TECHNISCHE UNIVERSITÄT MÜNCHEN

Software Engineering in der industriellen Praxis (SEIP)

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ENGINEERING FUNDAMENTALS

Software Classes

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EF 01.1

Business

Custom Software Development — CSD

Commercial development of **non**-standardised, **fully** individualised, and **non**-reusable **company**-specific software for a **single** customer.

Standard Software Development — STD

Commercial development of standardised, **partially** customisable, and **fully** reusable **domain**-specific software for **many** customers.

Open Source Software Development — OSS

Non-commercial development of standardised, **highly** customisable, and **fully** reusable **generic** software for **many** customers.

Class: Graphics & Media

target audience: **consumers & enterprises**

Graphics Editing Application — GEA

Software for editing and rendering graphics in vector and bitmap format.

Examples: Cinema4D, Maya, Blender, After Effects, Illustrator, Inkscape, Scribus, Photoshop, GIMP, etc.

~~CSD~~ STD OSS

Graphics Animation Engine — GAE

Software for animating the 2D/3D virtual worlds of games and overlays of TV productions.

Examples: Unity, Unreal Engine, CryENGINE, Godot, HUDS, SPX-GC, Holographics, H2R Graphics, etc.

CSD STD OSS

Audio/Video-Processing System — AVS

Software for live-processing and post-production of audio/video based multimedia streams.

Examples: vMix, OBS Studio, VLC, Lossless Cut, Handbrake, Adobe Premiere, FFmpeg, Nimble, etc.

~~CSD~~ STD OSS

Class: Business & Data

target audience: **consumers & enterprises**

Office Productivity Application — OPA

Software for productivity in the desktop-based office environment.

Examples: PowerPoint, Excel, Word, Visio, OmniGraffle, LibreOffice, Outlook, XMind, Firefox, Chrome, etc.

~~CSD~~ STD OSS

Business Information System — BIS

Software for driving business processes through interactive information management.

Examples: Vote, CampS, Mission Control, IPW, KEZ-PSC, TimeSheet, SAP ERP, OpenProject, etc.

CSD STD OSS

Data Management System — DMS

Software for protocol-based storing and retrieving of persistent data.

Examples: NextCloud, PostgreSQL, CockroachDB, Redis, InfluxDB, Neo4J, Tendermind, Gitea, Vault, etc.

~~CSD~~ STD OSS

Class: Machinery & Network

target audience: **consumers & enterprises**

Technical Control System — TCS

Software for controlling a physical machinery or technical system.

Examples: AquaTherm, AVM! FritzBox Firmware, BirdDog Camera Firmware, etc.

CSD STD OSS

Network Communication System — NCS

Software for protocol-based communication of data over a computer network.

Examples: Apache, NGINX, HAProxy, Mosquitto, RabbitMQ, Node-RED, KeyCloak, etc.

~~CSD~~ STD OSS

Operating System Kernel — OSK

Software kernel for low-level operating a physical or virtual device and run programs on it.

Examples: Windows, macOS, iOS, Linux, FreeBSD, QNX, ChibiOS/RT, Kubernetes, Wildfly, etc.

~~CSD~~ STD OSS

Class: Development & Tools

target audience: **vendors & suppliers**

Software Development Kit — SDK

Software libraries and frameworks of reusable functionality for developing software.

Examples: NDI SDK, HAPI, GraphQL-IO, Sequelize, JDK, Spring, Hibernate, etc.

~~CSD~~ STD OSS

Software Development Tools — SDT

Software tools for editing, linting, compiling, packaging, distributing, and installing software.

Examples: Visual Studio Code, Sublime Text, GCC, GNU Binutils, NPM, JDK, Docker, Helm, etc.

~~CSD~~ STD OSS

Operating System Tools — OST

Software tools for high-level operating a physical or virtual computing device.

Examples: Coreutils, Bash, Vim, TMux, FZF, cURL, RSYNC, OpenSSH, etc.

~~CSD~~ STD OSS

audience & deliverable

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Software Development Approaches

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Development Approaches

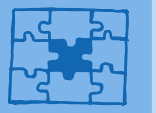
Software Prototyping *mocking* SP

Develop an early sample or model of a software solution by mocking and cheating in order to just once test a concept, idea or process.

Example: Customer Sales Demo

Software Bricolage *integrating* SB

Develop a single instance of a software solution by tinkering, cobbling and integrating partial solutions in order to prove feasibility or just provide a service.



Example: Company-Internal SaaS

Software Craftsmanship *crafting* SC

Develop a production-grade software solution by professional, clean but plain craftsmanship means in order to solve a usually complicated problem.

Example: Open Source Framework

Software Engineering *teaming* SE

Develop a production-grade software solution by a professional, risk-hedged engineering approach in order to solve a usually complex problem.

Example: Business Information System

Continuum & Process

The four development approaches do *not* form a hierarchy, but can be combined in practice: **Prototyping** and **Bricolage** can be earlier stages of **Craftsmanship** or **Engineering**. **Craftsmanship** can be part of **Bricolage** or **Engineering**. Each approach requires a special skill (mocking, integrating, crafting, teaming).

Development Approaches: **Characteristics Comparison** *

	Effort: Person-Days	Effort: Persons	Process: Risk-Hedge	Process: Traceability	Solution: Target Technology	Solution: Production-Grade	Solution: Sustainability	Solution: Claim	Solution: Life-Time Months	Solution: Lines of Code (k)
Software Prototyping	1-20	1-2	-	-	-	-	-	5%	0-3	0-3
Software Bricolage	5-100	1-2	-	-	X	(X)	-	60%	3-24	1-10
Software Craftsmanship	5-100	1-2	-	-	X	X	X	100%	24-48	5-25
Software Engineering	>150	5-50	X	X	X	X	X	80%	>48	>25

* All figures are just rough orders of magnitude for indication and illustration purposes.

Key Message

All four approaches are equally essential in practice. Which one(s) to choose, entirely depends on the particular requirements.

Development Approaches: **Success Patterns**

	Software Prototyping	**Software Bricolage**	**Software Craftsmanship**	**Software Engineering**
Performance	One-Man-Show	One-Man-Show	One-Man-Show	**Team Play**
Responsibility	Single	Single	Single	**Separated**
Model	Mental	Mental	Mental/**Documented**	**Documented**
Decisions	Implicit	Implicit	Implicit/**Explicit**	**Explicit**
Process	**Minimized**	**Partial**	**Partial**	Complete
Optimisation	**Time**	**Efficiency**	**Effectiveness**	**Economics**
Risks	Ignore	Ignore	Ignore	**Mitigate**
Stakeholders	Ignore	Ignore	Ignore	**Manage**
Mastering	**Time-Constraint**	Complexity	**Complication**	Complexity
Solutions	**Use Full**	Use Partial	Use Partial	Use Partial
Standards	Use	Use	**Potentially Create**	Use
Efforts	**Configuration**	**Integration**	Programming	Programming
Target	**Demo**	Solution	**Product**	**Product**
Sustainability	**No**	**Partial**	Full	Full
Traceability	**No**	**No**	**Partial**	Full

EF 01.2

goal & approach

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Software Engineering

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Engineering

Machinery

The collection of physical components of a mechanical apparatus using electrical power to perform a certain task.

specialised by

Hardware

The collection of physical components (machinery) of a computer system.

created by

Engineering

The systematic application of **scientific and technological knowledge, principles, approaches, practices, methods, and experiences**, to **design, build, operate, and maintain** complex production-grade solutions through a **traceable** process. *

taking into account

Engineering Code of Conduct

Commit yourself to the **highest ethical and professional conduct**, accept responsibility in making decisions consistent with the **safety, health, and welfare of the public**, apply the **state of the art in science and technology** of your field, perform services only in areas of your **competence**, and comply with the principles of **sustainable development**. *

* derived from definitions and Code of Ethics statements of ASCE, NSPE, ACM, IEEE, etc.

Wording

Engineering: derived from the *Latin* words **ingeniare** (to create, generate, contrive, devise) and **ingenium** (cleverness).

Software Engineering

Software

The collection of instructions and data that tell a computer system how to work.

operated by

created by

Software Engineering (transferred)

The systematic application of scientific and technological knowledge, principles, approaches, practices, methods, and experiences, to design, build, operate, and maintain complex production-grade **software** solutions through a traceable process.

transferred to

simplified to

Software Engineering (simplified)

The systematic application of **engineering** knowledge, principles, approaches, practices, methods, and experiences to **the development of software.**

also taking into account

EF 01.3

profession & ethics

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Profession Characteristics

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	creative	rational
	involving the use of **strong imagination** and **original ideas**	involving the use of **analytical thinking** and **logical reasoning**
practical: involving the **actual doing** and **real application** of something	**CRAFTSMAN** Handwerker Objectives: **solve problems** **create uniques** … Software Engineering: **Programming** **Configuration** …	**ENGINEER** Ingenieur Objectives: **solve problems** **create solutions** … Software Engineering: **Estimation** **Automation** …
theoretical: involving the **manifested imagination** or **analytical study** of something	**ARTIST** Künstler Objectives: **create beauty** **create uniques** … Software Engineering: **Visual Design** **Coding Style** …	**SCIENTIST** Wissenschaftler Objectives: **analyse problems** **create knowledge** … Software Engineering: **Methodology** **User Research** …

INVENTOR Erfinder

EF 01.4

diagram.direct / XIRF–NIIV

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Discipline Claim

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FA — FARSIGHTED
weitblickend

Be farsighted in your solution finding.

Sei weitblickend in deiner Lösungsfindung.

AR: Scalable Hub'n'Spoke
DV: Plugin SPI

TE — TENET-ORIENTED
grundsatzorientiert

Orientate yourself on fixed tenets in your approach and solution finding.

Orientiere dich an festen Grundsätzen in deinem Vorgehen und deiner Lösungsfindung.

AR: Separation of Concern
DV: Strict Coding-Style

TH — THOUGHTFUL
wohlüberlegt

Act thoughtful in your approach and solution finding.

Agiere wohlüberlegt in deinem Vorgehen und deiner Lösungsfindung.

AR: Modularization
DV: Algorithmical Control Structure

HO — HOLISTICALLY
ganzheitlich

Think holistically and in the long-term when finding your solutions.

Denke ganzheitlich und langfristig in deiner Lösungsfindung.

AR: Walking Skeleton Design
DV: Consistent Error Handling

AD — ADEQUATE
angemessen

Ensure that your approach and solutions are adequate to the boundary conditions.

Sorge dafür, daß dein Vorgehen und deine Lösungen angemessen zu den Rahmenbedingungen sind.

AR: No Cloud-Native Complexity
DV: No Over-Engineered Abstractions

FE — FEASIBLE
machbar

Ensure that your approach and solutions can be realised at reasonable costs.

Sorge dafür, daß dein Vorgehen und deine Lösungen mit vernünftigen Kosten realisiert werden können.

AR: Existing Framework Functionality
DV: Realistic Programming Model

IN — INCREMENTAL
inkrementell

Apply the depth of your discipline incrementally.

Wende die Tiefe deiner Disziplin inkrementell an.

AR: Identified Solution Cruxes
DV: Minimum Viable Product

VA — VALUEABLE
wertvoll

Provide clearly recognizable added values with your approach and solutions.

Liefere klar ersichtliche Mehrwerte mit deinem Vorgehen und deinen Lösungen.

AR: Technology Stack Design
DV: User-Story-Driven Functionality

SU — SUSTAINABLE
nachhaltig

Create sustainable solutions that are well integrated into their environment.

Erschaffe nachhaltige Lösungen, die gut in ihre Umgebung integriert sind.

AR: Interoperable Interfaces
DV: Maintainable Code

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Software Engineering Metamodel

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Craftsmanship Model (4)

WHEREBY & HOW

Know how in a profession to operationally perform certain practices with the help of templates and tools.

Profession
A person's occupation, founded upon specialized educational training and formal qualification.

+ suitable for

Know-How
Distinct overall knowledge on how to perform certain tasks.

Practice
Distinct steps to perform a certain task with the help of a certain know-how and template.

+ operationalised by

Template
The initial version of an artifact in order to speed up and/or support crafting the artifact.

+ derived from

Tool
Software application to create an artifact from scratch or from a template and further edit it.

Discipline Model (1)

HOW & WHAT

Based on personal inclinations, understand how to act in area-grouped disciplines and create artifacts and their aspects.

Inclination
A person's natural tendency or urge to act or feel in a certain way.

Area
Logical group of strongly related disciplines.

+ correlates to

Discipline
Distinct knowledge, responsibility and objectives within Software Engineering.

+ corresponds to

Artifact
Single representation of an internally used and/or externally delivered result.

Aspect
Smallest result unit of an artifact which can be created separately.

Workflow Model (2)

WHAT & WHO

Understand the workflow of separate iterating cycles and work streams, comprised of one or more steps.

Workflow
The five distinct iteration cycles Product Management, Business, Development, Operations and Project Management.

Cycle
Logical iteration cycle of a sequence of strongly related and dependent workflow steps.

serialized by 1

Step
Single step in a workflow cycle with a clear logical previous and next step in the logical work flow.

operationalises 1

Flow
Logical sequence of interweaved, inter-cycle, optionally skipped, and dependent steps.

Key Message
Mastering Software Engineering means to understanding (in this order) **Discipline**, **Workflow**, **Process** and **Craftsmanship** models. Especially, *never* start with a particular Process model, as it is secondary!

Process Model (3)

WHO & WHEN

Map activities onto a project execution schedule, based on horizontal team focus tracks and vertical temporal project periods and phases.

Role
Distinct responsibility and goal of an individual person.

Track
Work stream consisting of a continuously sequence of steps of a workflow cycle.

Activity
Distinct activity in the process to perform a certain task or complete a particular work-package.

Period
Minor time period in the process, to split the project phases into distinct time-, cost-, or scope-based time units.

Phase
Major time period in the process, to split the project into distinct focus periods, separated by major milestones.

EF 02.1

big picture & coherency

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Software Engineering Disciplines

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ANALYSIS (AN)

Software Requirements (REQ)

Identify Needs: 3 BB
We understand which outcomes of the solution are most valuable to users.
Requirements Engineer / Business Analyst

Domain Modeling (DOM)

Determine Solution: 2 WB
We model and specify the solution through involved functional and non-functional aspects.
Business Analyst / Business Architect

business-oriented & domain-specific

ARCHITECTURE (AR)

Software Architecture (SWA)

Design Software: 1 WB
We design an orthogonal, well-balanced and well-considered solution.
Software Architect

System Architecture (SYA)

Design Systems: 2 BB
We ensure that the solution fits optimally into its environment.
System Architect / Enterprise Architect

constructive & technological

CONFIGURATION (CF)

Software Versioning (VER)

Version Artifacts: 1 BB
We place every artifact of the solution under strict version control.
Configuration Manager

Software Assembly (ASM)

Assemble Artifacts: 1 BB
We build and package the solution through an automated and repeatable mechanism.
Build Manager / Build Engineer

infrastructural & technological

ANALYTICS (AC)

Software Reviewing (REV)

Review Code: 4 WB
We regularly and semantically peer-review the source code of the solution.
Software Tester

Software Testing (TST)

Test Solution: 2 BB
We adequately test the functional and non-functional aspects of the solution.
Software Tester

analytical & domain-specific

MANAGEMENT (MG)

Product Management (PRD)

Push Product: 3 BB
We continuously push the development and release of the solution to the users.
Product Manager / Product Owner

Project Management (PRJ)

Steer Process: 3 BB
We rigorously balance time, cost and scope to react on changes and reach the goals.
Project Manager

people-oriented & process-oriented

EXPERIENCE (EX)

User Experience (UXP)

Optimize Workflows: 3 BB
We align the solution to the perspective of the target audience.
User Experience Expert

User Interface (UID)

Design User Interfaces: 2 WB
We design a useful, intuitive, and beautiful user interface for the solution.
User Interface Designer / Graphics Designer

DEVELOPMENT (DV)

Software Development (DEV)

Implement Code: 1 WB
We develop the solution outside-in, from coarse to fine aspects.
Software Engineer / Software Developer

Software Refactoring (REF)

Refactor Code: 4 BB
We regularly and holistically refactor the solution to ensure long-term quality.
Software Engineer / Software Developer

DELIVERY (DL)

Software Deployment (DPL)

Deploy Artifacts: 1 BB
We ship and deploy the solution through an automated and repeatable mechanism.
System Engineer

System Operations (OPS)

Operate Solution: 4 BB
We ensure that our infrastructures and the solution can be operated in a resilient and secure way.
System Administrator / System Operator

COMPREHENSION (CP)

Usage Documentation (DOC)

Document Solution: 2 WB
We adequately document the usage and operation of the solution.
Technical Writer

User Training (TRN)

Train Users: 4 BB
We adequately train the users and operators of the solution.
Product Expert

ADJUSTMENT (AD)

Project Coaching (COA)

Support Members: 4 BB
We ensure that project members use state-of-the-art methodology, technology, and tools.
Project Coach / Methodology Master

Change Management (CHG)

Involve Stakeholders: 3 BB
We ensure that all stakeholders of the solution are suitably involved.
Change Manager

WB white-box view (details before whole)
BB black-box view (whole before details)
X scalability layer (from 4/most to 1/least dispensable)

EF 02.2

inclination & knowledge