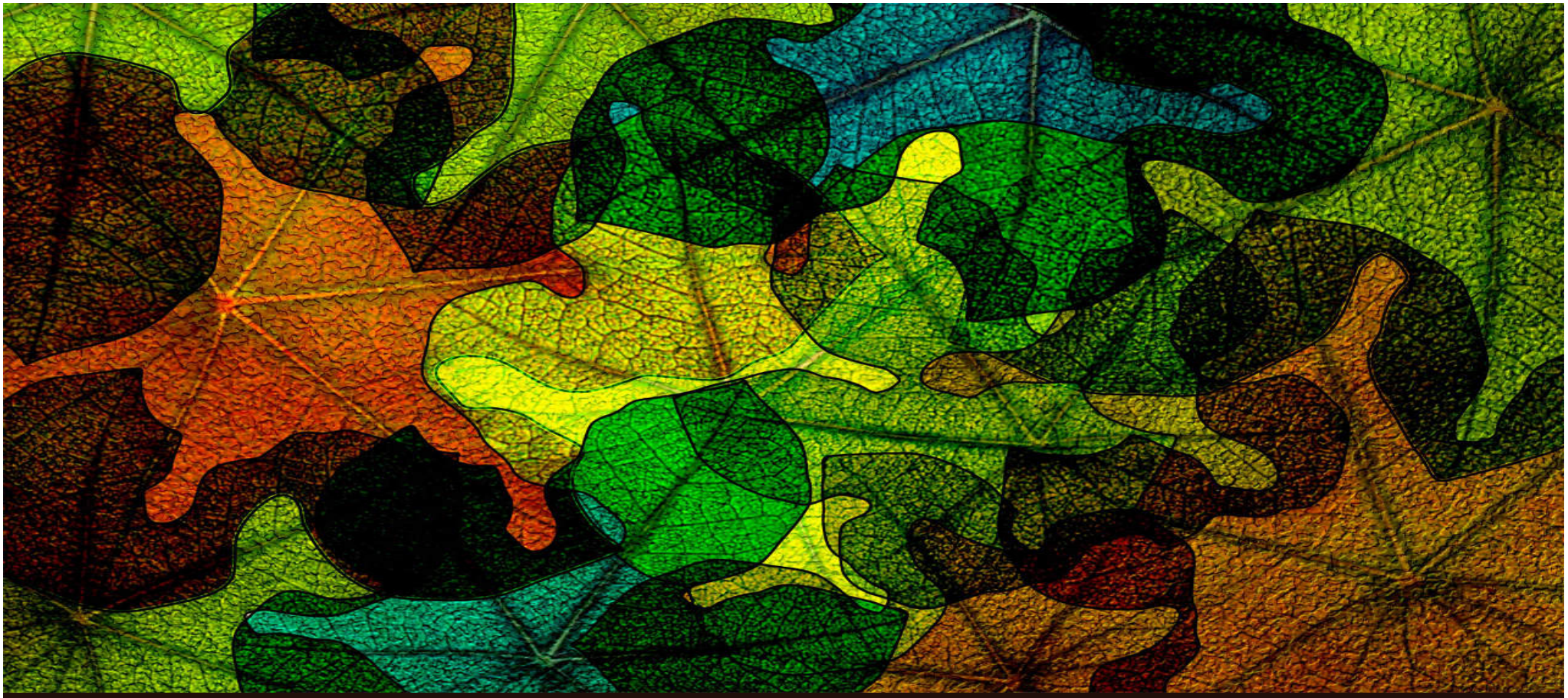

BEYOND THE PAIN OF TRACEABILITY:

Cost Effective Techniques for demonstrating Safety, Security, and Compliance of Software Intensive Systems

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DePaul University

COEST
Center of Excellence for Software Traceability

What is Traceability?

The ability to identify and document the lineage of each requirement, including its derivation (backward traceability), its allocation (forward traceability), and its relationship to other requirements.

International Institute of Business Analysis
Body of Knowledge
Version 2.0

Traceability is of particular concern in safety & mission-critical systems.

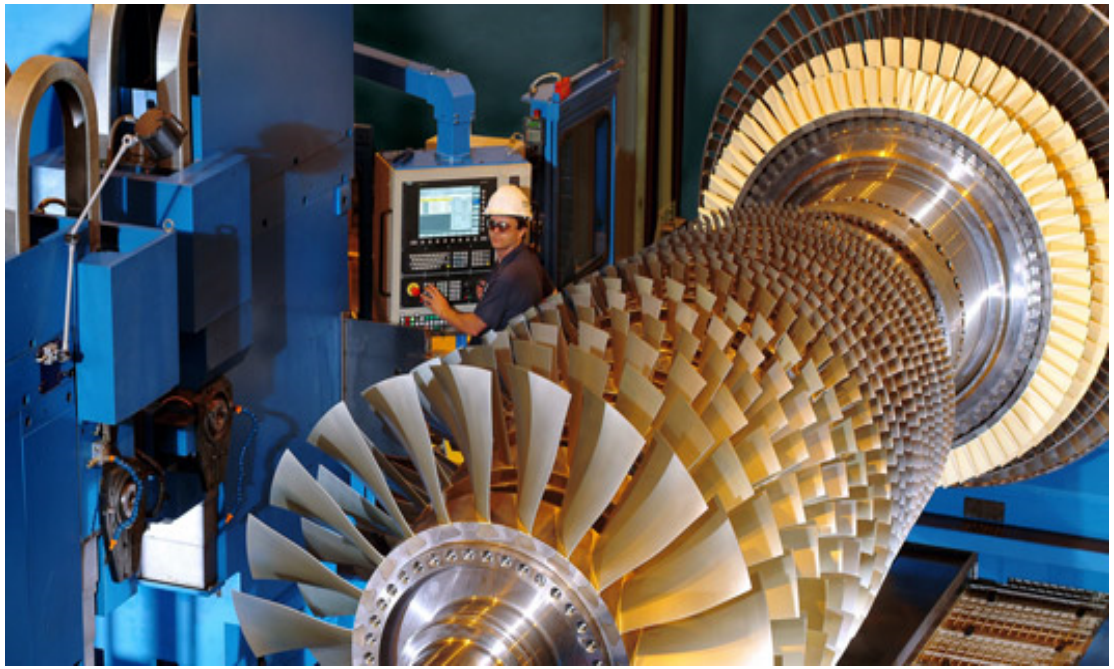
Standards require it..

The **Federal Aviation Administration**'s (FAA) DO-178B standard specifies that at each and every stage of development "software developers must be able to demonstrate traceability of designs against requirements.

The U.S. **Food and Drug Administration** (FDA) states that traceability analysis must be used to verify that the software design implements all of the specified software requirements, that all aspects of the design are traceable to software requirements, and that all code is linked to established specifications and test procedures.

Process improvement initiatives such as CMMI also require traceability.

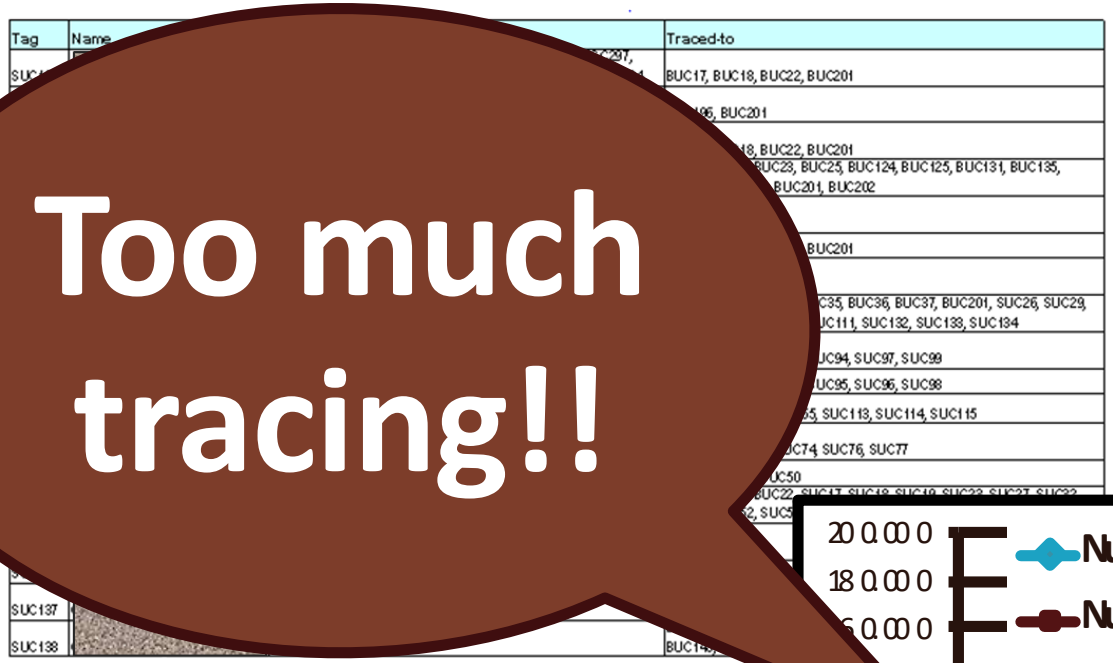
Important in both Software & Systems Projects



Strategic Traceability is needed across both systems models and software models.

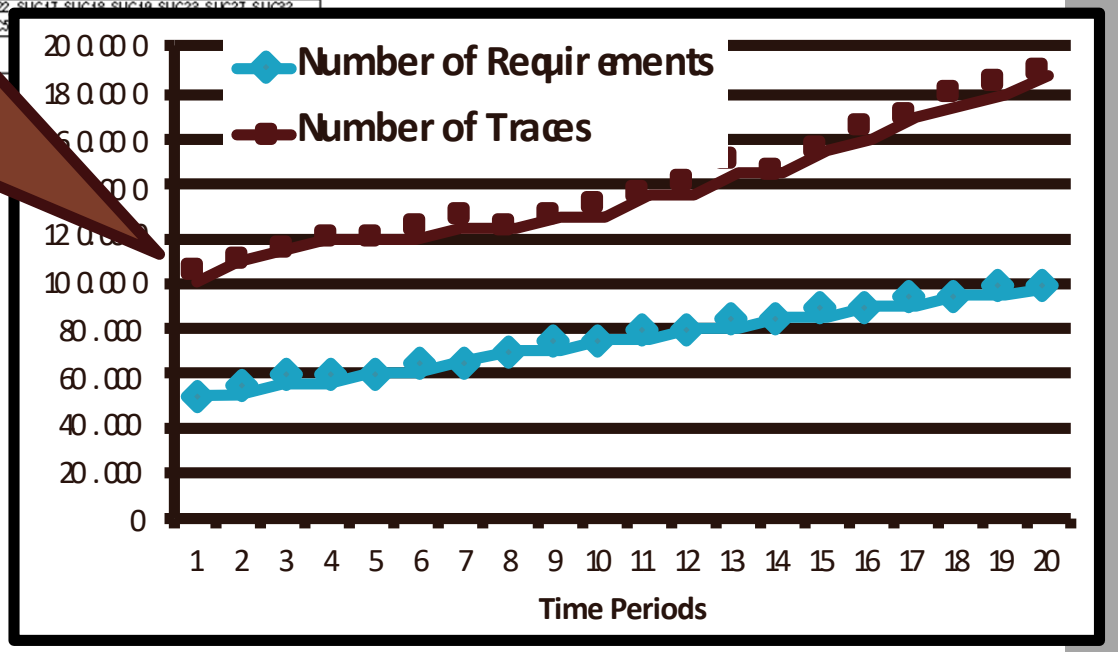
- Regulatory codes
- Requirements
- Software Control Systems
- Mechanical models
- Design & Test Cases
- Electrical models

…but



Too much tracing!!

The number of requirements and other artifacts grow quickly as the project progresses.



Excessive numbers of traceability links deteriorate into an unwieldy, inaccurate, tangle of relationships.

How will traces be created and used?

Trace Creators & Maintainers:
Requirements engineers, developers, architects.

Who? When? How? Why? What?

Trace users:
Compliance officers, requirements engineers, testers, developers.

Who? When? How? Why? What?

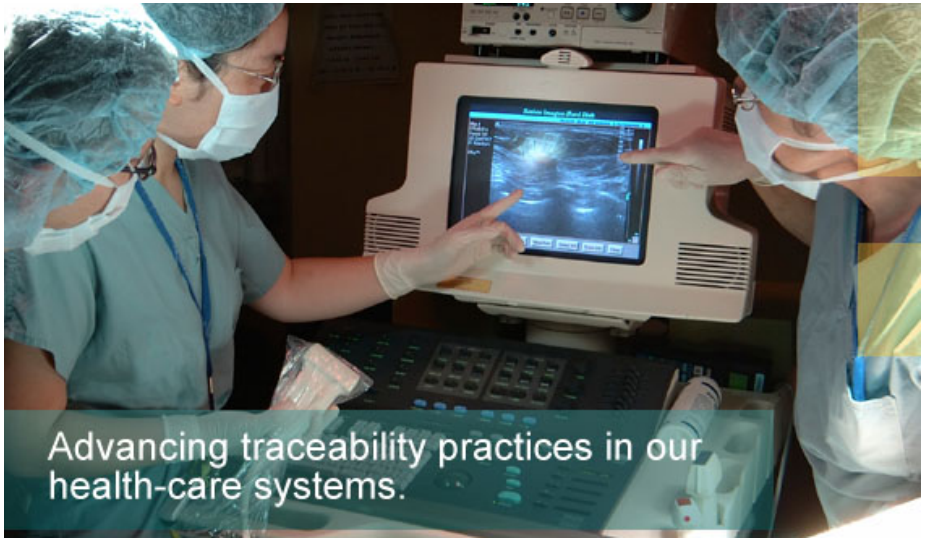
As creators and maintainers are often NOT the same people, there needs to be buy-in at the project level!

How this talk is structured

- Introduction to Traceability ✓
- Benefits of Traceability
  - Trace Example: Safety Analysis
  - Trace Example: Architectural Preservation
  - Trace Example: Regulatory Compliance
- Mistakes People Make
- Remedies
  - Creating and Maintaining Trace Links
  - Using Trace Links
  - Comprehending Trace Results
- Next Steps

What is the value of Tracing?

- Requirements validation
- Coverage analysis
- Change impact analysis
- Code comprehension
- Preservation of architectural knowledge
- Test regression selection
- Compliance verification



A Brief Look at 3 Tracing Scenarios

Safety Analysis

John is the safety engineer. He needs to demonstrate that **all identified hazards** have been addressed in the design, and ultimately in the deployed system

Architectural Preservation

Les is a Software Architect. He needs to ensure that **architectural know-ledge** and the integrity of the software is preserved despite maintenance and change.

Change Impact

Mary is a requirements engineer. She needs to understand the **impact of a change** upon **regulatory codes.** Will we be in compliance if we make this change?

How this talk is structured

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- Strategic ROI Driven Traceability ✓
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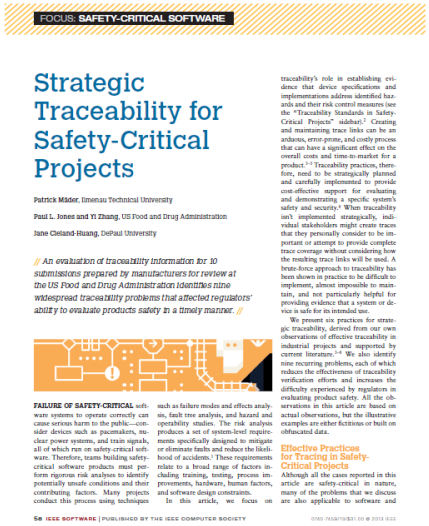
Tracing Mistakes People Make



FOCUS: SAFETY-CRITICAL SOFTWARE

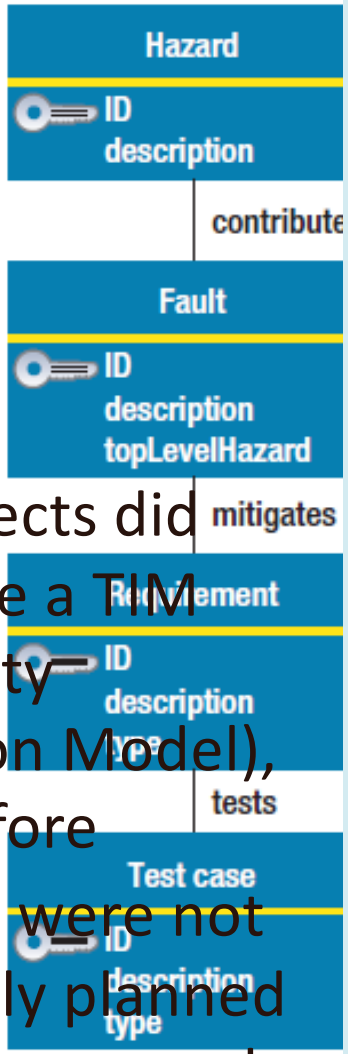
Strategic Traceability for Safety-Critical Projects

Patrick Mäder, Ilmenau Technical University
Paul L. Jones and Yi Zhang, US Food and Drug Administration
Jane Cleland-Huang, DePaul University

An evaluation of traceability information for 10 submissions prepared by manufacturers for review at the US Food and Drug Administration identifies nine widespread traceability problems that affected regulators' ability to evaluate products safety in a timely manner.

Our observations are based upon over a decade of engagements in industrial projects, and a study of the traceability components of Medical Device submissions to the FDA.

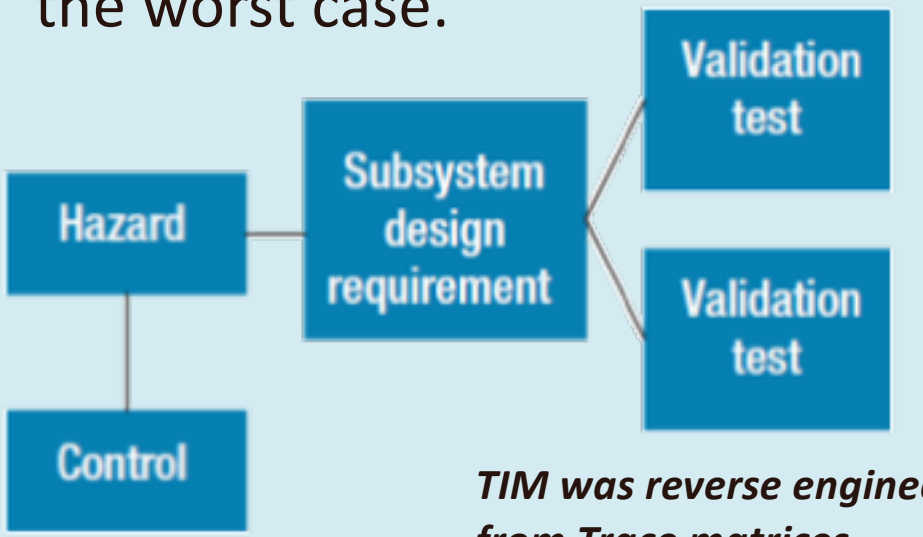
Mistake # 1: Failure to plan



Most projects did not include a TIM (Traceability Information Model), and therefore TraceLinks were not strategically planned and/or represented.

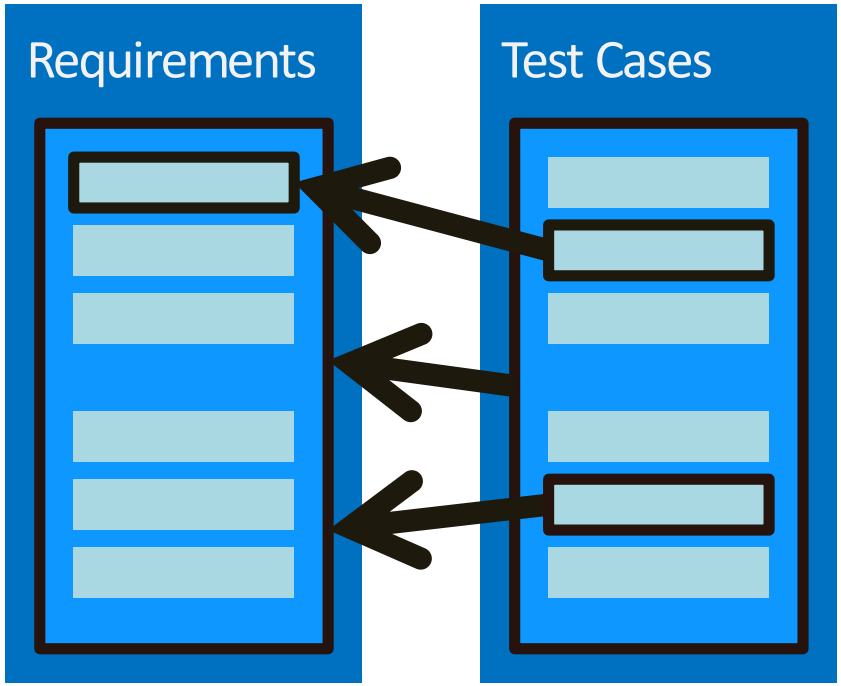
1. Difficult to understand/use the trace links.
2. In this example, links were created without careful planning. Faults were not included in the trace paths.

Hazards were traced directly up to 15 subsystem design requirements in the worst case.



TIM was reverse engineered from Trace matrices.

Mistake 2: Trace granularity not clearly defined.



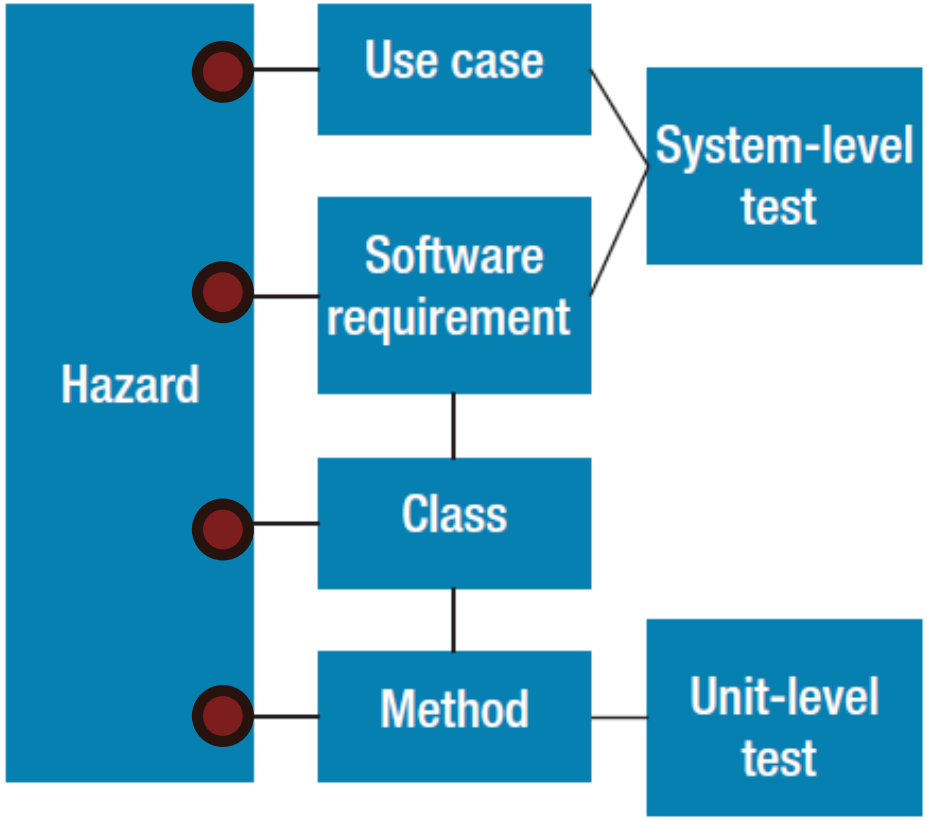
Fine grained (source) to coarse grained (target) links don't provide enough information to evaluate whether the target artifacts are fully satisfied.

Ill-defined trace granularity leads to unacceptably high, unacceptably low, or mismatched links, making it difficult to determine whether hazards and faults are fully addressed.

Links can be:

- Too coarse grained
- Too fine-grained
- Inconsistently granulated

Mistake 3: Redundant Traceability Paths.



In this example the TIM shows redundant trace paths between sets of artifacts. Trace Links were created at multiple granularities.

Redundant paths lead to inconsistent data i.e. links between A and B traversed along path A->B->C may my different from links between A->X->C.

Not clear how incompatibilities should be resolved.

Mistake 4: Lack of Project-Wide Unique IDs

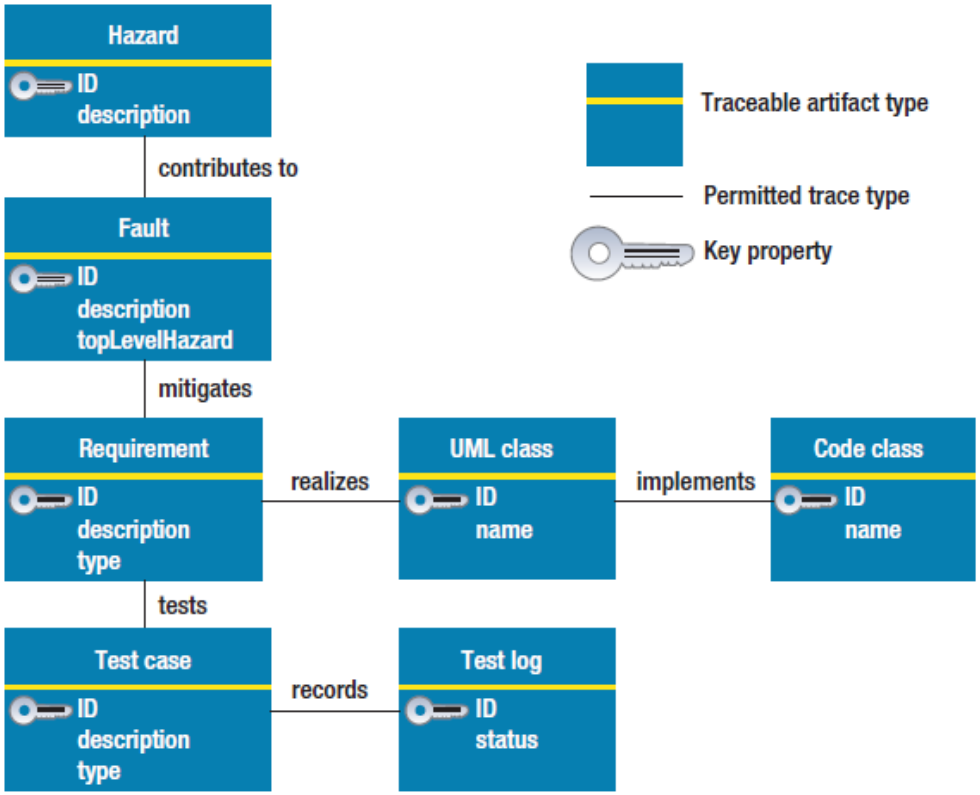
> ...
> During the […], the timeout SHALL (5.5a) be set to 60 seconds. Upon completion of the […], the default SHALL (5.5b) be set to 30 seconds.
> After the specified interval […], the […] SHALL (5.5c) turn off and […].
> ...

For traceability purposes, ID's should be

- Unique
- Represent primitive requirements
- Stable

In this example, the IDs are sequentially inserted for phrases in the text. i.e. hard to change and maintain in a way that preserves the above properties.

Mistake 5: Important Links Missing

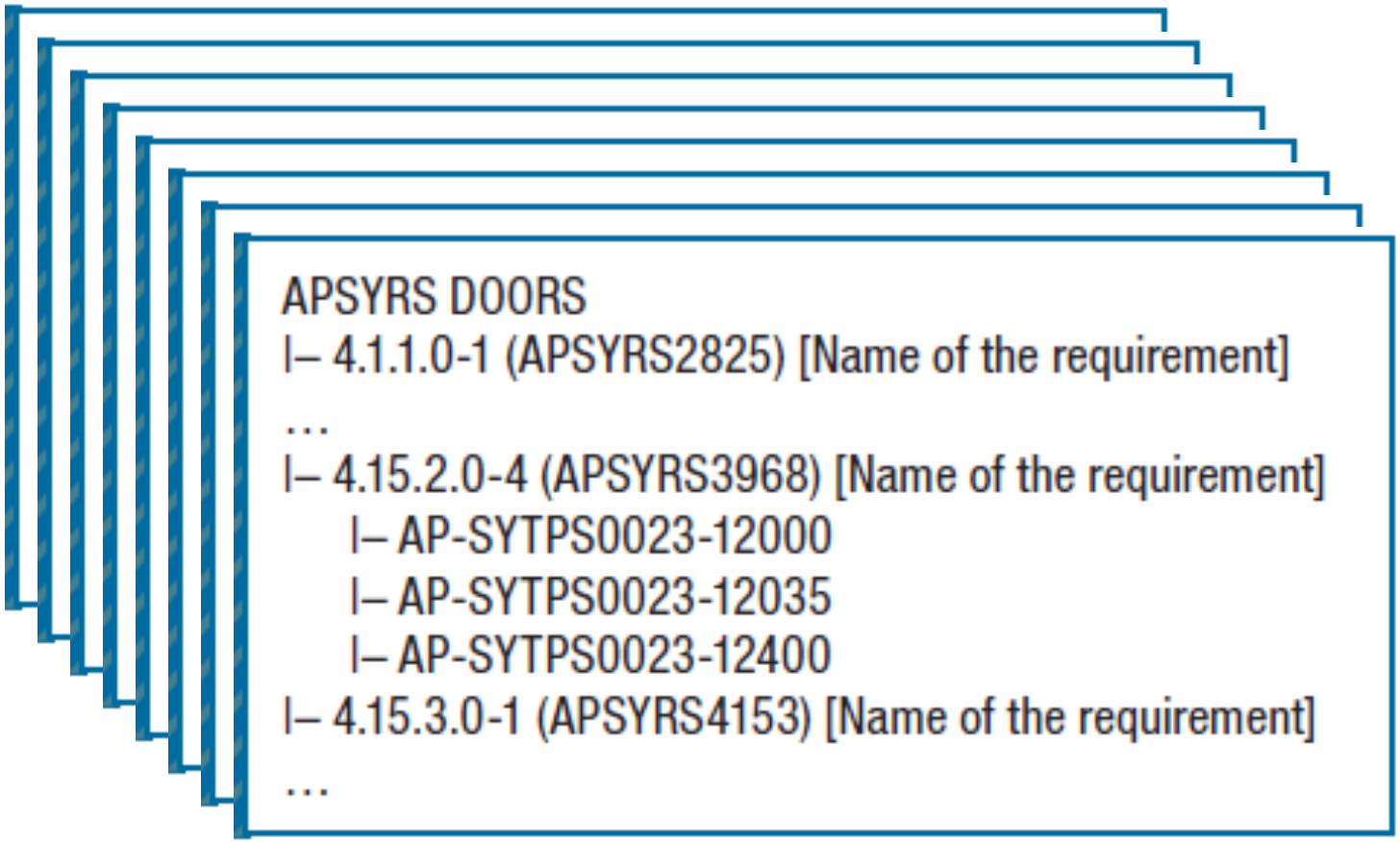


1. **Widows**:
   e.g. Mitigating requirements not traced from test cases.

2. **Orphans**:
   e.g. Test cases not traced to requirements.

Missing links means that certifiers/approvers are unable to determine whether a hazard has been fully addressed etc.

Mistake 5: The “DOORS” dump



Pages…
and
pages..
and
pages…
of links.

Such traceability ‘evidence’ submitted to approving agencies is difficult to process and ‘smacks’ of obfuscation. Instead of arranging information in massive tables.. Collate it into **trace slices.**

Mistake 6: Traceability as an Afterthought

Trace Links that are created at the end of the development process for certification purposes often suffer from:

- Incorrectness/incompleteness
- Unavailability earlier in the project to support:
  - Impact analysis
  - Architectural preservation
  - Compliance validation

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- Remedies
  - Trace Query Languages
  - Commercial tools
  - Just in Time Tracing (JITT)
- Next Steps