

IN5140 – Smart processes and agile methods in software engineering

**Lecture 25 August 2025:
Standard software process
models. Frameworks for
process improvement.**

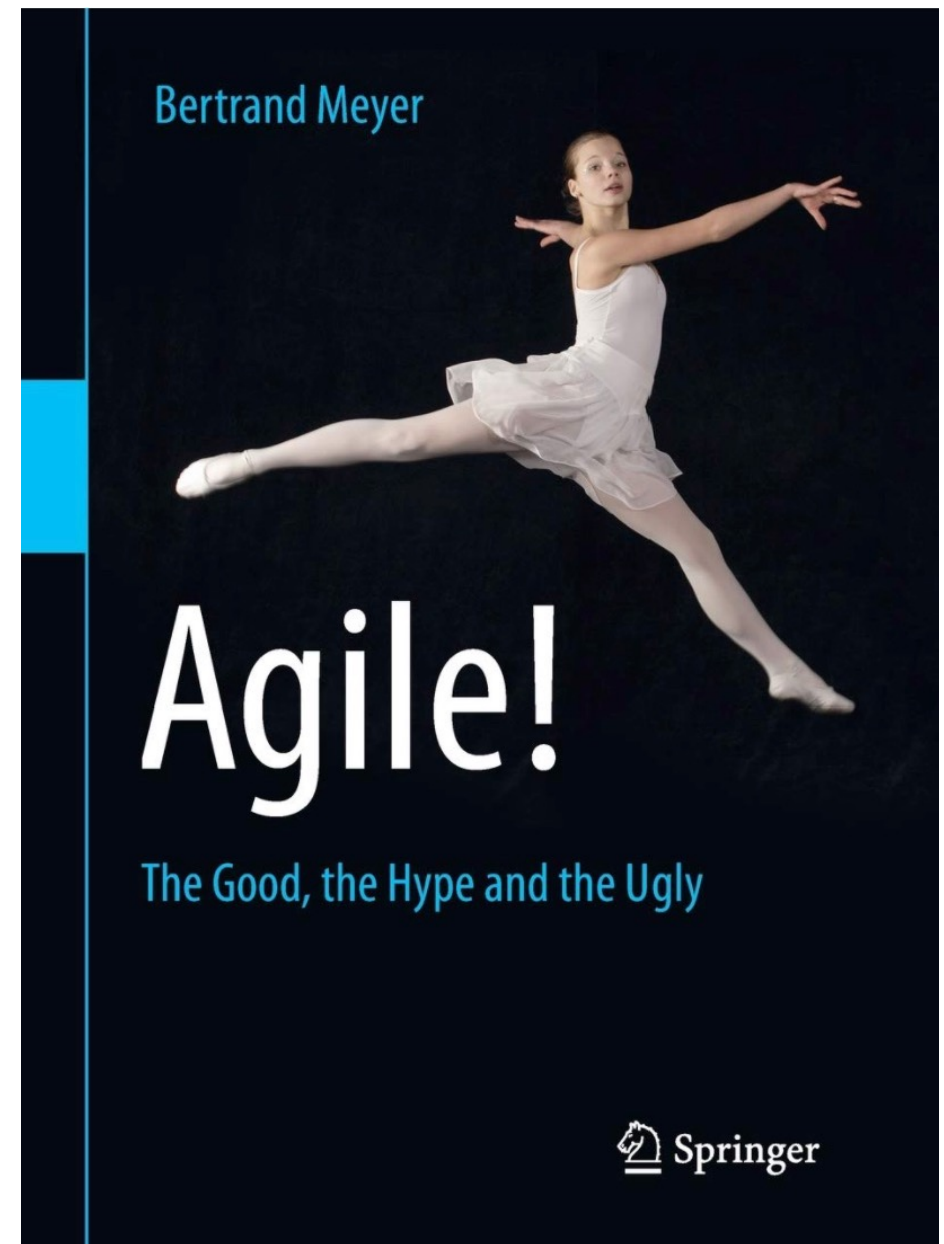


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Syllabus

- References to “book” →
- The whole book is syllabus apart from sections explicitly stated excluded
 - Informal style
 - Useful for making questions and comments
- The slides of the lectures are also syllabus



Structure of this lecture

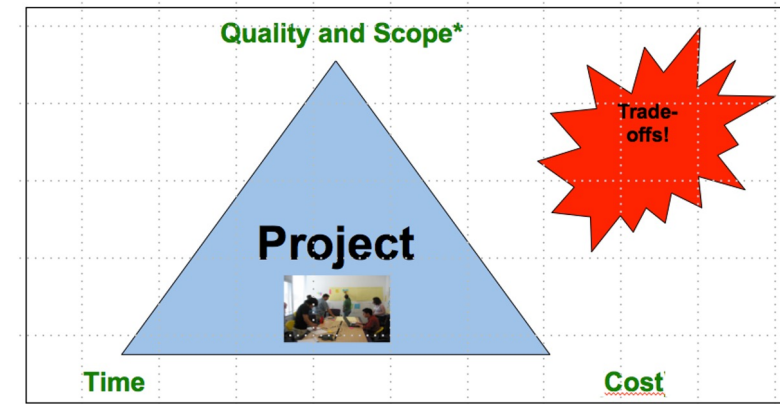
- Software process and process model
- Standard process models
- Choosing, adapting and improving software process models
- Frameworks/models for process improvement



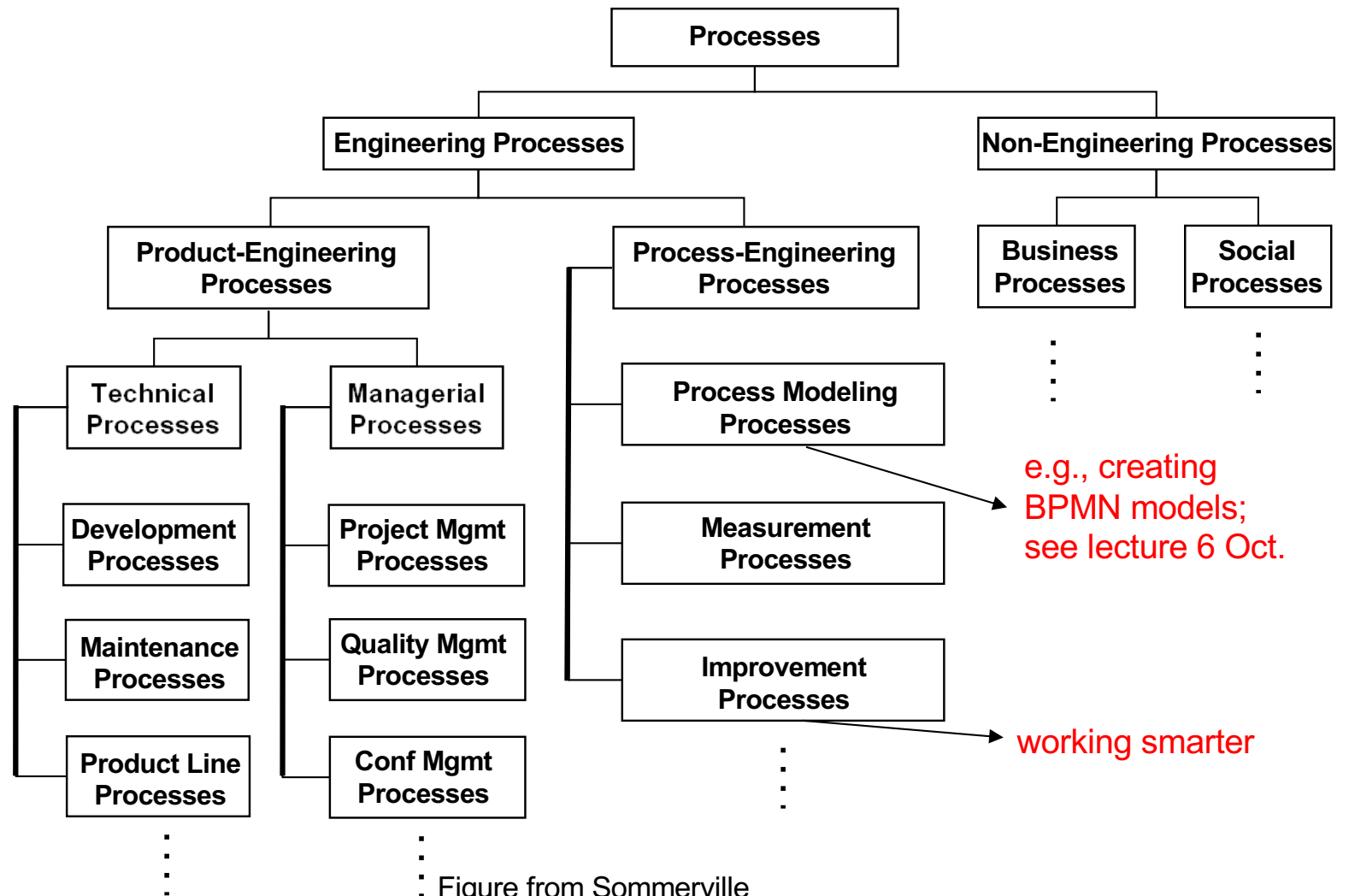
Software process

(Work) process: what is done by whom when and how?

- The great challenge in software development: Designing and implementing efficient work processes and practices that support developing software within acceptable
 - time
 - quality
 - cost
- Every software organization and project need to consider:
 - how should the work be organized?
 - which and how should activities be conducted?
 - what should be produced (software, documents, data, etc.)?

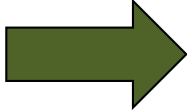


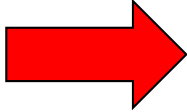
Taxonomy of work processes



Discuss with the person beside you for two minutes which processes affect you as a student at the University of Oslo.

Are there any processes that could or should be improved?

Good processes  **Successful organization**

Poor processes  **Unsuccessful organization**

Obvious?

Real process vs. model of a process

- System development process (=actual, real process)
 - Those activities that are carried out in a development project
- Process model (= formal process)
 - An abstract representation of a process. The model describes the process from a particular perspective
- A process model may be
 - Descriptive: describes an *actual* process
 - Prescriptive (normative): describes a process the way *it should be**
(*model for*)

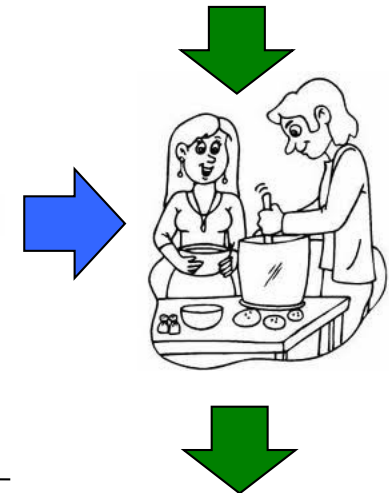
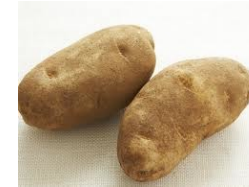
See book pages 41, 42, 49

*The term “Process model” is mostly used in the prescriptive meaning, also in this course

'Process' versus 'Process Model'

Lee Osterweil:

"While a process is a vehicle doing a job, a process description is a specification of how the job is to be done. Thus, cookbook recipes are process descriptions while the carrying out of the recipes are processes."



Why process models are important

- They accumulate knowledge from former processes
- They guide work
- They are useful for improving processes

You should be able to describe/model what you are doing (descriptive)

“If you can't describe what you are doing as a process, you don't know what you are doing”

— W. Edwards Deming

– and then it's difficult to improve ...

How do you study?

Can you describe it?

Do you know how to improve it?

Repetition from IN1030:

Generality of process models

Standard process models (waterfall, V-model, Scrum, etc.)



General for all software development

Company/group process models



Tailored to a
company/department/group

Project process models

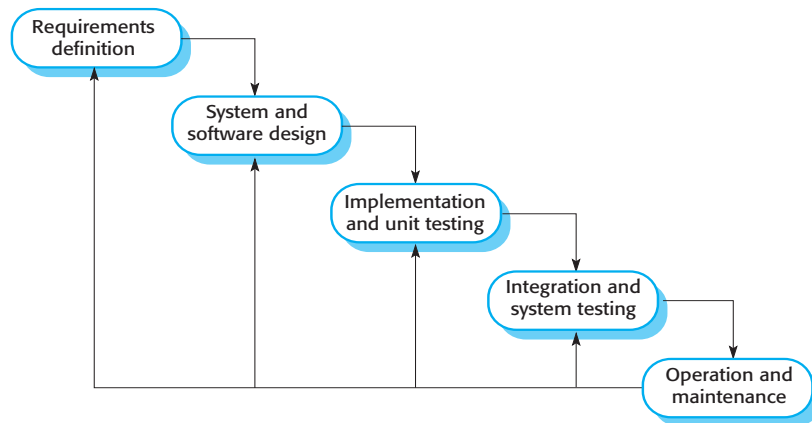
Tailored to a given project/situation
(for example, using BPMN)

Structure

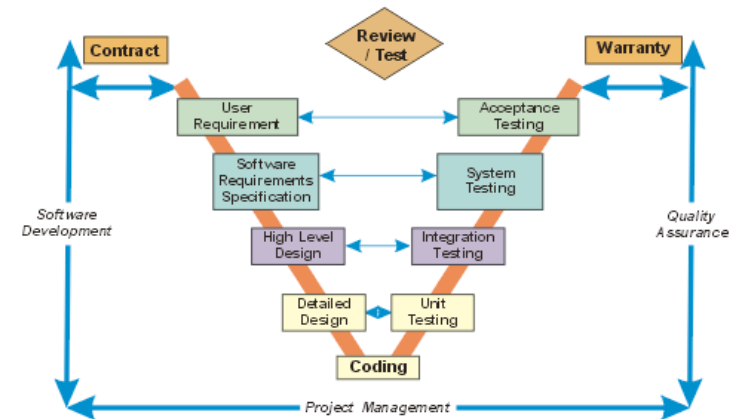
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Well-known standard software process (lifecycle) models

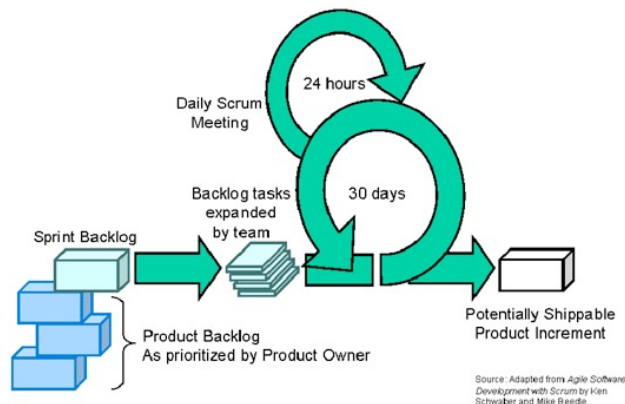
Waterfall



V-Model



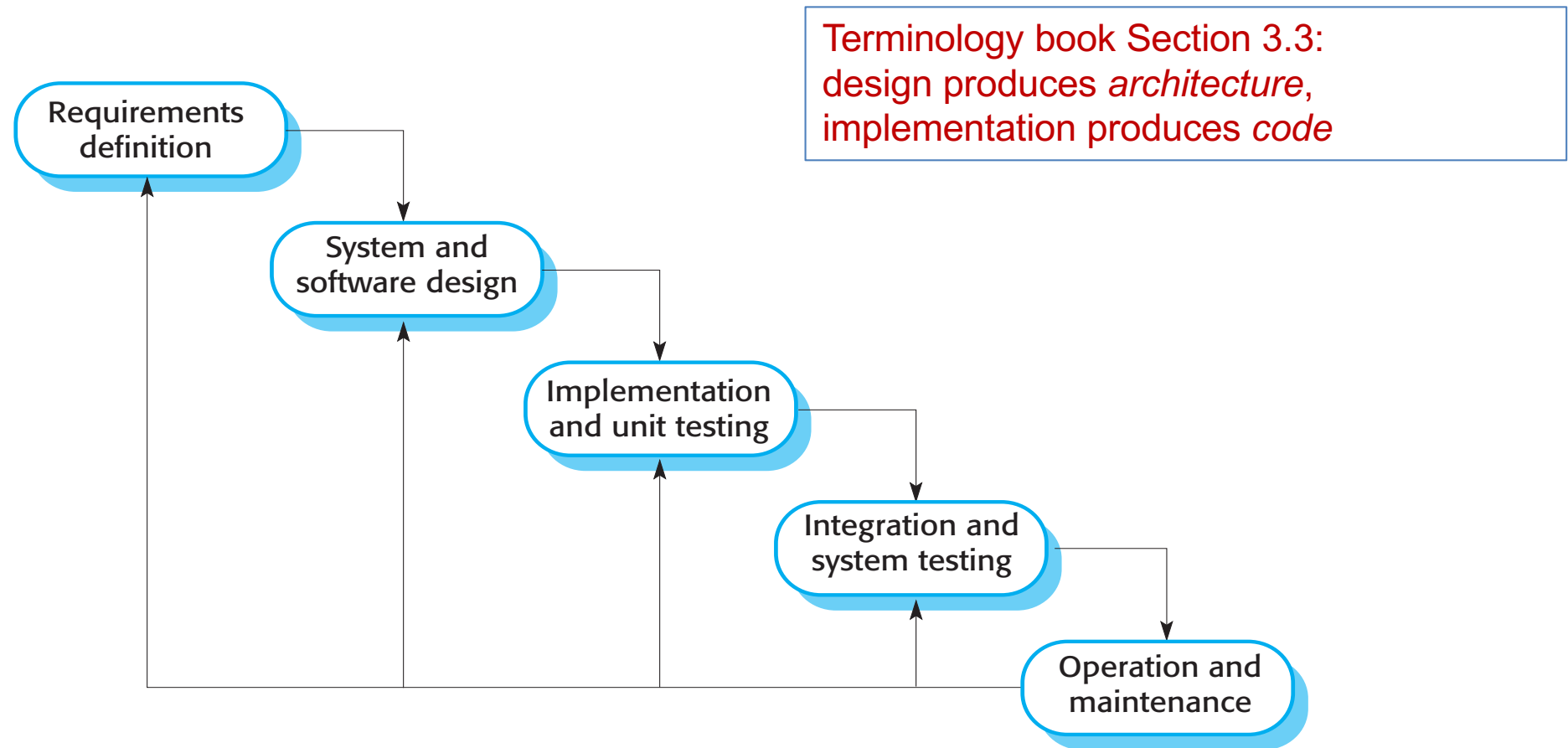
SCRUM



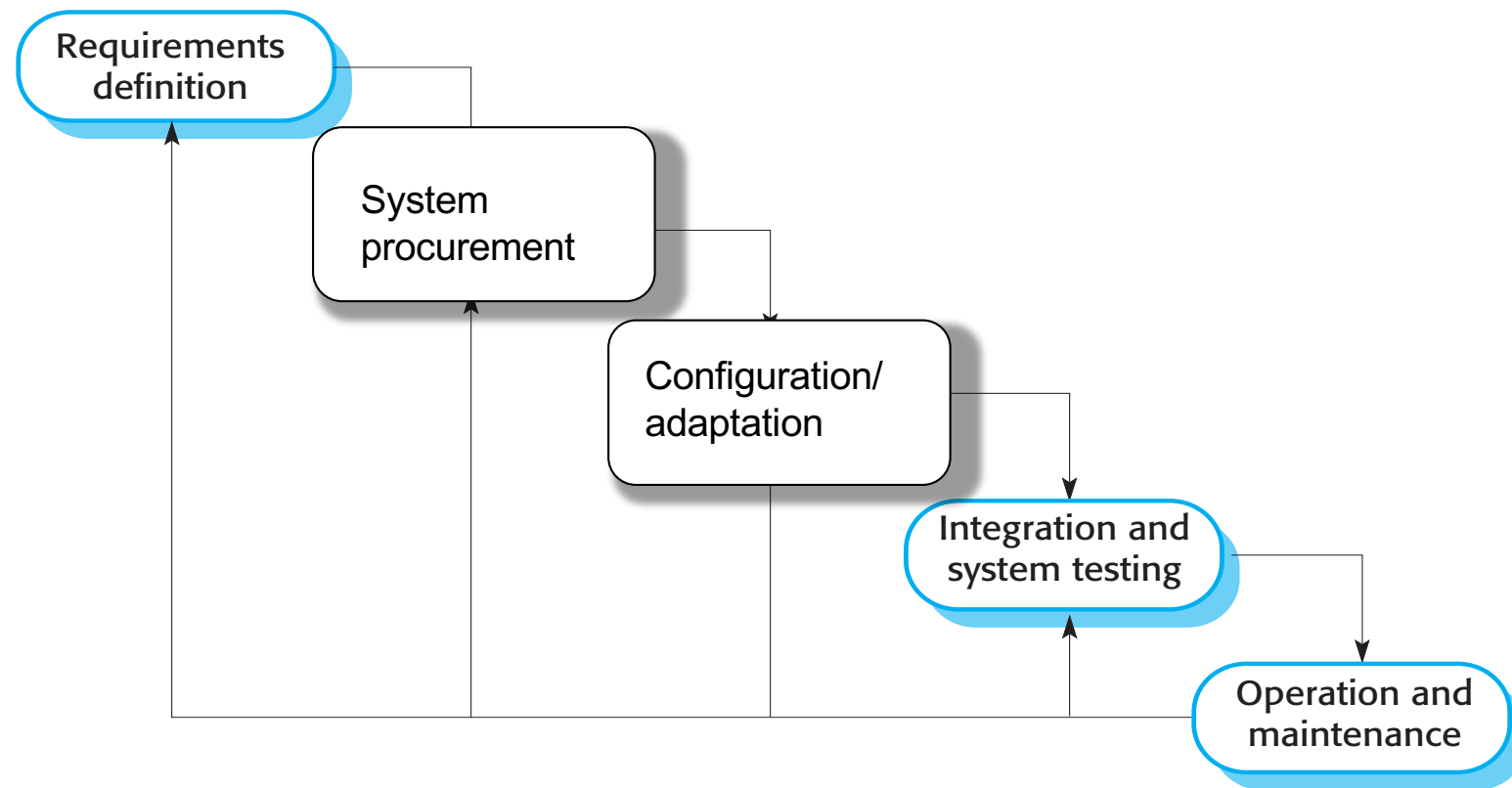
Lifecycle models, book Section 3.5. RUP (Section 6) is not included in the syllabus

The Waterfall model

- Sequential: requirements before design, design before implementation (coding), etc.
- Controlled improvement of earlier phases is still acceptable



The Waterfall model, software procurement



The V-model

A simplified version of this figure in book p. 82. Customer involved in the validation phases only, book Section 5.5.

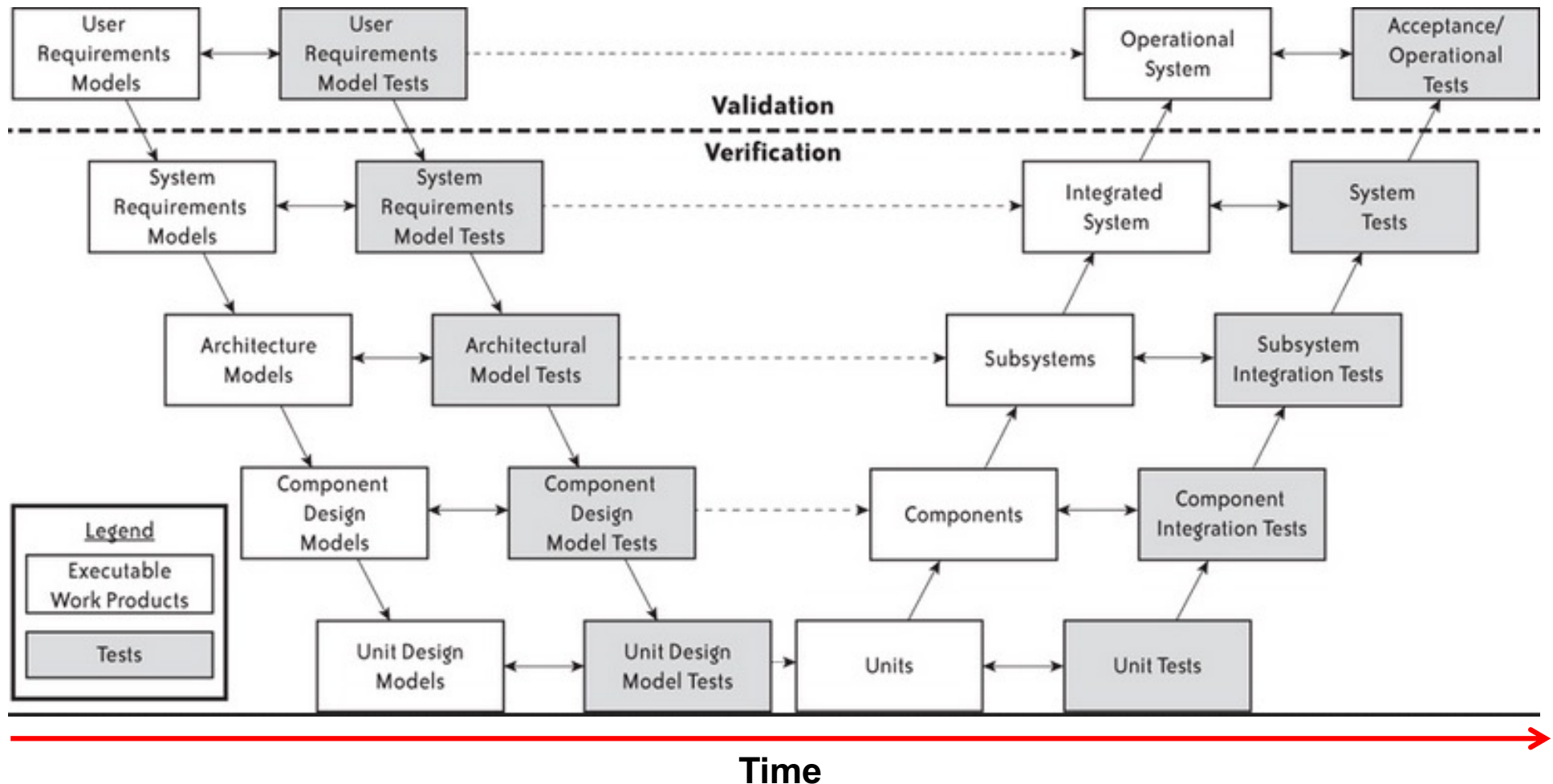


*Figure from: Donald G. *Common system and software testing pitfalls: how to prevent and mitigate them: descriptions, symptoms, consequences, causes, and recommendations*. Addison-Wesley Professional, 2014

The waterfall and V models

Advantages of both

- Easy to understand
- Well-defined stages (phases) make it clear who are responsible at each time and facilitates management

Advantages of V model

- Demonstrates the relationships between each phase of development and associated testing
- Strong emphasis on testing, emphasizes early test planning

Disadvantages

- Requirements and design risks are not discovered until late in the life cycle, for example, different interests among different stake holders
- Inflexible regarding changes in requirements
- Written definitions of requirements often lead to misinterpretations
- Working software is produced late

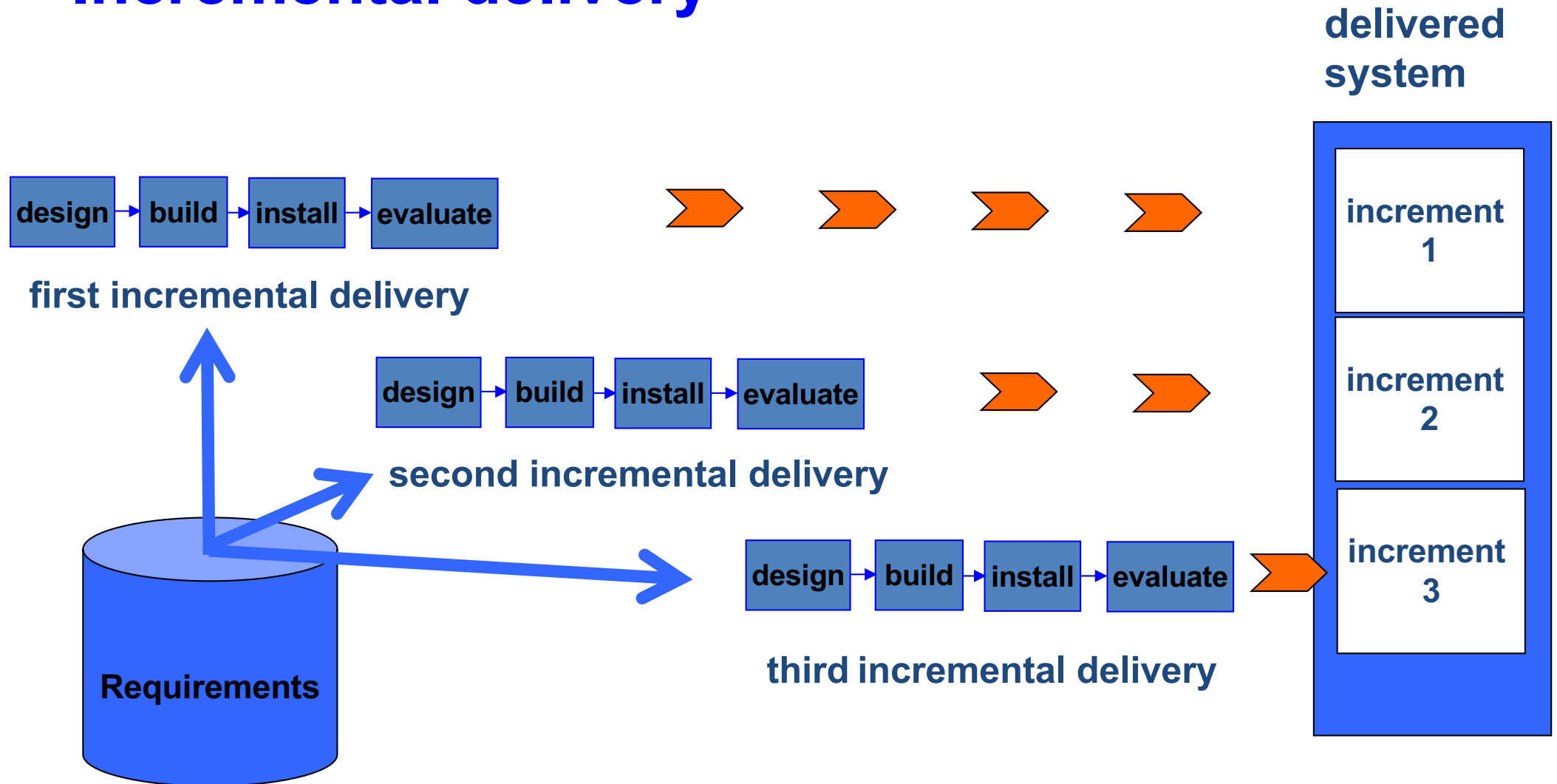
Waterfall and V models represent plan-driven processes

- In plan-driven projects, like typical civil engineering projects, relatively much time is spent on planning, including writing documents that guide the projects
- The critics talk about “big upfront” (book Chapter 3), for example, too much emphasis on requirements engineering (book Section 3.2)

Incremental and iterative systems development (agile)

- An *increment* is a part that fulfills a subset of the requirements – an aspect of the *system*
- An iteration is a cycle in the development – an aspect of the *process*
 - The purpose of an iteration is to develop or improve an increment but may also be to improve the structure of a system

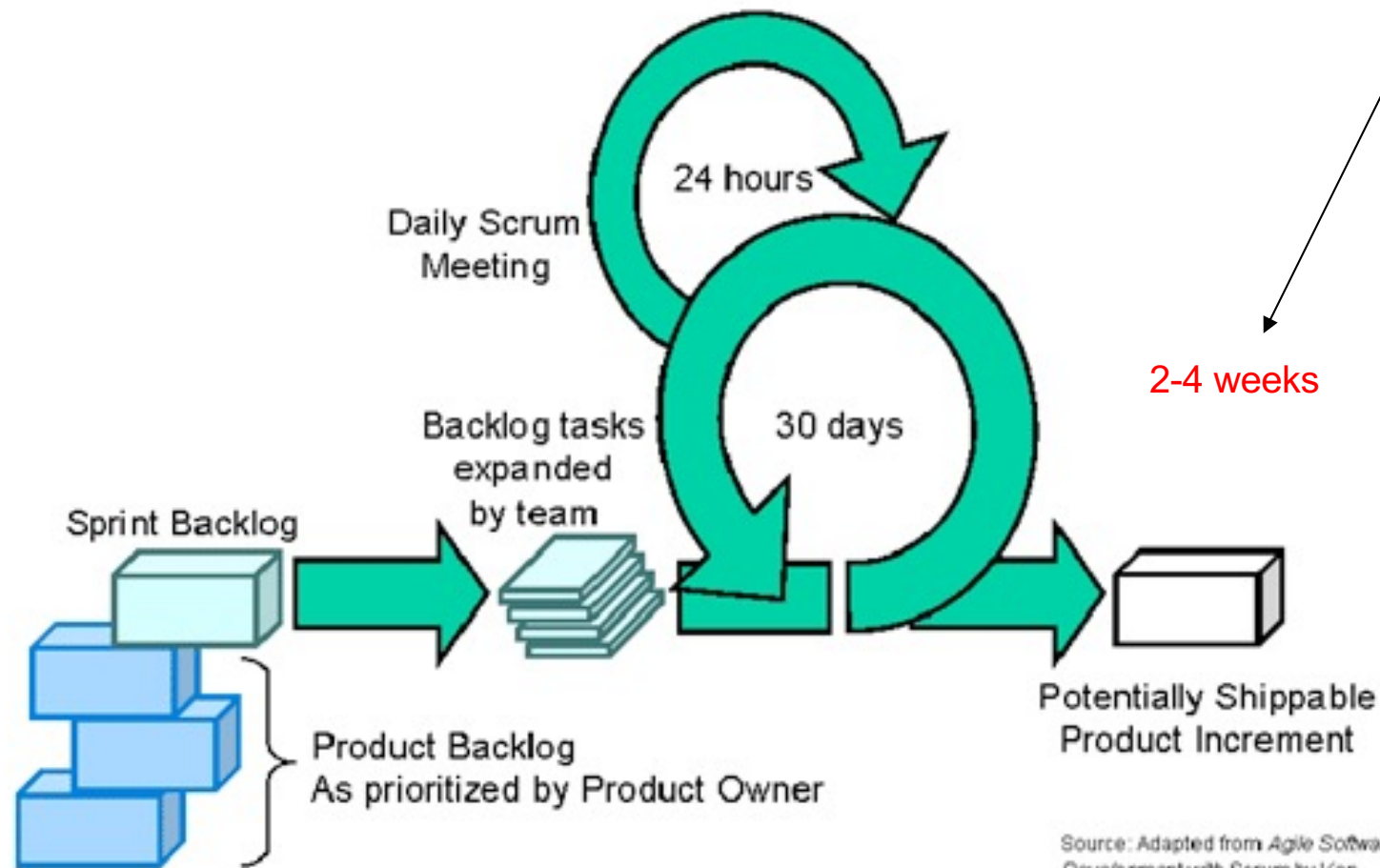
Incremental delivery



Agile development with Scrum

Incremental and iterative

An iteration is called a “sprint” in Scrum



Source: Adapted from *Agile Software Development with Scrum* by Ken Schwaber and Mike Beedle.

Structure

- Software process and process model
- Standard process models
- Choosing, adapting and improving software process models ←
- Frameworks/models for process improvement

Which software process model to use?

Suppose you are an IT manager (project leader, head of department, etc.), how would you find or define a good model for the processes in your company, department or project?

Suitability of processes (and methods and practices) depends on context

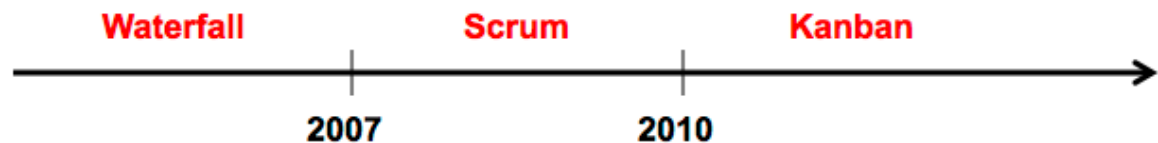
- Organizational setting: size, competence, motivation, ownership, social and technological environment of
 - development organization
 - development team
 - customer organization
- Project setting
 - time (to market)
 - resources/cost
 - requirements, stability of requirements
- System setting
 - quality criteria, size, complexity, application domain, criticality, etc.

Larger projects, more process

- The larger the project, the more process elements need to be defined (for example, regarding planning, analysis and design) to ensure sensible decisions and necessary control over the project
- The more scattered the organization of the project, the more process elements need to be defined to ensure smooth communication between team members

How to choose a standard process model?

- Most software organizations have already adopted and adapted an existing standard process model
- If not:
 - Consult developers, leaders, users, customers and possibly other stakeholders for their opinions
 - Consult relevant literature that may indicate what may fit your organization
 - Perform a study in your environment where you compare alternatives (see lecture 15 September)



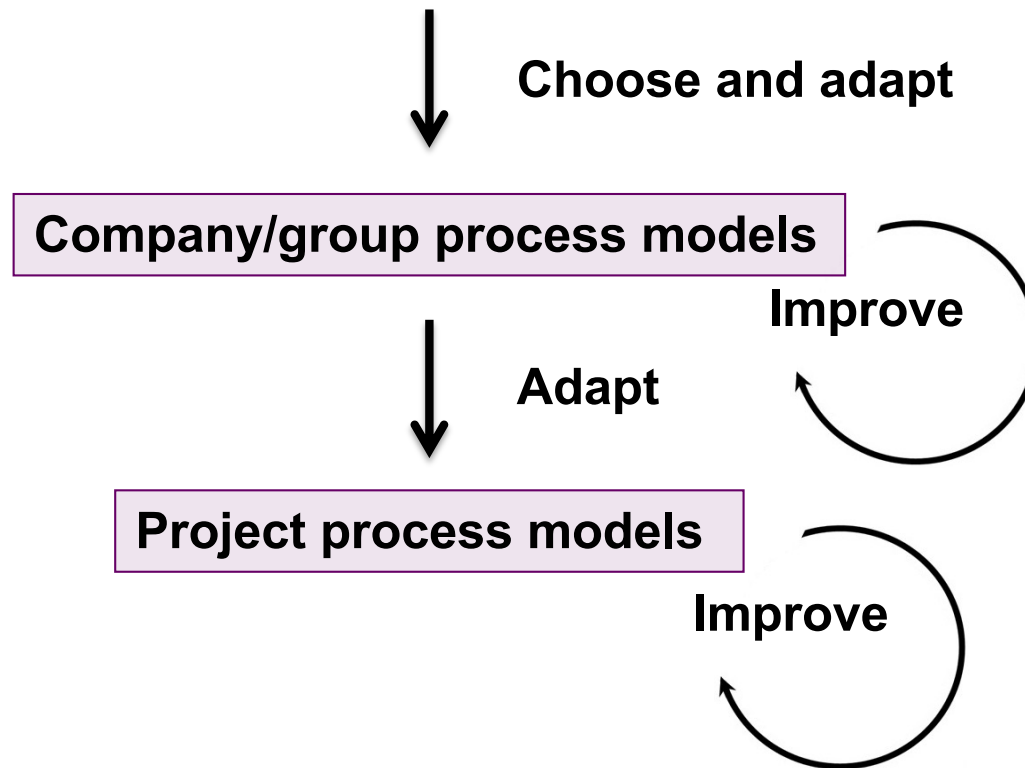
Processes must be adapted and improved

- Few projects are equal
- Few software teams are equal
- A process/process model may be adapted and improved to fit the needs of your project or operational tasks

To succeed, you need to improve your processes

Choice, adaptation and improvement of software process models

Standard process models (waterfall, V-model, spiral, Scrum, Kanban, etc.)



Choice of process/process model

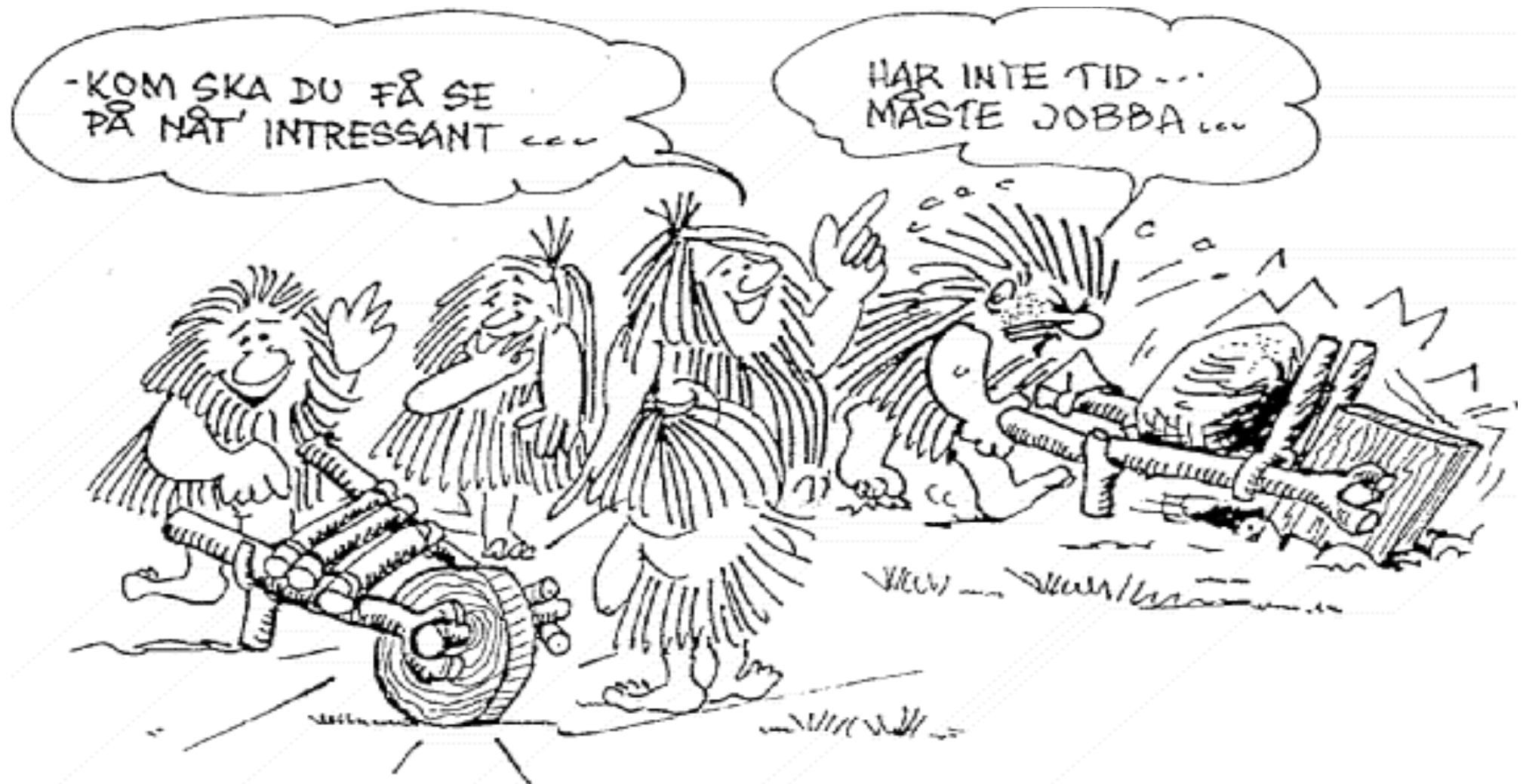
- IN5140 cannot teach which process (model) to choose or how to improve a process in all cases
- But we teach you
 - principles for how to improve processes
 - aspects you should think of
 - frameworks that you can use
 - how to measure and evaluate processes and their elements

Structure

- Software process and process model
- Standard process models
- Choosing, adapting and improving software process models
- Frameworks/models for process improvement ← 

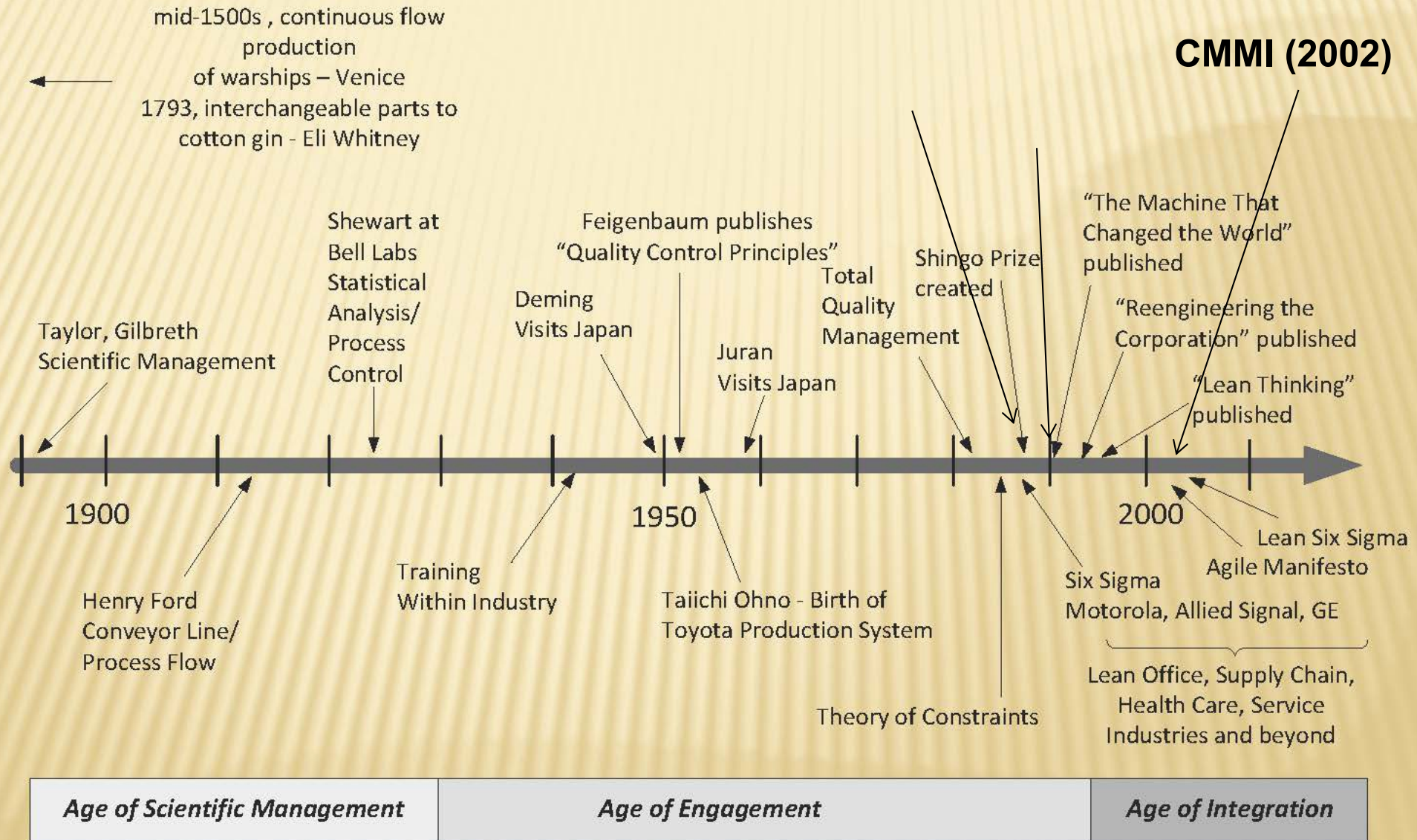
All processes can be improved

- The way we study
- The way way we travel
- The way we train
-
- The way we develop software (IN5140)



process improvement
=
working smarter

HISTORY OF PROCESS IMPROVEMENT



Frameworks/models and standards for process improvement

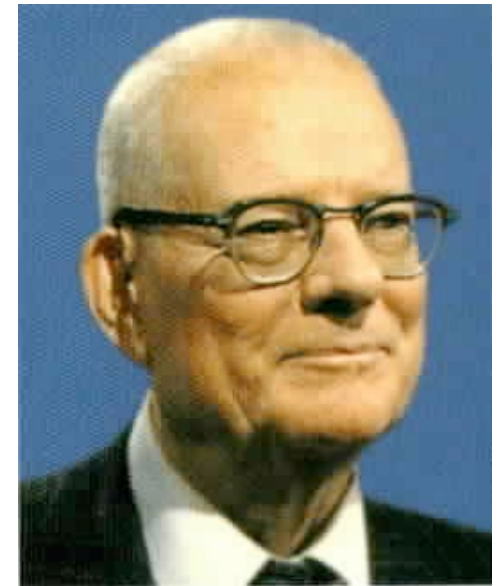
- PDCA
- GQM
- OKR
- CMMI
- ITIL
- ISO*: software related standards
 - 9001-2000: Quality Management System
 - 15504-SPICE: Software Process Assessment
 - 12207: Software Life Cycle Process
 - 14598: Software Product Evaluation

*ISO = International Organization for Standardization

PhD (mathematical physics)

W. Edwards Deming

- Founder of modern quality control, which popularized PDCA, also called Deming circle/cycle
- After 1950, Deming was involved in improving design, product quality, testing and sales techniques in Japanese industry
- Toyota's management system (cf. Lean, lecture 19 September) is based on Deming's ideas
- Used statistical methods to reach production goals



Book p. 57: “[Scrum and Lean] are rooted in the tradition of industrial production engineering; their authors keep citing Deming and Toyota, blasting waste and extolling productivity.”

A systematic approach to Software Process Improvement (SPI)



- **PLAN** what you want to accomplish over a period of time and what you might or need to do, to get there
- **DO** what you planned to do
- **CHECK** the results of what you did to see if the objective was achieved
- **ACT** on the information – standardize or plan for further improvement

Plan-Do-Check-Act

Process assessment – measurements



Where are we today? 

Where do we want to be?

How do we get there?

How do we monitor?

How do we check whether we got to where we wanted to get to? 

What have we learnt and how do we follow-up?

Characterize

Set Goals

Plan

Execute

Analyse

Package

Later, Deming called the circle *plan*, *do*, ***study***, *act* because he felt that "check" emphasized inspection over analysis

Deming's 14 key principles (1993), 1–7

1. Create constancy of purpose for **continual improvement** of products and service to society, allocating resources to provide for **long range needs** rather than only **short term profitability**
2. We are in a new economic age, created in Japan. We can no longer live with commonly accepted levels of delays, mistakes, defective materials and defective workmanship. Eliminate the need for mass inspection as the way of life to achieve quality by building quality into the product in the first place. Require **statistical evidence of built in quality** in both manufacturing and purchasing functions.
3. End the practice of awarding business solely on the basis of price tag. Instead require **meaningful measures of quality along with price**.
4. Improve constantly and forever **every process** for planning, production, and service.
5. Institute modern methods of **training on the job for all**, including management, to make better use of every employee. New skills are required to keep up with changes in materials, methods, product and service design, machinery, techniques, and service.
6. The aim of supervision should be to help people and machines and gadgets to do a better job. **Supervision of management** is in need of overhaul, as well as supervision of production workers.

Deming's 14 principles (1993), 8–14

8. Encourage **effective two-way communication** and other means to drive out fear throughout the organization so that everybody may work effectively and more productively for the company.
9. **Break down barriers** between departments and staff areas. People in different areas, such as Leasing, Maintenance, Administration, must work in teams to tackle problems
10. Eliminate the use of slogans, posters and exhortations for the work force, demanding zero defects and new levels of productivity, without providing methods.
11. Eliminate work standards that prescribe quotas for the work force and numerical goals for people in management. Substitute aids and helpful leadership in order to achieve continual improvement of quality and productivity.
12. Remove the barriers that rob hourly workers, and people in management, of their right to pride of workmanship. Again, the responsibility of managers, supervisors, foremen must be changed from sheer numbers to quality.
13. **Encourage education**: Institute a vigorous program of education and encourage self improvement for everyone.
14. Clearly define top management's permanent commitment to ever improving quality and productivity, and their obligation to implement all of these principles. Indeed, it is not enough that top management commit themselves for life to quality and productivity. They must know what it is that they are committed to – that is, what they must do. Support is not enough: **action is required!**

High-quality process in Japan: operation of high-speed trains

- No fatalities over 50 years
- Tokyo-Osaka (500 km):
 - 285 trains with with 360 000 passengers every day
 - Average delay: 24 seconds (mostly due to heavy rain, snow and typhoons)

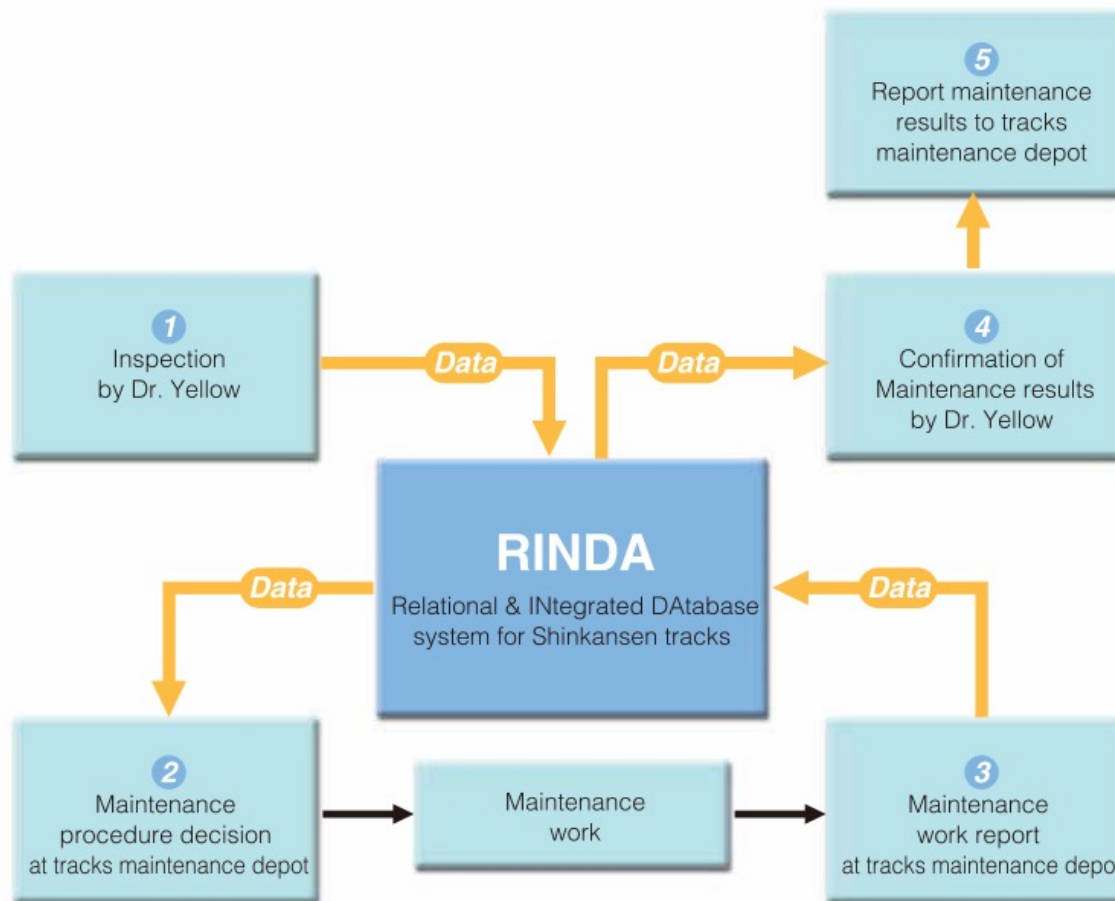


Railway Inspection Process Model in Japan

Maintenance System with Dr. Yellow

Culture (Hofstede)

RINDA manages various data for streamlining daily operations and improving reliability, and also receives and stores data from measurements performed by the multipurpose inspection train, Dr. Yellow.



Dr. Yellow: Multiple Inspection Train

- 7-car EMU train
- Inspects track, catenaries, and signaling and telecommunications facilities
- Conducts inspections at 270 km/h during operating hours
- Runs every 10 days

RINDA: Relational & Integrated Database system for Shinkansen Tracks

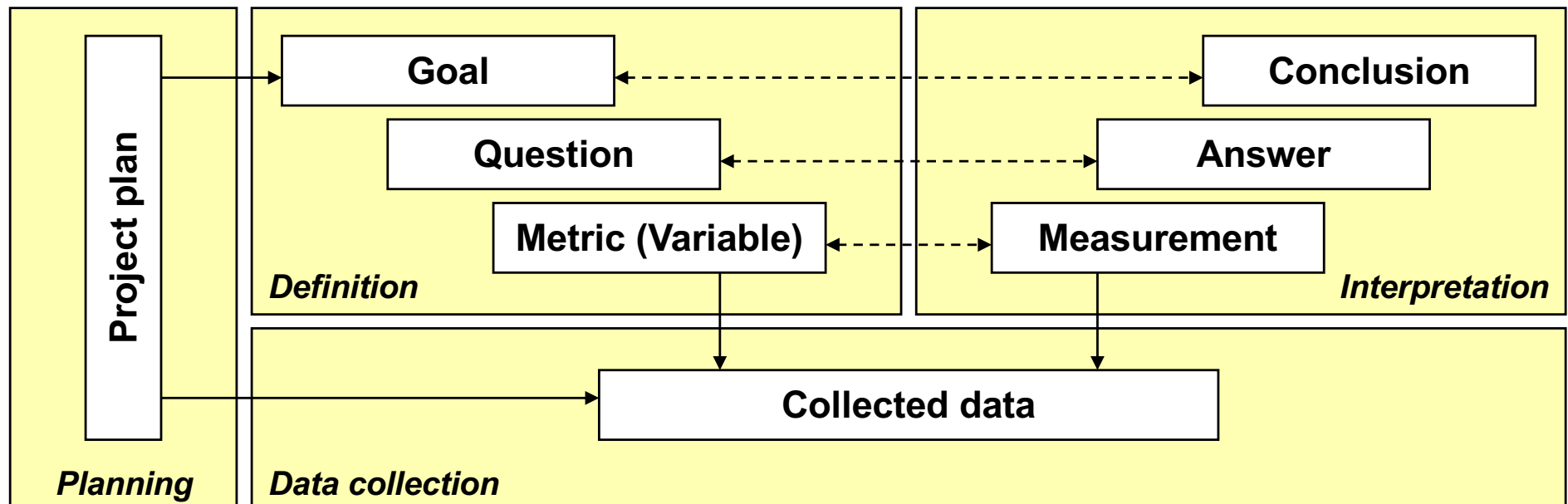
- Management of data relating to each type of plan, riding comfort, rail inspection, and maintenance cars and machinery.

Maintenance Work

- Performed after midnight to 6:00 a.m.
- No disruption to regular train operation

Goal-Question-Metric (GQM)

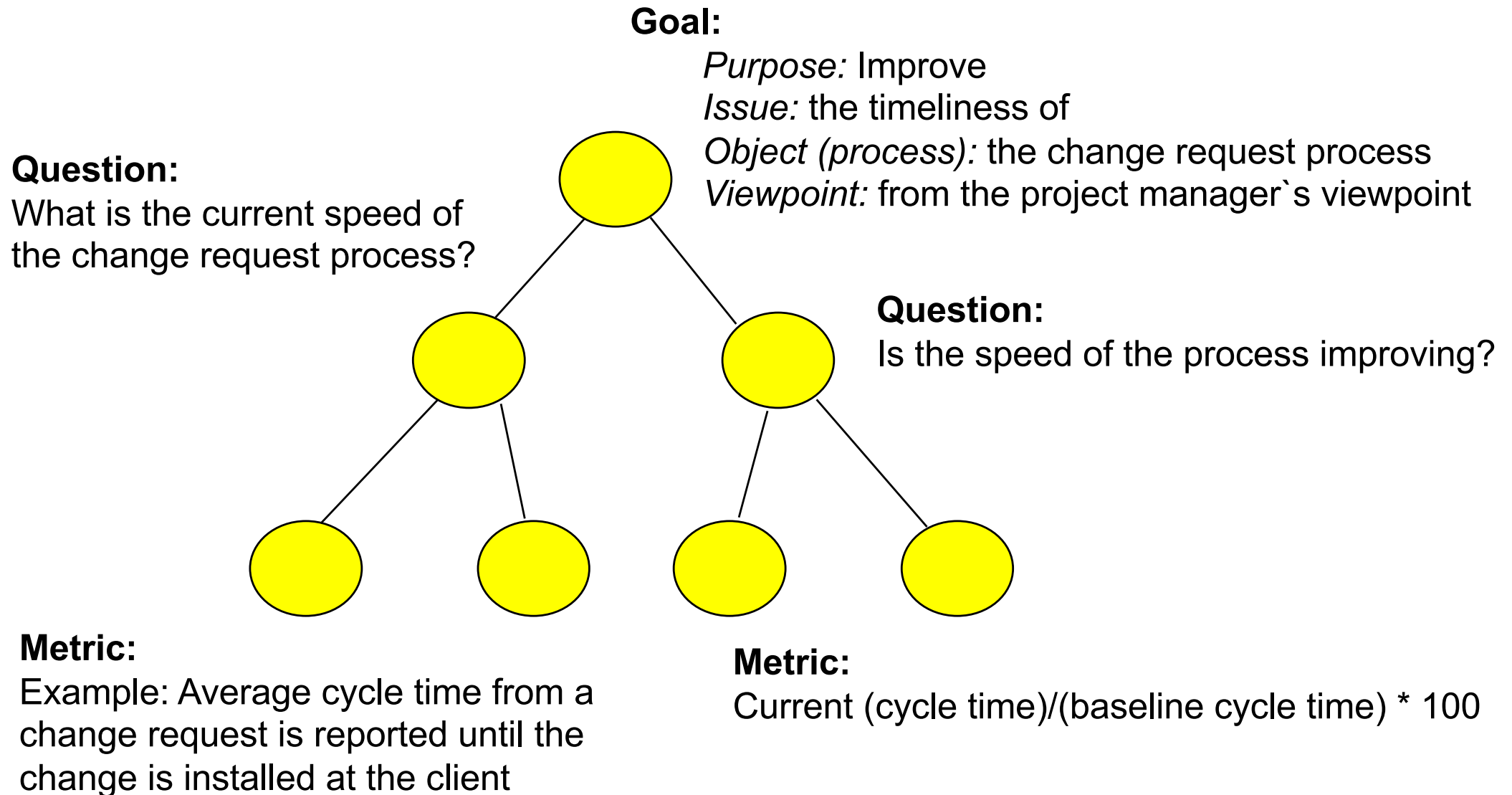
A model for improvement based on measurements



Questions: should address critical aspects related to achieving the goal

Metrics: give a quantifiable way to track progress/actual improvement

Example of goal structure



OKR: Objectives and Key Results

- Objectives
 - Qualitative, inspirational goals shared by the organization
 - Example: "Improve software quality"
- Key results
 - For each objective, define quantifiable outcomes that measure progress towards the objective (percentage)
 - Example: Reduce the number of bugs with 10 %
- Frequent reviews, e.g., every three or four months

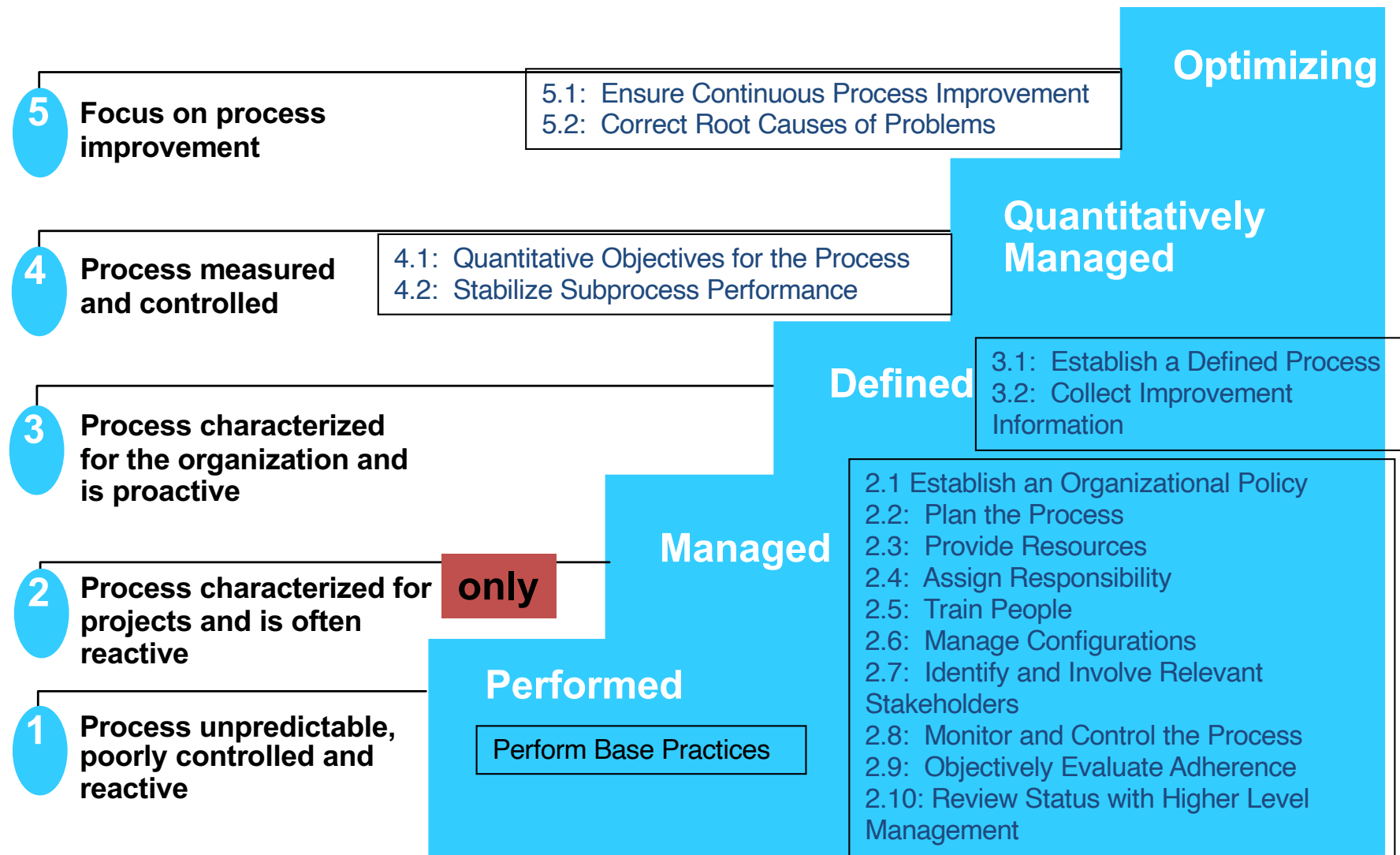
**Is setting goals and checking if
you are on track a new idea?**

CMMI – Capability Maturity Model Integrated

(book Section 3.6)

- **Motivation:**
Easier to assess the processes of the vendor companies than to check all the code in the purchased products

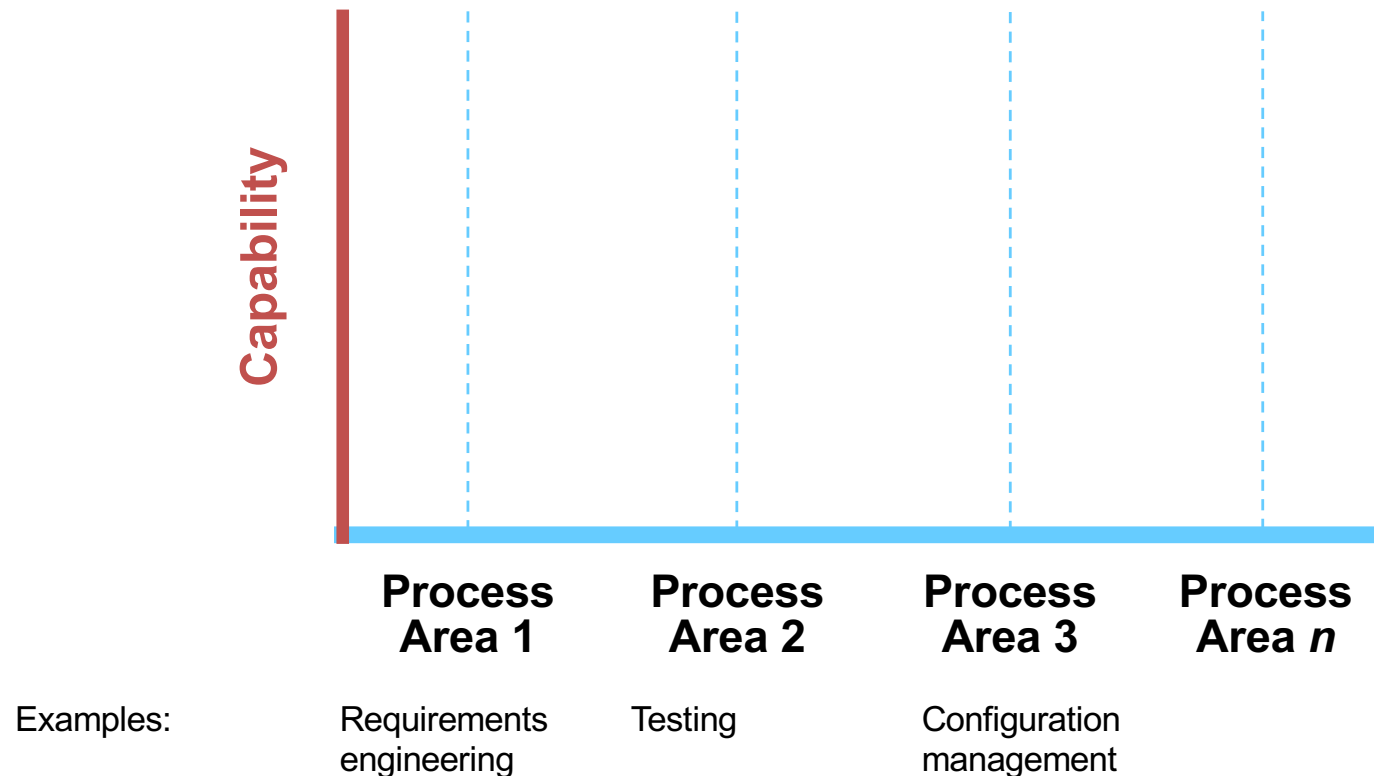
Maturity levels*



“Managed process”

- Process is planned according to a specified policy
- Skilled people involved
- Process is monitored
- The process is “institutionalized” if the whole organization supports and commits to it

Maturity (=capability) in different process areas



Prosessområder*

Category	Process Area
Project management	Project Planning Project Monitoring and Control Supplier Agreement Management Integrated Project Management(IPPD) Integrated Supplier Management (SS) Integrated Teaming (IPPD) Risk Management Quantitative Project Management
Support	Configuration Management Process and Product Quality Assurance Measurement and Analysis Causal Analysis and Resolution Decision Analysis and Resolution Organizational Environment for Integration (IPPD)
Development	Requirements Management Requirements Development Technical Solution Product Integration Verification Validation
Process management	Organizational Process Focus Organizational Process Definition Organizational Training Organizational Process Performance Organizational Innovation and Deployment

Example of results from a CMMI assessment

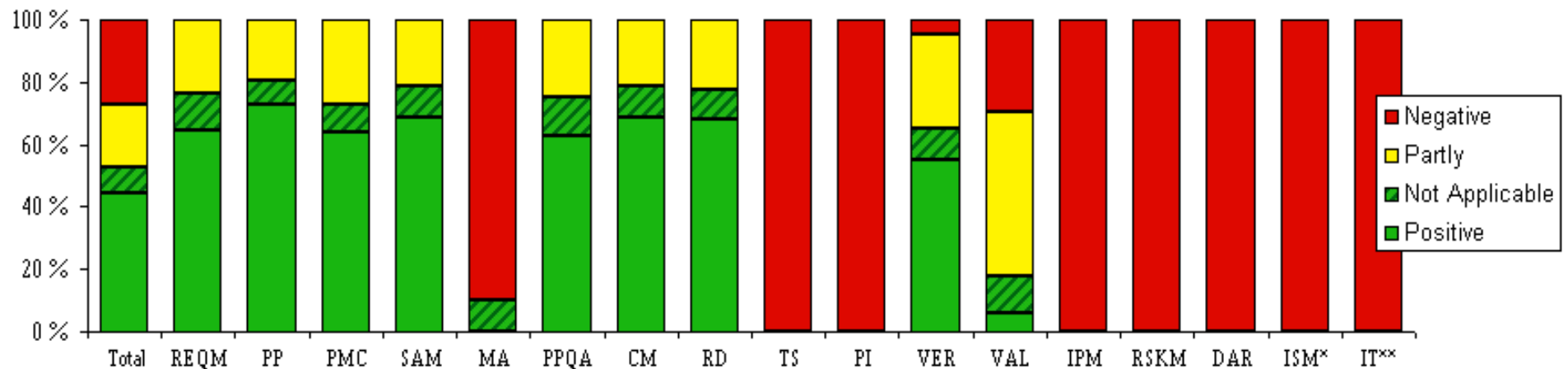
Total CMMI Compliance: 63 %

CMMI Level 2 compliance: 77 %

Tailoring: Use of Not Applicable: 8 %

CMMI Level 3 compliance: 22 %

CMMI Level 2/3



Process areas

Example Process Area: Requirements Management

Capability Levels 1 & 2

Specific practices (CL1 - “base”)

SP1.1-1: Obtain an Understanding of Requirements

SP1.3-1: Manage Requirements Changes

SP1.5-1: Identify Inconsistencies Between Project Work and Requirements

Generic practices (CL1)

GP1.1: Perform Base Practices

Specific practices (CL2 - “advanced”)

SP1.2-2: Obtain Commitment to Requirements

SP1.4-2: Maintain Bidirectional Traceability of Requirements

Generic practices (CL2)

GP2.1: Establish an Organizational Policy

GP2.2: Plan the Process

GP2.3: Provide Resources

GP2.4: Assign Responsibility

GP2.5: Train People

GP2.6: Manage Configurations

GP2.7: Identify and Involve Relevant Stakeholders

GP2.8: Monitor and Control the Process

GP2.9: Objectively Evaluate Adherence

GP2.10: Review Status with Higher Level Management

Example Process Area: Requirements Management

Capability Level 3

Specific practices (CL3)

All the CL1 & CL2 Specific Practices

Generic practices (CL3)

All the CL1 & CL2 Generic Practices plus(+):

GP3.1: Establish a Defined Process

GP3.2: Collect Improvement Information

Example Process Area: Requirements Management

Capability Levels 4 & 5

Specific practices (CL4)

All the CL1 & CL2 Specific Practices

Generic practices (CL4)

All the CL1 & CL2 & CL3 Generic Practices plus(+):

GP4.1: Establish Quantitative Objectives for the Process

GP4.2: Stabilize Subprocess Performance

Specific practices (CL5)

All the CL1 & CL2 Specific Practices

Generic practices (CL5)

All the CL1 & CL2 & CL3 & CL4 Generic Practices plus(+):

GP5.1: Ensure Continuous Process Improvement

GP5.2: Correct Root Causes of Problems

Advantages of CMMI assessment

- Puts focus on and may initiate money to process improvement
- The performance of the company may improve
- Customers will (to some extent) know the quality of the processes

Challenges with CMMI assessment

- Costly
 - Book, p. 45: “Moving from one level to the next is typically a matter of many months and hundreds of thousands of dollars.”
- Certain formal criteria are met, but do they reflect real improvement?
 - Much effort before the inspectors arrive, but don't work that way when they have left?
 - May become very good at areas in which the processes are easy to improve but that are less important in the organization?

CMMI and agile

- CMMI assessment requires administrative overhead (waterfall-ish), which prevents agile adaptation and improvement?
 - Top-down process driven by management and external consultants may lead to resistance among employees and not real improvement of the culture – as opposed to a bottom-up approach, where the initiatives come from individuals and teams
 - However, there is nothing intrinsic in CMMI that means it could not be initiated bottom-up (book p. 46), but the external assessment and associated “industry” around certification (like the Scrum certification industry, book p. 45) is not “agile”

ITIL – IT Infra-structure Library

- Standard framework for IT service management
- Based on the PDCA process model (Deming)
- Focus on
 - customer satisfaction
 - service quality and time
 - cost efficiency
- More focus on software *operation* than software *development*



Use standards and frameworks as checklists and inspiration for areas of improvement



Summary

- Process models in systems development are useful
 - as guide for the work of teams and individuals
 - as a tool for process improvement
- Process models may be standardized or specific to company or project
- One should regularly think of how to improve the way we develop software, that is, process improvement
- Many frameworks support software improvement