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Introduction to Software Engineering (ESE : Einführung in SE)

Prof. O. Nierstrasz

ESE — Introduction

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Assistants	Erwann Wernli Aaron Karper, Joel Krebs
Lectures	Engehaldenstrasse 8, 001, Wednesdays @ 13h15-15h00
Exercises	Engehaldenstrasse 8, 001 Wednesdays @ 15h00-16h00
WWW	scg.unibe.ch/teaching/ese

Selected material courtesy of Prof. Serge Demeyer, U. Antwerp

Roadmap

- Course Overview
- What is Software Engineering?
- The Iterative Development Lifecycle
- Software Development Activities
- Methods and Methodologies

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Principle Texts

- *Software Engineering*. Ian Sommerville. Addison-Wesley Pub Co; ISBN: 020139815X, 7th edition, 2004
- *Software Engineering: A Practioner's Approach*. Roger S. Pressman. McGraw Hill Text; ISBN: 0072496681; 5th edition, 2001
- *Using UML: Software Engineering with Objects and Components*. Perdita Stevens and Rob J. Pooley. Addison-Wesley Pub Co; ISBN: 0201648601; 1st edition, 1999
- *Designing Object-Oriented Software*. Rebecca Wirfs-Brock and Brian Wilkerson and Lauren Wiener. Prentice Hall PTR; ISBN: 0136298257; 1990

Recommended Literature

- *eXtreme Programming Explained: Embrace Change.* Kent Beck. Addison-Wesley Pub Co; ISBN: 0201616416; 1st edition (October 5, 1999)
- *The CRC Card Book*. David Bellin and Susan Suchman Simone. Addison-Wesley Pub Co; ISBN: 0201895358; 1st edition (June 4, 1997)
- *The Mythical Man-Month: Essays on Software Engineering.* Frederick P. Brooks. Addison-Wesley Pub Co; ISBN: 0201835959; 2nd edition (August 2, 1995)
- *Agile Software Development*. Alistair Cockburn. Addison-Wesley Pub Co; ISBN: 0201699699; 1st edition (December 15, 2001)
- *Peopleware: Productive Projects and Teams.* Tom Demarco and Timothy R. Lister. Dorset House; ISBN: 0932633439; 2nd edition (February 1, 1999)
- *Succeeding with Objects: Decision Frameworks for Project Management.* Adele Goldberg and Kenneth S. Rubin. Addison-Wesley Pub Co; ISBN: 0201628783; 1st edition (May 1995)
- *A Discipline for Software Engineering.* Watts S. Humphrey. Addison-Wesley Pub Co; ISBN: 0201546108; 1st edition (December 31, 1994)

Course schedule

Week	*Date*	*Lesson*
1	21-Sep-11	Introduction: The Software Lifecycle
2	28-Sep-11	Requirements Collection
3	05-Oct-11	The Planning Game
4	12-Oct-11	Responsibility-Driven Design
5	19-Oct-11	Modeling Objects and Classes
6	26-Oct-11	Modeling Behaviour
7	02-Nov-11	Software Validation
8	09-Nov-11	User Interface Design
9	16-Nov-11	Project Management
10	23-Nov-11	Software Architecture
11	30-Nov-11	Software Quality
12	07-Dec-11	Software Metrics
13	14-Dec-11	Guest lecture: SE in practice
14	21-Dec-11	Software Evolution
15	12-Jan-12	Final Exam: ExWi A6 @ 10h00-12h00

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Why Software Engineering?

A naive view:

Problem Specification —coding→ Final Program

But ...

- Where did the *specification* come from?
- How do you know the specification corresponds to the *user's needs*?
- How did you decide how to *structure* your program?
- How do you know the program actually *meets the specification*?
- How do you know your program will always *work correctly*?
- What do you do if the *users' needs change*?
- How do you *divide tasks up* if you have more than a one-person team?

What is Software Engineering? (I)

Some Definitions and Issues

"state of the art of developing quality software on time and within budget"

> Trade-off between perfection and physical constraints
  —SE has to deal with real-world issues
> State of the art!
  —Community decides on "best practice" + life-long education

What is Software Engineering? (II)

"multi-person construction of multi-version software"

— Parnas

- Team-work
  - —Scale issue ("program well" is not enough) + Communication Issue
- Successful software systems must evolve or perish
  - —Change is the norm, not the exception

What is Software Engineering? (III)

"software engineering is <u>different</u> from other engineering disciplines"

— Sommerville

- Not constrained by physical laws
  - —limit = human mind

- It is constrained by political forces
  - —balancing stake-holders

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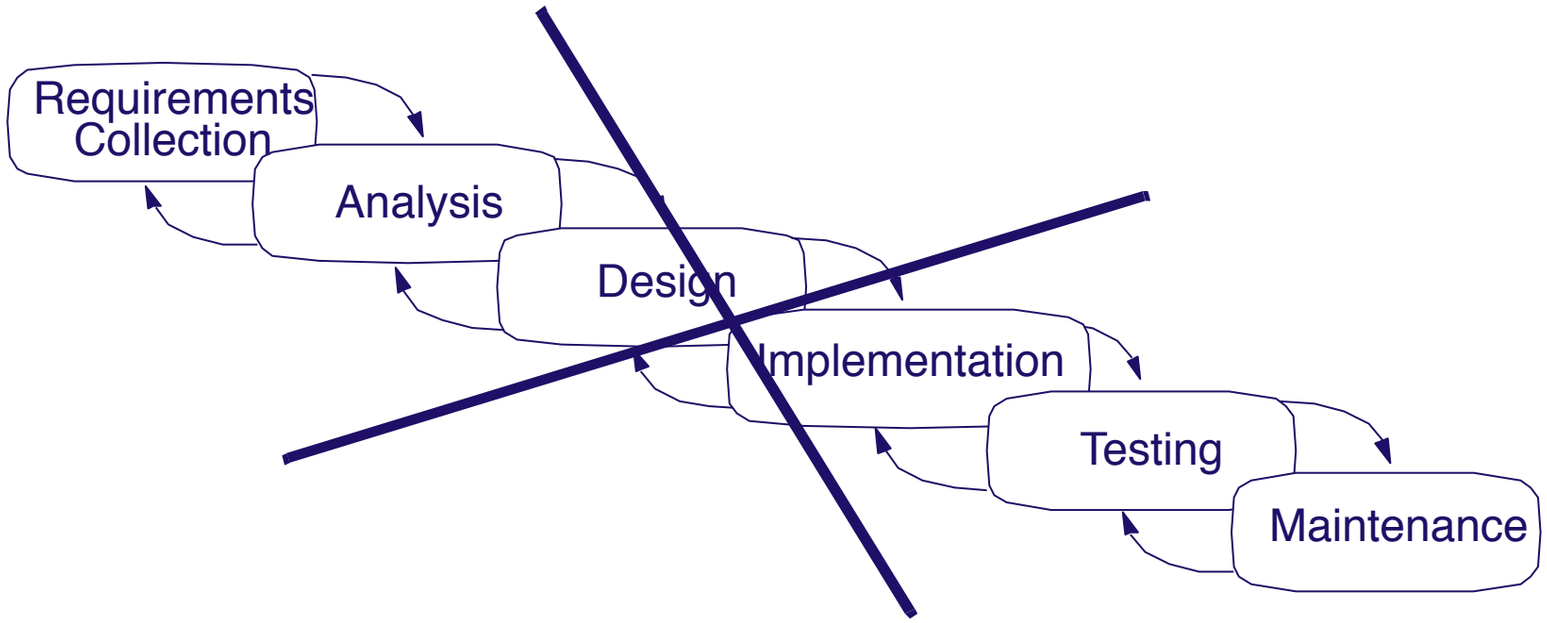
Software Development Activities

Requirements Collection	Establish customer's needs
Analysis	Model and specify the requirements ("what")
Design	Model and specify a solution ("how")
Implementation	Construct a solution in software
Testing	Validate the solution against the requirements
Maintenance	Repair defects and adapt the solution to new requirements

NB: these are ongoing activities, not sequential phases!

The Classical Software Lifecycle

The classical software lifecycle models the software development as a step-by-step "waterfall" between the various development phases.



The waterfall model is unrealistic for many reasons:

- requirements must be *frozen too early* in the life-cycle
- requirements are *validated too late*

Problems with the Waterfall Lifecycle

1. "Real projects rarely follow the sequential flow that the model proposes. *Iteration* always occurs and creates problems in the application of the paradigm"

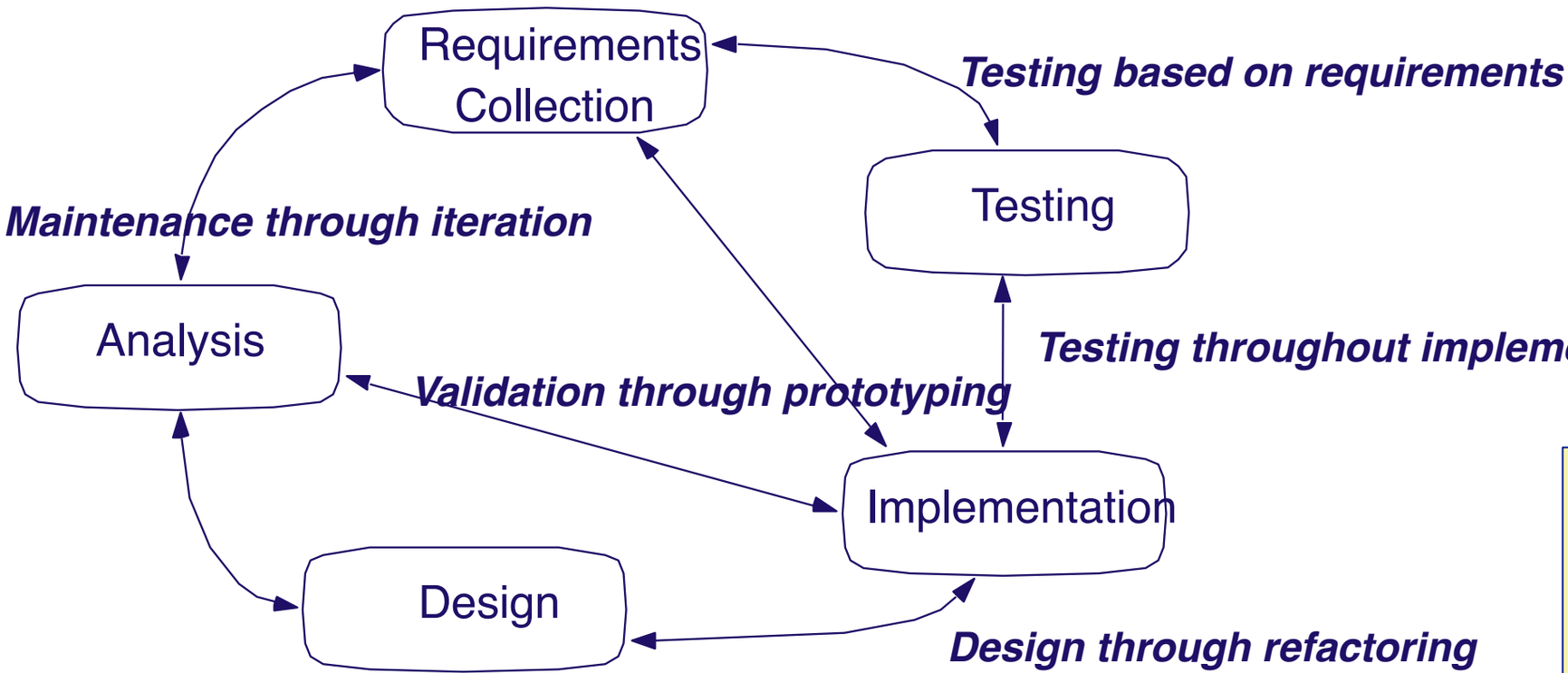
2. "It is often *difficult* for the customer *to state all requirements* explicitly. The classic life cycle requires this and has difficulty accommodating the natural uncertainty that exists at the beginning of many projects."

3. "The customer must have patience. A *working version* of the program(s) will not be available until *late in the project* timespan. A major blunder, if undetected until the working program is reviewed, can be disastrous."

— *Pressman, SE, p. 26*

Iterative Development

In practice, development is always iterative, and *all* activities progress in parallel.



If the waterfall model is pure fiction, why is it still the dominant software process?

Iterative Development

Plan to *iterate* your analysis, design and implementation.

— You won't get it right the first time, so *integrate, validate and test* as frequently as possible.

— "You should use iterative development only on projects that you want to succeed."

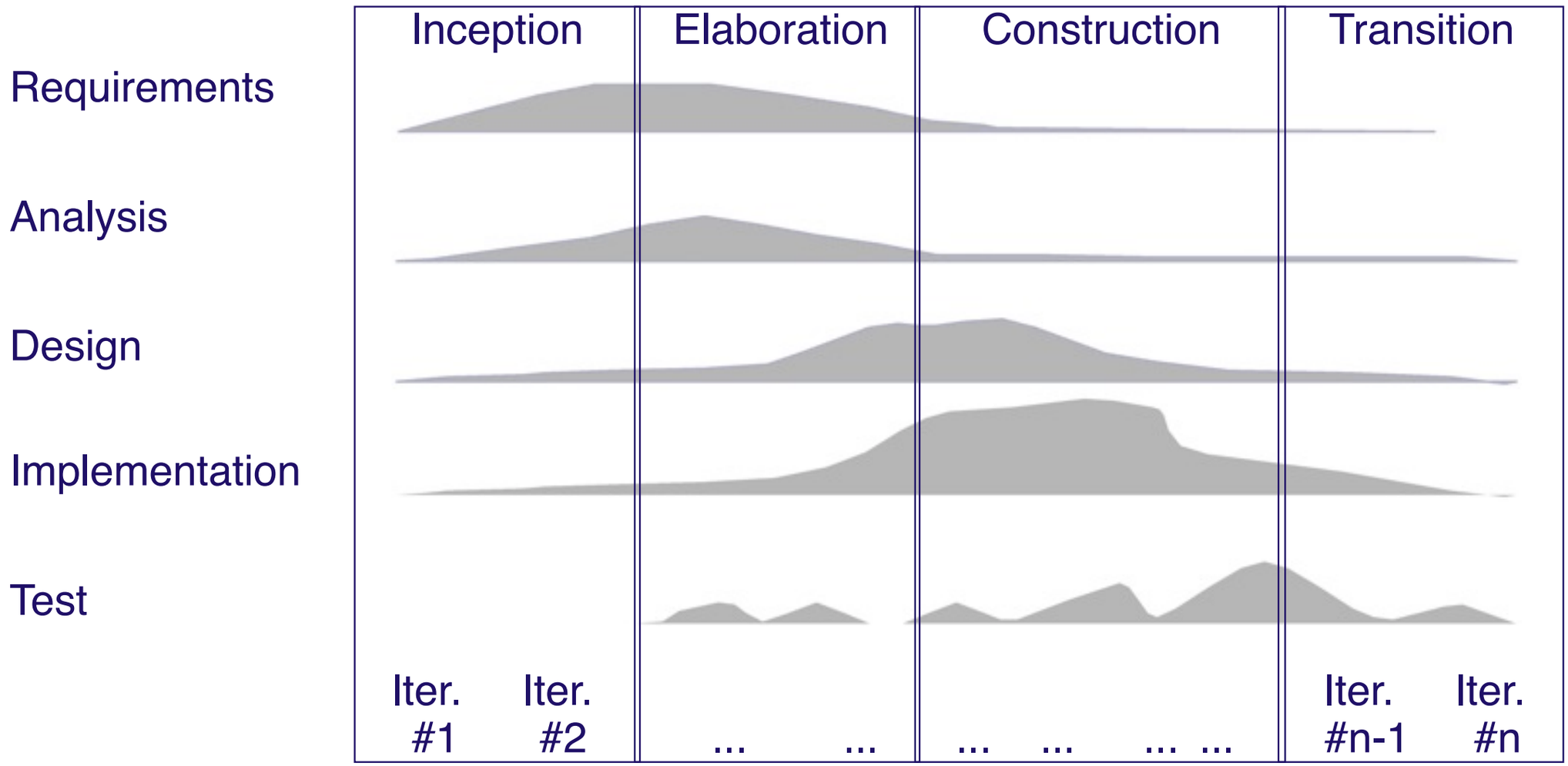
  – *Martin Fowler, UML Distilled*

Incremental Development

Plan to *incrementally* develop (i.e., prototype) the system.

- If possible, always have a *running version of the system*, even if most functionality is yet to be implemented.
- *Integrate* new functionality as soon as possible.
- *Validate* incremental versions against user requirements.

The Unified Process



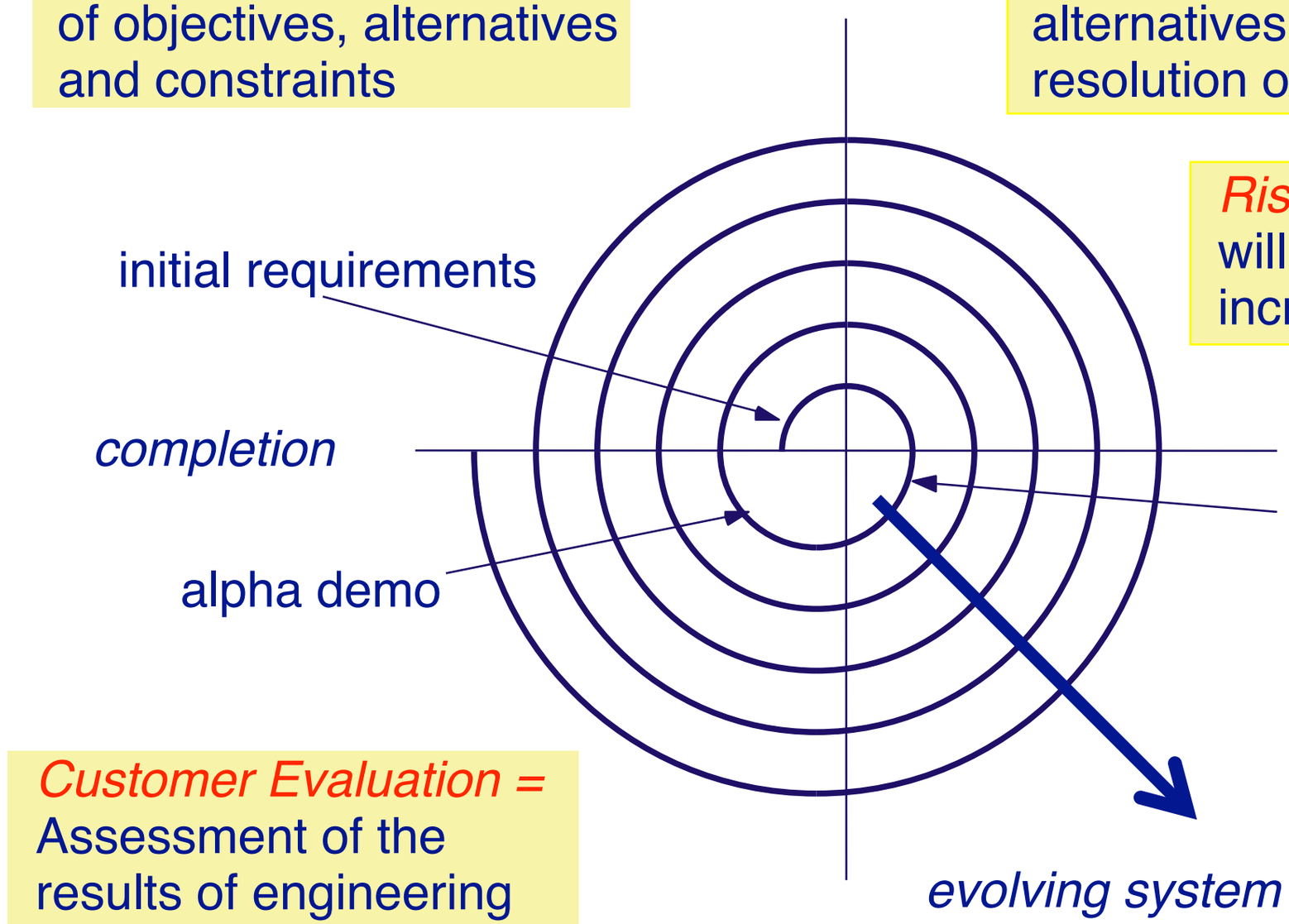
How do you plan the number of iterations?
How do you decide on completion?

Boehm's Spiral Lifecycle

Planning = determination of objectives, alternatives and constraints

Risk Analysis = Analysis of alternatives and identification/ resolution of risks

Risk = something that will delay project or increase its cost



Customer Evaluation = Assessment of the results of engineering

Engineering = Development of the next level product

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Requirements Collection

User requirements are often expressed *informally*:

—features

—usage scenarios

Although requirements may be documented in written form, they may be *incomplete*, *ambiguous*, or even *incorrect*.

Changing requirements

Requirements *will* change!

- —*inadequately captured* or expressed in the first place
- —user and business *needs may change* during the project

Validation is needed *throughout* the software lifecycle, not only when the “final system” is delivered!

- —build constant *feedback* into your project plan
- —plan for *change*
- —early *prototyping* [e.g., UI] can help clarify requirements

Requirements Analysis and Specification

Analysis is the process of specifying *what* a system will do.

—The intention is to provide a clear understanding of what the system is about and what its underlying concepts are.

The result of analysis is a *specification document*.

Does the requirements specification correspond to the users' actual needs?

Object-Oriented Analysis

An *object-oriented analysis* results in models of the system which describe:

- *classes* of objects that exist in the system
  - —*responsibilities* of those classes
- *relationships* between those classes
- *use cases* and *scenarios* describing
  - —*operations* that can be performed on the system
  - —allowable *sequences* of those operations

Prototyping (I)

A *prototype* is a software program developed to test, explore or validate a hypothesis, i.e. *to reduce risks.*

An *exploratory prototype*, also known as a *throwaway prototype*, is intended to *validate requirements* or *explore design choices*.

- —UI prototype — validate user requirements
- —rapid prototype — validate functional requirements
- —experimental prototype — validate technical feasibility

Prototyping (II)

An *evolutionary prototype* is intended to evolve in steps into a finished product.

- iteratively "grow" the application, *redesigning* and *refactoring* along the way

First do it,
then do it right,
then do it fast.

Design

Design is the process of specifying *how* the specified system behaviour will be realized from software components. The results are *architecture* and *detailed design documents*.

Object-oriented design delivers models that describe:

—how system operations are implemented by *interacting objects*

—how classes refer to one another and how they are related by *inheritance*

—*attributes* and *operations* associated to classes

Design is an iterative process, proceeding in parallel with implementation!

Conway’s Law

—“Organizations that design systems are constrained to produce designs that are copies of the communication structures of these organizations”

Implementation and Testing

Implementation is the activity of *constructing* a software solution to the customer's requirements.

Testing is the process of *validating* that the solution meets the requirements.

—The result of implementation and testing is a *fully documented* and *validated* solution.

Design, Implementation and Testing

Design, implementation and testing are iterative activities

—The implementation does not "implement the design", but rather the design document *documents the implementation*!

> System tests reflect the requirements specification

> Testing and implementation go hand-in-hand

—Ideally, test case specification *precedes* design and implementation

Maintenance

Maintenance is the process of changing a system after it has been deployed.

- *Corrective maintenance*: identifying and repairing *defects*
- *Adaptive maintenance*: *adapting* the existing solution to new platforms
- *Perfective maintenance*: implementing *new requirements*

In a spiral lifecycle, everything after the delivery and deployment of the first prototype can be considered "maintenance"!

Maintenance activities

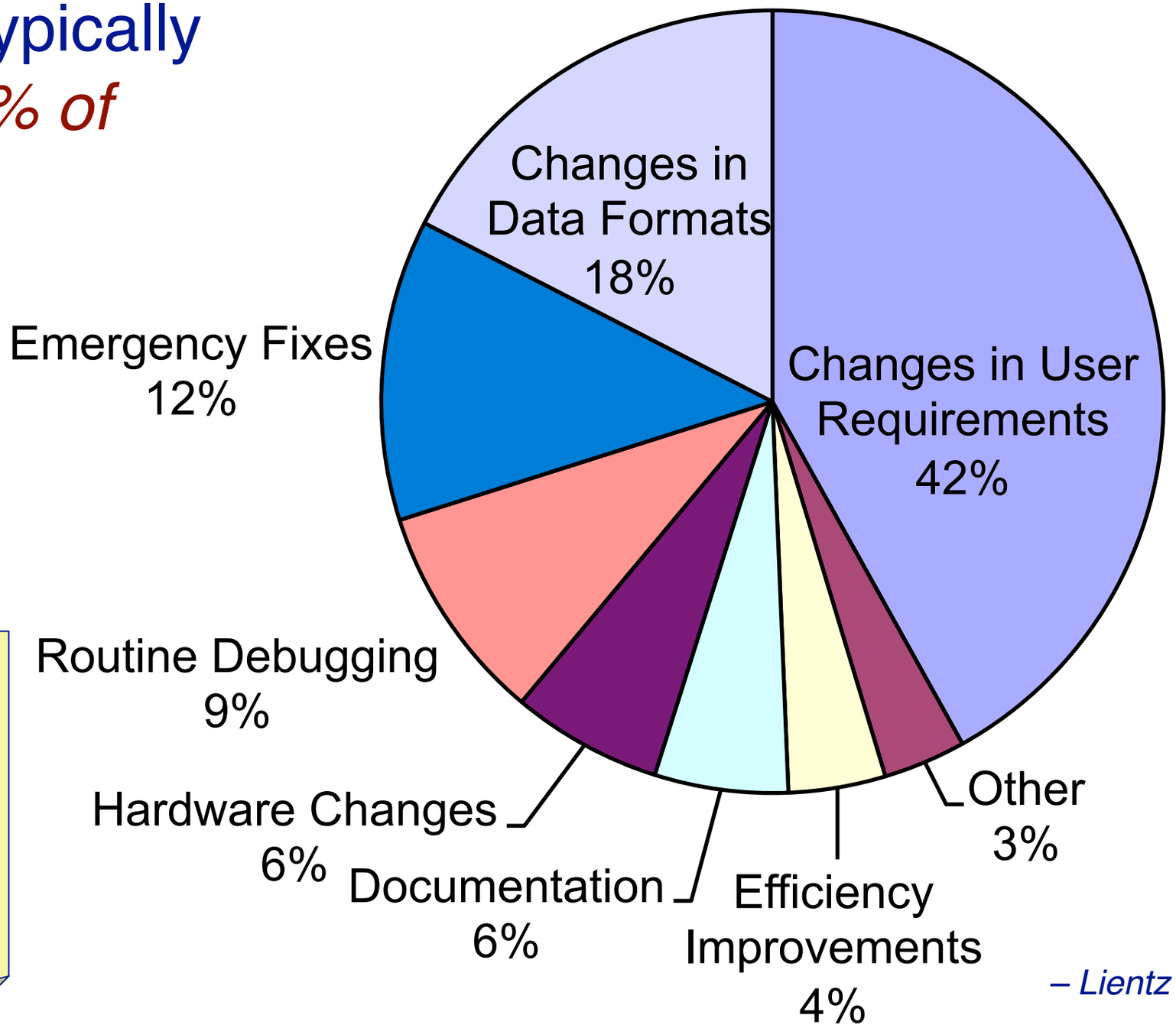
"Maintenance" entails:

- configuration and version management
- reengineering (redesigning and refactoring)
- updating all analysis, design and user documentation

Repeatable, automated tests enable evolution and refactoring

Maintenance costs

"Maintenance" typically accounts for *70% of software costs!*



– Lientz 1979

Means: most project costs concern continued development *after* deployment

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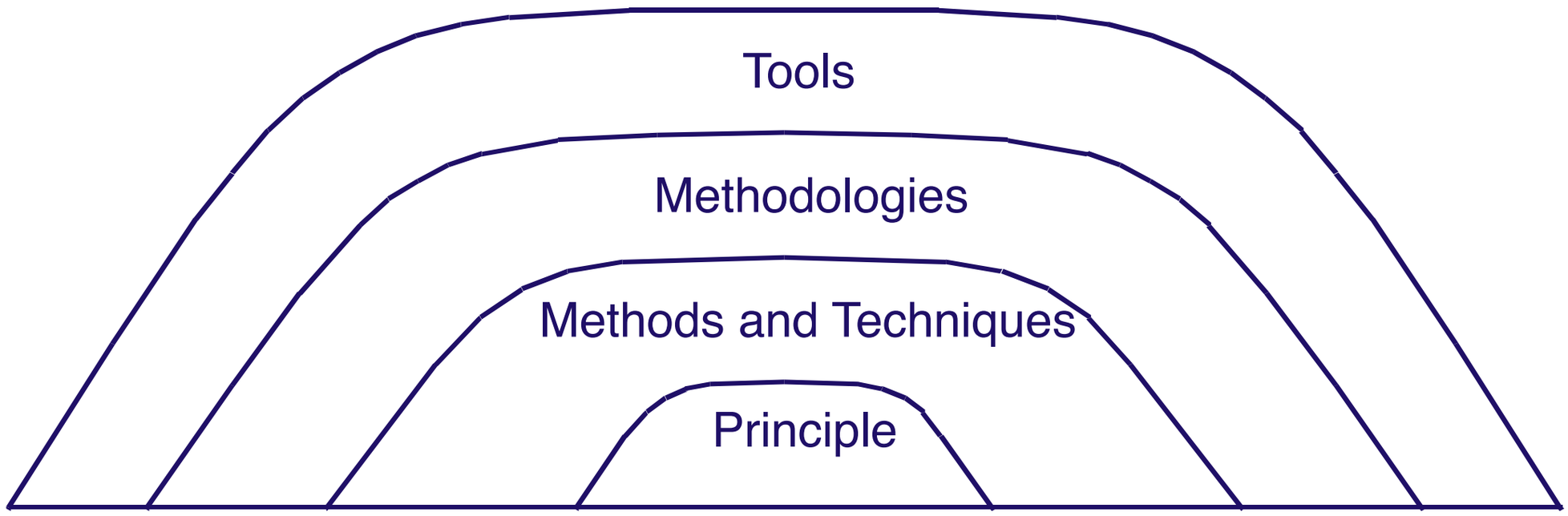
Methods and Methodologies

Principle = general statement describing desirable properties
Method = general guidelines governing some activity
Technique = more technical and mechanical than method
Methodology = package of methods and techniques packaged



— *Ghezzi et al. 1991*

Object-Oriented Methods: a brief history

- **First generation:**
  - Adaptation of existing notations (ER diagrams, state diagrams ...): Booch, OMT, Shlaer and Mellor, ...
  - Specialized design techniques:
    - *CRC cards; responsibility-driven design; design by contract*
- **Second generation:**
  - Fusion: Booch + OMT + CRC + formal methods
- **Third generation:**
  - Unified Modeling Language:
    - *uniform notation: Booch + OMT + Use Cases + ...*
    - *various UML-based methods (e.g. Catalysis)*
- **Agile methods:**
  - Extreme Programming
  - Test-Driven Development
  - Scrum …

What you should know!

- How does Software Engineering differ from programming?
- Why is the “waterfall” model unrealistic?
- What is the difference between analysis and design?
- Why plan to iterate? Why develop incrementally?
- Why is programming only a small part of the cost of a “real” software project?
- What are the key advantages and disadvantages of object-oriented methods?

Can you answer these questions?

- What is the appeal of the “waterfall” model?
- Why do requirements change?
- How can you validate that an analysis model captures users’ real needs?
- When does analysis stop and design start?
- When can implementation start?
- What are good examples of Conway’s Law in action?

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