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Introduction to Software Engineering

Software Process Models



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The **Software (Engineering) Process** is the set of activities and associated results that produce a software product.

- *Requirements specification*

- **Software specification**

Definition of the software to be produced and the constraints of its operation.

- **Software development**

Design and implementation of the software.

- **Software validation**

To ensure that the software does what the customer requires.

- **Software evolution**

Adaptation and modification of the software to cope with changing customer and market requirements.

Software (Engineering) Process Models are simplified and abstract description of a software process that presents one view of that process.

Software Process (Models) | 3

- Process models may include activities that are part of the software process, software products, e.g. architectural descriptions, source code, user documentation, and the roles of people involved in software engineering.
- Examples:
 - The waterfall model
 - The spiral model
 - "V-Modell (XT)" (dt.)
 - eXtreme Programming
 - ...

Large(r) projects may use different (multiple) software process models to develop different parts of the software.

The Waterfall Model



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The Waterfall Model can be considered as a generic process model.

1. Requirements analysis and definition

The requirements are established by consultation with system users.

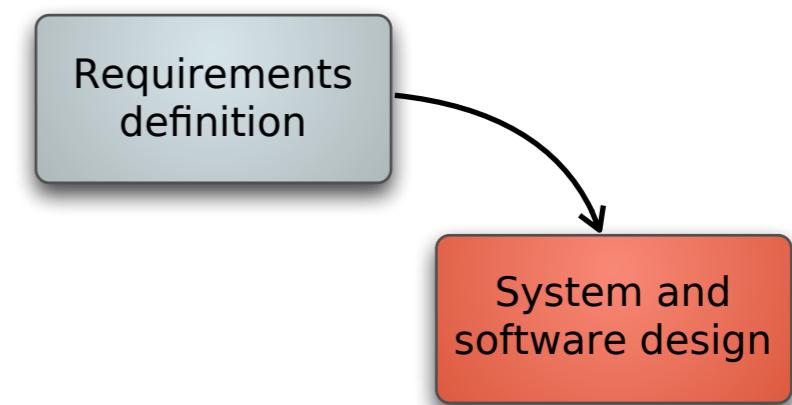
After that they are defined in detail and serve as the system specification.

Requirements definition

The Waterfall Model can be considered as a generic process model.

2. System and Software design

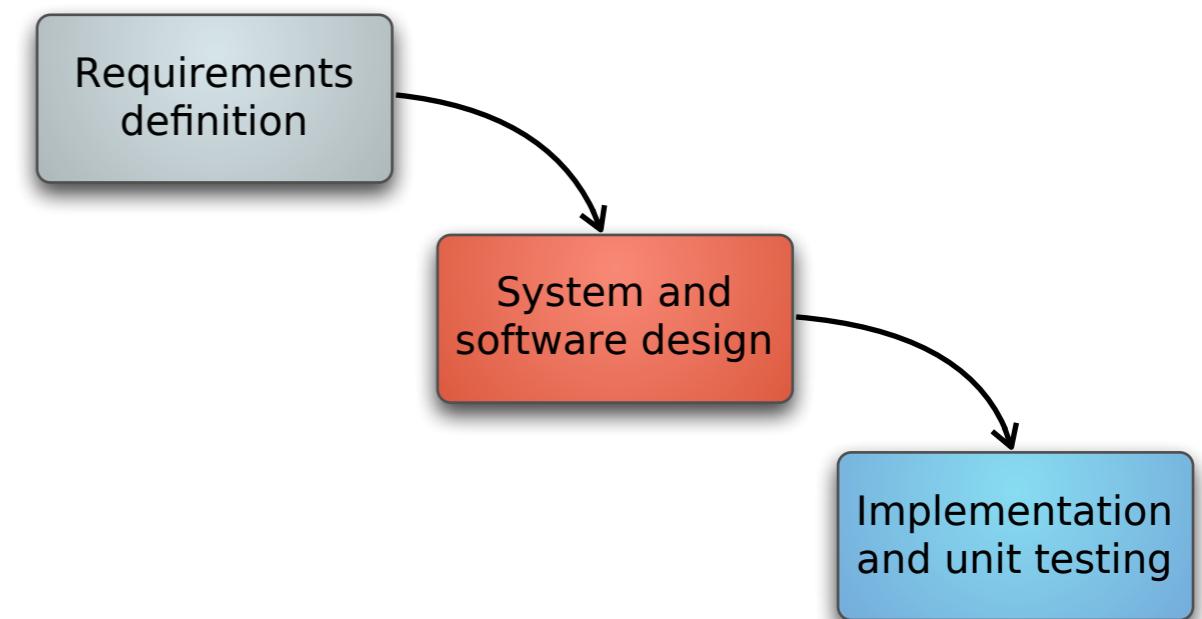
The overall system architecture is defined. The fundamental software system abstractions and their abstractions are identified.



The Waterfall Model can be considered as a generic process model.

3. Implementation and unit testing

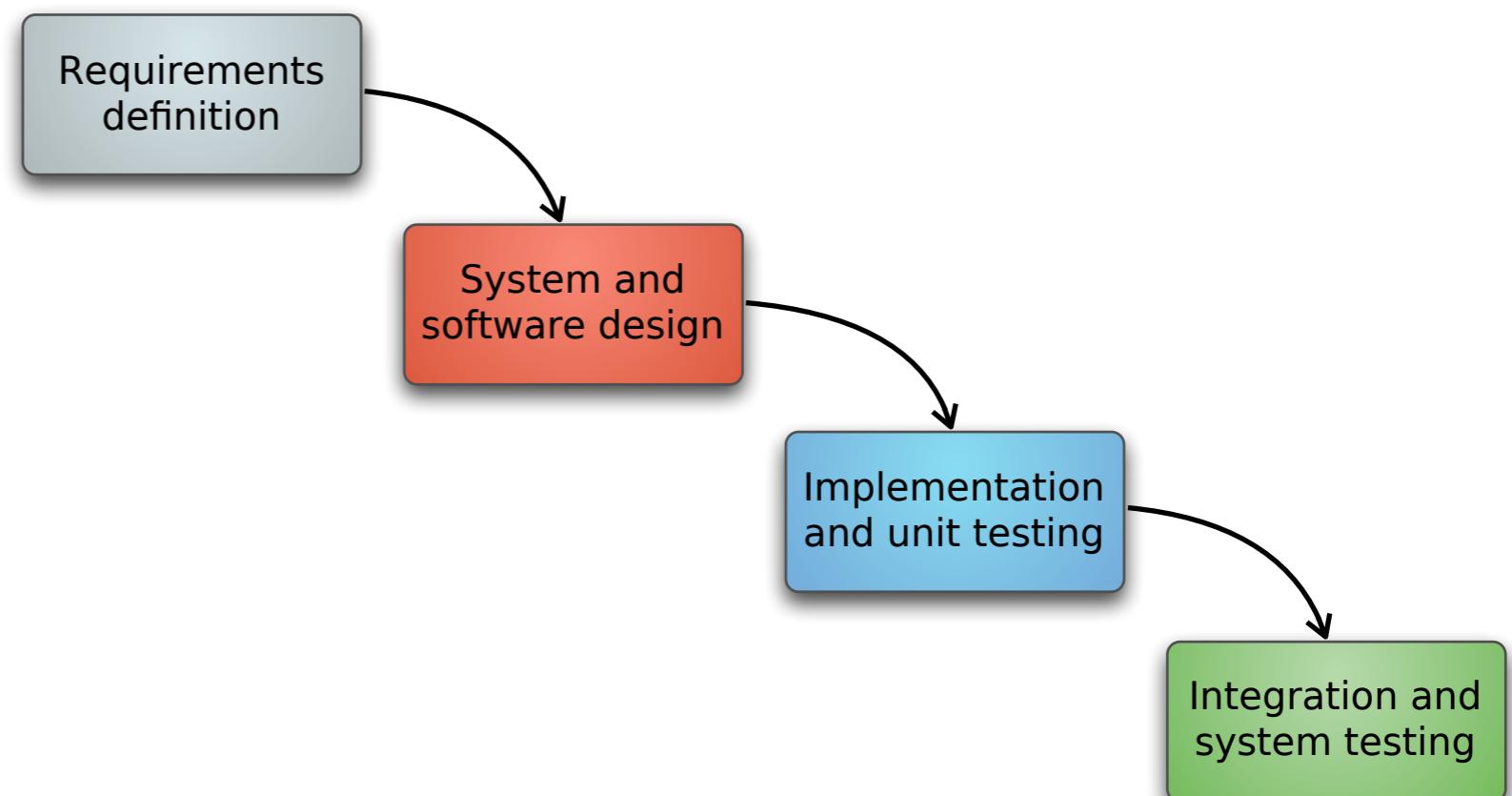
The software design is realized as a set of program units; testing verifies that each unit meets its specification.



The Waterfall Model can be considered as a generic process model.

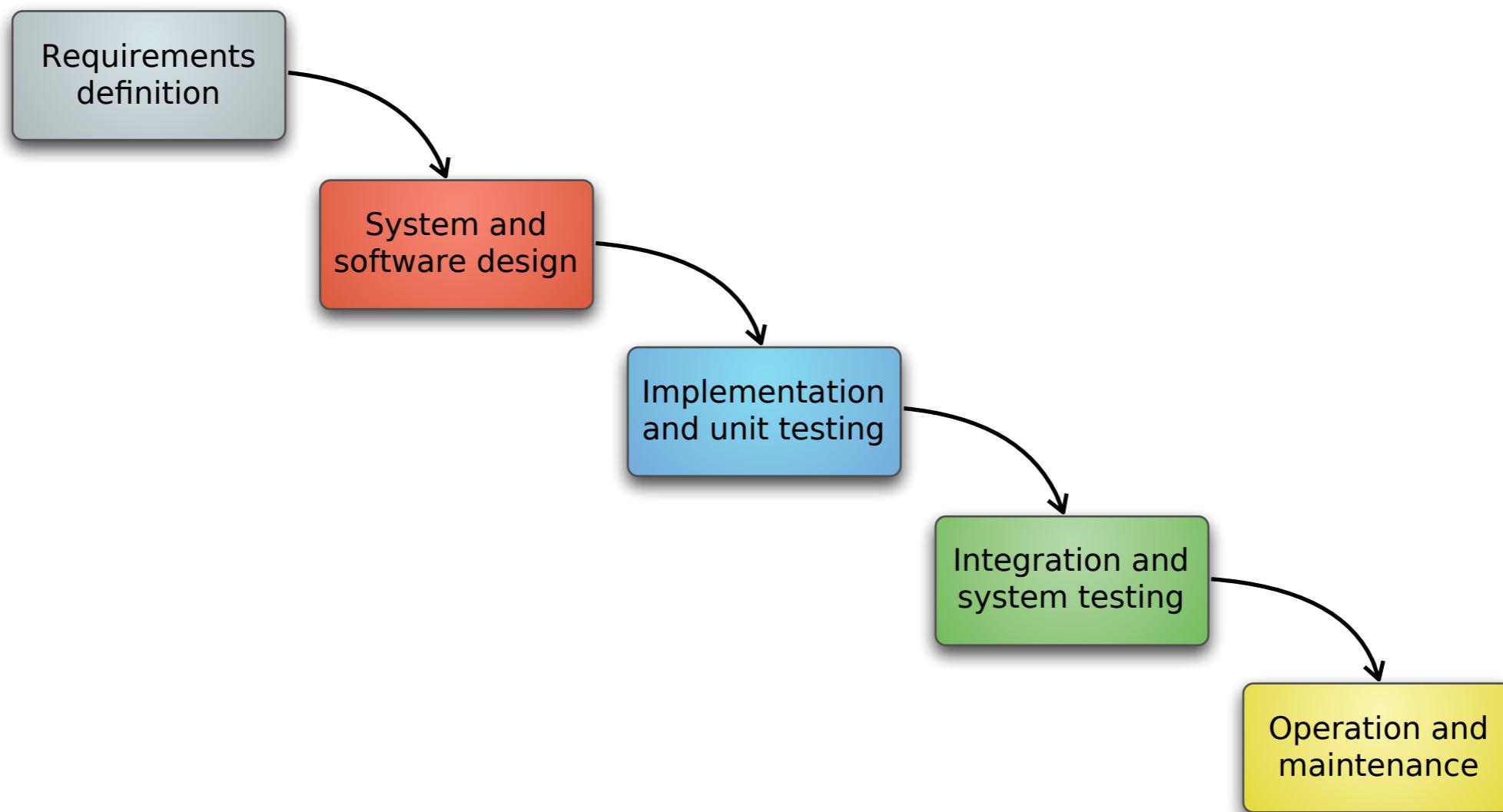
4. Integration and system testing

Program units are integrated and tested as a complete system.



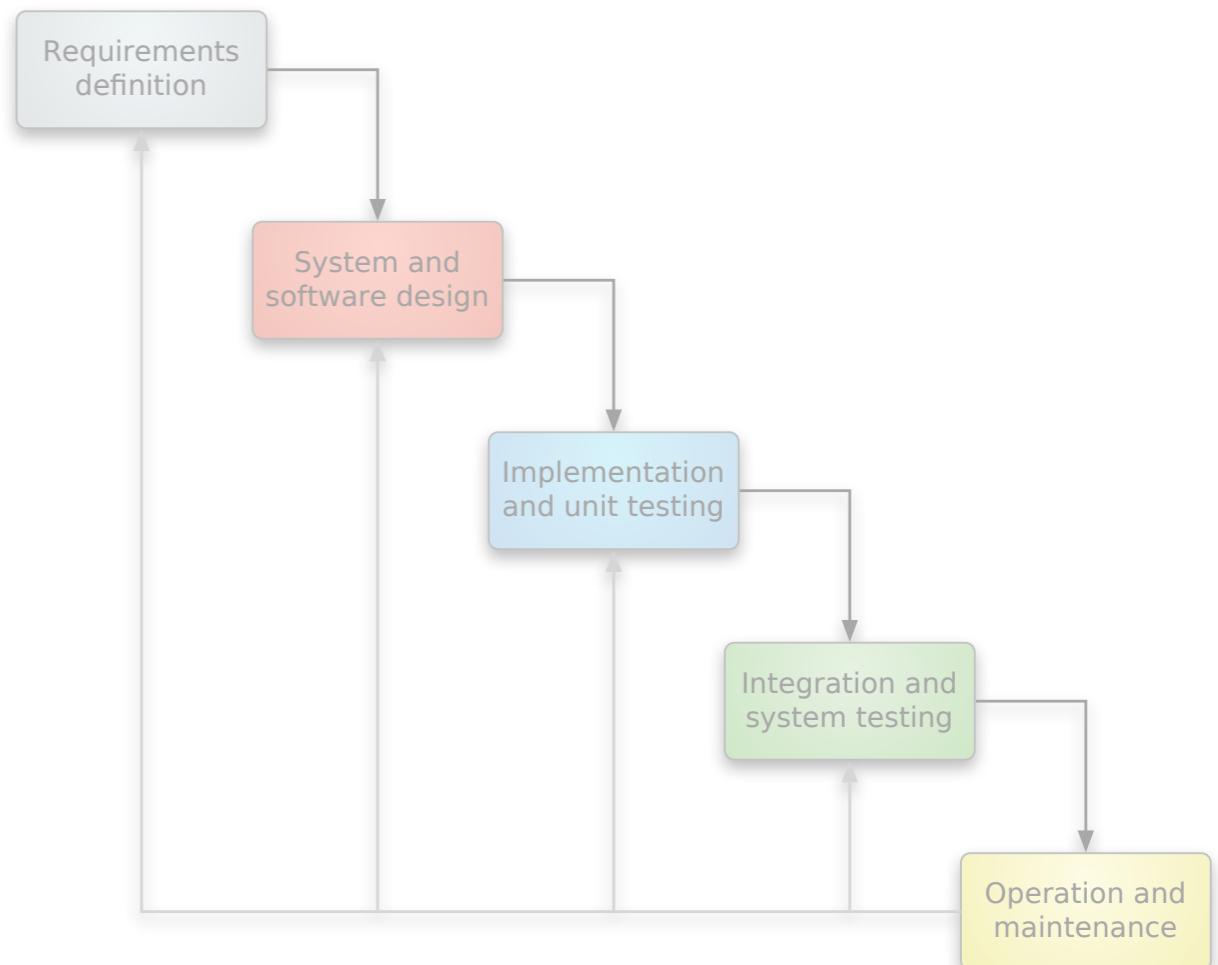
The Waterfall Model can be considered as a generic process model.

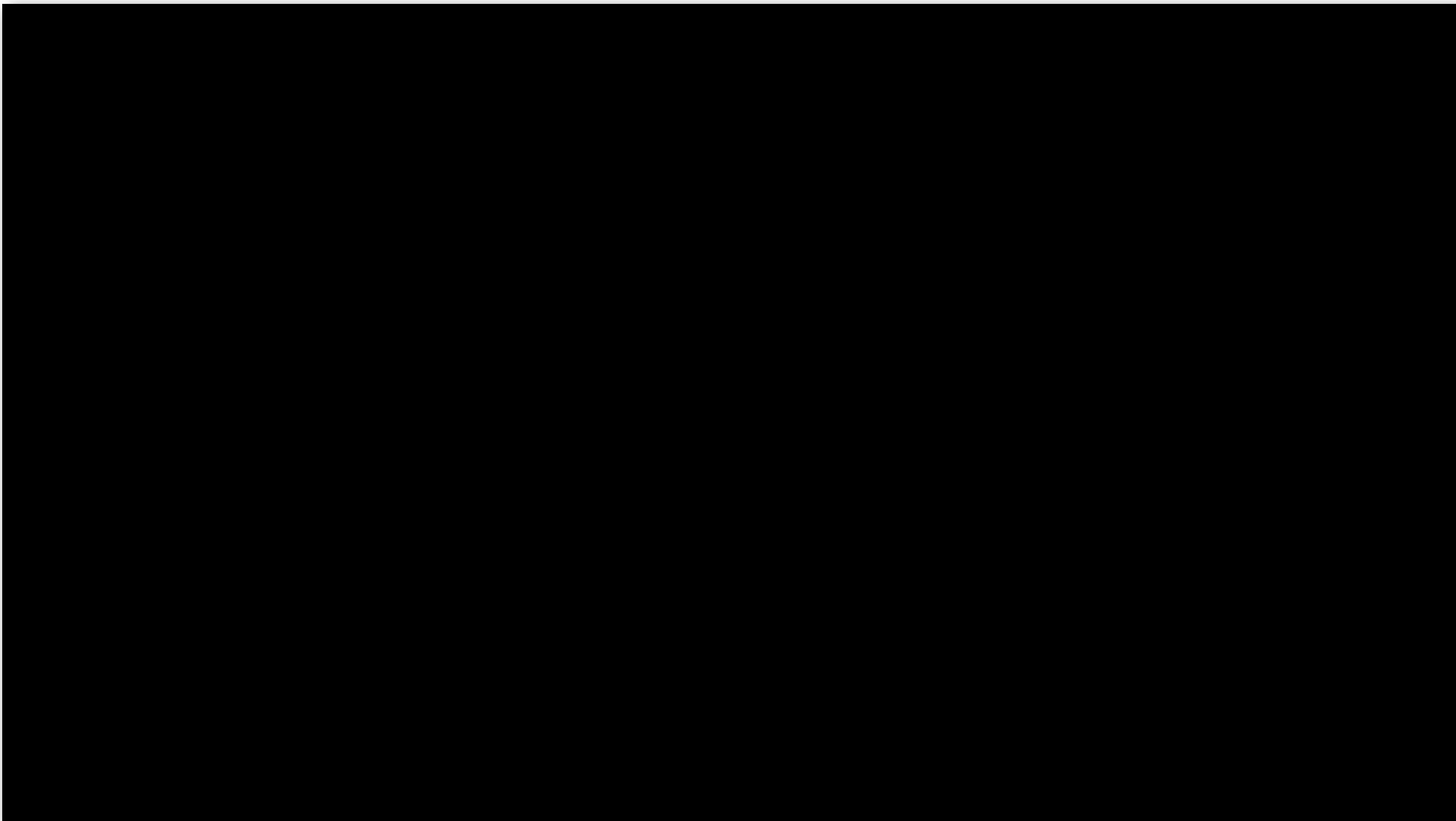
Software Process Models - The Waterfall Model | 10



Key Properties of the Waterfall Model

- The result of each phase is a set of artifacts that is approved.
- The following phase starts after the previous phase has finished.
(In practice there might be some overlapping.)
- In case of errors previous process stages have to be repeated.
- **Fits with other (hardware) engineering process models.**





Agile Development

- Agile Software Development - Principles, Patterns, and Practices; Robert C. Martin; 2003

Im Deutschen wird gelegentlich von “schneller Softwareentwicklung” gesprochen wenn iterative Entwicklung gemeint ist - agile Methoden bauen auf iterativen Ansätzen auf.



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Agile Development - Key Points

Agile Software Engineering Process Models - Agile Development | 14

- The goal is to develop software quickly, in the face of rapidly changing requirements
- Originally conceived for small to mid-sized teams
- To achieve agility we need to ...
 - employ practices that provide the *necessary discipline* and feedback
 - employ design principles that keep “our” software flexible and maintainable
 - know the design patterns that have shown to balance those principles for specific problems

Using an agile method does not mean that the stakeholders will always get what they want. It simply means that they'll be able to control the team to get the most business value for the least cost.

Agile Development

- Manifesto



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Manifesto for Agile Software Development

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Individuals and interactions over process and tools.

The best tools will not help if the team doesn't work together. Start small and grow if needed.

Manifesto for Agile Software Development

Agile Software Engineering Process Models - Agile Development | 18

Working software over comprehensive documentation.

The structure of the system and the rationales for the design should be documented.

Manifesto for Agile Software Development

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Customer collaboration over contract negotiation.

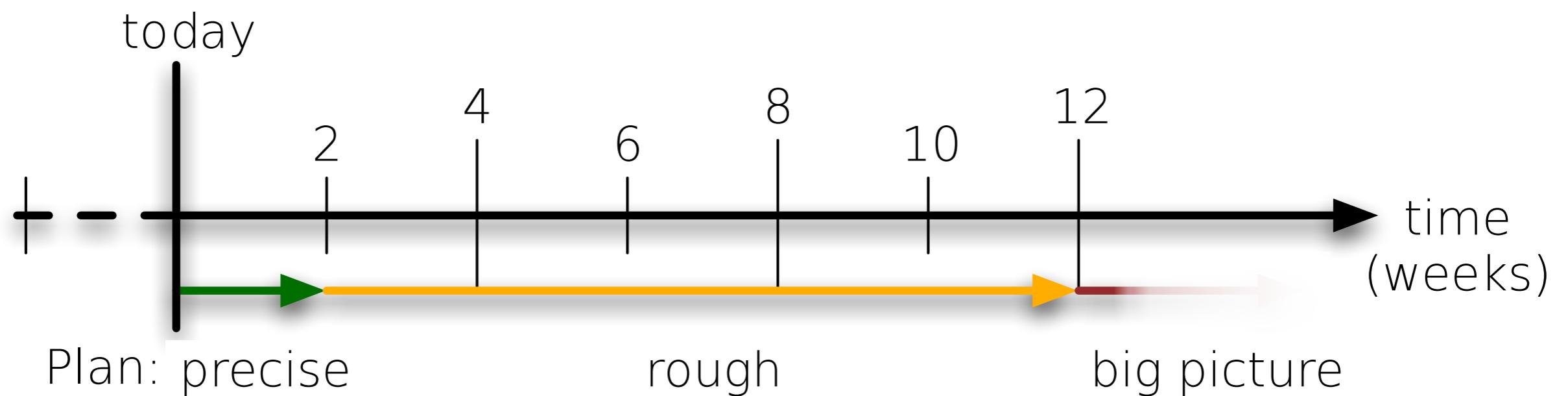
The contract should specify how the collaboration between the development team and the customer looks like.

A contract which specifies a fixed amount of money that will be paid at a fixed date will likely fail.

Manifesto for Agile Software Development

Agile Software Engineering Process Models - Agile Development | 20

Responding to change over following a plan.



Agile Development

- Principles



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Principles of Agile Development

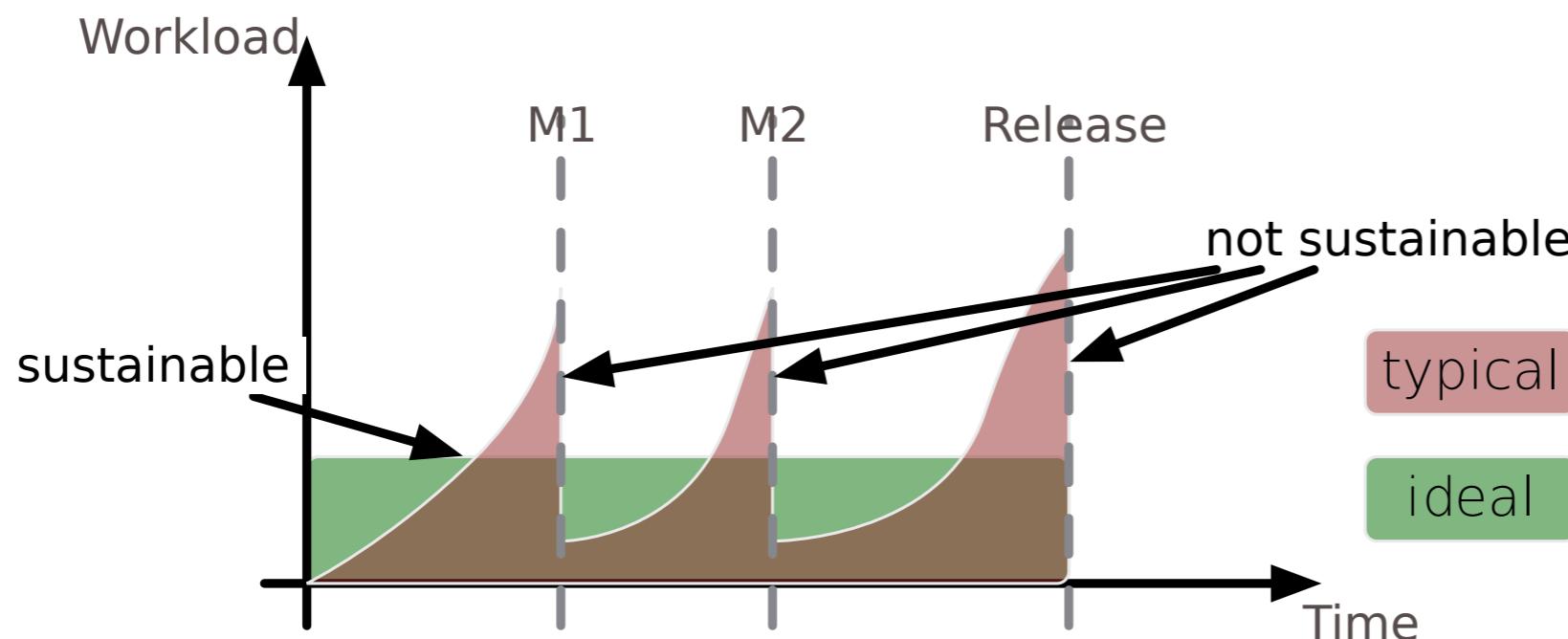
- Our highest priority is to satisfy the customer through **early and continuous delivery of valuable software**
- **Deliver working software frequently** (e.g. every two weeks), from a couple of weeks to a couple of months, with a strong preference to the shorter timescale
- Working software is the primary measure of progress
If 30% of the functionality is implemented, 30% of the project is done.
- Continuous attention to **technical excellence and good design** enhances agility
- **Simplicity** - the art of maximizing the amount of work not done - is essential
- ...

Principles of Agile Development

- ...
- Welcome changing requirements, even late in development; agile processes harness change for the customer's competitive advantage
- At regular intervals, the team **reflects on how to become more effective**, then tunes and adjusts its behavior accordingly
Process Improvement
- The best architectures, requirements, and designs emerge from self-organizing teams

Principles of Agile Development

- Business people and developers must work together daily throughout the project
- Build projects around **motivated individuals**; give them the environment and support they need, and trust them to get the job done
- Agile processes promote **sustainable development**; the sponsors, developers, and users should be able to maintain a constant pace indefinitely



Agile Processes

- SCRUM(~Project Management Method)
- (Agile) Unified Process
- Crystal
- Feature Driven Development
- Adaptive Software Development
- Extreme Programming
- ...

Unified Process

A Very First Glimpse



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Unified Process - Phases

1. Inception (~dt. Konzeption)

Feasibility phase, where just enough investigation is done to support a decision to continue or stop

2. Elaboration (~dt. Entwurf)

The core architecture is iteratively implemented; high risks are mitigated

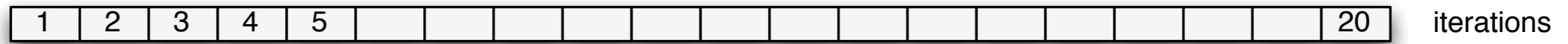
(mitigate =dt. mildern / abschwächen)

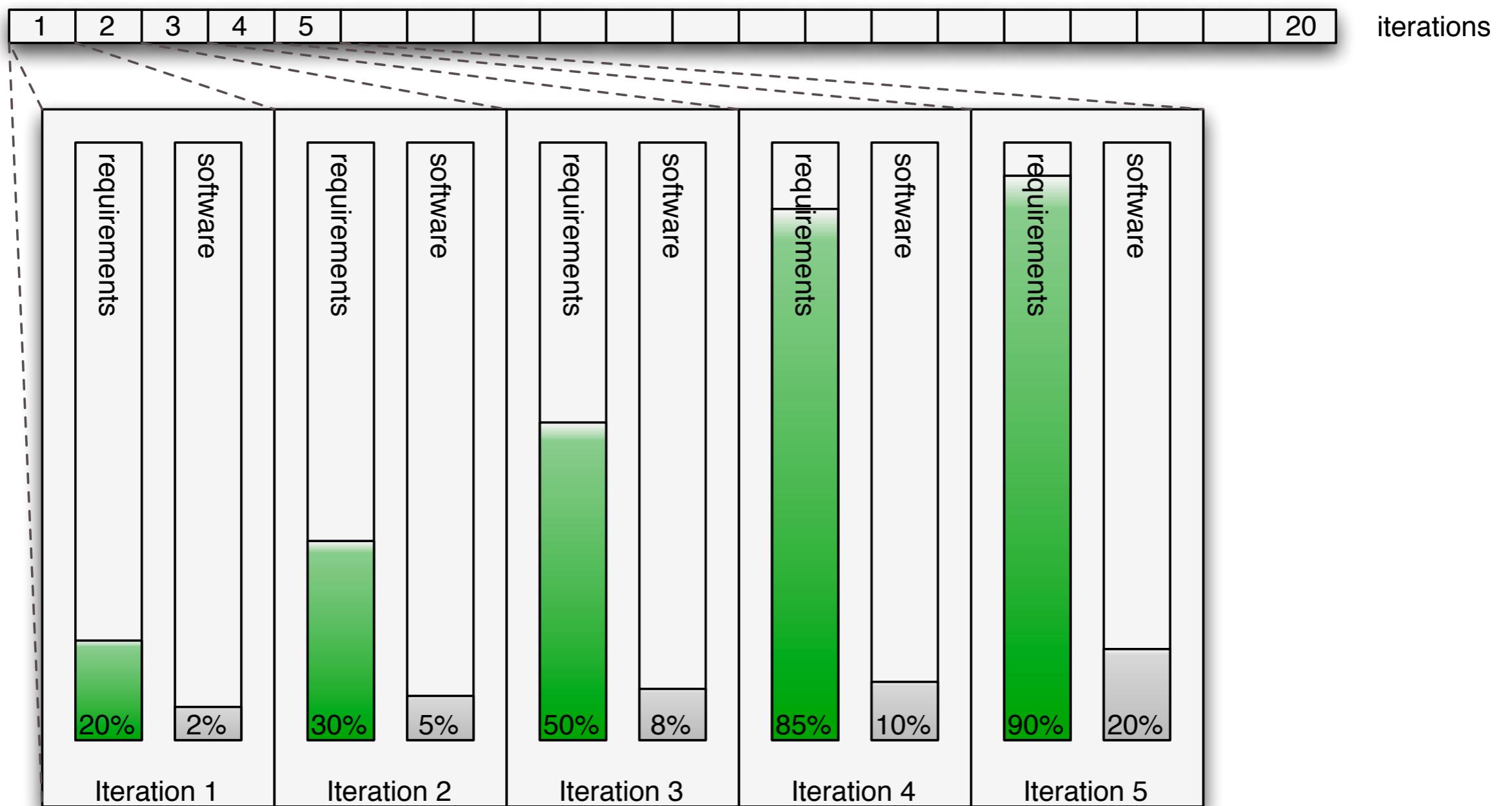
3. Construction (~dt. Konstruktion)

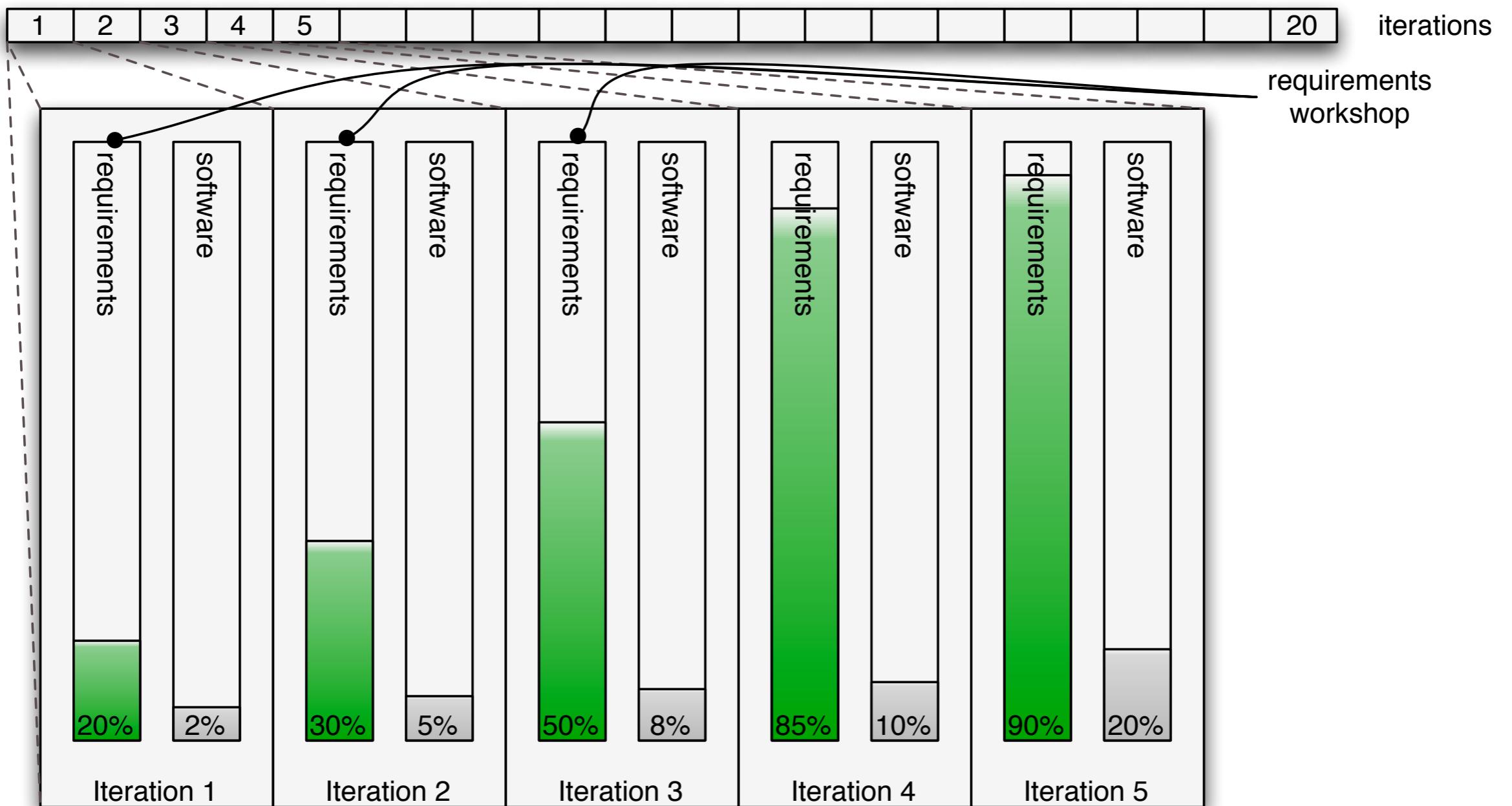
Iterative implementation of remaining lower risk and easier elements, and preparation for deployment

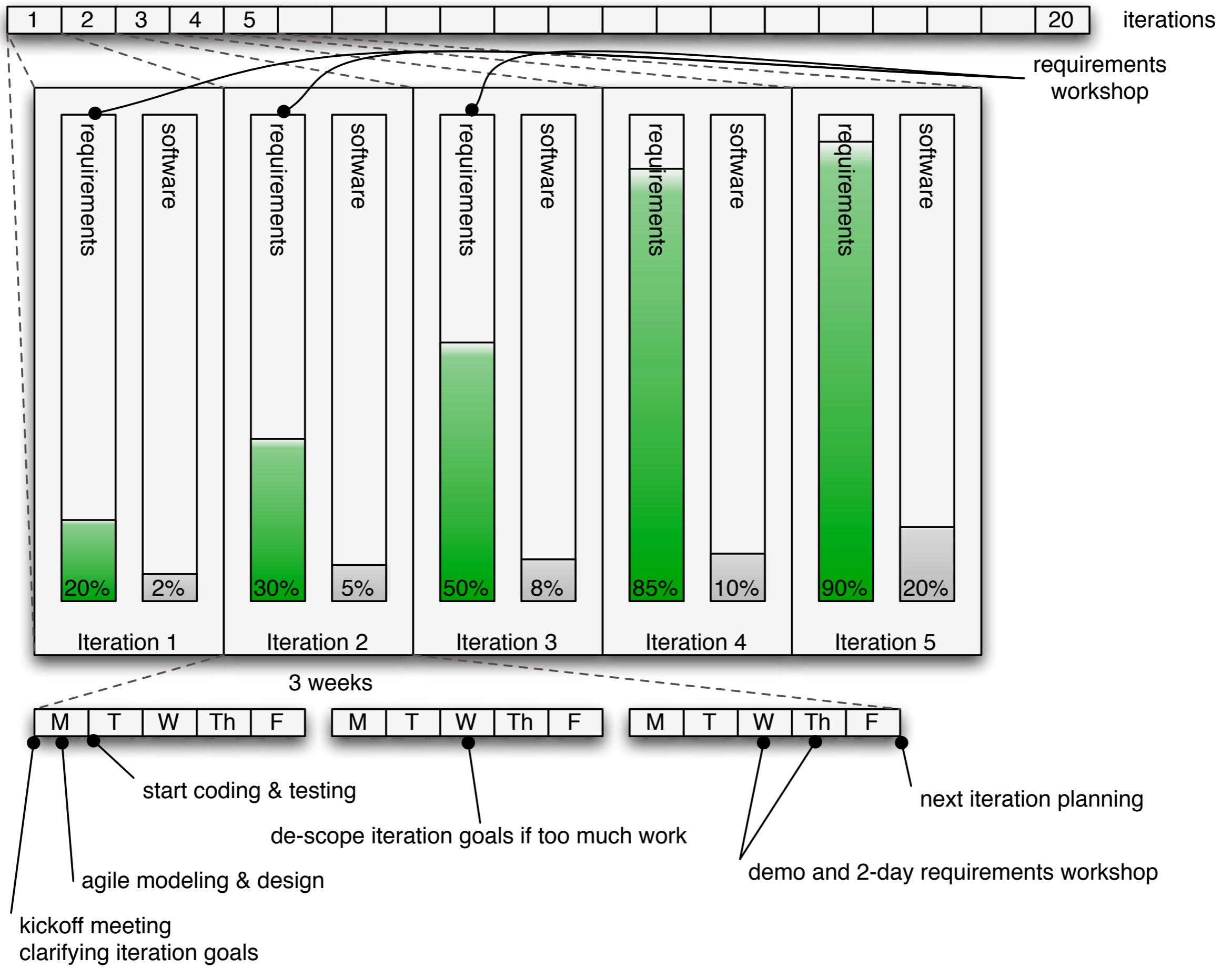
4. Transition (~dt. Übergabe)

Beta tests, deployment









General Practices

- Tackle high-risk and high-value issues in early iterations
- Continuously engage users for evaluation, feedback, and requirements
- *Build a cohesive core architecture in early iterations*
- Continuously verify quality; test early, often, and realistically
- Apply use cases where appropriate
- Do some visual modeling
- Carefully manage requirements
- Practice change request and configuration management

In the following, we assume that **we are on a project that uses the unified process (UP)** as the process model for developing our POS application.

Current Development State

Start of the Elaboration Phase

OOA/D - Case Studies - Setup | 34

- The inception phase is over; we are entering iteration 1 of the elaboration phase
- Most actors, goals and use cases were named
- Most use cases were written in brief format
- ~10-20% of the use cases are written in fully dressed format
- Version one of the vision is available
- Technical proof of concept prototypes were developed (E.g., can Java Swing be used with touch screen?)
- Candidate tools have been identified

Artifacts That May Be Started In the Elaboration Phase

OOA/D - Case Studies - Setup | 35

- **Domain Model**

Visualization of the domain concepts

- **Design Model**

Description of the logical design using class diagrams, object interaction diagrams, package diagrams....

- **Software Architecture Document**

Summary of key architectural issues and their resolution in the design

- **Data Model**

E.g., database schemas, mapping strategies between object and non-object representations



Planning the First Iteration Of the Elaboration Phase

OOA/D - Case Studies - Setup | 36

- Apply the following criteria to rank work across iterations:
 - **Risk**
Tackle high risk issues related to technical complexity, usability,....
 - **Coverage**
Try to touch all major parts of the system in early iterations
 - **Criticality**
Implement functionality of high business value

Ranked Requirements for the POS application

Rank	Requirement (Use Case or Feature)	Comment
High	Process Sale Logging	Pervasive; hard to add late
Medium	Maintain Users	Affects security subdomain
Low

Requirements For the First Iteration Of the POS Application

OOA/D - Case Studies - Setup | 38

- Implement a basic, key scenario of the **Process Sale use case**: entering items and receiving a cash payment
- Implement a start up use case as necessary to support the initialization needs of the iteration
- No collaboration with external services, such as tax calculator or product database
- No complex pricing rules are applied

Extreme Programming



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Practices = dt. Verfahren / Verfahrensregeln

Extreme programming
is made up of a set of
simple, interdependent practices.

Extreme Programming - Practices

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Customer Team Member

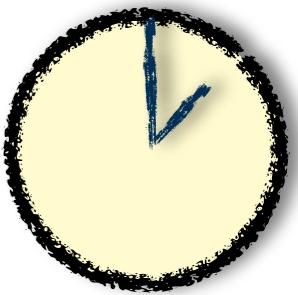
Customer is the person (or group) who defines and prioritizes features. The customers are members and available to the team.

Extreme Programming - Practices

Software Engineering Process Models | 42

User Stories

Requirements are talked over with the customer but only a few words that reminds everybody of the conversation are written on an index card along with an estimate.



Extreme Programming - Practices

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Short Cycles

Working software is delivered every, e.g., two weeks (an iteration); the delivered software may or may not be put into production.

Iterations are timeboxed - date slippage is illegal; if you cannot complete all tasks scheduled for the iteration remove some.



Extreme Programming - Practices

Short Cycles



Iteration Plan

During each iteration the user stories and their priorities are fixed.

The customer selects the user stories they want to have implemented. The number of stories is limited by the budget, which is set by the developers.



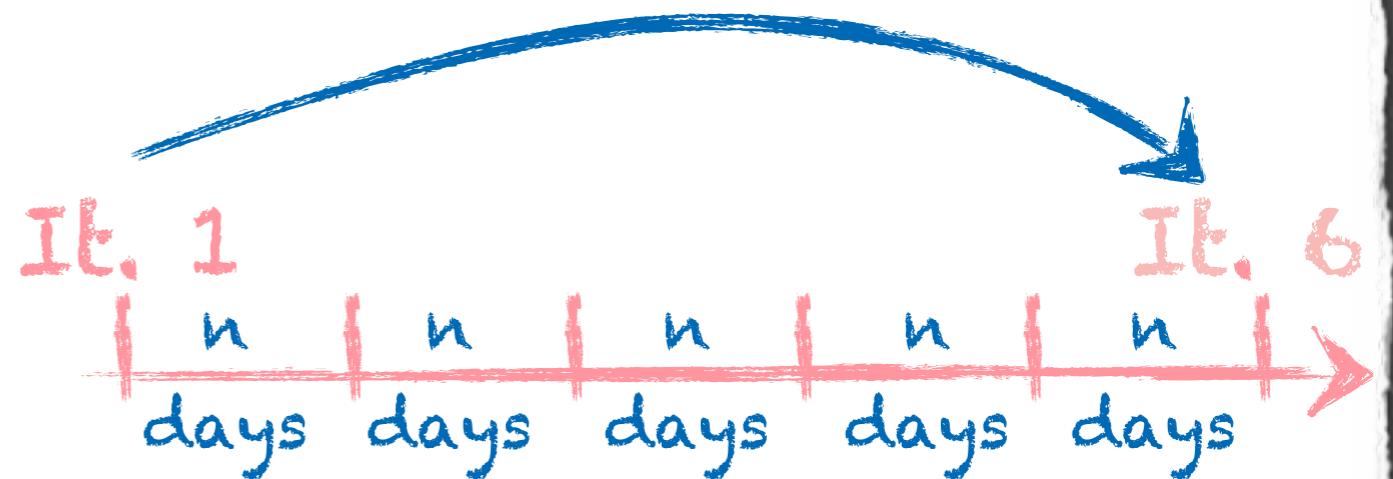
Extreme Programming - Practices

Short Cycles



Release Plan

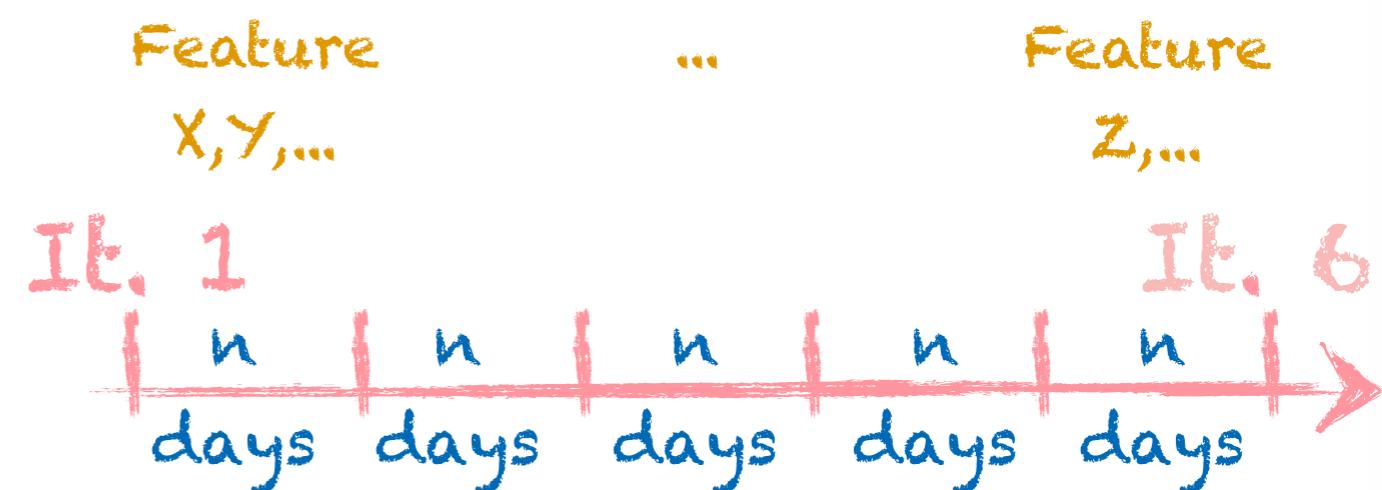
Maps out approx. six iterations. Can always be changed.



Extreme Programming - Practices

The Planning Game

Division of responsibility between business and development. Business people decide how important a feature is and the developers decide how much that feature will cost to implement.



Extreme Programming - Practices

Acceptance Tests

Details of the user stories are captured in the form of acceptance tests.

Acceptance tests are written before or concurrent with the implementation of a user story.

Once an acceptance test passes, it is added to the set of passing acceptance tests and is never allowed to fail again.

Acceptance tests are (ideally) black-box tests developed by the customer.

Extreme Programming - Practices

Pair Programming

The code is written by pairs of programmers; one types the code and the other member watches the code being typed - the keyboard is moved between the developers. The pairs change after half a day to make sure that the knowledge is spread.

Collective Ownership

The team owns the code. A pair has the right to check out any module.

Extreme Programming - Practices

Software Engineering Process Models | 49

Refactoring

Do frequent refactorings to avoid that the code “rots” due to adding feature after feature.

Refactoring means improving the structure **without changing behavior.**

Extreme Programming - Practices

Software Engineering Process Models | 50

Test-Driven Development

All code is written to make failing (unit) tests pass! Having a (very) complete body of test cases facilitates refactorings and often (implicitly) leads to less coupled code.

These tests are white-box unit tests developed by the "developers".

Extreme Programming - Practices

Software Engineering Process Models | 51

Continuous Integration

Programmers check in their code and integrate several times per day; non-blocking source control is used. After check-in the system is build and every test (including running acceptance tests) is run.

Extreme Programming - Practices

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Sustainable Pace

No overtime; except in the very last week before a release.

Open Workspace

The team works together in an open room.

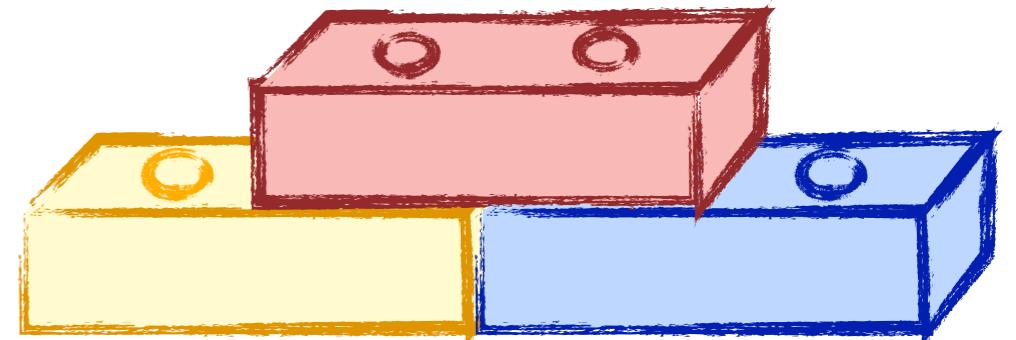
Extreme Programming - Practices

Software Engineering Process Models | 53

Simple Design

Make the design as simple and expressive as possible.
Focus on the current set of user stories; don't worry
about future user stories.

E.g. only add the infrastructure when a story forces it.



Extreme Programming - Practices

Consider the simplest thing that could possibly work
Find the simplest design option for the current set of user stories.

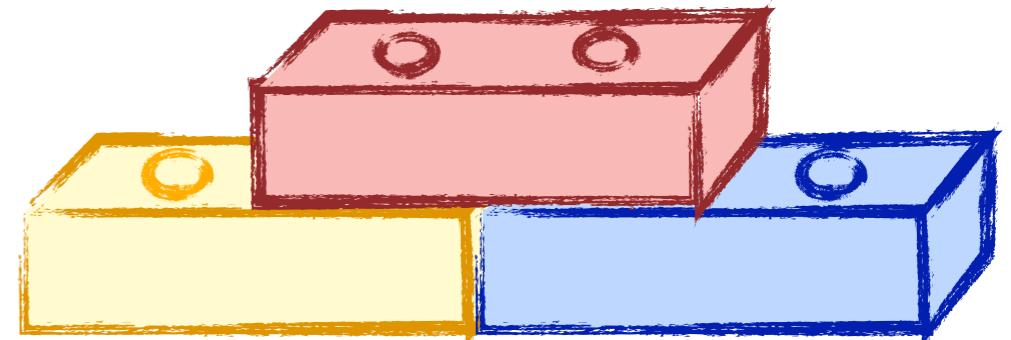
You aren't going to need it

Add infrastructure only if there is proof or at least compelling evidence.

Once and only once

Don't tolerate code duplication;
eliminate code redundancies by creating
abstractions. Employ patterns to remove
redundancies.

Simple
Design



Extreme Programming - Planning

- Initial Exploration (Start of the Project)
 - Developers and customers try to identify all significant user stories; i.e., they do not try to identify all stories
 - The developers estimate - relative to each other - the stories by assigning **story points**; a story with twice as much points as another story is expected to take twice as long to implement
 - To know the true size we need the **velocity** ($\text{velocity} = \text{time required per story point}$)
The velocity will get more accurate as the project proceeds; initially it is just guessed based on "experience"

A prototype developed to measure the velocity is called a **spike**.

Extreme Programming - Planning

- **Release Planning**

- Developers and customers agree on a date for the first release (2-4 months)
- The customers pick the stories and the rough order; a customer cannot choose more stories than the current velocity enables
- As the velocity becomes more accurate the release plan (i.e. the number of user stories) will be adjusted

An Example Release Plan For a Travel Booking Project

Extreme Programming | 57

Story	Time Estimate	Assigned Iteration	Assigned Release
Find lowest fare.	3	2	1
Show available flights.	2	1	1
Sort available flights by convenience.	4		2
Purchase ticket.	2	1	1
Do customer profile.	4		
Review itineraries	1	2	1
...

Extreme Programming - Planning

- **Iteration Planning**

- The customer picks the stories for the iteration
- The order of the stories within the iteration is a technical decision
- The iteration ends on the specified date (timeboxed), even if all stories aren't done
- The estimates for all the stories are totaled and the velocity for that iteration is calculated
- The planned velocity for each iteration is the measured velocity of the previous iteration

Extreme Programming - Planning

- **Task Planning**

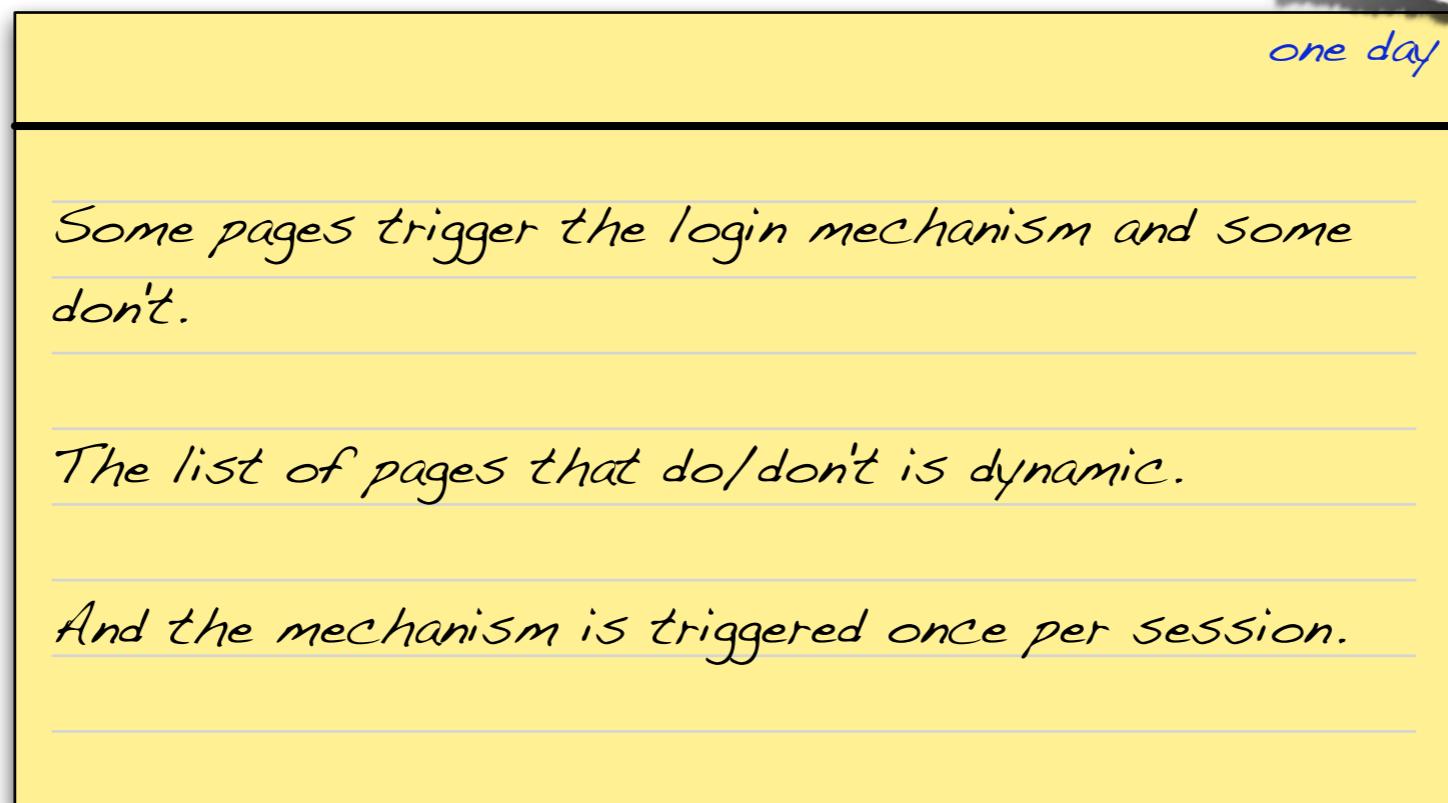
- At the start of each iteration the developer and customers get together to plan
- The stories are broken down into tasks which require between 4 and 16 hours to implement
- Each developer signs up for tasks
A developer can choose an arbitrary task - even if he is not an expert

Example: User Stories for a Web Application



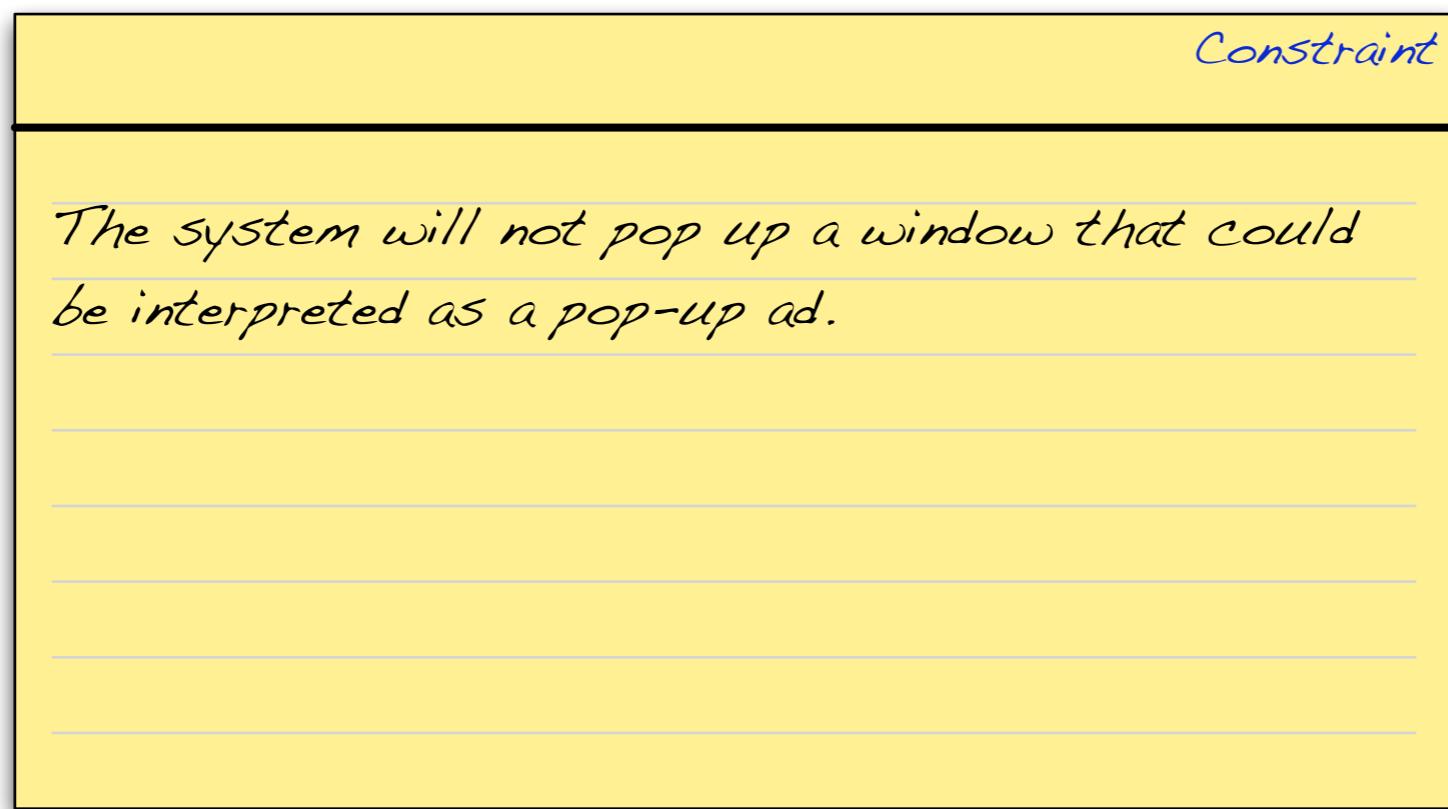
James Newkirk and Robert C. Martin
Extreme Programming in Practice; Addison Wesley, 2001

Example: User Stories for a Web Application



Estimates (upper right corner) are given in ideal days in this case

Example: User Stories for a Web Application



Example: User Stories for a Web Application

Login Story - two days

When the login is triggered, and the site cannot detect that the user is a member, the user is transferred to a login page, which asks for their username and password and explains the login process & philosophy of the site.

Breaking down stories into tasks.

The story is broken up into tasks.

Login Start

Read cookie.
If present
Display login ack. with user e-mail address and option to login as someone else.
else
Bring up login page.

Login Task

Takes data from HTML input. Checks the database for e-mail and password. Stores cookie if selection has been made. Routes to URL from where you came from if successful. Creates session. If not successful, back to login with message indicating failure.

...

Example: User Stories for a Web Application

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for e-mail and password. Stores cookie if
selection has been made. Routes to URL from
where you came from if successful. Creates
session. If not successful, back to login with
message indicating failure.

Principles of Good Stories

- Stories must be understandable to the customer
- Each story must provide something of value to the customer
- Stories need to be of a size that you can build a few of them in each iteration
- Stories should be independent
- Each story must be testable

Established Templates for User Stories

- *Long template:*

"As a **<role>**, I want **<goal/desire>** so that
<benefit>"

- *Shorter template:*

"As a **<role>**, I want **<goal/desire>**"

Different types of systems need different development processes.

E.g. software used in an aircraft has to be developed using a different development process as an e-commerce web page. An operating system has to be developed differently from a word processor.

In large software systems different parts may be developed using different process models.

The one software process does not exist.

Software Process Models | 68

Processes have to exploit the capabilities of the people in an organization and the specific characteristics of the systems that are being developed.

Summary

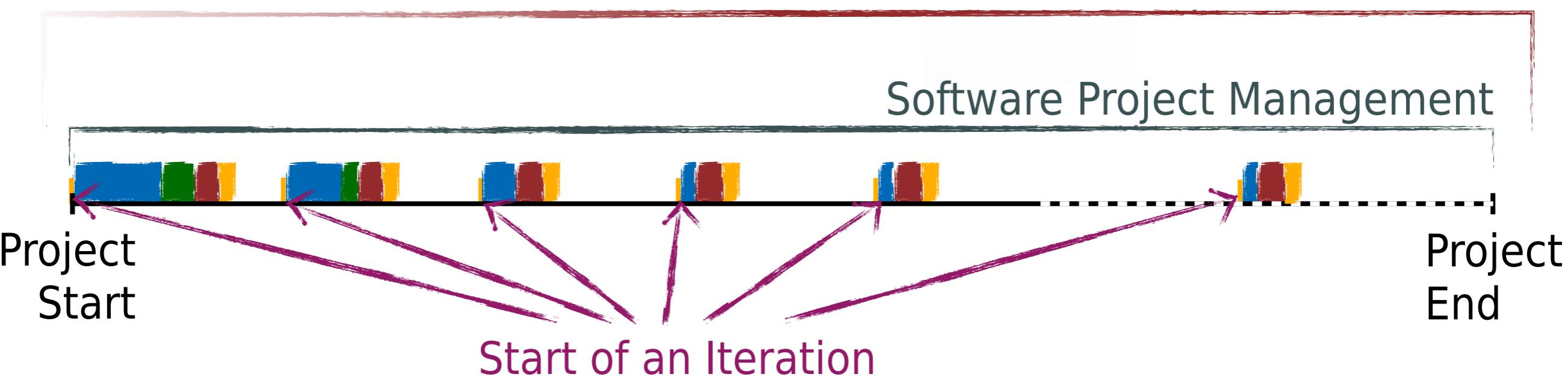


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The goal of this lecture is to enable you to systematically carry out small(er) software projects that produce quality software.

-
- To systematically develop software, you have to follow a well-defined process that suites the needs of the project under development.
 - It is practically impossible to work out all requirements right at the beginning of a project.

The goal of this lecture is to enable you to systematically carry out small(er) commercial or open-source projects.



■ Requirements Management

■ Domain Modeling

■ Modeling

■ Testing