SWEN 223
Software Engineering Analysis

Software Engineering

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Significance of Software

BMFT Study from 1994

- Software develops into an independent economic asset and plays a significant role in society
- Software has become an intrinsic part of most high-tech products and services
- In some areas—such as banks and insurance companies, almost all services are realized by software

Significance of Software

BMFT Study from 1994 (contd.)

- In many products from telecommunication, the automobile industry, machine-building, plant manufacturing, medicine, and consumer electronics, the proportion of software is continually increasing
- Software takes over essential tasks of controlling installations and devices and hence increasingly shapes their functionality and quality

Significance of Software

BMFT Study from 1994 (contd.)

- In export-oriented branches of the German economy the proportion of software in creating added value is often higher than 50%
- In digital switching technology 80% of the development costs are software related

The BMFT concluded that increasing the product quality and the productivity in software development are decisive factors for the international competitiveness of an economy.

Birth of the Discipline

1968 NATO-conference in Garmisch, Germany

> ***The whole trouble comes from the fact that there is so much tinkering with software. It is not made in a clean fabrication process, which it should be. What we need is software engineering.***
>
> **– F.L. Bauer**

Birth of the Discipline

Motivation of the conference

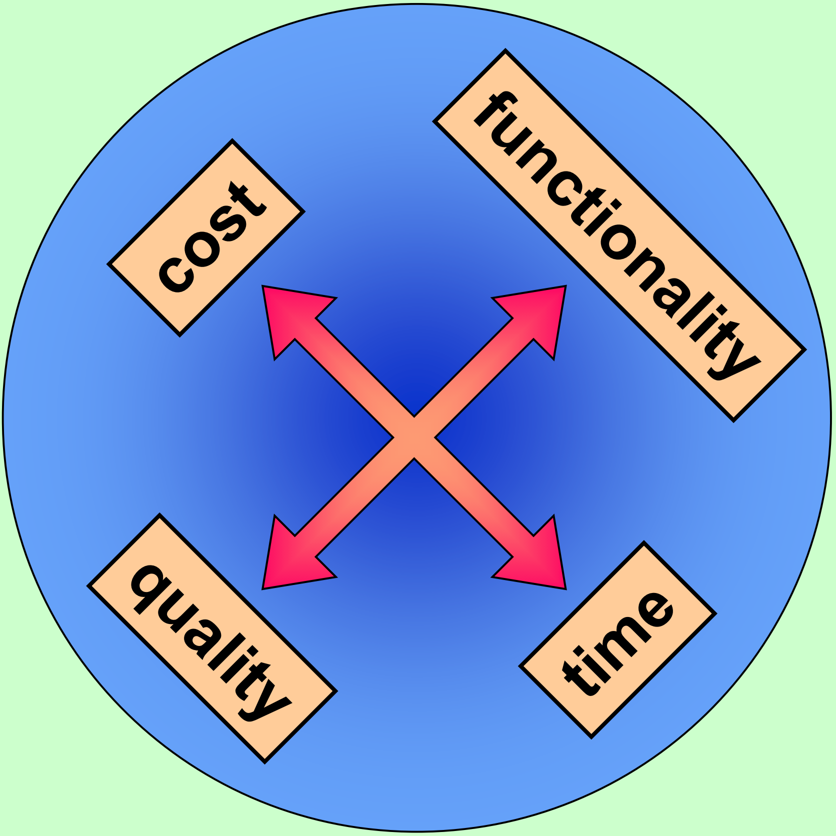
- software systems are incorrect and/or unreliable
- user requirements are not fulfilled…
- … (and) or the development is too costly

Shortcomings in the development and maintenance of software

The Problem

Declaration of Capitulation

- of four factors in software development…
- …the client may prioritise three.
- the fourth factor is determined by this choice!

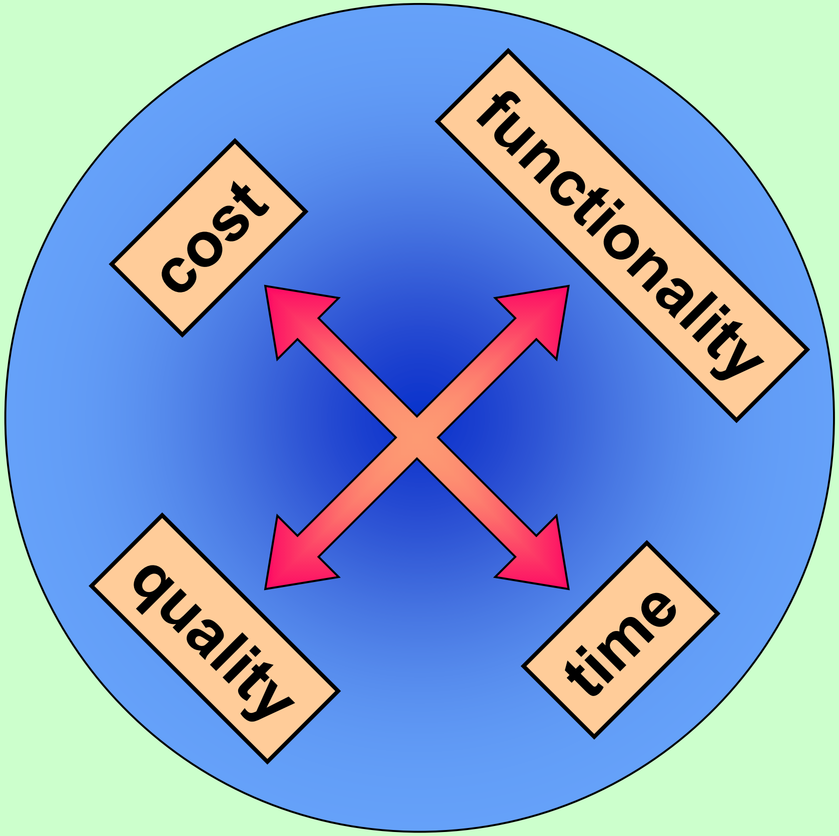


The Problem

Declaration of Capitulation

Success Factor

productivity



Definitions

Bauer 1968

The establishment and use of sound engineering principles in order to obtain economically software that is reliable and works efficiently on real machines

Parnas 1974

Software Engineering is programming under at least one of these two conditions:

- more than one person writes and uses the program
- more than one version of the program is created

Definitions

Dennis 1975

Software Engineering is the application of principles, abilities and craftsmanship on the design and the construction of program systems

Fairley 1985

Software Engineering is the technical and organisational discipline for the systematic construction and maintenance of software products, which are produced timely and within given cost limits

Definitions

Boehm 1979

Software Engineering is the practical application of scientific rationale on the design and the construction of program systems

Sommerville 1985

Software Engineering deals with the construction of software systems, which cannot be produced by a single developer. It rests on the application of engineering principles and includes technical as well as non-technical aspects

Definitions

IEEE 1990 (Std 610.12-1990)

(1) The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software.

(2) The study of approaches as in (1).

Definitions

Summary

Systematic construction & maintenance of complex software systems by teams, with expectations towards the quality of the product (reliability / efficiency) and the development (timely / cost-controlled) regarding technical and non-technical issues.

Change of Focus

Focus until 1970:

Time and Space Complexity

Elaboration

How long does it take for a program/algorithm to run and what amount of memory is required?

Issues back then

unreliable hardware

small memories

long execution times

Racing with Hardware Advances

> ***As long as there were no machines, programming was no problem at all; when we had a few weak computers, programming became a mild problem, and now we have gigantic computers, programming has become a gigantic problem.***
>
> **Edsger W. Dijkstra**

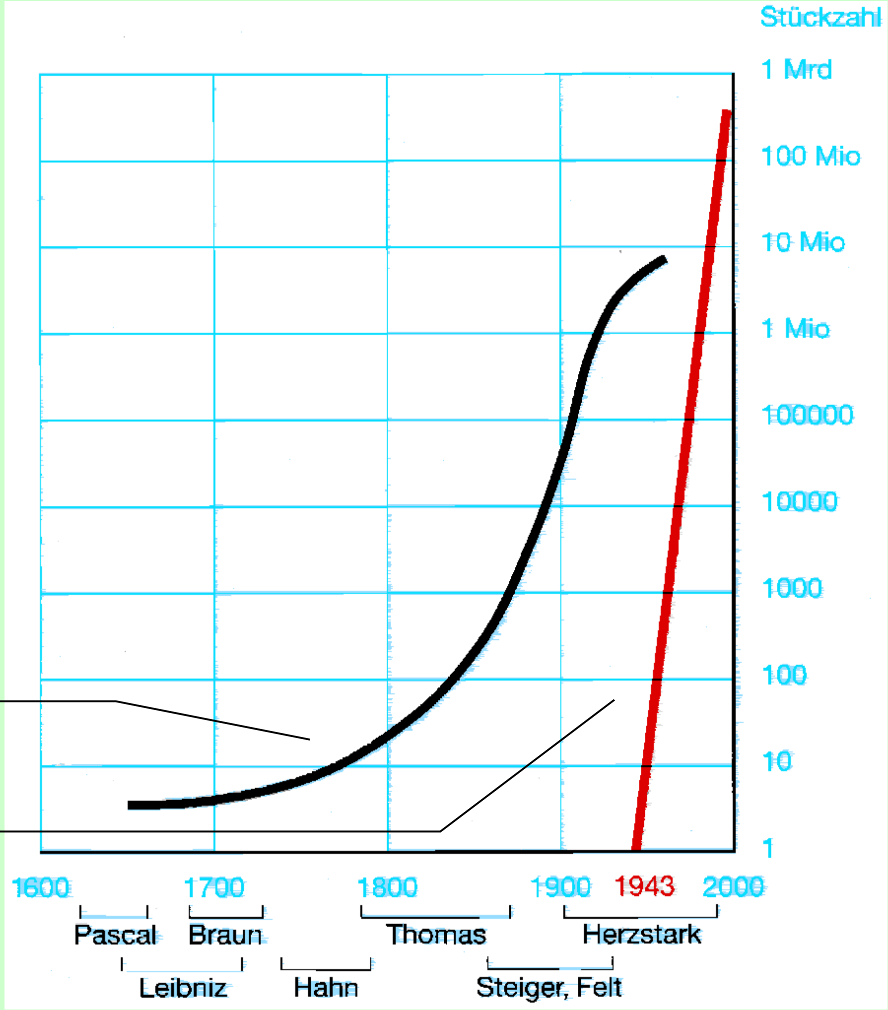
Hardware Development

Supporting Factors

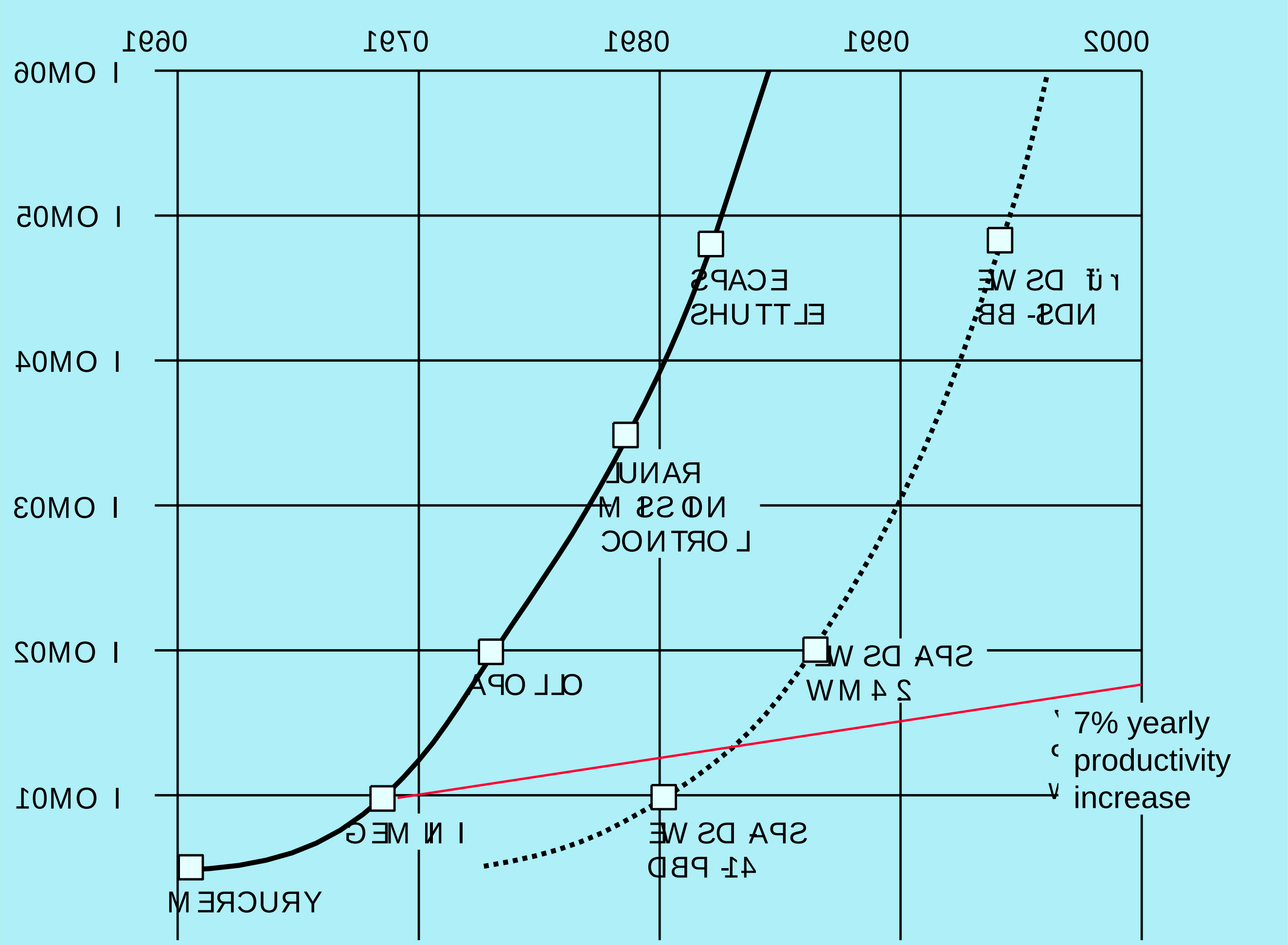
- reduction of hardware cost
- stepwise mastering of programming complex systems

mechanical

electronic



Software Development



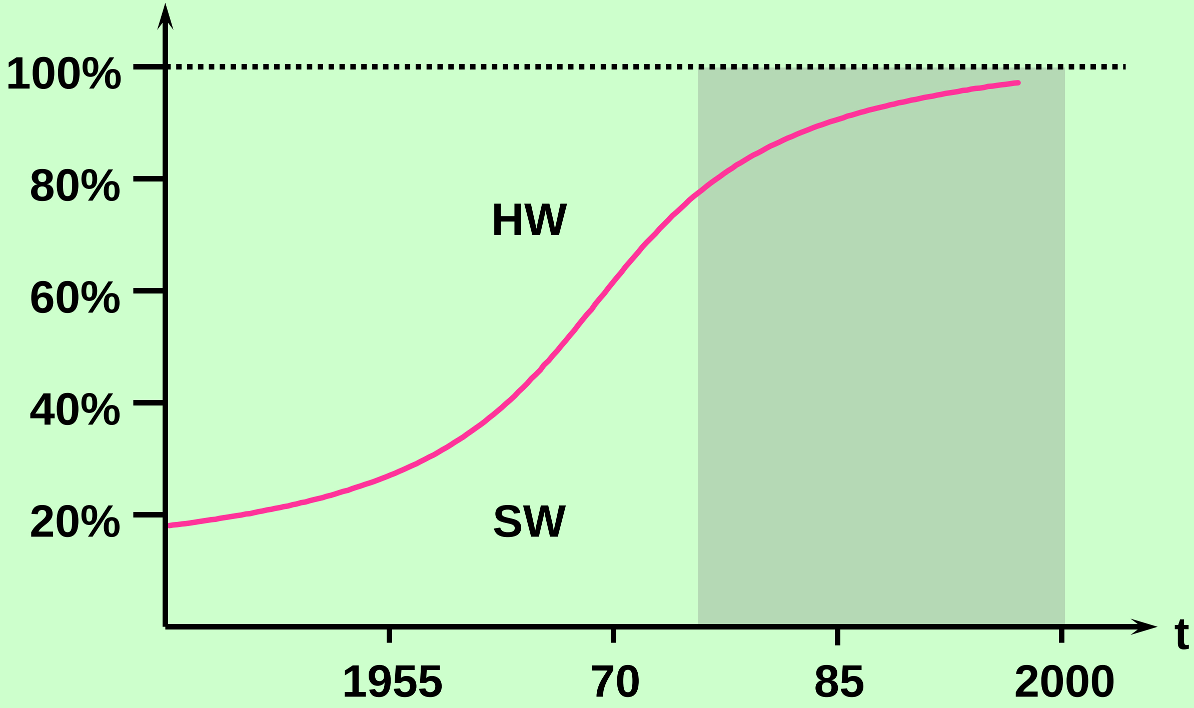
7% yearly productivity increase

MOI = million object code instructions

EWSD: digital dialing system

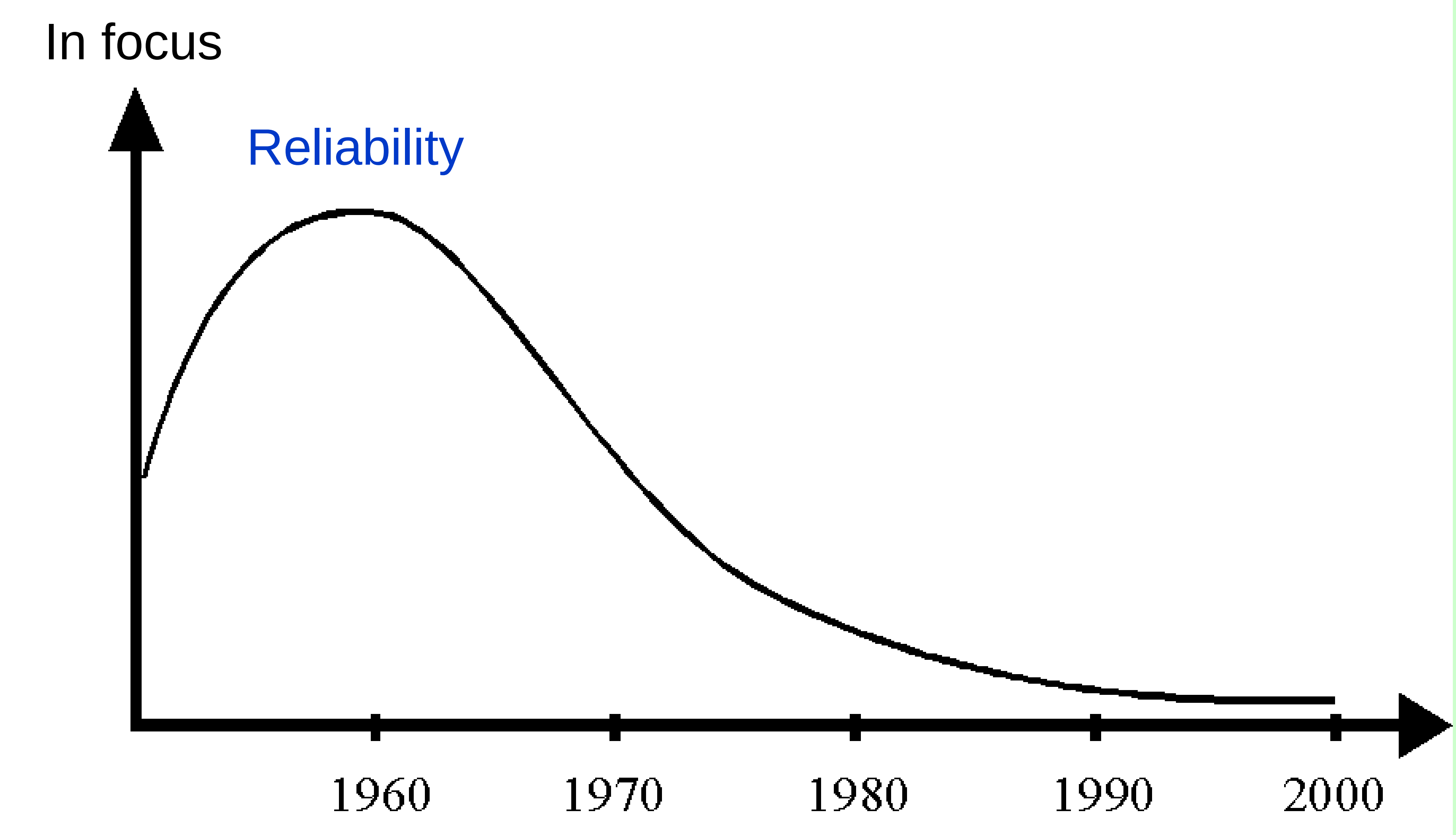
Shift of Costs

Relative cost of computer supported systems



(Boehm 1976)

Change of Focus



Change of Focus

Focus 1965–1980:

Reliability

Elaboration

What is the failure rate of a system?

Issues back then

programming methodology

errors per line: 3%
(today: 0.3%)

team development

Change of Focus

Aspects of Reliability

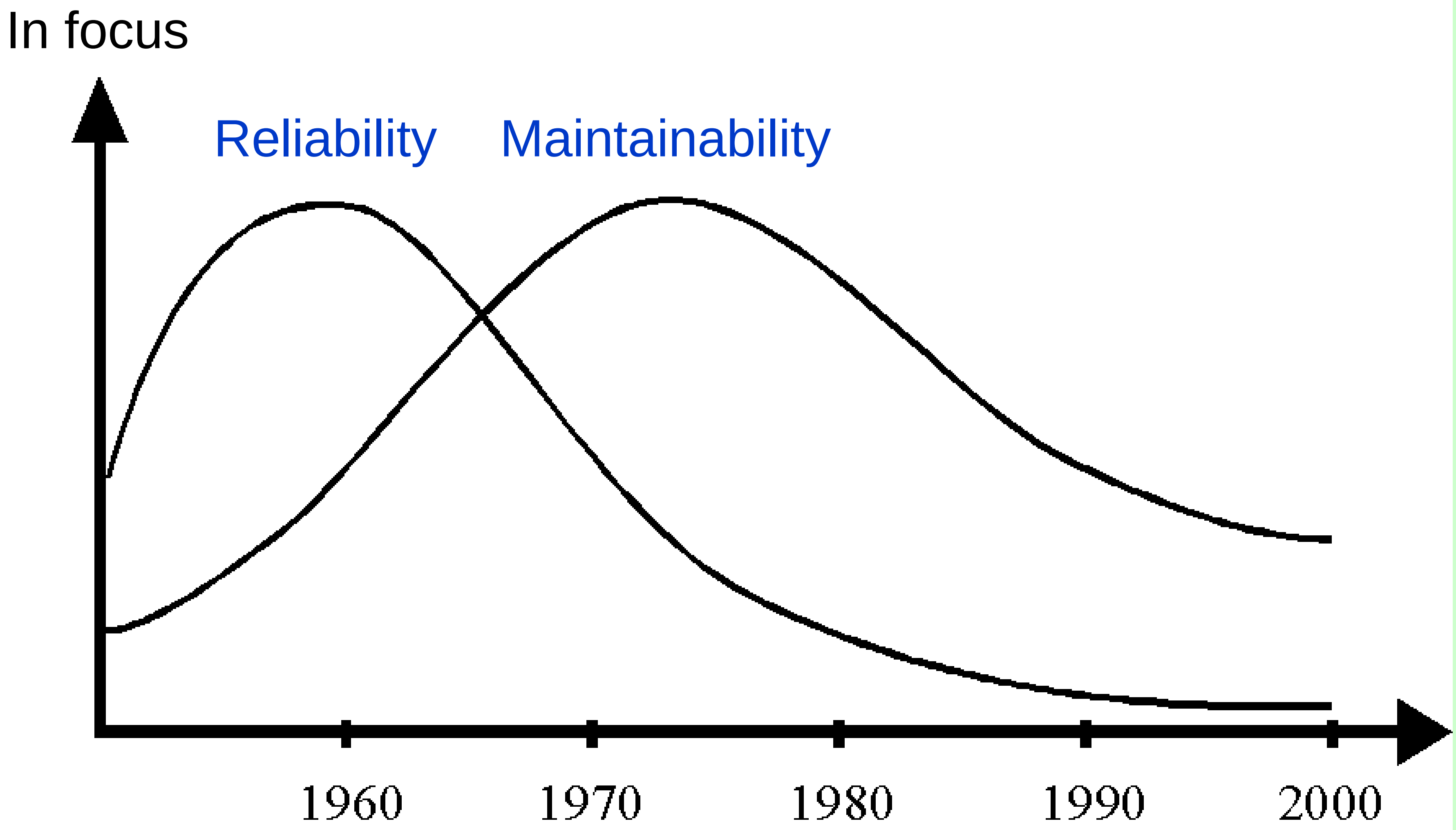
Correctness is defined as the conformance of the system to its specification

→ “Are we building the right system?”

Robustness is defined as the ability of a system to (continue to) perform despite being forced to operate outside specified parameters

→ “Are we building the system right?”

Change of Focus



Change of Focus

Focus since 1970:

Maintainability

Elaboration

How easy or hard is it to detect and correct errors in a system? How easy or hard is it to change the system?

Issues back then

- programming in the large
- system structure
- error propagation
- change avalanches

Maintainability

> ***This complexity is compounded by the necessity to conform to an external environment that is arbitrary, unadaptable, and everchanging.***
>
> **F.P. Brooks**

Priorities for Development

Productivity Enhancers

- High Reuse
  - using parts multiple times
- Good Maintainability
  - fix shortcomings
  - extend functionality
  - address changing requirements

______________ of a software‘s lifetime is spent in maintenance!

Maintenance?

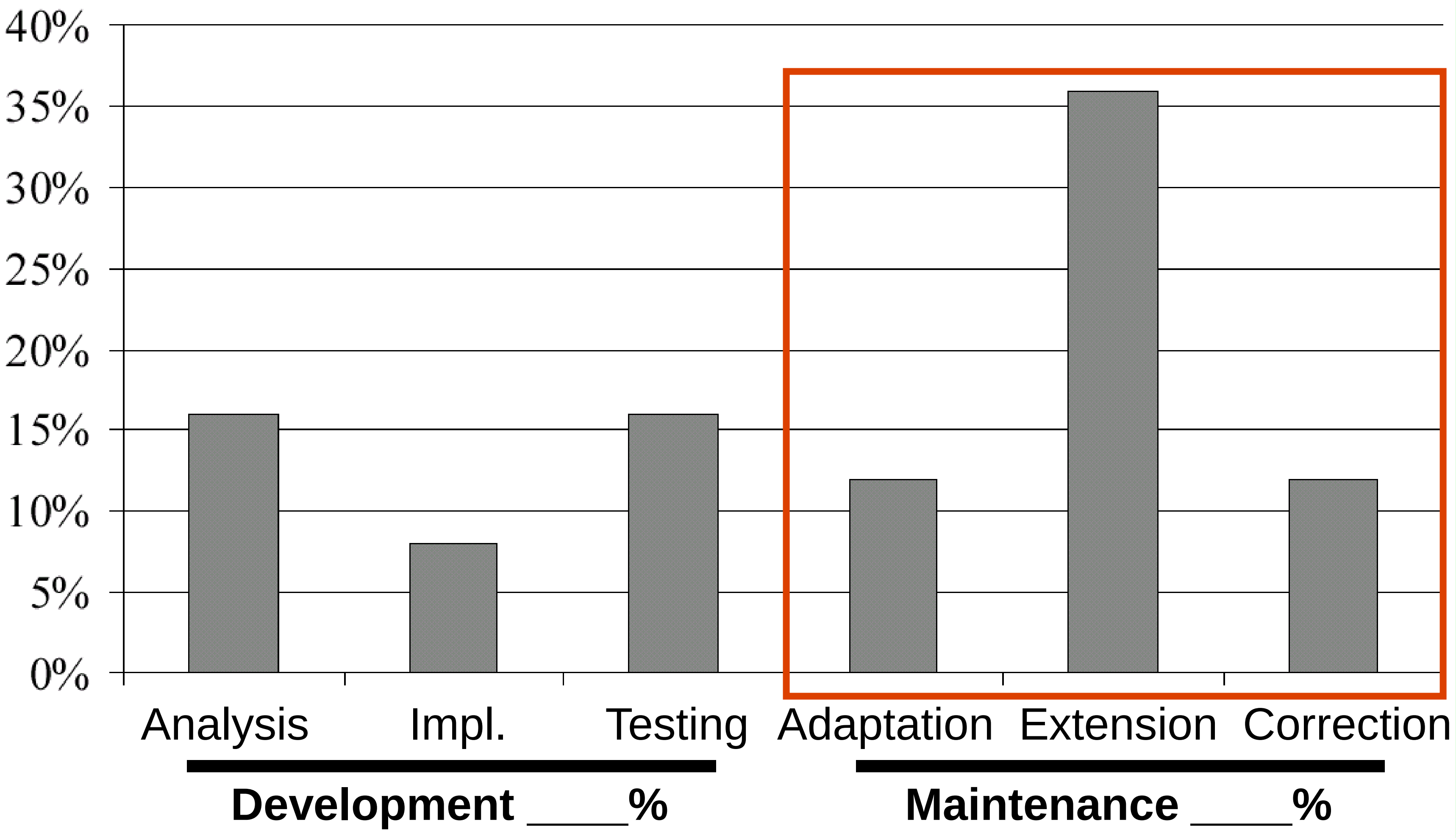
Why “maintain” software?

- The term “maintenance” does not make sense (with its classical meaning) for software
  - software does not age

- Euphemism for

error correction	(„right“,	ca. 20%)
change of construction	(„better“,	ca. 20%)
change of specification	(„different“,	ca. 60%)

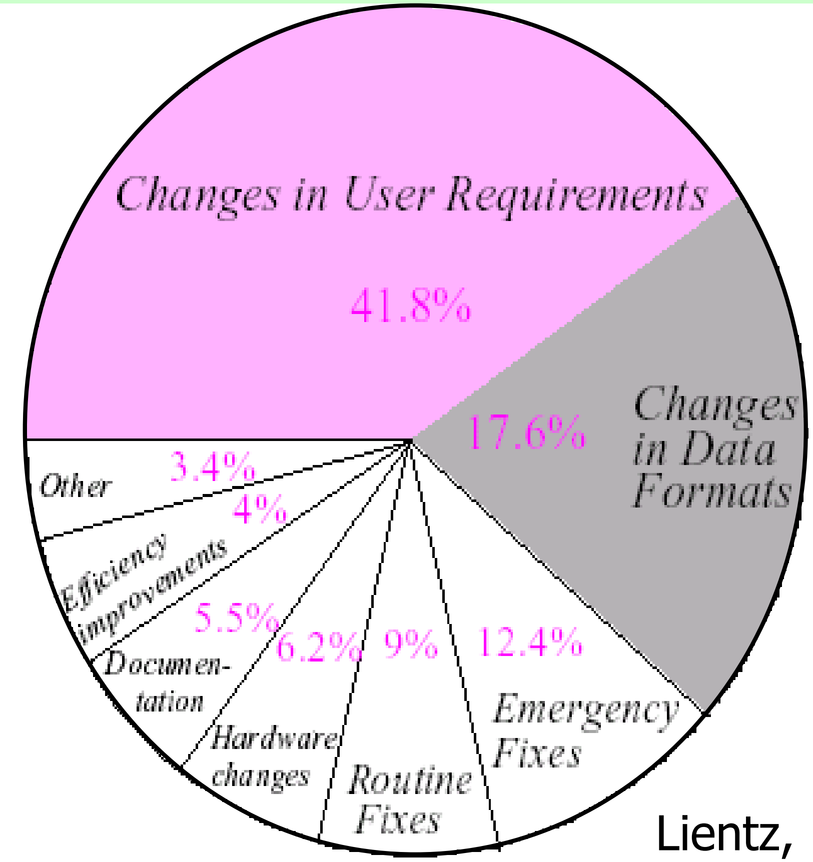
Significance of Maintenance



Maintenance

- 2/5 of the cost due to customer (extensions, modifications)

→ big advantage, if software is easy to adapt

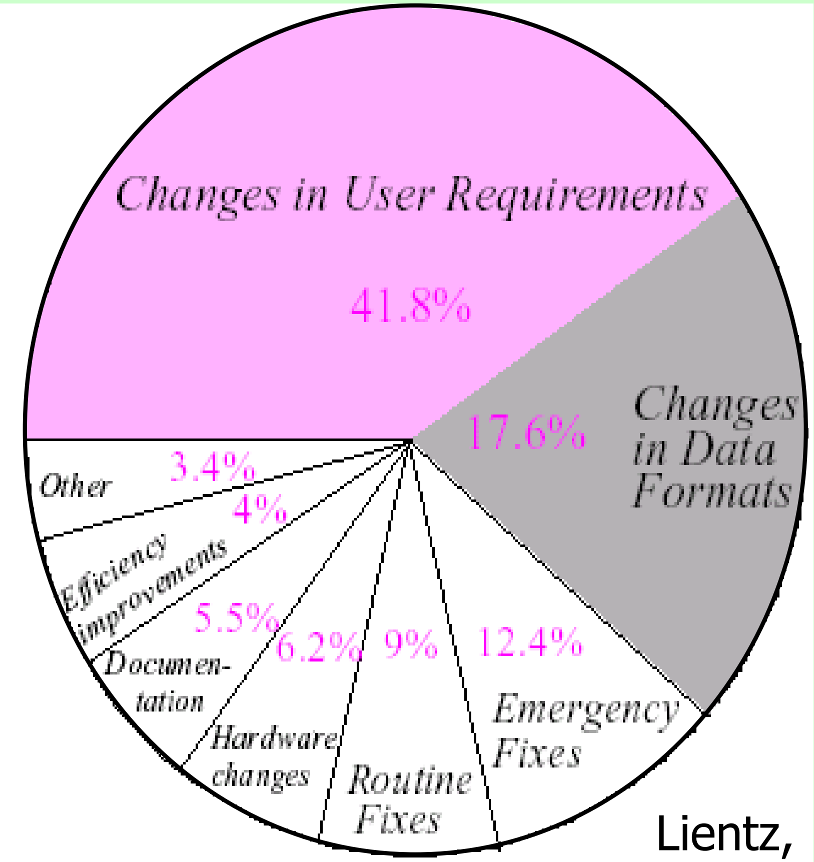


Lientz, Swanson 1980, survey of 487 projects

Maintenance

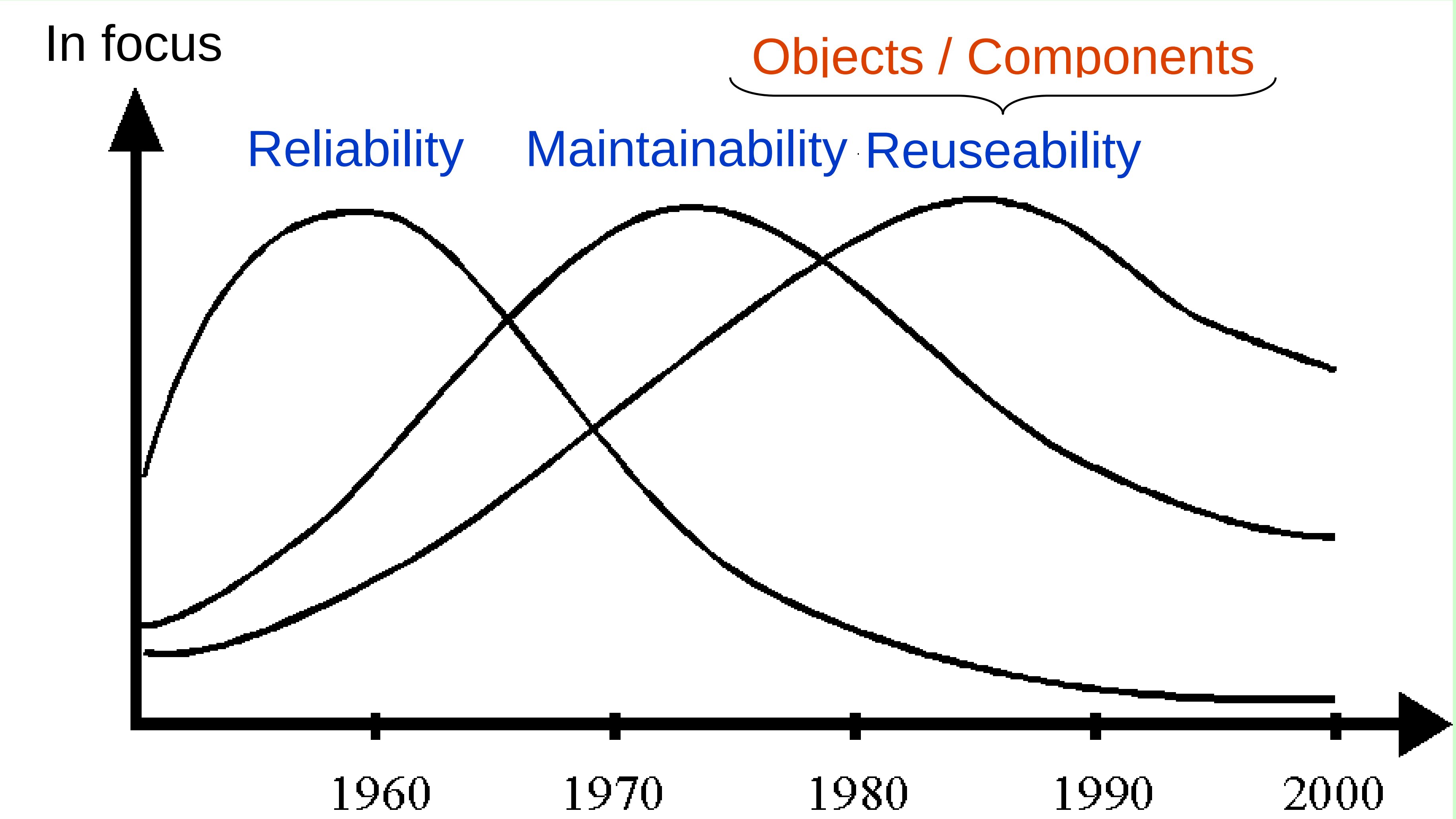
- 1/5 (almost) of the cost due to data format changes

→ big advantage, if formats can be kept flexible and/or local



Lientz, Swanson 1980, survey of 487 projects

Change of Focus



Change of Focus

(external) **Reuse**
vs
(internal) **Sharing**

Focus since 1980:

Reuse

Elaboration

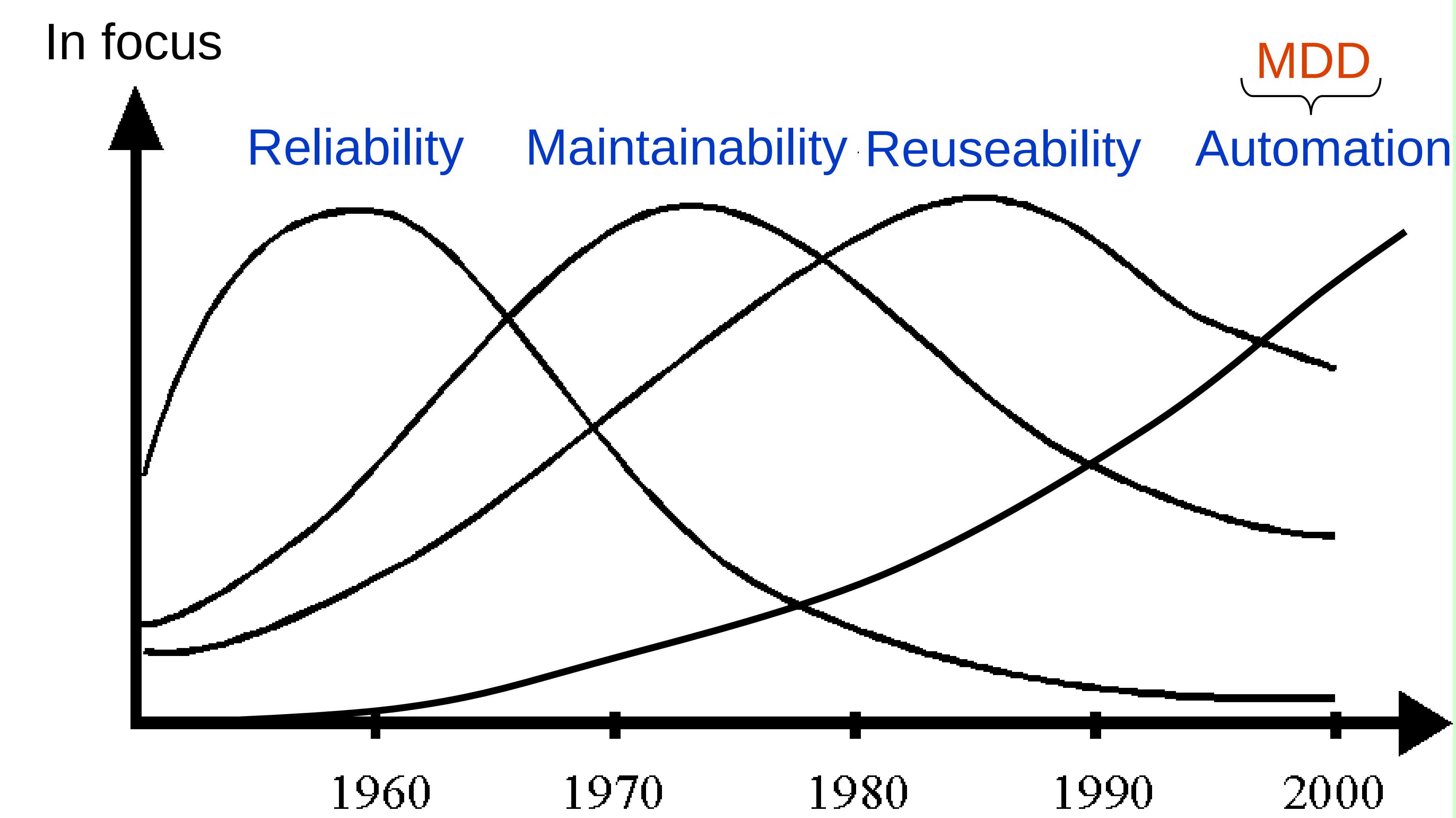
How easy or hard is it to reuse a part of a system in another system, i.e., reuse its functionality in a different context?

c.f.: Portability: *How easy or hard is it to use the system in a different technical environment?*

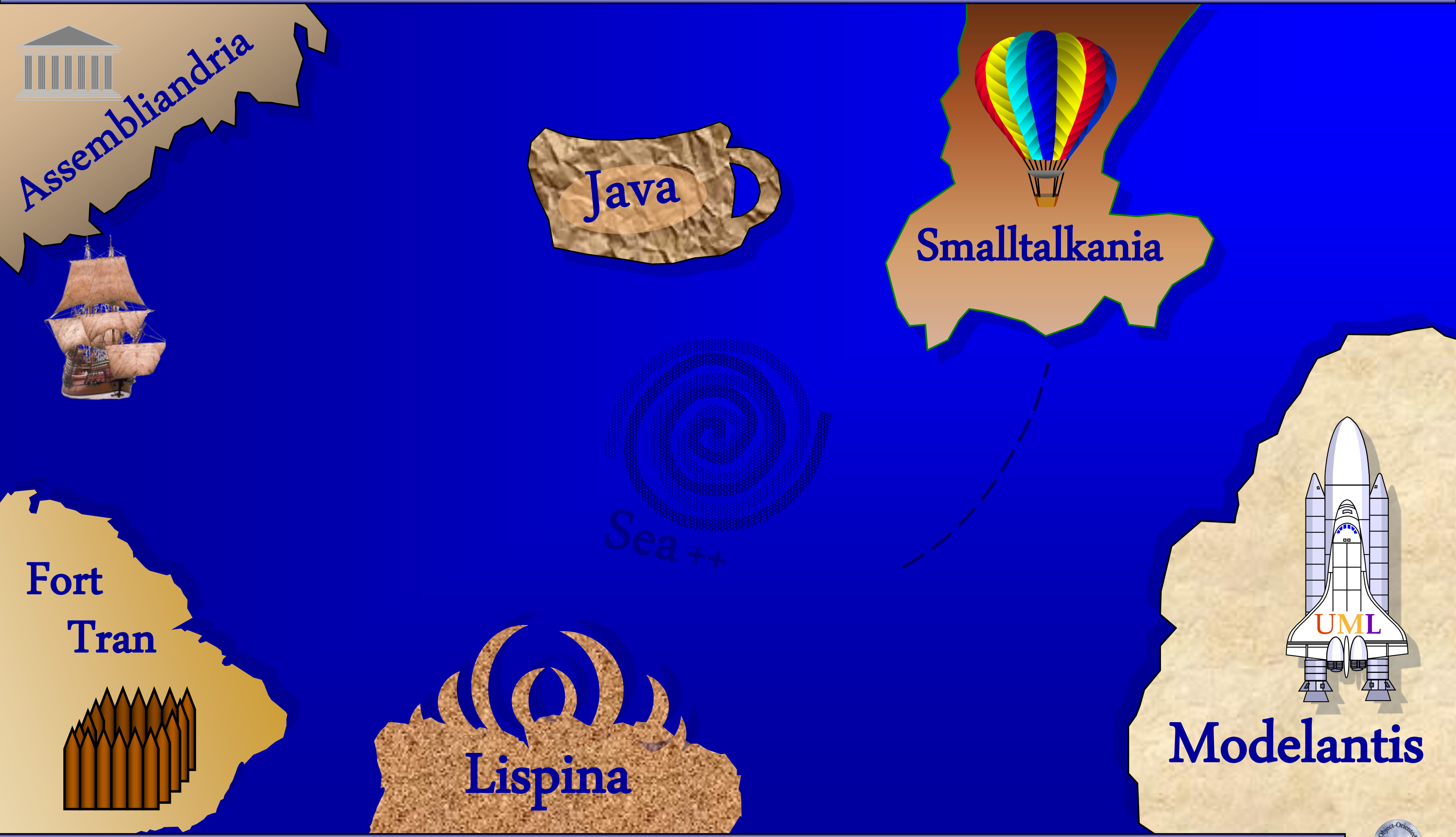
Issues large scale reuse

adaptability without encapsulation loss

Change of Focus



Model-Driven Development



Software Era or Crisis?

Era

software systems belong to the biggest, most complex and hence most difficult to handle systems build by mankind.

Crisis

software systems are always more costly and require more time to build than planned. Moreover, reliability and correctness are rarely impeccable.

Crisis or Disease?

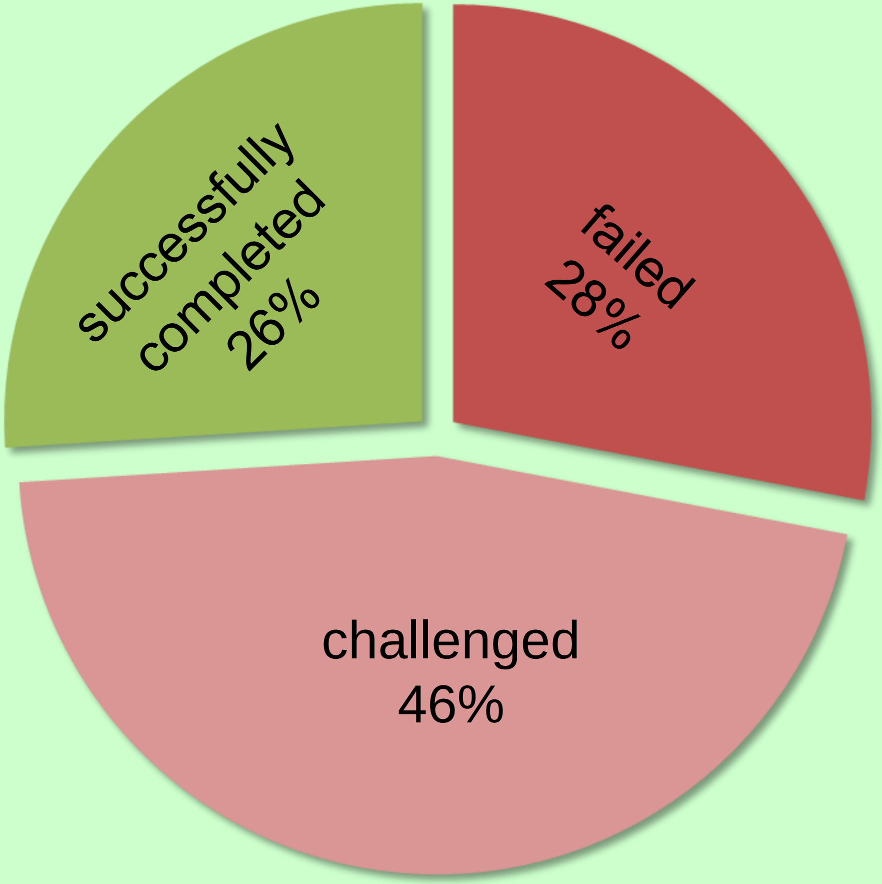
- Software developments frequently
  - finish late (up to a factor of 2)
  - become too expensive (up to a factor of 10)
  - are cancelled because of the above

31.1% of projects will be cancelled
52.7% of projects will cost 189% of their original estimates
16.2% are completed on-time and on-budget
9% of large company projects come in on-time and on-budget
many are no more than a mere shadow of their original specification requirements.

THE CHAOS REPORT; THE STANDISH GROUP, 1994

Reality of IT Projects

- Standish Group
  - published in PM Network, Sept. 1998
  - less than 1/3 successfully completed
  - almost 3/4 struggling



Crisis or Disease?

CS catastrophes

- cancer treatment system, Therac-25 (`85)
  - radiation overdose
- Warsaw Airbus crash (`93)
  - reverse thrust unavailable
- Ariane 5 Flight 501 (`96)
  - loss of rocket and cargo ($500,000,000)
- many, many more...

Software Problems

- Software with quality problems
  - operating system stability
  - >50% unused functionality
- Deficiencies regarding maintainability and timely development
  - German highway toll system for lorries
  - Year-2000 problem
  - Novopay

Software Problems

Imagine this

This car is provided under this license on an “as is” basis, without warranty of any kind, either expressed or implied, including, without limitation, warranties that the car is free of defects, merchantable, fit for a particular purpose or non-infringing. The entire risk as to the quality and performance of the car is with you. Should the car prove defective in any respect, you (not the initial developer or any other contributor) assume the cost of any necessary servicing, repair or correction.

In Our Defence

Software Engineering

- is rather young and continually developing
- hard to do empirical studies
  - » experiments with tractable size are restricted to systems of a different quality
  - » repeatability is a problem

→ difficult to measure objectively

In Our Defence

Other Engineering Disciplines

- are not necessarily better
- had their dark hours as well
  - » e.g., in architecture big projects, such as churches, have been risk projects not so long ago

In Our Defence

Tacoma Narrows Bridge

7. November 1940

In Our Defence

- DeHavilland DH-106 Comet-1
  - one of the world’s first passenger jets
  - on 8th April 1954, 26 minutes into the flight the plane explodes, killing 35 people
  - ten month later another Comet crashes in the same way
- Reason for failure
  - aluminium skin fatigue
  - mostly around the square windows

→ round windows!

In Our Defence

- Explosion of Requirements and Application areas
  - » once, writing a compiler was a major effort and the end result contained many errors
  - » building a compiler today can be done as a student project

→ software project failures are often a sign of expectations growing faster then engineering methods

Software Crisis

Attenuators

- improvement of methodologies
- tools become more powerful
- larger and richer libraries
- increasing qualification & experience of actors

→ product quality has improved considerably (assuming fixed requirements)

Software Crisis

Amplifiers

Workload associated with the development of a typical product is increasing by a factor of ___ every 7-8 years (study at Philips Electronics)

- typical product size grows enormously
- new challenges (networks, multimedia, concurrency)

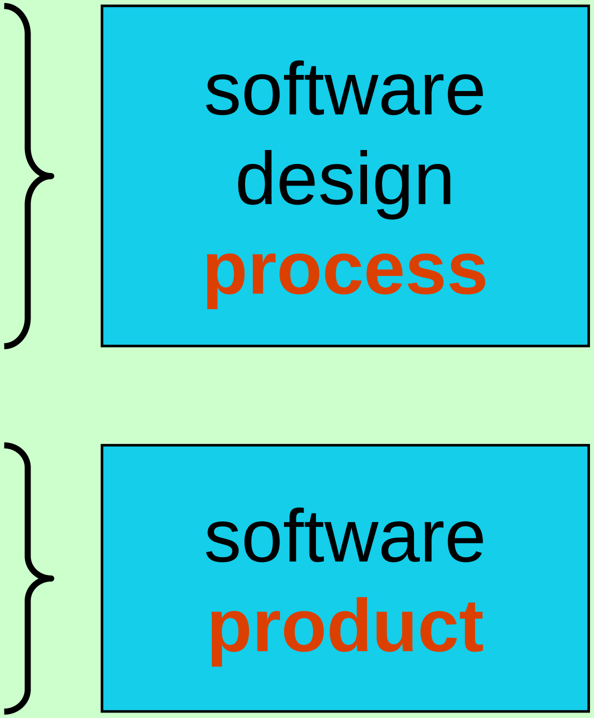
→ extensive & novel requirements demand new learning and consolidation phases

Software Crisis is here to stay for a while!

Two Tracks

Software Engineering as a Guide for

1. organised team action
   - » e.g., participative product design
2. construction principles
   - » e.g., ban on self-modifying code



software design **process**

software **product**

Themes not Covered Here

- Project Management
  - » *process management, team management*
- Requirements Elicitation
  - » *from the user to the system requirements*
- Quality Control
  - » *Verification, Validation*