Teil 3.2: Software Qualität

Falk Howar

Softwarekonstruktion WS 2018/19

LS14

Qualität

The bitterness of poor quality remains long
after the sweetness of low price is forgotten

Benjamin Franklin

Motivation

Software ist omnipräsent in modernen Geräten!

Bugs auch …

Bugs im Betrieb können wirklich teuer werden!

⇒ Methoden, um Fehler zu finden und zu verhindern

Klassisches Beispiel: Ariane 5

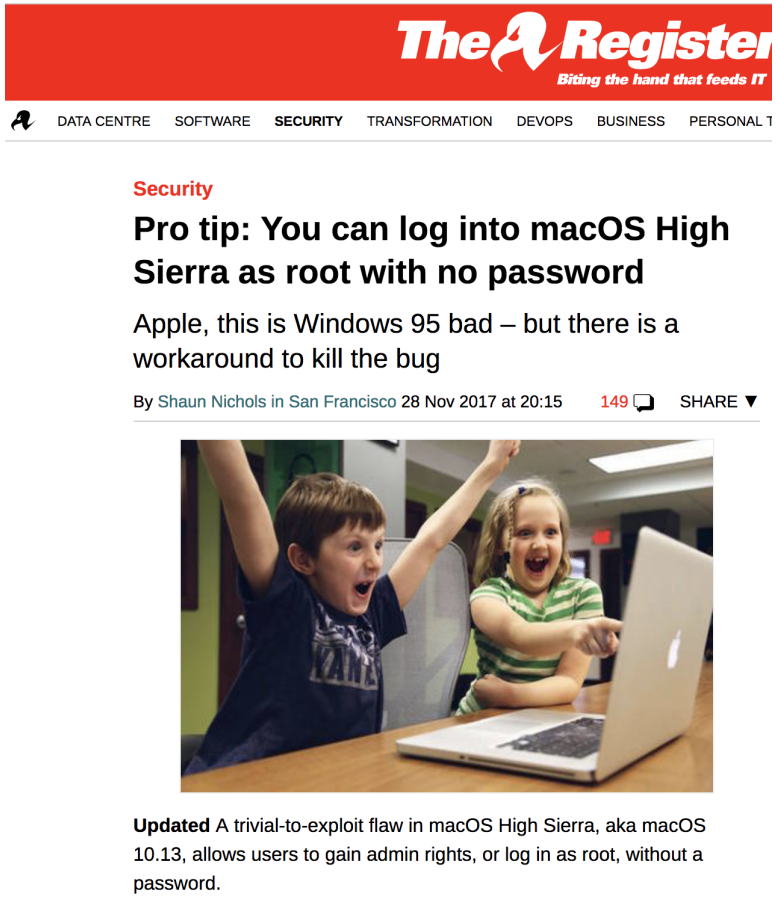
- Junfernflug 4. Juni, 1996
- Explodiert 40 Sekunden nach Start
- Lange teuerster Software Fehler : 500M USD

Fehlerhafte Integration von (unnötigem) Legacy Code:

- Unbehandelte Exception in floating-point Umwandlung
- Umwandlung von a 64-bit int to a 16-bit signed integer
- Funktioniert für Zahlen kleiner oder gleich 2^{15}
- Größere Zahl $\Rightarrow$ Exception ...

`https://archive.eiffel.com/doc/manuals/technology/contract/ariane/`

Aktuellstes Beispiel



The Register
Biting the hand that feeds IT

DATA CENTRE SOFTWARE **SECURITY** TRANSFORMATION DEVOPS BUSINESS PERSONAL T

Security

Pro tip: You can log into macOS High Sierra as root with no password

Apple, this is Windows 95 bad – but there is a workaround to kill the bug

By Shaun Nichols in San Francisco 28 Nov 2017 at 20:15 149 SHARE ▼

Updated A trivial-to-exploit flaw in macOS High Sierra, aka macOS 10.13, allows users to gain admin rights, or log in as root, without a password.

- Anmeldung als ‘root’ ohne Passwort nach Update
- Alle Administrator Rechte
- November 2017
- Auch aktuelles Update löst Problem nicht ganz

Qualitätssicherung

- Was ist Qualität von Software?
- Wie kann Qualität sichergestellt werden?

- Warum, Wer, Wann, Was, Wie?

Software Qualität

Software Qualität

Quality

The standard of something as measured against other things of a similar kind; the degree of excellence of something.

`http://www.google.com`

Software Qualität

Quality

The standard of something as measured against other things of a similar kind; the degree of excellence of something.

... the standard of something ...
... degree of excellence ...

Sehr unspezifisch:
Exzellenz in was?

Man kann Qualität messen!
Im Vergleich?

`http://www.google.com`

Aus Beispielen (Vorlesung I)

Wir wollen, dass unser Produkt . . .

Aus Beispielen (Vorlesung I)

Wir wollen, dass unser Produkt ...

- ... nicht explodiert,
- ... Menschen nicht gefährdet,
- ... nicht ausfällt,
- ... Erwartungen der Benutzer erfüllt,
- ... kein Sicherheitsrisiko darstellt.

Software Qualität (zweiter Versuch)

Quality

The measurable standard of something in some concrete respect; the degree of excellence of something in some concrete respect.

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- Wie oft es explodiert,
- Verursachte Todesfälle,
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- …

Wir akzeptieren eine bestimmte Häufigkeit von Problemen

Oft ist die akzeptierte Häufigkeit 0.

Technische Definition

Quality (P. B. Crosby)

Conformance to requirements. The requirements may not fully represent customer expectations.

- Qualität relativ zu Anforderungen,
- Messbar als Conformance (Erfüllen von Anforderungen),
- Anforderungen drücken Erwartungen aus

Faults and Failures

Ausfall

Wenn eine Anforderung nicht (mehr) erfüllt wird.

Der Moment in dem das System explodiert . . .

Faults and Failures

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Wenn eine Anforderung nicht (mehr) erfüllt wird.

Der Moment in dem das System explodiert ...

Fehler

Ursache für einen Ausfall

Exception, die geworfen wurde bei 64-bit float nach 16-bit Umwandlung ...

Qualitätssicherung

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Verhinderung von Ausfällen in Produkten oder Services (durch das Verhindern oder Finden von Fehlern).

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- Nur Ausfälle können beobachtet werden
- Fehler finden ist oft schwierig

- Verschiedene Strategien: Ausfälle durch Testen finden, Fehler verhindern, . . . \

Warum, Wer, Wann, Was, Wie?

Warum

Weil wir gute Menschen sind?

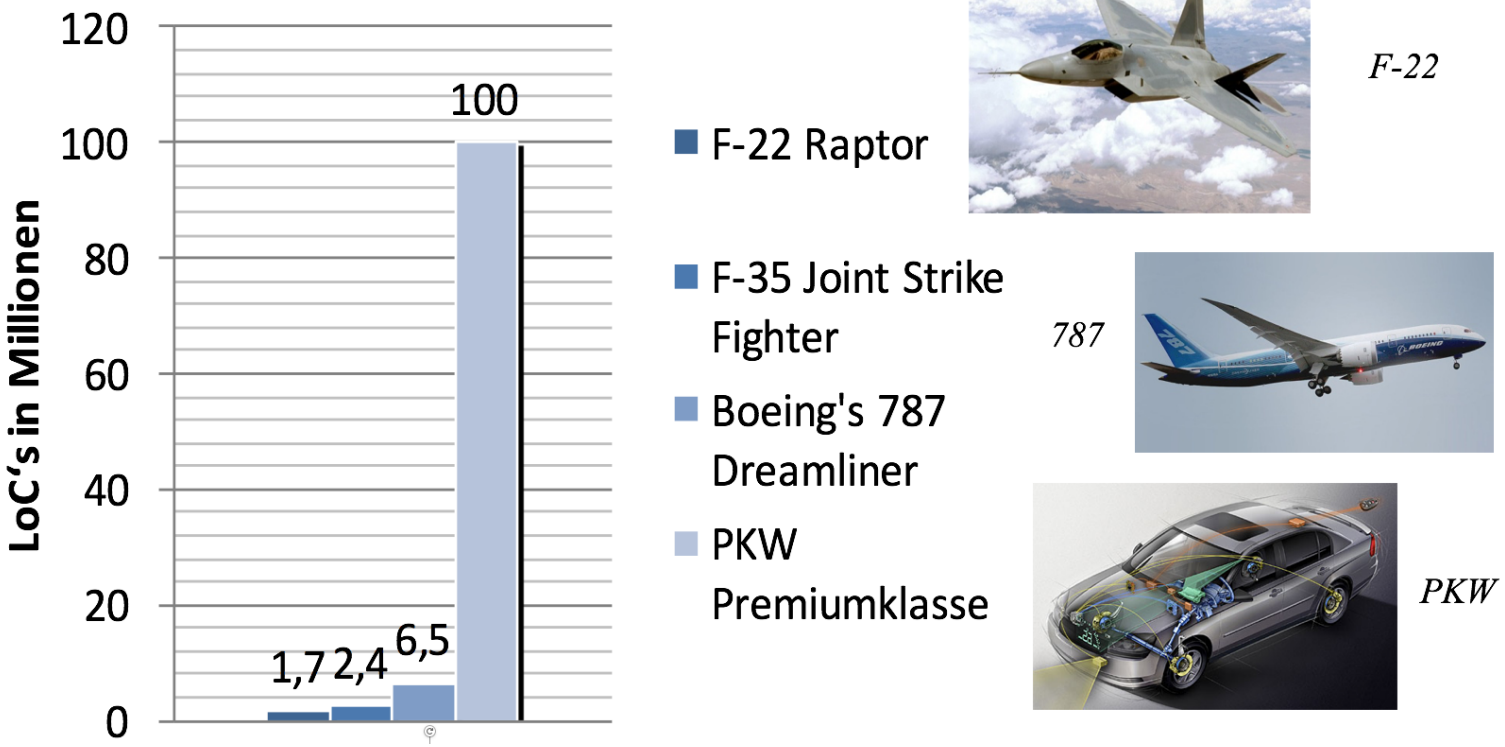
Warum

Weil wir gute Menschen sind?

- Um Kunden zufriedenzustellen (damit sie Kunden bleiben)
- Produkthaftung (damit wir nicht verklagt werden)
- Gesetzlich verlangt für bestimmte Produkte (Autos, Flugzeuge, etc.)
- …

Wer?

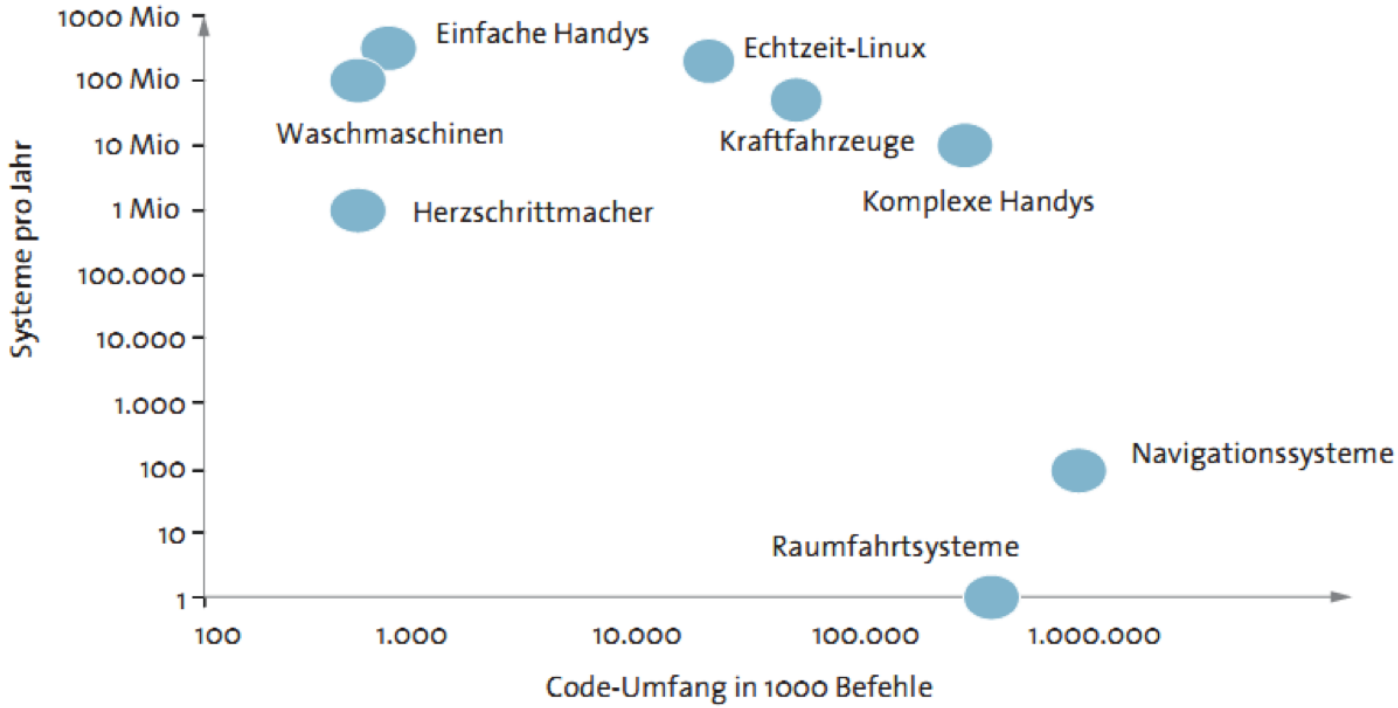
Die offensichtlichen Kandidaten: Sicherheitskritische Systeme.



http://spectrum.ieee.org/green-tech/advanced-cars/this-car-runs-on-code

Wer (II)

Zwei Grupen:
Sicherheitskritische, teure Systems und Systeme mit vielen Installationen.



Eingebettete Systeme – Ein strategisches Wachstumsfeld für Deutschland Studie Bitkom, 2010

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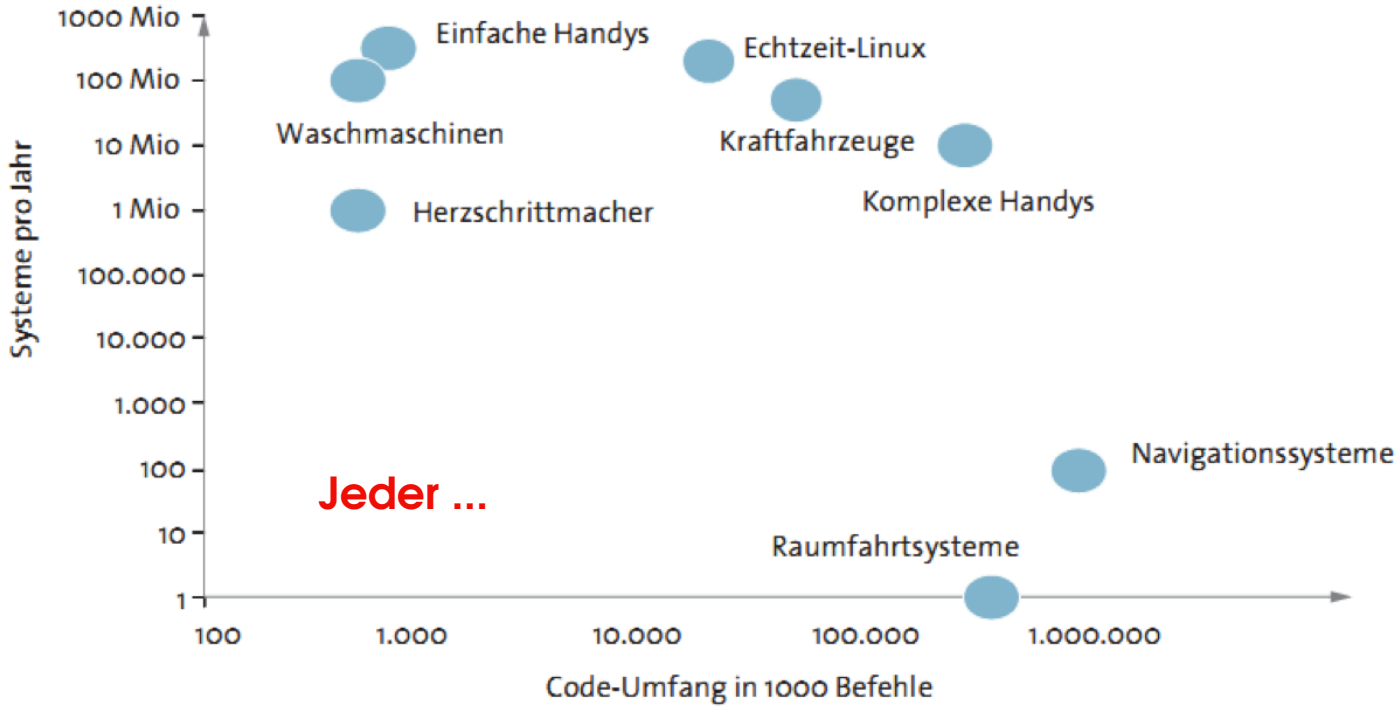
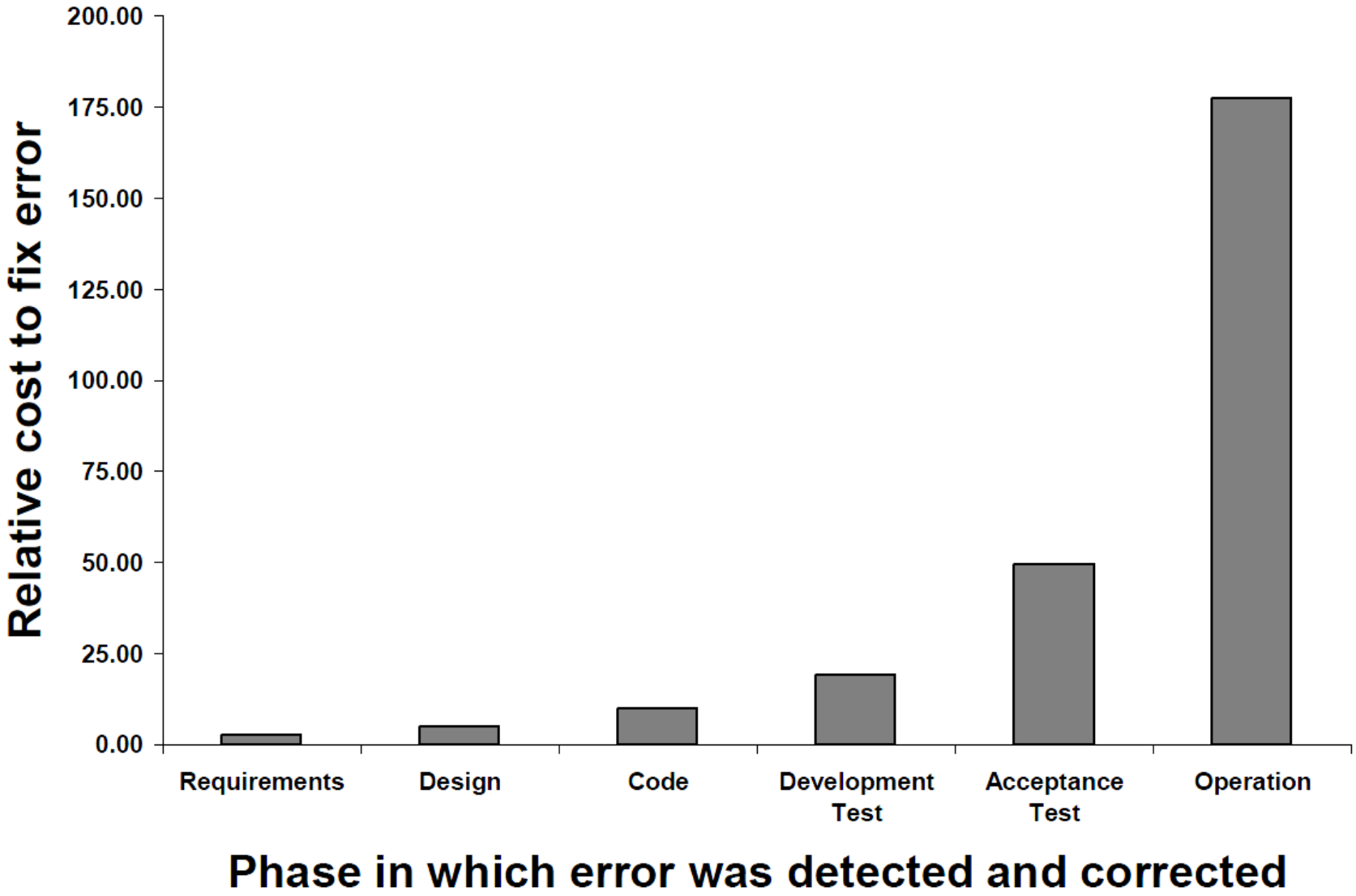
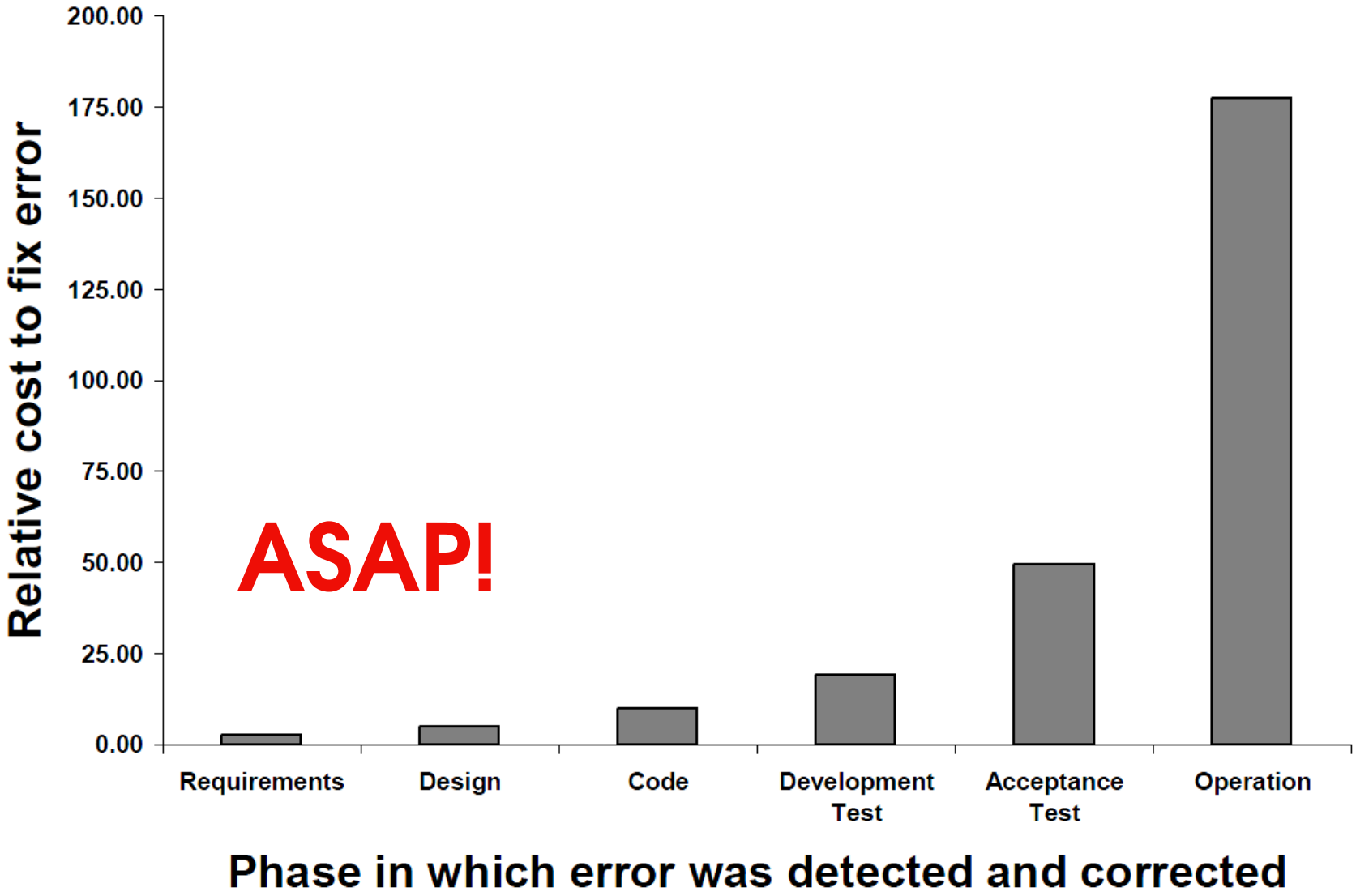


Eingebettete Systeme – Ein strategisches Wachstumsfeld für Deutschland Studie Bitkom, 2010

Wann?


Relative cost to fix error
200.00
175.00
150.00
125.00
100.00
75.00
50.00
25.00
0.00
Requirements
Design
Code
Development Test
Acceptance Test
Operation
Phase in which error was detected and corrected

Wann?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ASAP!
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Design
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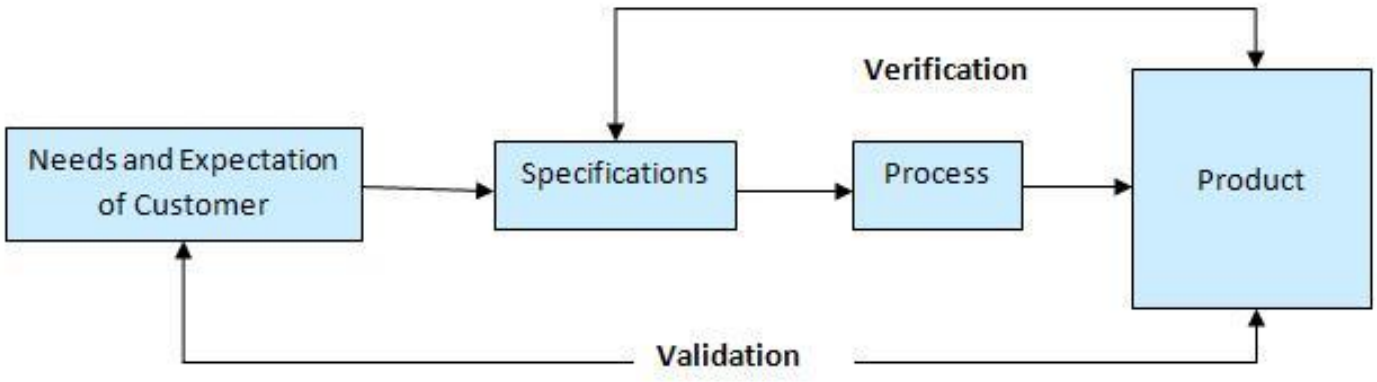
Phase in which error was detected and corrected

Was?

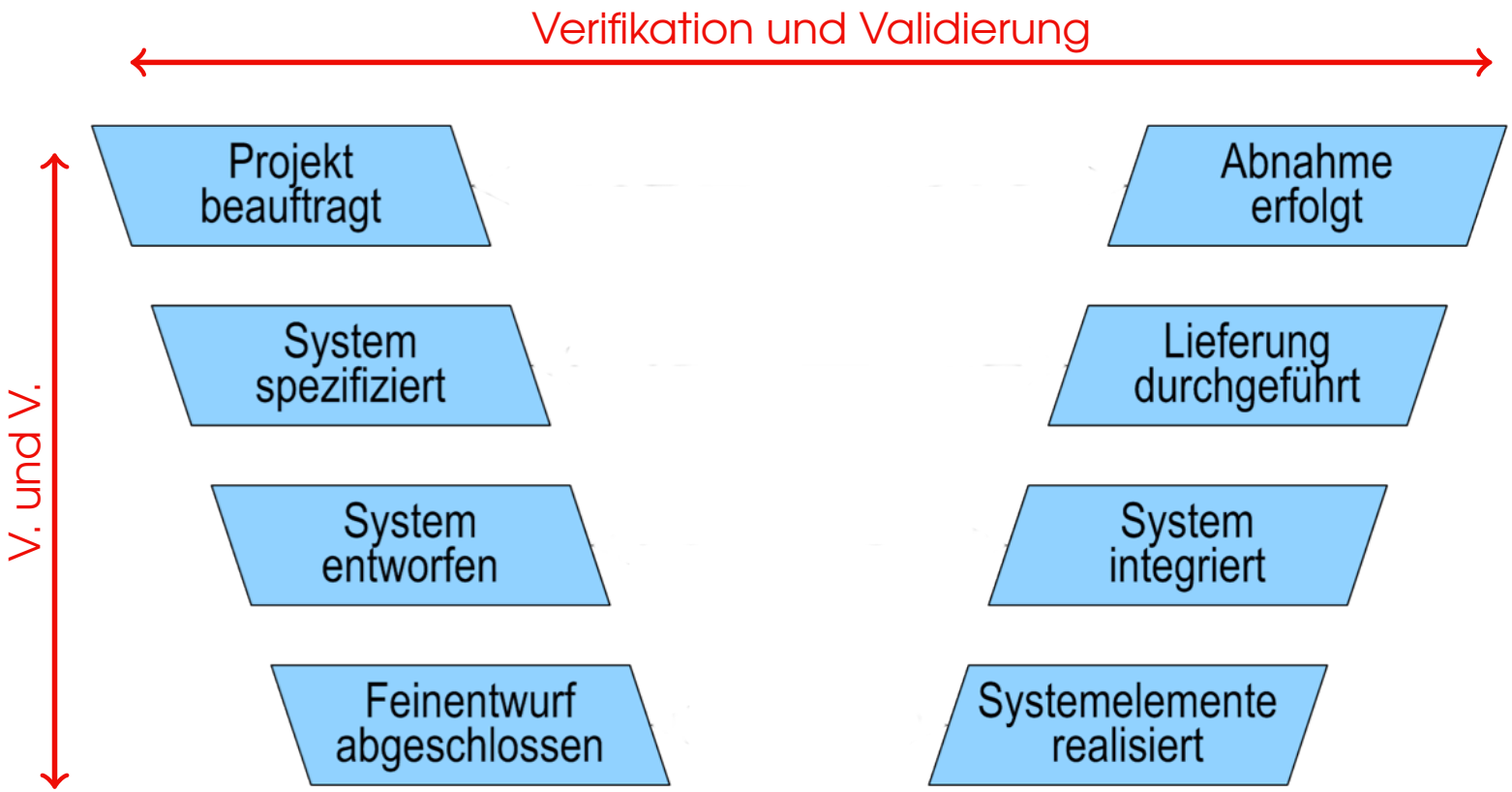
Verifikation: Bauen wir das Produkt richtig?

Validierung: Bauen wir das richtige Produkt?



B. Boehm

V & V im Entwicklungsprozess



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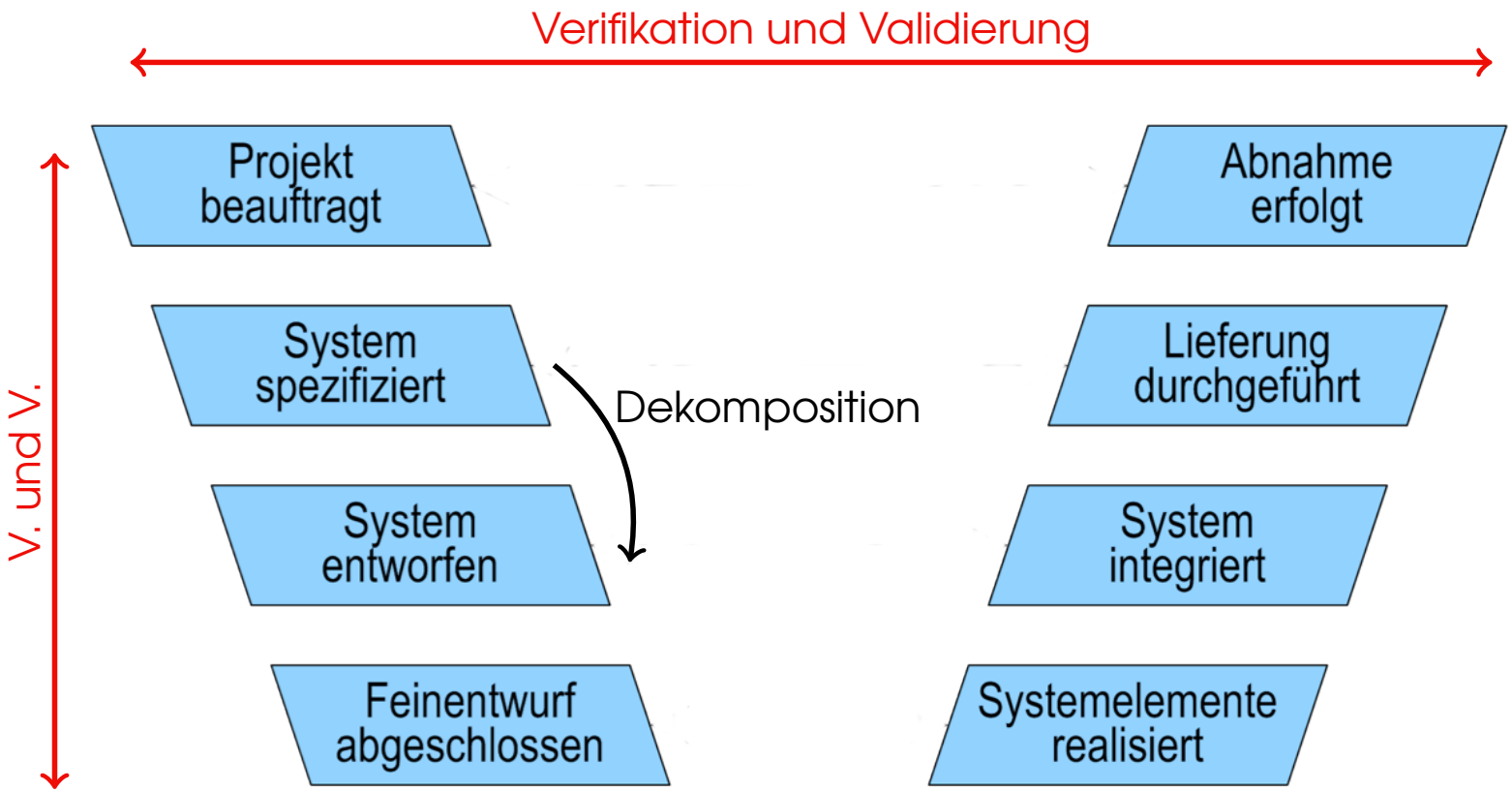

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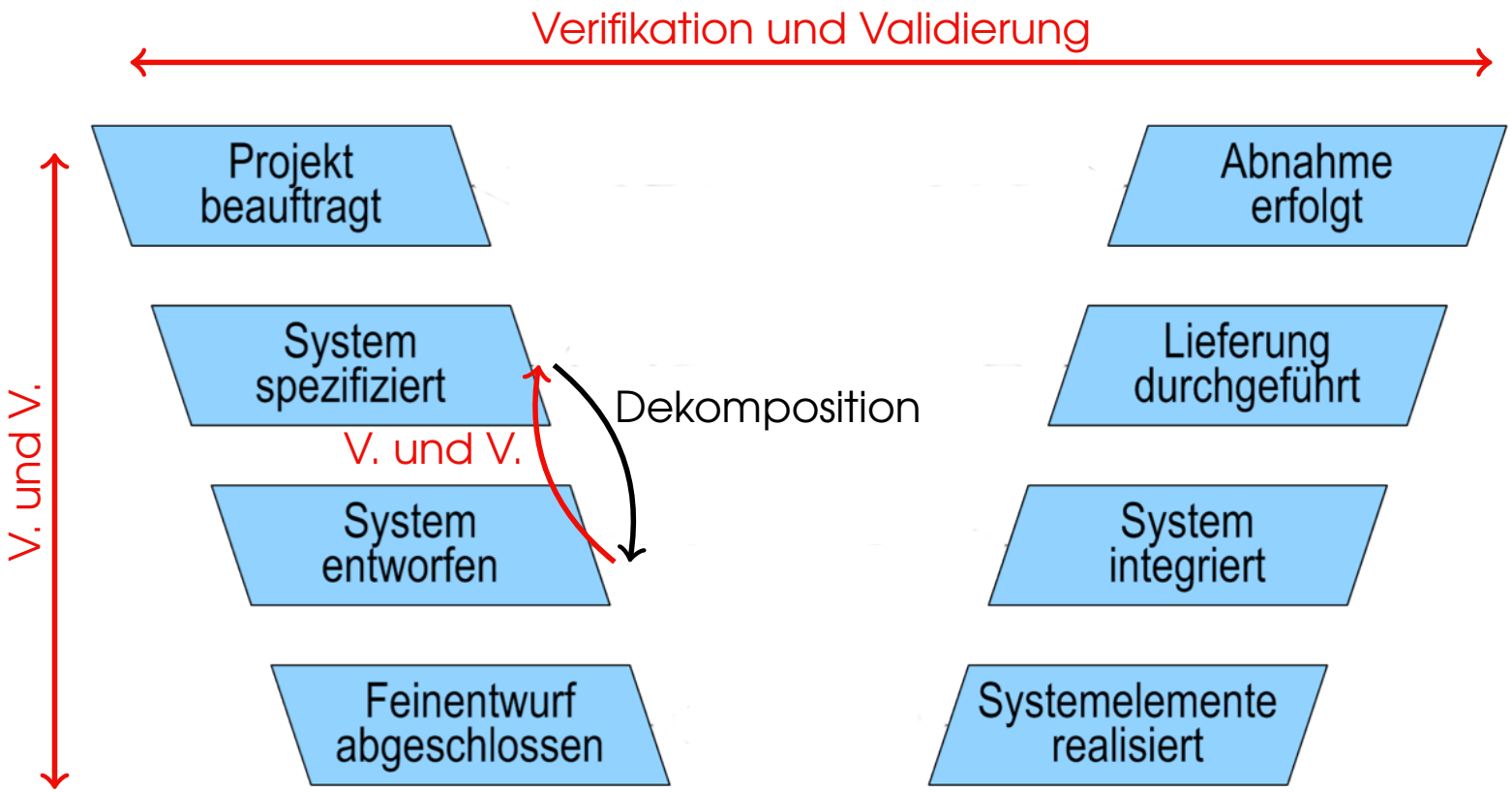

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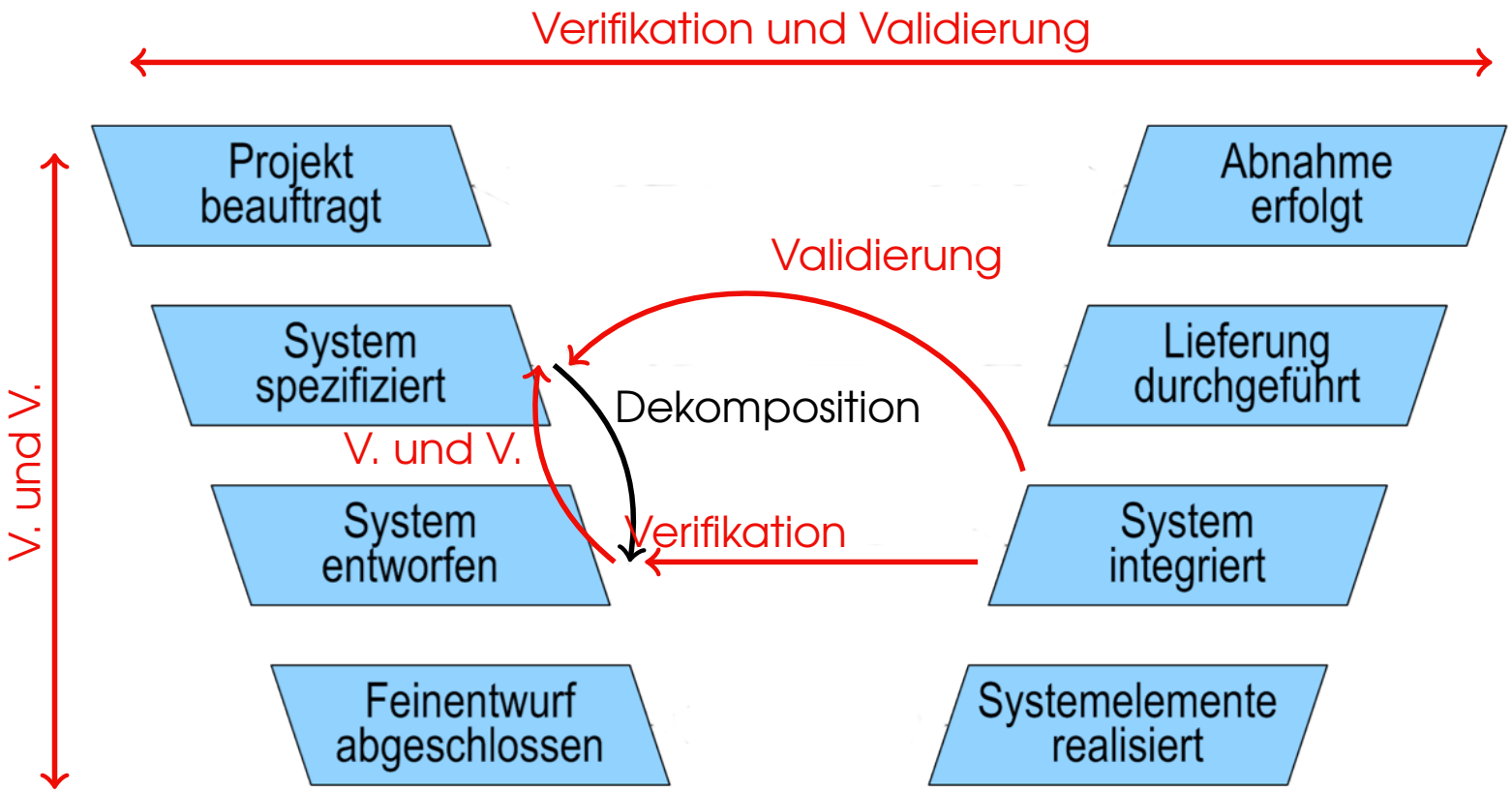

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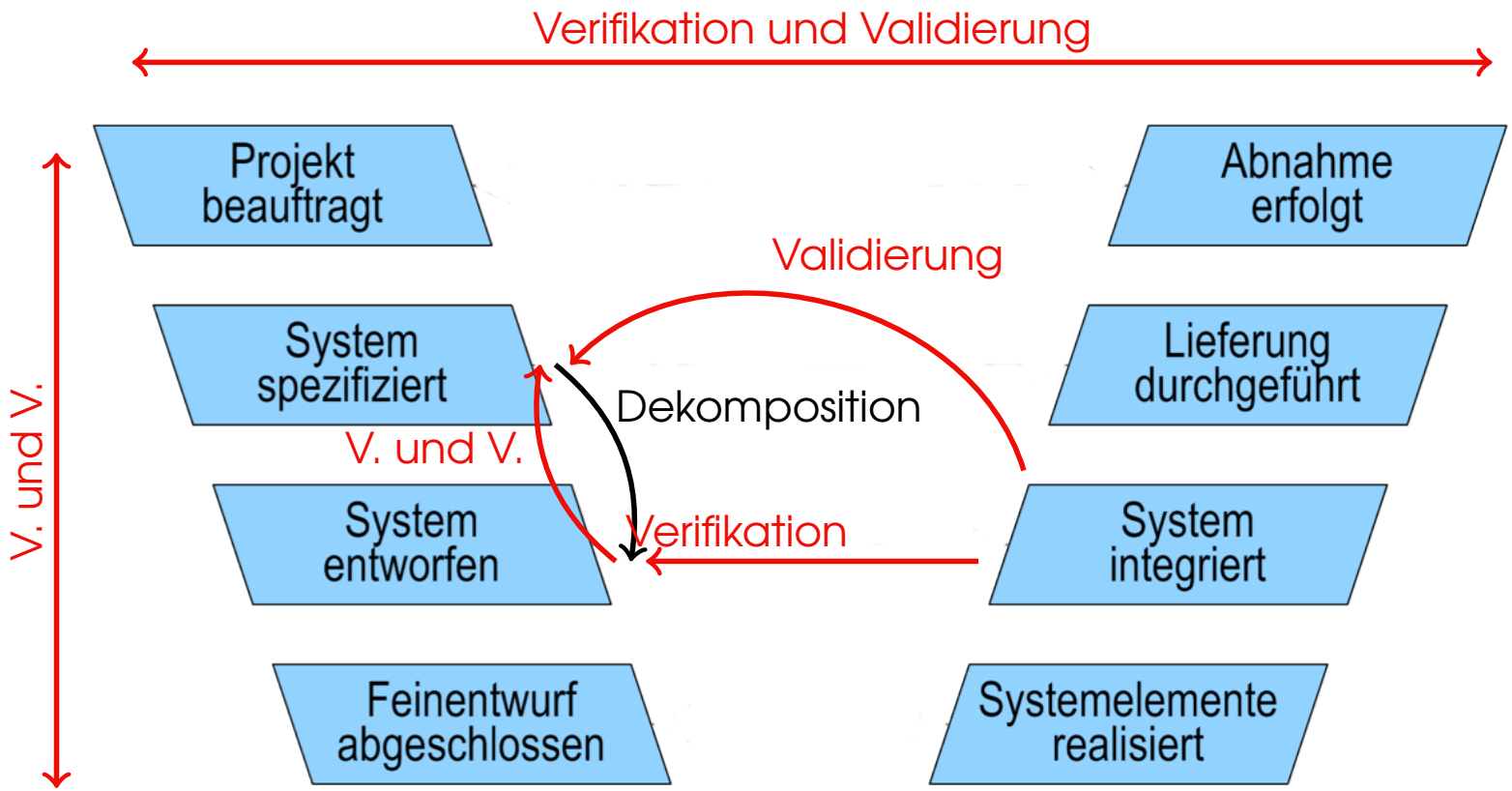
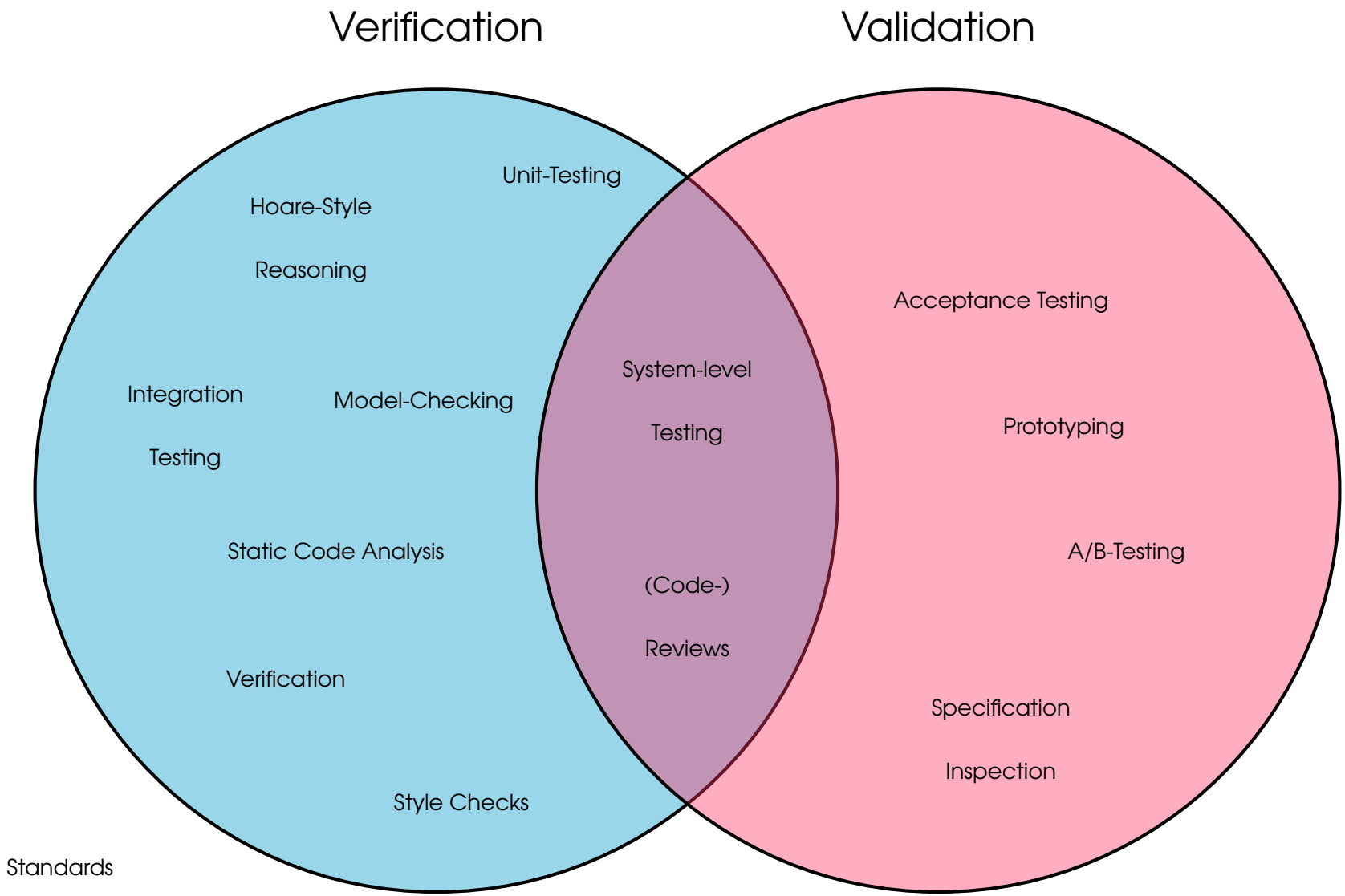


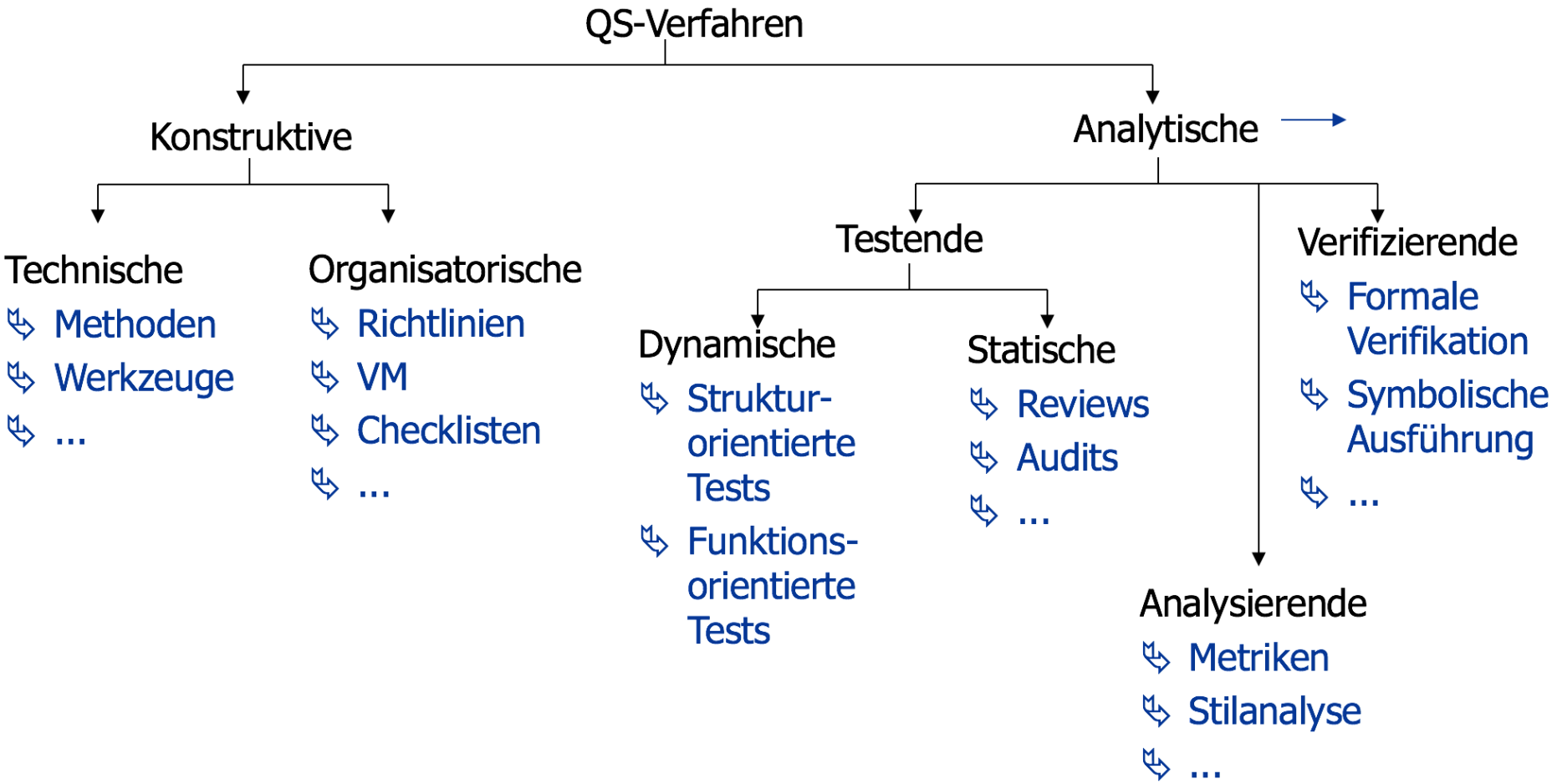
$\Rightarrow$ Wann? In jedem Prozessschritt!

Jedes Artefakt des Entwicklungsprozesses kann verifiziert und validiert werden.

Wie? - Verifikation vs. Validierung

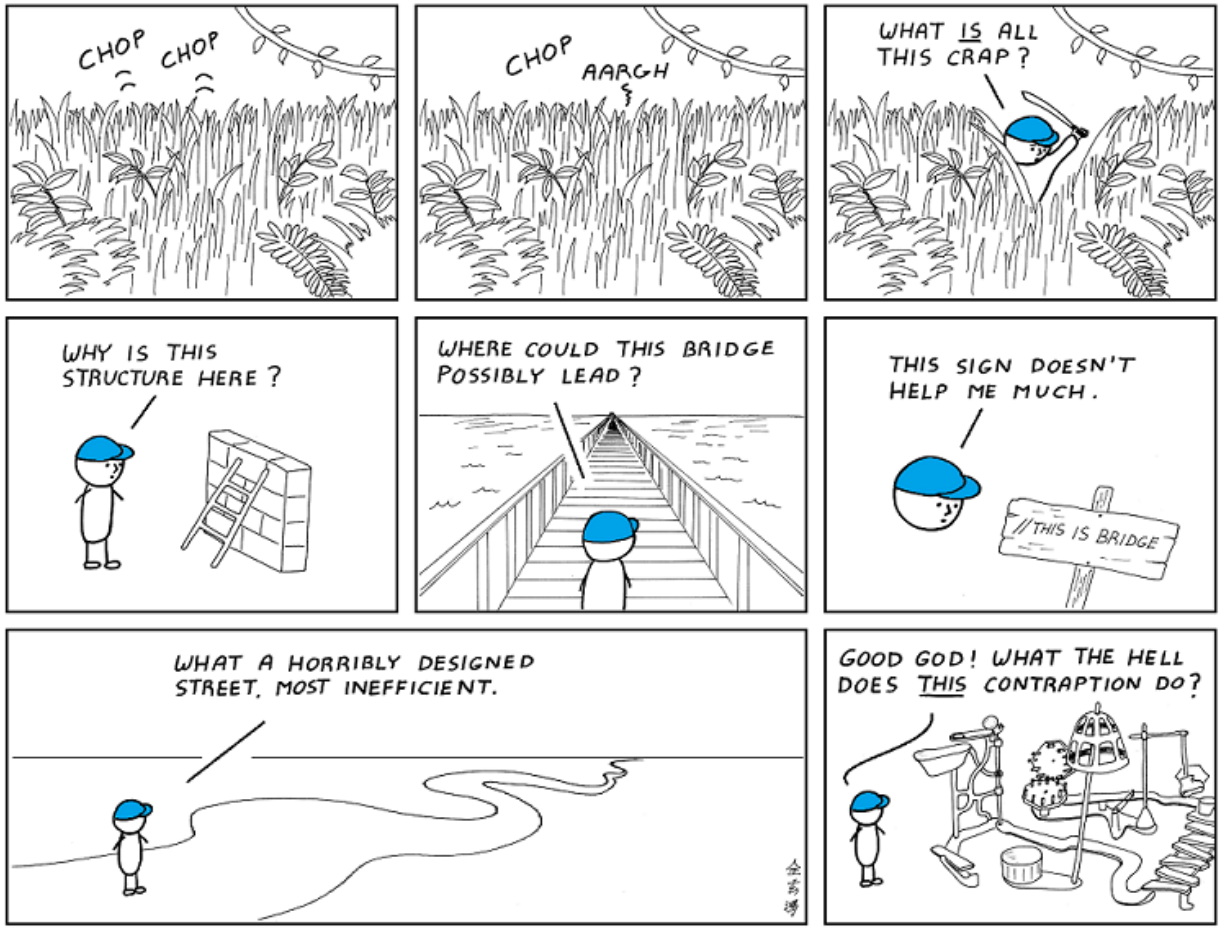


Wie? - Klassifizierung von Ansätzen



P. Liggesmeyer 2002

Code Qualität



I hate reading
other people's code.

http://abstrusegoose.com/432

Code Qualität: Motivation

In großen Software Projekten ...

- ... Entwickler verteilt über verschiedene Standorte,
- ... Viele verschiedene Entwickler, geteilter Code (über Zeit bzw. nebeneinander),
- ... Code aus Jahrzehnten, auch wenn Entwickler wechseln.

$\Rightarrow$ Entwickler müssen in der Lage sein
den Code von anderen zu lesen und zu verstehen

Code Qualität: Definition

Code Quality or Software Structural Quality

How well a a software meets non-functional requirements that support the delivery of it functional requirements:

- Reliability / Resilience: How well the software deals with faults.
- Performance / Efficiency: How efficiently the software performs.
- Security: How secure a software is for a user.
- Maintainability: How easy/hard it is to maintain the software.

(Zuverlässigkeit / Fehlertoleranz, Performanz / Effizienz, Sicherheit, Wartbarkeit)

Im Gegensatz zu: funktionaler Qualität die beurteilt, wie gut Software funktionale Anforderungen erfüllt.

CISQ Recommendations and ISO/IEC 25010

Code Qualität: Agenda

Ansätze zur Sicherstellung von Code Qualität:

(1) Coding Standards stellen sicher das Code wartbar / lesbar ist und ggf. andere nicht-funktionale Anforderungen erfüllt,
(2) Code Reviews stellen gemeinsames Verständnis sicher und finden Fehler möglichst früh,
(3) Code Metrics helfen bei der Bewertung der Qualität von Code.

Coding Standards

The Ten Commandments, George Bannister, `https://www.flickr.com/`

Coding Style Examples

Some Examples

```
if(foo)
  // bar();
doSomethingElse();
```

And better alternatives

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And better alternatives

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```

```
/**
  * computer a random prime
  * number between
  * 0 and upperBound.
  */
int findPrime(int upperBound) {...}
```

Coding Standards: Definition

Coding Standards

A coding standard is a set of rules prescribing a certain programming style. Rules usually cover:

Indentation, Organization, Declaration, Error Handling, Conditional Statements, Test Coverage ...

Example: All Variables shall be declared at the top of a class.

Coding Standards: Motivation

Code standards are useful for a number of reasons:

- Maintainability: Code standards can improve the readability of code,
- Security: Code standards can help enforce security requirements,
- Reliability: Code standards can limit the use of potentially "dangerous" practices.
- Efficiency: Code standards can help enforcing efficient code.

Coding Standards: Examples

Maintainability

- Documentation required for all public methods.
- Placement of braces: 1TBS.

Security

- SQL Statements are not built from Strings but using library . . .
- Only hashes are stored for passwords.
- All code needs to be tested.

Reliability

- All exceptions must be caught and handled.
- All parameters of methods must be validated.

Efficiency

- Use StringBuilder instead of repeated concatenation.

Coding Standards: Examples

Maintainability

- Documentation required for all public methods.
- Placer

Bad Example!

How much?, When?, ...

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Reliability

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Coding Standards: Discussion

Some Good Practices:

- Rules have to be specific: E.g., what does "Don't use Hacks" mean?
- Less is more: Nobody will remember 50 rules,
- Enforcement is essential,
- Tool support is valuable ($\Rightarrow$ static code analysis).

Example: NASA JPL

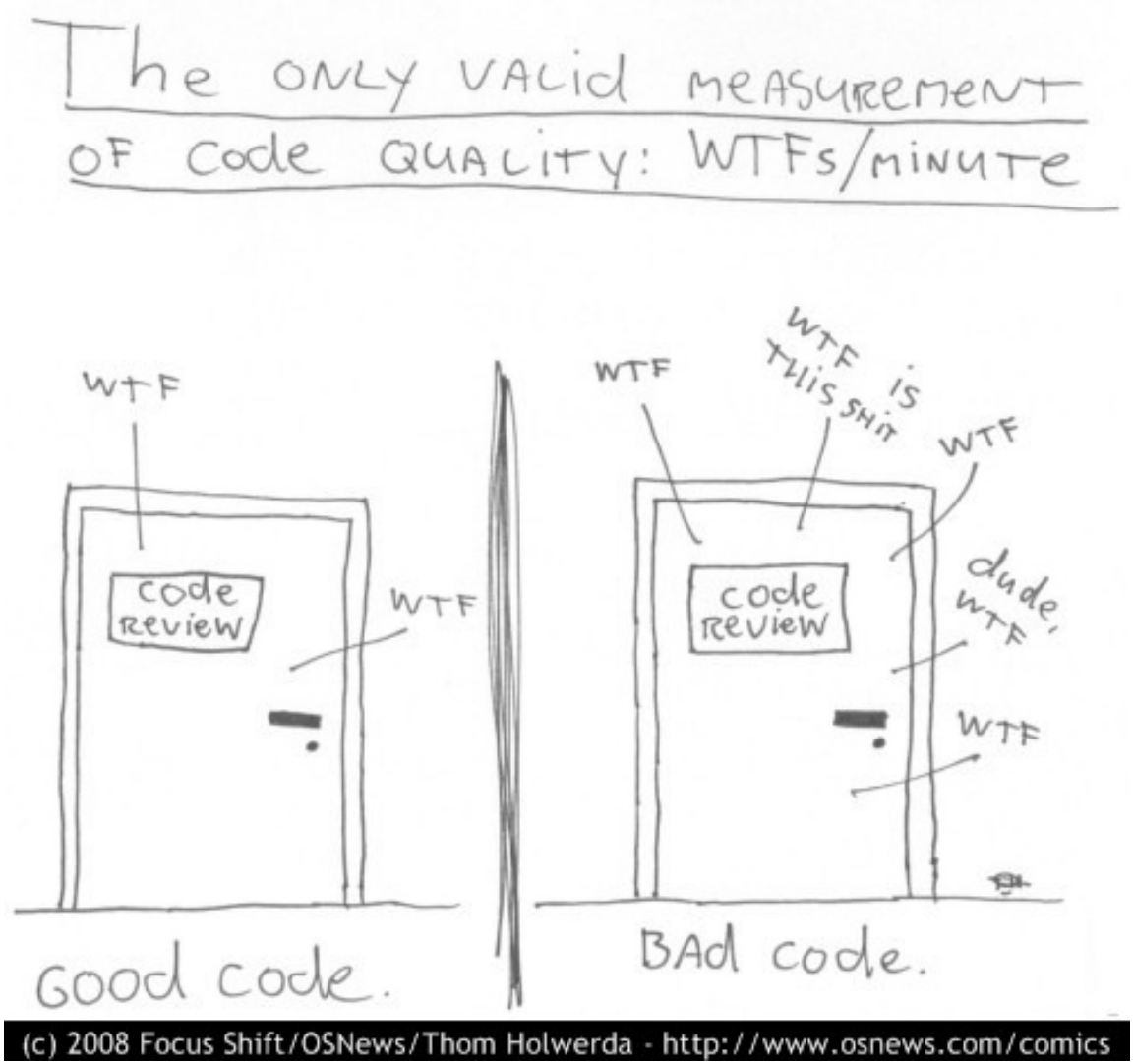
Rules used at Jet Propulsion Laboratory's (JPL) Laboratory for reliable software (specifically written for C).

(1) Restrict all code to very simple control flow constructs – do not use goto ...
(2) All loops must have a fixed upper-bound. It must be trivially possible for a checking tool to prove statically that a preset upper-bound on the number of iterations of a loop cannot be exceeded. If the loop-bound cannot be proven statically, the rule is considered violated.
(3) Do not use dynamic memory allocation after initialization.
(4) No function should be longer than what can be printed on a single sheet of paper in a standard reference format with one line per statement and one line per declaration. Typically, this means no more than about 60 lines of code per function.
(5) The assertion density of the code should average to a minimum of two assertions per function. Assertions are used to check for anomalous conditions that should never happen in real-life executions. ...
(6) The return value of non-void functions must be checked by each calling function, and the validity of parameters must be checked inside each function.
(7) All code must be compiled, from the first day of development, ... All code must be checked daily with at least one, ..., state-of-the-art static source code analyzer ...
(8) ...

Summary: Coding Standards

- Rules / Guidelines for Code (or other documents)
- “Codex“
- Goal: High-quality code without “code smells“
- High-quality: maintainable, safe, secure, and fast

Code Reviews



Code Reviews: Definition

Code Review

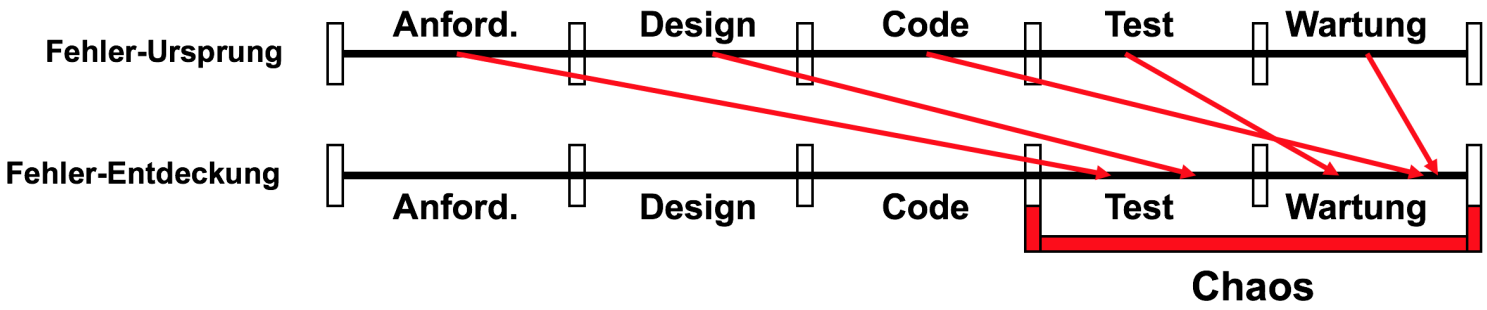
Systematic examination of source code — often by others than the author.

Code reviews can help

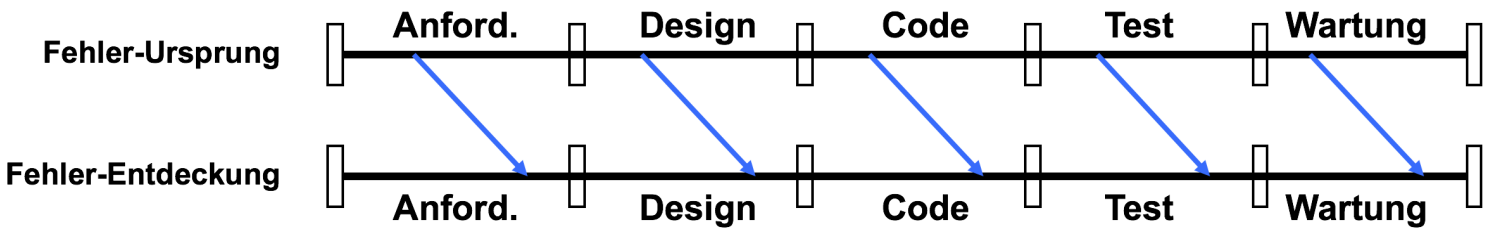
- finding bugs early,
- improve the quality of software,
- sharing knowledge.

Code Reviews: Desired Effect

Ohne Reviews

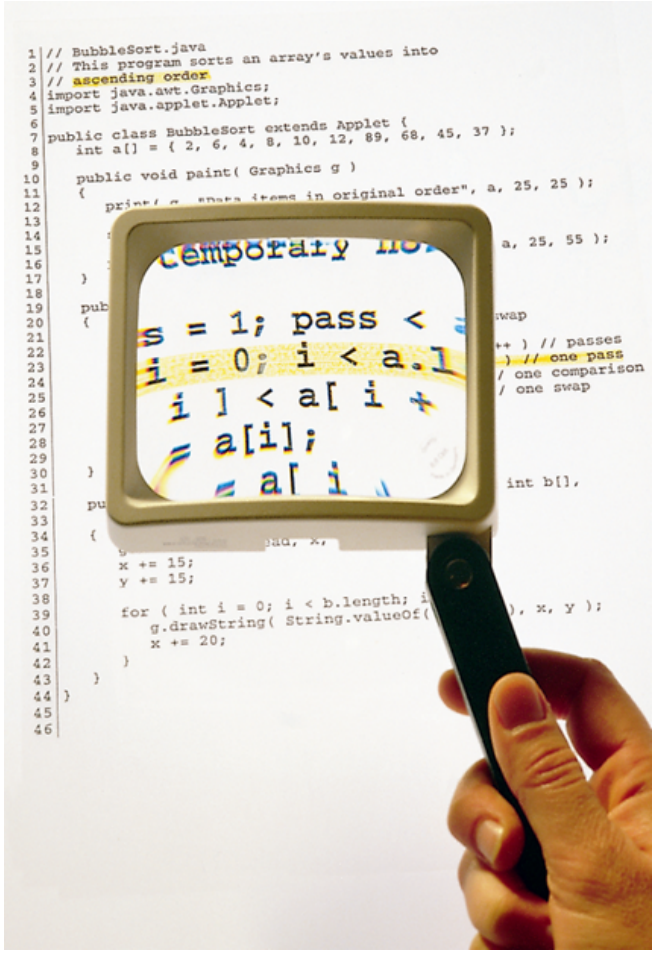


Mit Reviews (ideal)

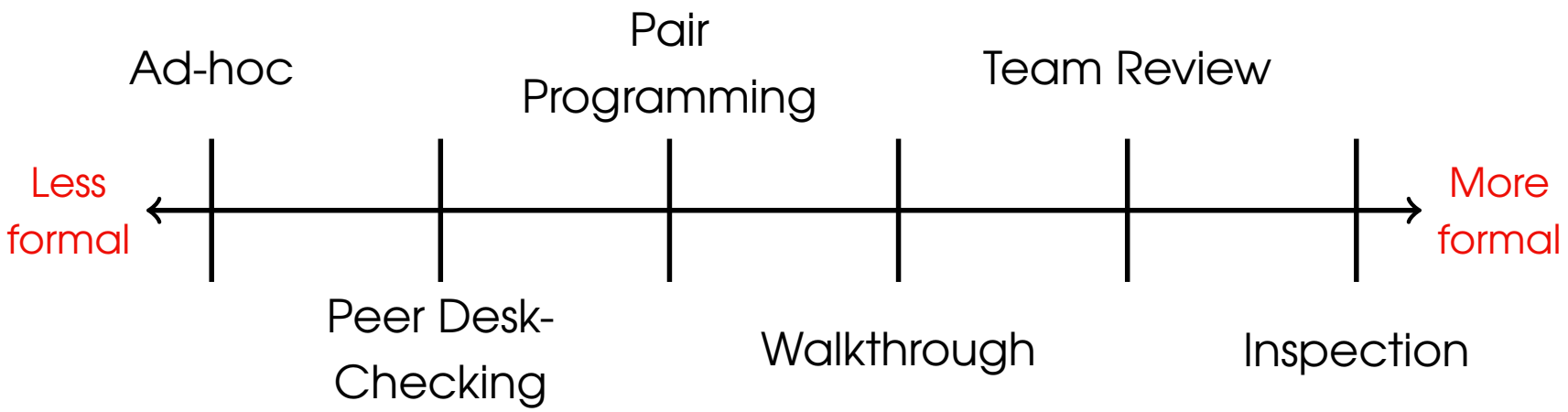


Code Reviews: Discussion

- Often used in safety critical domains
- Reviews can be done early in the process
- Reading, discussing, and presenting code helps better understanding



Code Reviews: Overview



Empirical studies show that Inspection is most effective.

- Inspections lead to 50% more errors discovered than in walkthroughs (Ford)
- Inspections lead to 6x more errors discovered than in ad-hoc reviews

Code Reviews: Methods (1)

Ad-hoc

- Ask colleague for help with problems
- Only problems reviewed
- Outcome depends on who you ask

Peer Desk-Checking

- Similar to ad-hoc review
- Reviewer executes product to be reviewed (e.g., code) on paper

Code Reviews: Methods (2)}

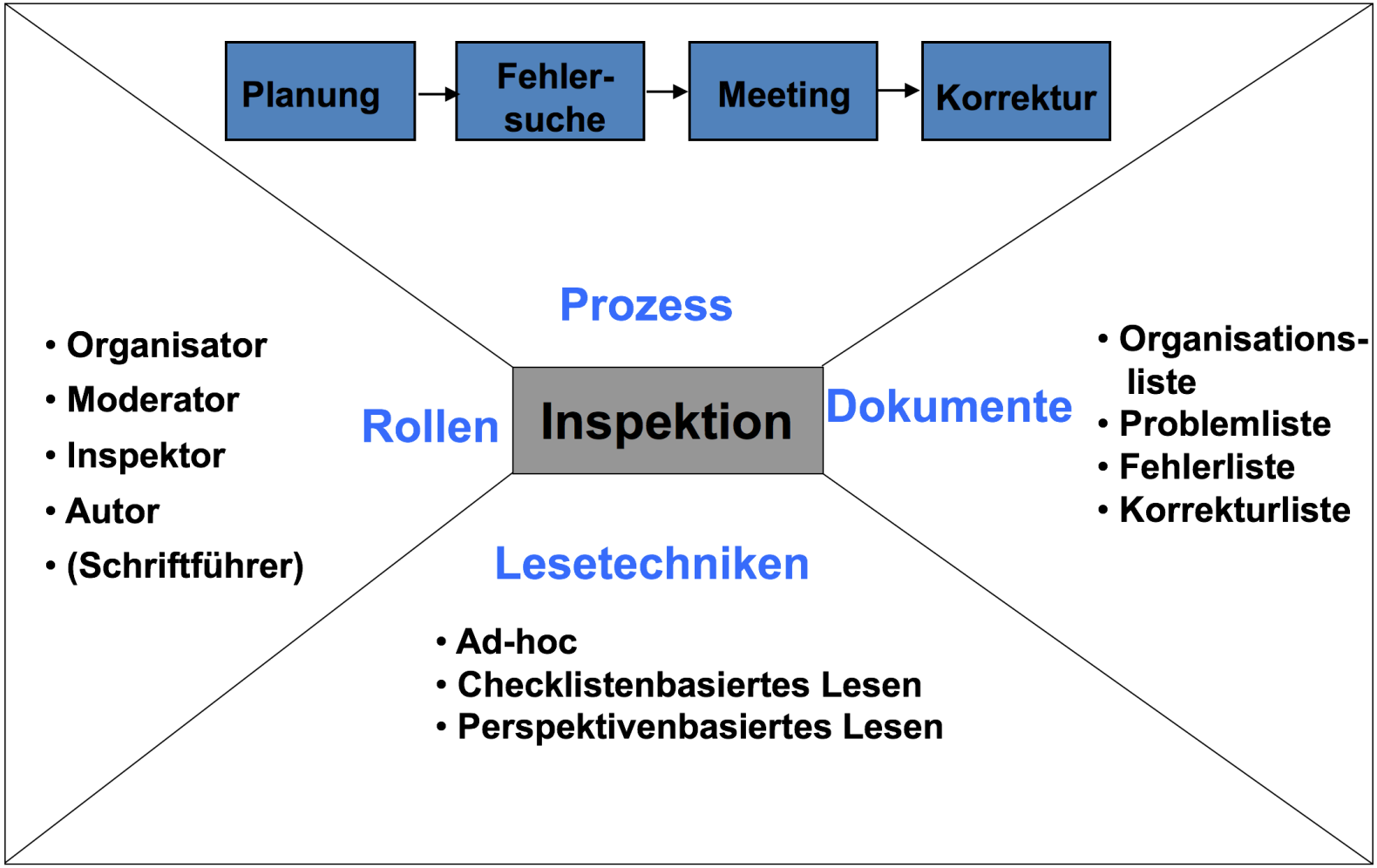
Pair-Programming

- Developers work in pairs of two. One person types and explains, the other person listens and checks
- one technique of "eXtreme programming"

Walkthrough

- Author presents code or document to reviewers
- No defined process or guideline for finding faults
- Risk: author controls focus of review

Code Reviews: Inspection



Inspection is often used for software requirements specifications and test plans.

Code Reviews: Team Review

Team-Review

- Similar to Inspection but less formal
- Several people produce individual reviews
- Results are discussed in a meeting with the author

Examples: Google

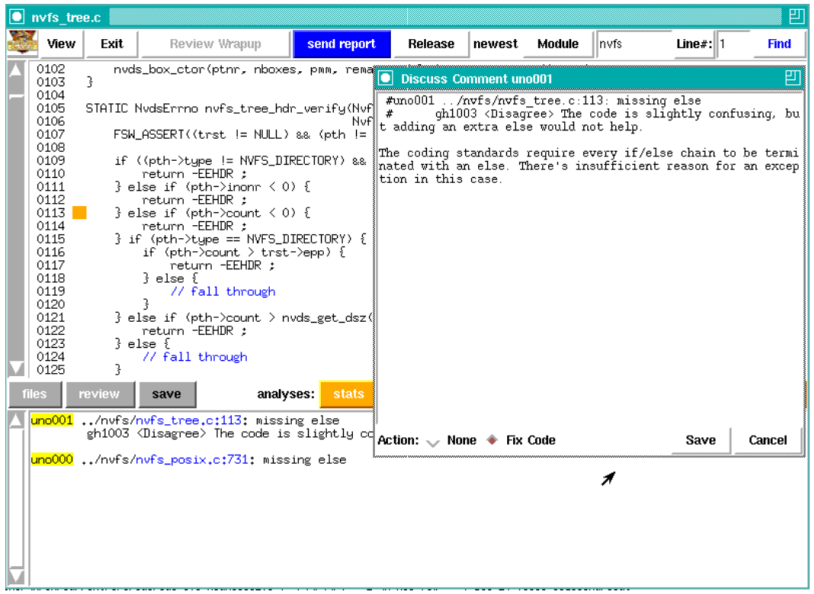
Email- / Web-based Team Review

- Everyone works on HEAD revision
- Every single change to code-base is reviewed before commit
- Custom web-based system: Mondrian

Examples: NASA JPL

Tool-assisted Inspection

- Tool-based review / response process
- Tool reports added to reviews
- Agrees and disagrees are tracked
- Short meeting (60-90 min) for each module to review comments and responses
- Only disagrees have to be discussed in a meeting



Summary: Code Reviews

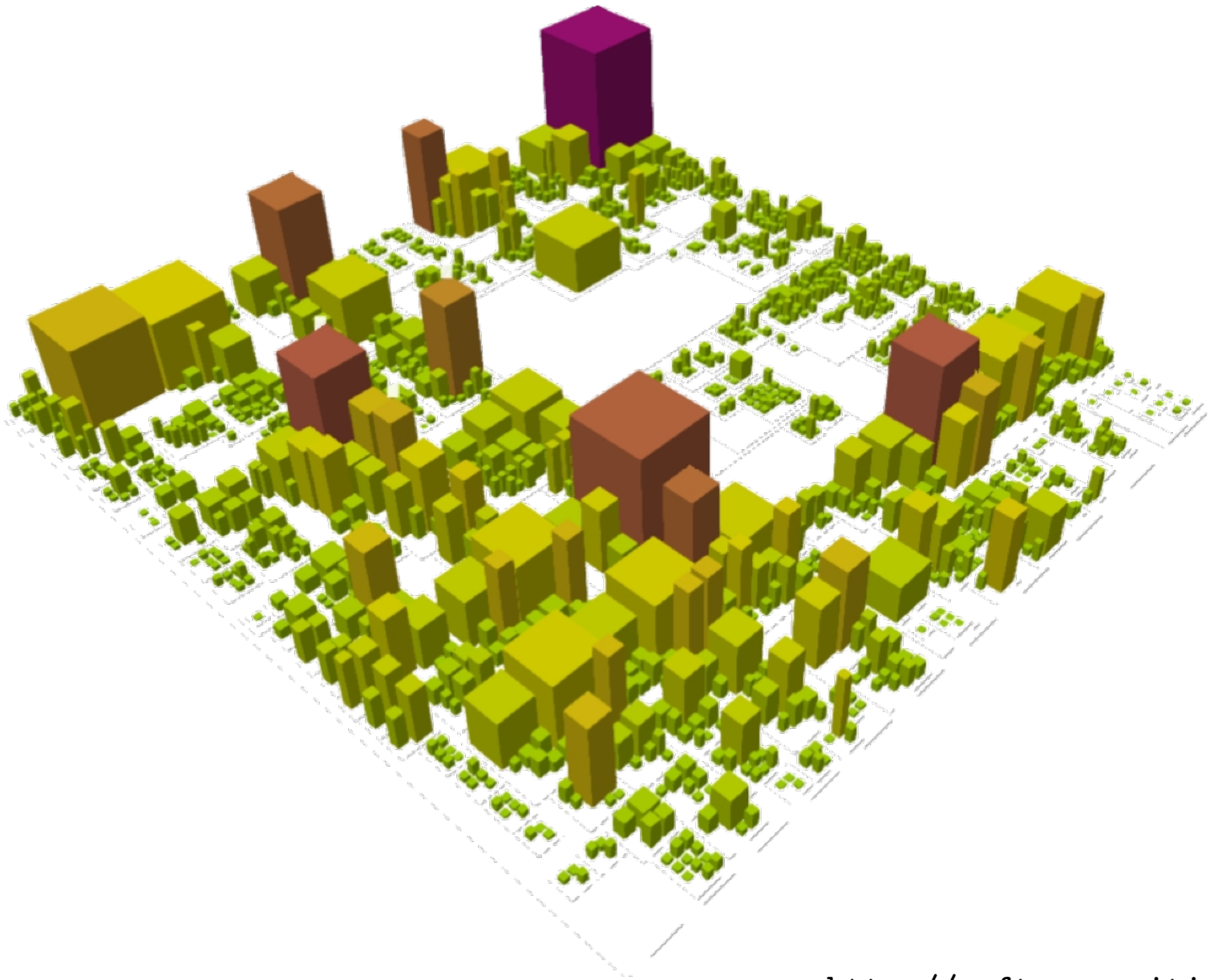
Goals:

- Finding defects (failures and/or faults) as early as possible
- Increase quality of code
- Decrease costs of quality
- Idea: Two pairs of eyes catch more than one
- Shared knowledge (increasing bus factor)
- Better understanding through discussion / presentation

Methods:

- Can be more or less formal
- Today often tool-based
- Ad-hoc, Pair Programming, Inspection, ...

Software Metrics



http://software-cities.org/

Software Metrics

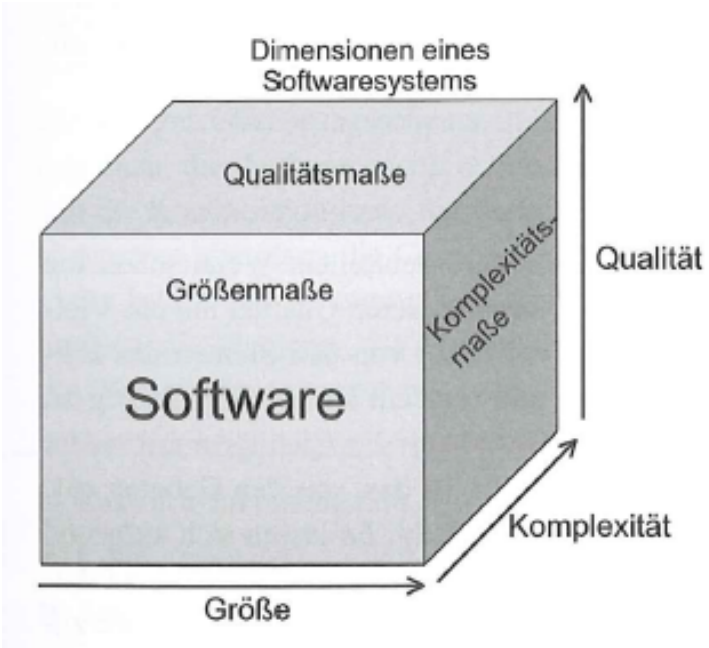
Software Metrics

A software metric is a standard of measure of a degree to which a software system or process possesses some property.

- A metric is not a measurement!
- Measurements are the numbers obtained by the application of metrics

Software Metrics: Outline

- LOC: Lines of Code
- LCOM: Lack of Cohesion
- CC: Cyclomatic Complexity



Lines of Code (LOC)

Lines of Code (LOC)

LOC counts the number of lines in the text of a program's source code.

- Simplest indicator for project complexity.
- Similar Metrics: Number of Classes, Number of Methods, Number of ...

Lack of Cohesion Metric (LCOM)

Cohesion: Degree to which things belong together.

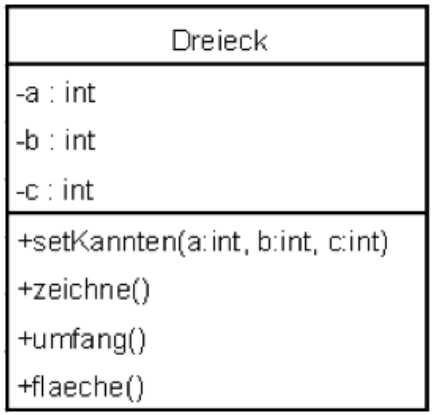
Lack of Cohesion Metric (LCOM)

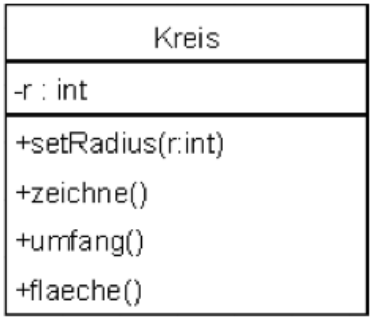
For a class with a fields, and m methods, let $n(A_j)$ count the number of methods that access field A_j. Lack of cohesion is computed as

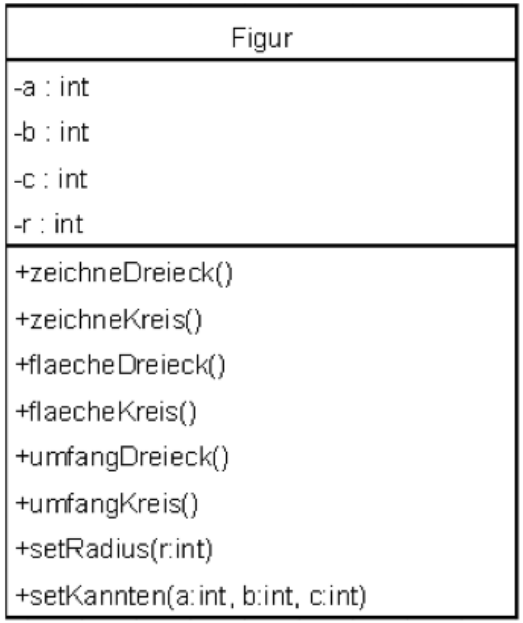
$$LCOM = \frac{\left(\frac{1}{a}\Sigma_{i=1}^{a} n(A_i)\right) - m}{1 - m}$$

- "Belong together" measured by counting access
- High LCOM value $\Leftrightarrow$ low cohesion

Lack of Cohesion Metric (LCOM) - Example







Classes Dreieck and Kreis
access every field in every method.

Dreieck:

$$a = 3,\ m = 4,\ A_1 = 4,\ A_2 = 4,\ A_3 = 4$$

$$\Rightarrow LCOM = \frac{(1/3 \cdot 12) - 4}{1 - 4} = 0$$

Kreis:

$$a = 1, m = 4, A_1 = 4$$

$$\Rightarrow LCOM = \frac{(1/1 \cdot 4) - 4}{1 - 4} = 0$$

Figur = Dreieck + Kreis:

$$a = 4, m = 8, A_1 = 4, A_2 = 4, A_3 = 4, A_4 = 4$$

$$\Rightarrow\ LCOM = \frac{(1/4 \cdot 16) - 8}{1 - 8} = \frac{4}{7}$$

Cyclomatic Complexity (CC)

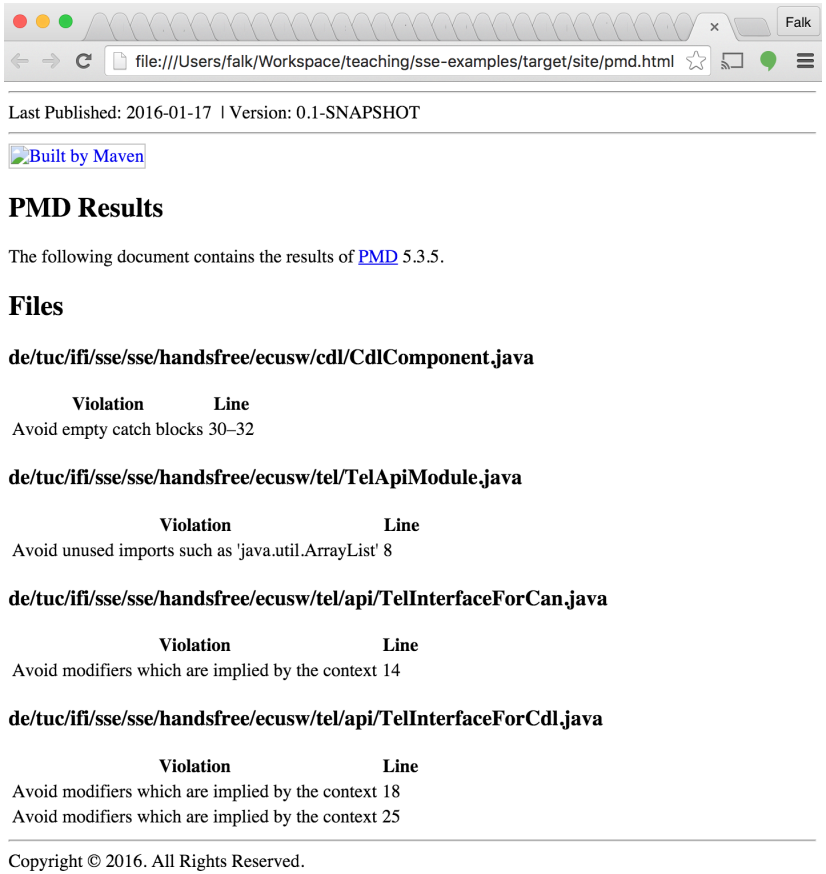
In the next deck of slides ...

Tools

PMD

PMD scans Java source code and looks for potential problems like:

- Duplicate code - copied/pasted code means copied/pasted bugs
- Overcomplicated expressions - unnecessary if statements, for loops that could be while loops
- Many other things (we will come back to PMD later)



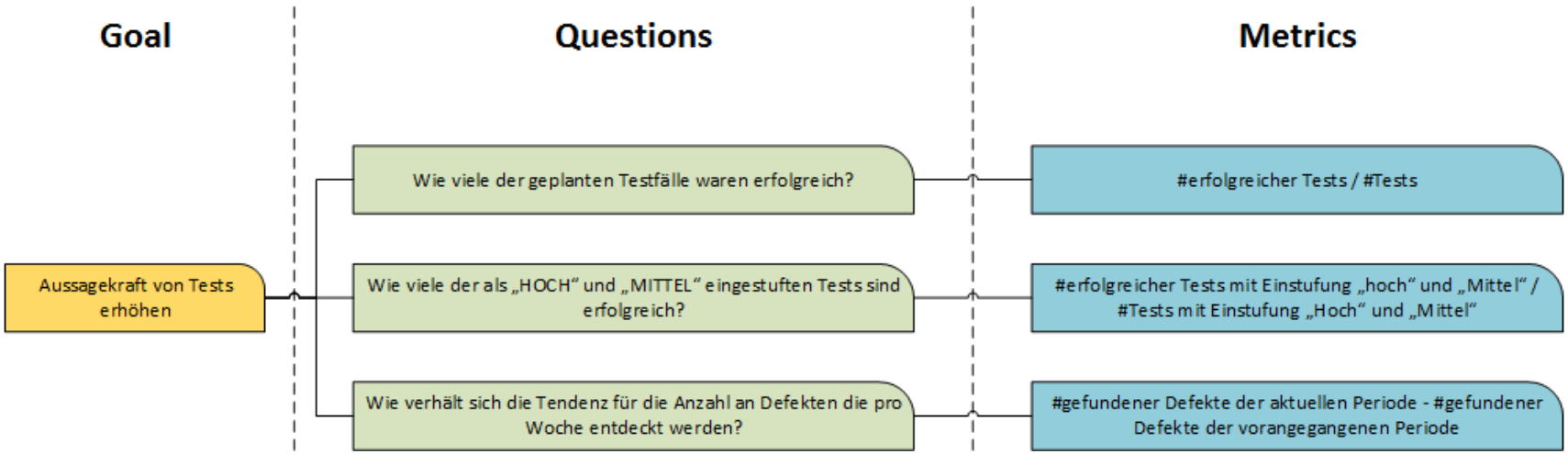
https://pmd.github.io/

How to decide what to measure

Goal Question Metric Paradigm (GQM)

Goal: What is the goal?	Example: Improving Code-Design
Question: What needs to be analyzed?	Analyze: Nesting level, cohesion, ...
Metric: What is a relevant software metric?	Metric: Lack of Cohesion (LCOM)

GQM Example 2



Summary: Code Metrics

Metric:

- Standard of Measure
- Can be computed for Software
- Examples: LOC, LCOM, CC, ...

Goal:

- Quantify some Aspect of Product

Careful!

- Only Indicators
- Relationship between Goal and Metric?