IREB

Certified Professionals for Requirements Engineering

Wim Decoutere

- Master Informatics - KuLeuven
- Senior Test Analyst / Test Expert / Trainer
- 15 years experience (mostly financial sector)
- IREB Associate member

- Hasselt (Belgium) - 39 years old
- Happily married with Caroline
- 2 children: Jules (8 years old) & Alice (6 years old)
- Hobbies: reading, music, catching up sleep (see previous bullet)

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IREB

- International Requirements Engineering Board
- non-profit organization
- Board members are international recognized experts
- Working parties for syllabi and exams
- Goal: to improve practices in requirements engineering and requirements management

- www.ireb.org

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IREB Foundation Exam

- IREB Syllabus (v3.0 - October 2020)
- Defined Educational Objectives and Levels of Knowledge
  - L1: knowing
  - L2: mastering and using
  - L3: applying
- iSQI active as examination body
- 75 (+ 15) minutes exam, 45 questions
- English language (translating dictionary allowed)
- Questions vary in difficulty and different (indicated) marking accordingly
- At least 70% of possible score needed to pass
- ID required

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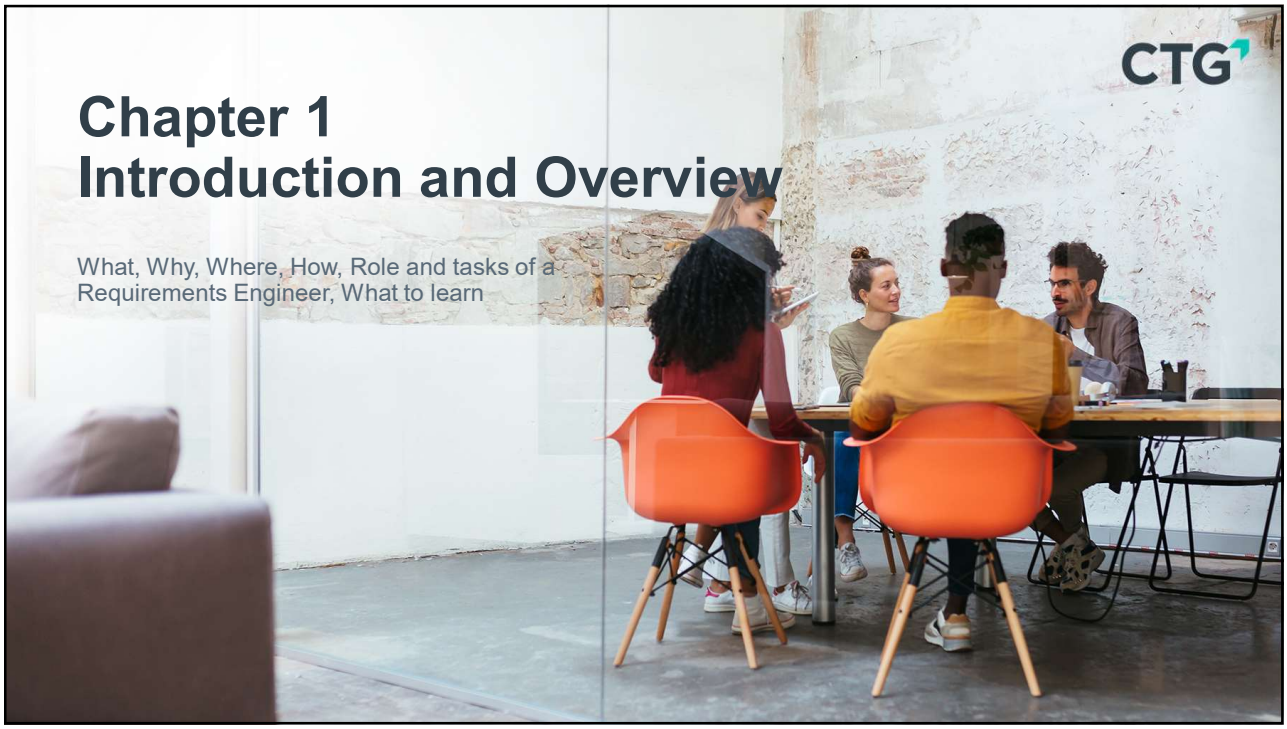

Chapter 1
Introduction and Overview

What, Why, Where, How, Role and tasks of a Requirements Engineer, What to learn

Learning goals

- L1 Remember the fundamental terminology
- L2 Explain the value of RE
- L1 Enumerate symptoms and reasons for inadequate RE
- L1 Know where RE can be applied
- L2 Understand the different sorts of requirements
- L1 Know that an RE process has to be tailored based on a set of influencing factors
- L1 Characterize the role and tasks of a Requirements Engineer
- L1 Remember what a Requirements Engineer needs to learn

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Requirements engineering: What?

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Goal of Requirement Engineering (RE)

Specify and manage **requirements** for **systems** such that implemented and deployed systems satisfy their **stakeholders**' desires and needs

Requirements: People and organizations' desires and needs

- Build new things
- Evolve existing things

Systems: All things stakeholders have requirements for

- Products provided to customers
- Services available to customers
- Other deliverables (e.g. devices, procedures, tools…)
- Compositions or components of products, services or other deliverables

Stakeholders

- Persons or organizations who influence requirements of a system or are impacted by that system

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Requirements engineering: What?

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3 types of requirements

Functional requirements

- Result or behavior provided by a function of a system
- Describe WHAT the system does

Quality requirements

- Quality concerns not covered by functional requirements
- Describe HOW the system does it

Constraints

- Limit solution space to meet functional and quality requirements

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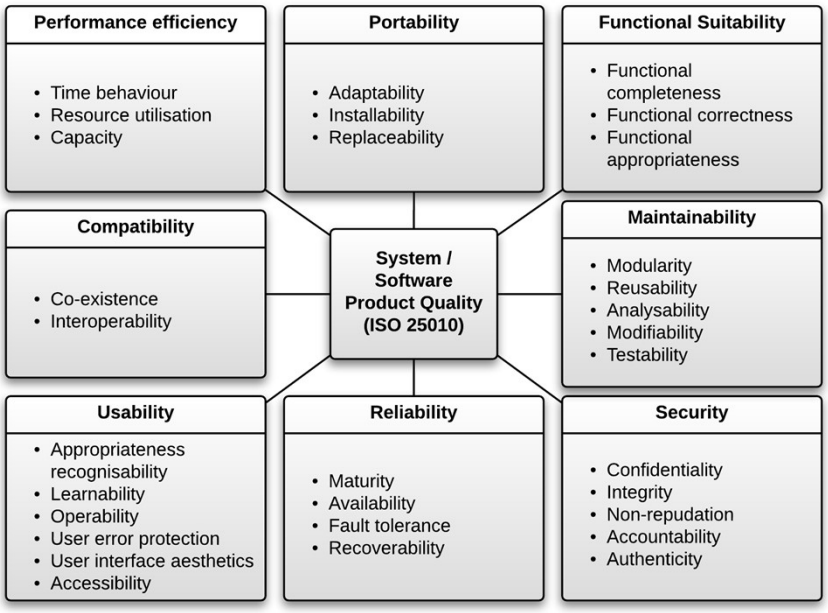
Quality Requirements

ISO 25010



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Requirements engineering: Why?

RE adds value

- Most significant contributors to project failure relate to requirements
  [Standish Group CHAOS report]
- Most frequently named cause of total project failure: changing requirements
  [Study Computer Industry Daily of 500 IT managers USA &UK]
- Requirements Management seen as biggest problem in software development processes
  [EU Survey]
- Investing less than 5% in gathering and processing requirements will lead to budget overruns of approximately 80% - 200%
- 50% of defects reported during dynamic testing can be traced to requirements engineering and/or requirements management

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Requirements engineering: Why?

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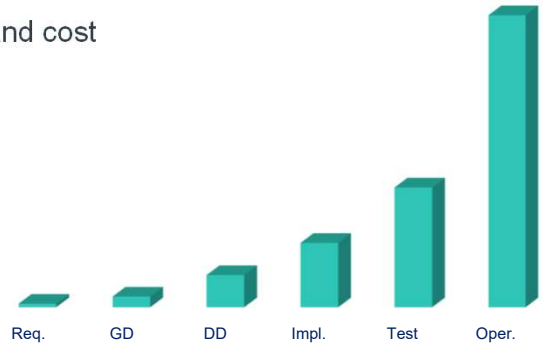
RE adds value

- Reduce risk of developing the wrong system
  - Early detection and correction of wrong or missing requirements
- Better understand the problem
  - Eases intellectual complexity
- Basis for estimating development effort and cost
- Prerequisite for testing the system



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Requirements engineering: Why?

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Exercise

- As a group
- Describe in one or two keywords
  - Important requirements problems (from your project/organization)
  - What resulted from these problems (consequences)
  - Ideas for improvement (solutions)

Problems	Consequences	Solutions

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Requirements engineering: Why?

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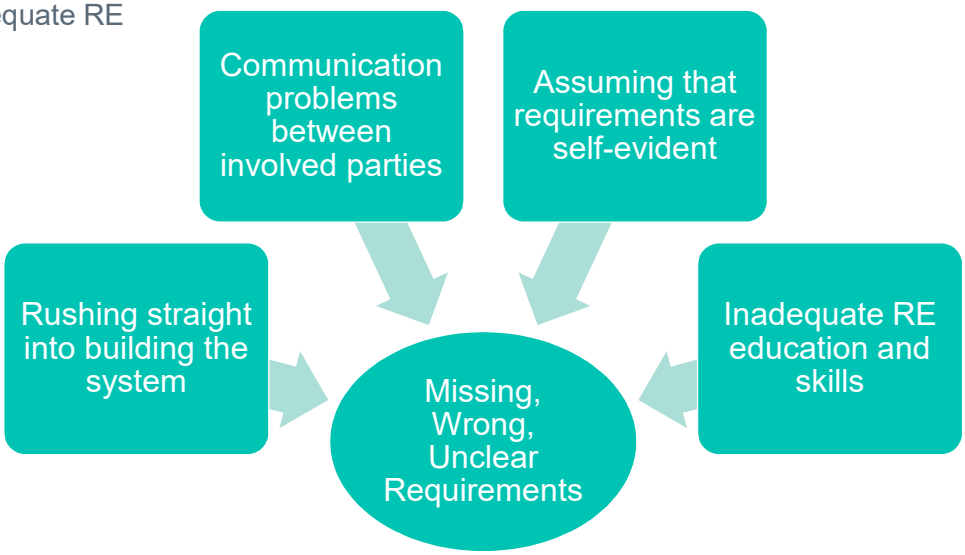
Inadequate RE



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Requirements engineering: Where?

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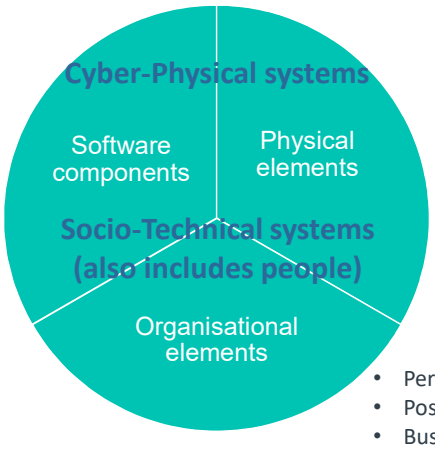
- Applicable for requirements of any kind of system
  - Mostly systems where **software** plays a major role



- Technical products
- Computing hardware
- Devices
- Sensors

- Persons
- Positions
- Business Processes
- Legal and compliance issues

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Requirements engineering: Where?

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Sorts of requirements

System Requirements	• What a system shall do to satisfy stakeholders' desires and needs • "Software requirements" for pure software systems
Stakeholder Requirements	• What stakeholders want, from their perspective
User Requirements	• What users want, from their perspective • Subset of stakeholder requirements
Domain Requirements	• Required domain properties • For socio-technical or cyber-physical system
Business Requirements	• Business goals, objectives & needs of an organization

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Requirements engineering: How?

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4 Major tasks in RE

- Elicitation
- Documentation
- Validation
- Management of requirements

- Analysis
- Conflict resolution

- Tool support may help perform these tasks
- RE must be **tailored** for every project
  - No universal process

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The Role and Tasks of a Requirements Engineer

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- Requirements Engineer typically not a job title, but a *role*:
  - Elicit, document, validate and/or manage requirements as part of their duties
  - Have in-depth knowledge of RE
  - Bridge the gap between problem and potential solutions

- In practice following functions act in role of a Requirement Engineer:
  - Business analysts
  - Application specialists
  - Product owners
  - Systems engineers
  - Developers

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The Role and Tasks of a Requirements Engineer

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Exercise

- A small scale bank is looking for a business analyst
- In teams of 2
- Rank the 5 requirements that are most relevant (make your Top 5)

Position	Requirement #
1	
2	
3	
4	
5	

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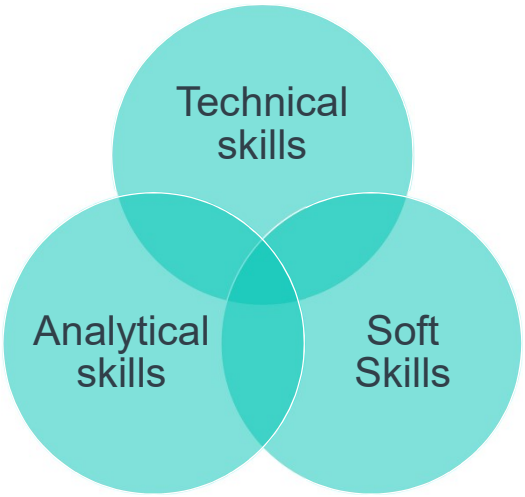
What to learn about Requirements Engineering



- Listen
- Moderate
- Negotiate
- Mediate
- Empathy for stakeholders
- Openness to needs and ideas of others

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What to learn about Requirements Engineering

- Chapter 2 • Fundamental principles
- Chapter 3 • Proper form of documentation and work products
- Chapter 4 • Elaboration practices
- Chapter 5 • Processes and working structures
- Chapter 6 • Management practices
- Chapter 7 • Tool support

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Quiz Questions

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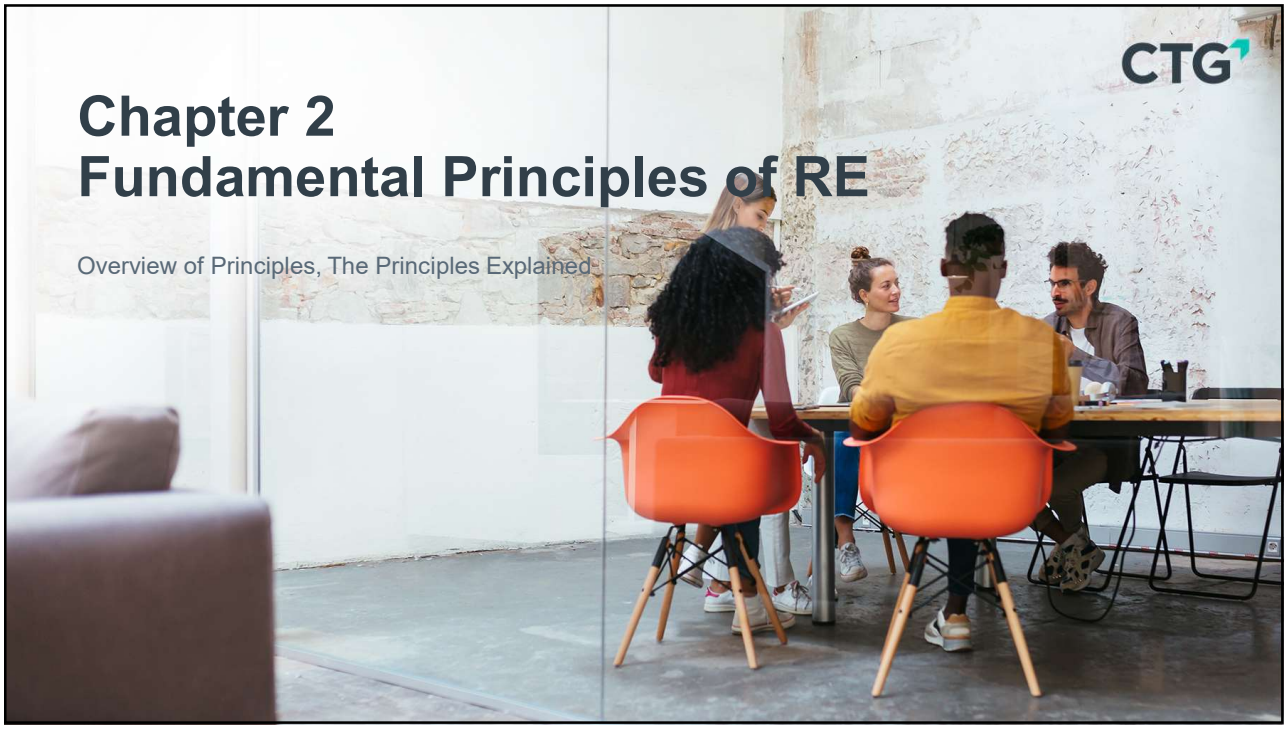

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Chapter 2
Fundamental Principles of RE

Overview of Principles, The Principles Explained

Learning goals

- L1 Enumerate the principles of RE
- L1 Remember the terms associated with the principles
- L2 Explain the principles and the reasons why they are important

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Fundamental Principles

- 9 principles
- Used to govern Requirement Engineering
- Applicable to all tasks, activities and practices

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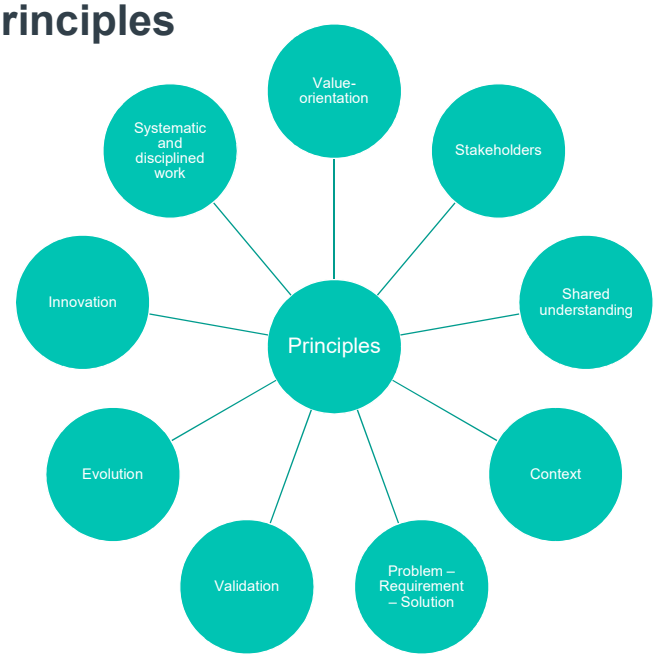
Overview of Principles



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The Principles explained

1 - Value-orientation: Requirements are a means to an end, not an end in itself

- Requirements are only useful if they add value
- RE needs to find balance between benefit and cost

- Build systems which **satisfy desires and needs of stakeholders**
- **Reduce risk of failure and costly rework** when developing the system

- Elicitation
- Documentation
- Validation
- Management

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1 – Value-orientation

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Factors influencing benefit

- Criticality
- Effort needed to specify requirement
- Distinctiveness of requirement
  - How much it contributes to success of overall system
- Degree of shared understanding between stakeholders and developers and among stakeholders
- Existence of reference systems
  - Can serve as a specification by example
- Length of feedback cycle
  - Time between getting a requirement wrong and detecting the error
- Kind of customer-supplier relationship
- Regulatory compliance required

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1 – Value-orientation

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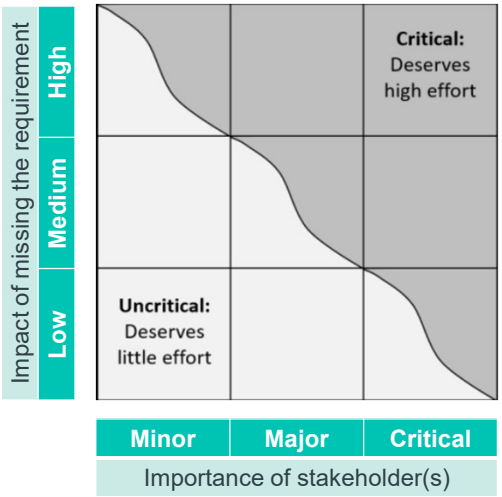
Assessing criticality



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The Principles explained

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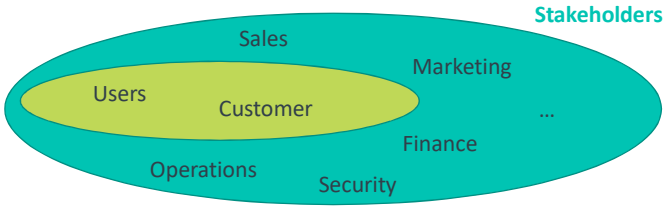
2 - Stakeholders: RE is about satisfying the stakeholders' desires and needs

- Properly dealing with stakeholders is a core task of RE
- Different stakeholder needs and viewpoints → conflicting requirements
  - Identify and resolve such conflicts
- Not only requirements of end users or customers
  - Might miss critical requirements from other stakeholders
  - Involving right people in relevant stakeholder roles



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Classifying Stakeholders

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Degree of influence on success of system

Critical

- Results in severe problems
- Makes system fail or renders it useless

Major

- Adverse impact on succes of system
- Won't make it fail

Minor

- No or minor influence on success of system

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The Principles explained

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3 - Shared understanding: Successful systems development is impossible without a common basis

- RE creates, fosters, and secures shared understanding between and among parties involved: stakeholders, Requirements Engineers, and developers

Explicit shared understanding

- Achieved by documented and agreed requirements

Implicit shared understanding

- Based on shared knowledge about needs, visions, context, etc

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Shared Understanding

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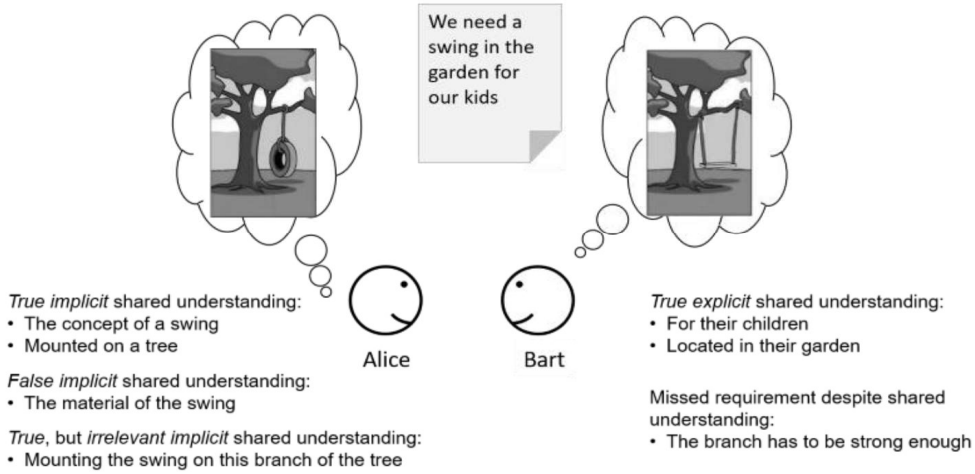
Never rely blindly on shared understanding

- Assess whether there is true shared understanding



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Shared Understanding

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Achieve shared understanding

- Creation of glossaries
- Creating prototypes
- Using existing system as reference point
- Use process with short feedback loops
  - Most important practice for reducing impact of misunderstandings

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Shared Understanding

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Assess shared understanding

Explicit shared understanding

- Validating all specified requirements

Implicit shared understanding

- Examples of expected outcomes
- Exploring prototypes
- Estimating the cost of implementing a requirement

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Shared Understanding

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Enablers

- Domain knowledge
- Domain specific standards
- Previous successful collaboration
- Existence of reference systems known by all involved
- Shared culture and values
- Mutual trust

Obstacles

- Geographic distance
- Supplier-customer relationship guided by mutual distrust
- Outsourcing
- Regulatory constraints
- Large and diverse teams
- High turnover among people involved

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The Principles explained

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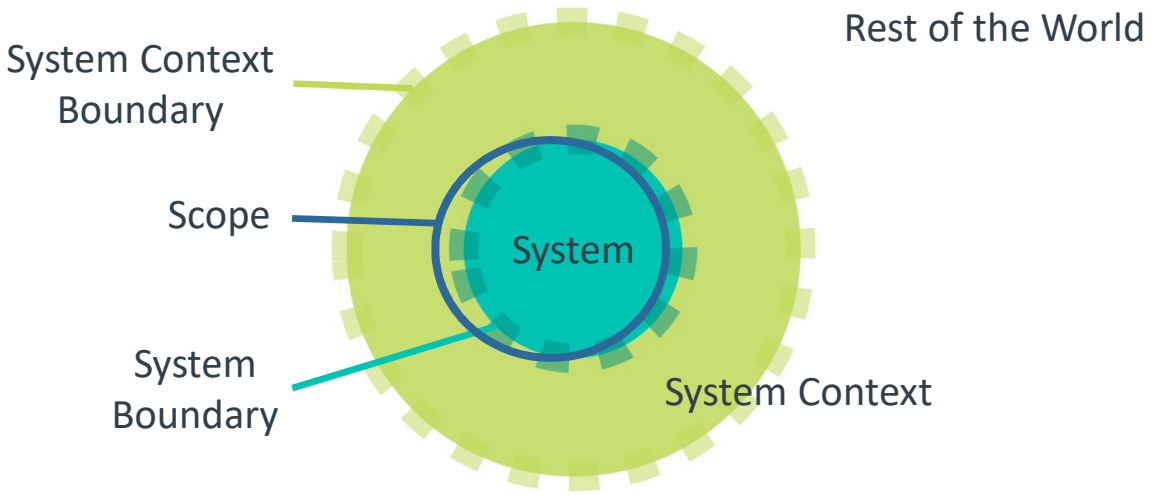
4 - Context: Systems cannot be understood in isolation



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Systems cannot be understood in isolation

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Context

- part of systems' environment relevant for understanding system and its requirements

System Boundary

- Boundary between system and its surrounding context

Context Boundary

- Boundary between context of a system and those parts of the application domain irrelevant for the system and its requirements

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Scope

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- Range of things that can be shaped and designed when developing a system

- Frequently coincides with system boundary
- Sometimes no match
  - Reuse of components within system boundary → out of scope
  - Redesign of things in system context during system development → in scope

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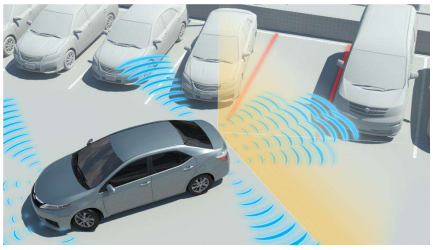
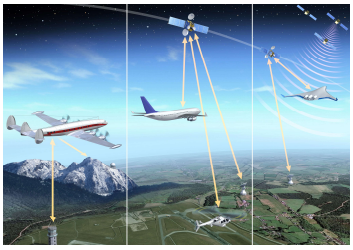
The Principles explained

4 - Context: Systems cannot be understood in isolation

- Don't consider only requirements within system boundary, also:
  - Changes in context impacting system requirements
  - Real-world requirements relevant for the system (Domain requirements)
    → how to map them to system requirements
  - Context assumptions that must hold for making system work and meeting real-world requirements





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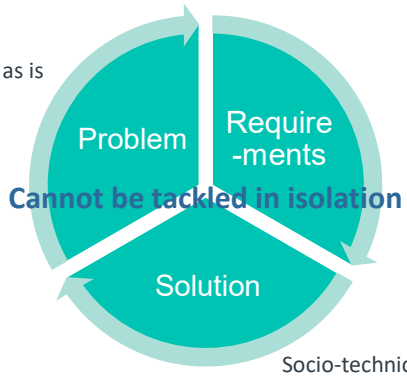
The Principles explained

5 - Problem – Requirement – Solution: An inevitably intertwined triple

Stakeholder not satisfied with solution as is



Capture what stakeholder needs
- get rid of problem
- simplify it

Socio-technical system that satisfies these requirements

Even though problems, requirements and solutions are intertwined, Requirements engineers aim to separate them when thinking, communicating and documenting

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Problem – Requirement – Solution

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Intertwinement

Hierarchical intertwinement

- Large systems with multi-level hierarchy of subsystems and components
- High-level requirements lead to high-level design decisions
  - Inform lower-level requirements that lead to lower-level design decisions

Technical feasibility

- Specifying non-feasible requirements is a waste of effort
- Assessing feasibility of a requirement sometimes only possible when exploring technical solutions

Validation

- Prototypes constitute partial solutions of problem

Solution bias

- Different stakeholders may envisage different solutions for given problem
- They specify different, conflicting requirements for that problem

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The Principles explained

CTG

6 - Validation: Non-validated requirements are useless

Validation

- Process of confirming that an item matches its stakeholders' needs
- Confirming whether right requirements have been specified

- Agreement about requirements achieved among stakeholders?
  - Conflicts resolved
  - Priorities set
- Stakeholders' desires and needs adequately covered by requirements?
- Reasonable context assumptions?
  - Assumptions can be met when system is deployed and operated

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The Principles explained

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7 - Evolution: Changing requirements are no accidents, but the normal case

- Systems and requirements are subject to evolution:
  - Changing business processes
  - Competitors launching new products or services
  - Clients changing their priorities or opinions
  - Changes in technology
  - Feedback from system users asking for new or changed features
  - Detection of errors in requirements or detection of faulty domain assumptions
- Requirements may change due to
  - Feedback from stakeholders when validating requirements
  - Detection of faults in previously elicited requirements
  - Changing needs

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No accidents, but the normal case

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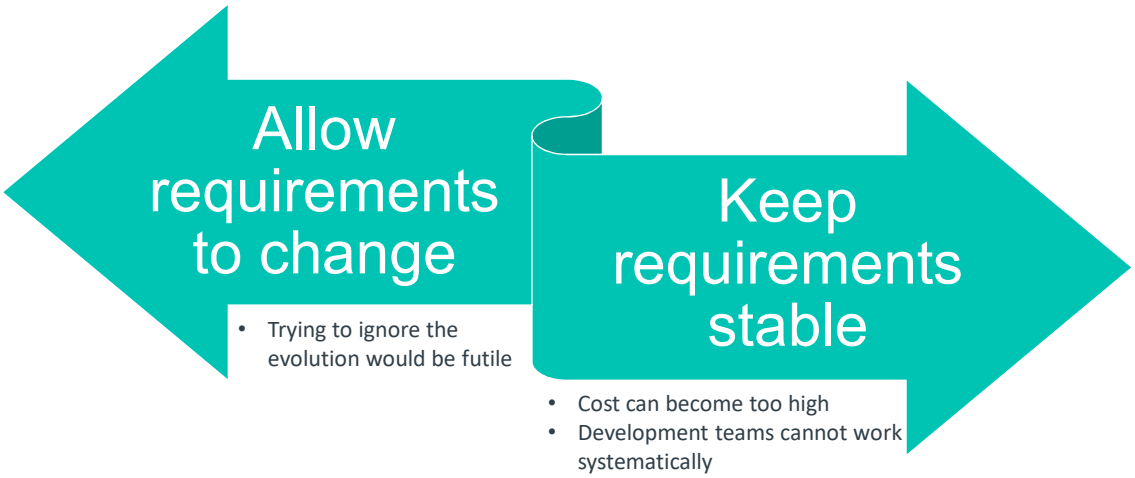
Contradictory goals



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The Principles explained

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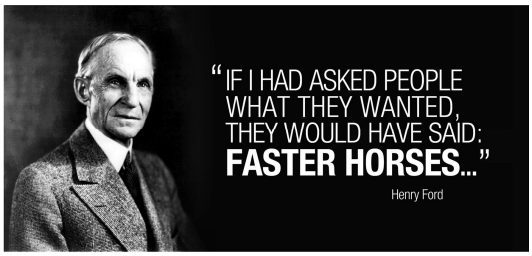
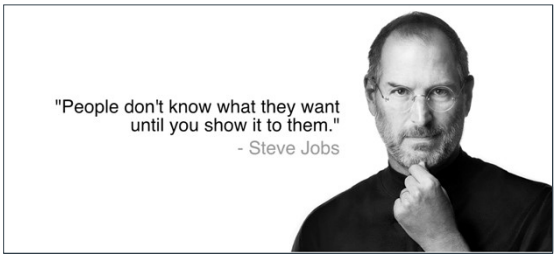
8 - Innovation: More of the same is not enough





- Not just satisfy stakeholders, but make them happy, excited, or feel safe
- Don't miss out on opportunity to do things better than before
- Go beyond what stakeholders tell you
- RE shapes innovative systems:
  - Small scale: striving for exciting new features and ease of use
  - Large scale: striving for disruptive new ideas

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The Principles explained

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9 – Systematic and disciplined work: We can't do without in RE

- Systematic and disciplined approach to RE improves quality of resulting system
  - Configure RE process
    - well suited for the problem at hand
    - fits development process
  - Select RE practices and work products
    - Best suited to given problem, context and environment

- No single process or practice works well in every situation
  - Choose processes, practices and work products that fit situation the best!
  - Do not always use same processes, practices and work products
  - Do not reuse same processes and practices from the past without reflection

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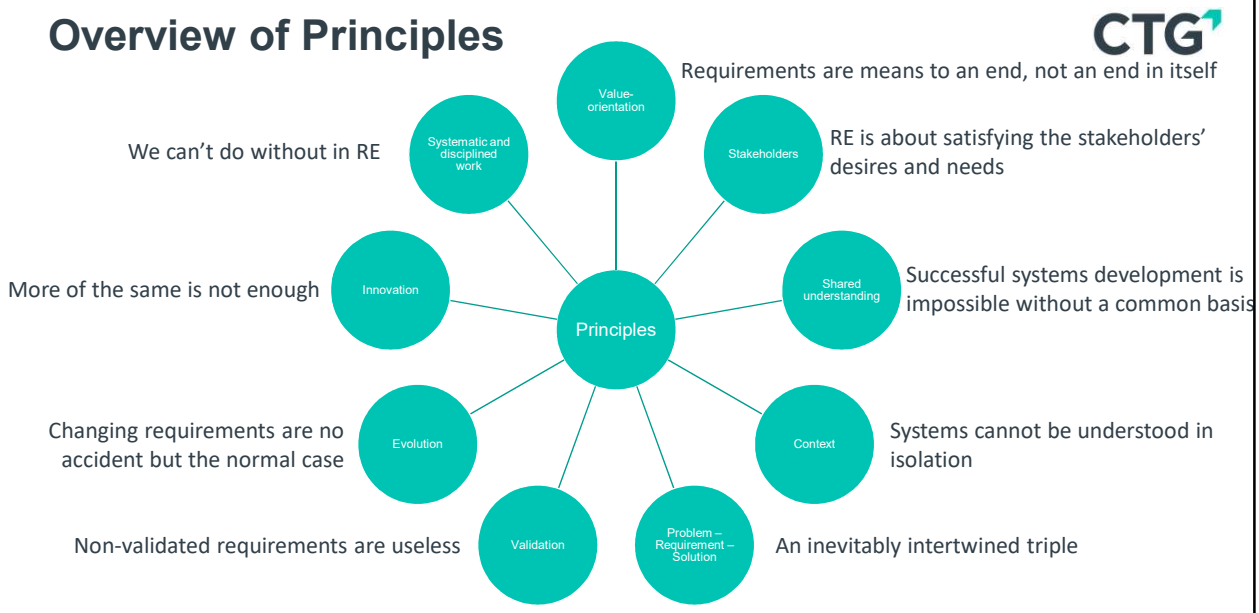
Overview of Principles



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Quiz Questions

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Chapter 3
Work Products and Documentation Practices

Work Products in RE, Natural-Language-Based, Template-based & Model-based Work Products, Glossaries, Requirements Documentation Structures, Prototypes, Quality Criteria for Work Products and Requirements

Learning goals

- L1 Know the characteristics of RE work products and enumerate frequently used types of work products
- L1 Know what each work product can be used for and know the life span of work products
- L2 Explain the different categories and abstraction levels for requirements, including how to choose appropriate abstraction levels and levels of detail
- L1 Know aspects to be considered in work products and the interrelationships between these aspects
- L1 Name the general documentation guidelines
- L1 Describe why it is worth planning the work products to be used
- L1 Know natural-language-based work products and their advantages and disadvantages
- L2 Explain the rules for writing good natural-language-based requirements
- L1 Know the categories of template-based work products and their advantages and disadvantages
- L3 Specify an individual requirement and a user story using a phrase template
- L3 Specify a use case using a form template
- L2 Understand the role, purpose, and use of models in RE
- L2 Understand the advantages and limitations of modeling in RE
- L1 Know the terms model, modeling language, activity model, activity diagram, class model, class diagram, context model, context diagram, domain model, goal model, interaction model, process model, sequence diagram, statechart, state machine, state machine diagram, use case, use case diagram

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Learning goals

- L2 Understand how to select an appropriate model type for specifying requirements in a given situation
- L2 Understand and interpret simple models, written in UML where applicable, of the following types: context models, use cases and use diagrams, domain models, class models, activity models, process models and statecharts
- L3 Specify a simple model of a system's data or the objects in a model using a UML class diagram
- L3 Specify a simple system function or business process by a UML activity diagram
- L2 Explain the purpose of glossaries and how to create one
- L1 Know frequently used requirements specification documents
- L2 Explain which document structures serve which purpose and the criteria for structuring
- L1 Know different kinds of prototypes and what they are used for
- L1 Know quality criteria for single requirements
- L1 Know quality criteria for work products

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Overview

1. Work Products in Requirements Engineering
   - Characteristics of Work Products
   - Categories and Abstraction Levels
   - Level of Detail
   - Aspects to be Considered in Work Products
   - General Documentation Guidelines
   - Plan the Work Products to be Used
2. Natural-Language-Based Work Products
3. Template-Based Work Products
4. Model-Based Work Products
5. Glossaries
6. Requirements Documentation Structures
7. Prototypes in Requirements Engineering
8. Quality Criteria for Work Products and Requirements

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Work Products in Requirements Engineering

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Work Product

- Recorded intermediate or final result
- Generated in a work process
- Aka 'Artifact'
- May contain other work products

- Variety of work products in RE
- Short-lived graphic sketches
- Evolving collections of user stories
- Formally release contractual requirements specification documents with hundreds of pages
- …

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Work Products in Requirements Engineering

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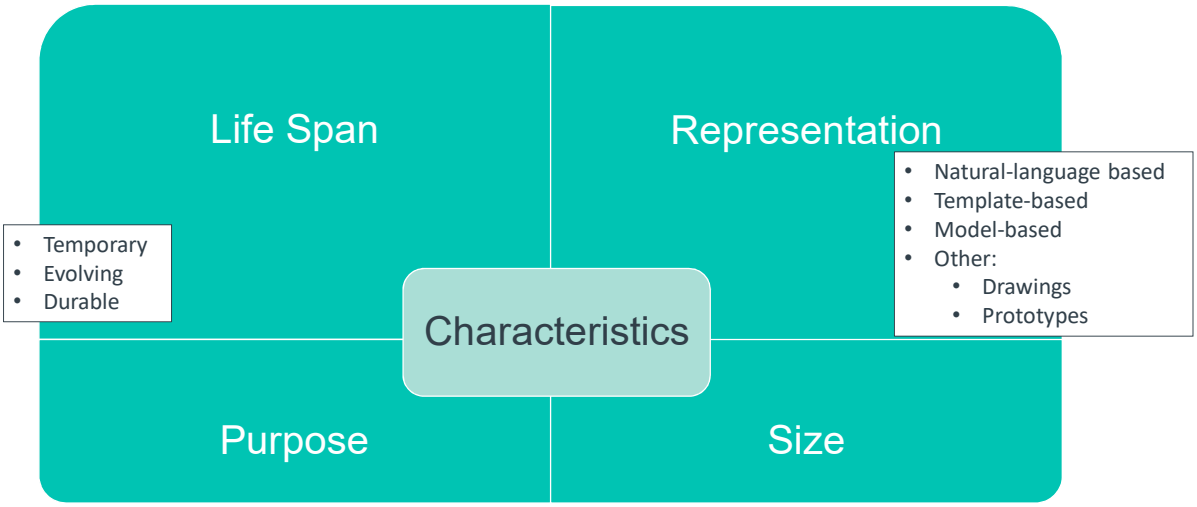
Characteristics of Work Products



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Work Products in Requirements Engineering

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3 categories in life span of work products

Temporary Work Products

- Support communication & shared understanding
- Discarded after use

Decide to keep it and develop it further

Evolving Work Products

- Grow in several iterations over time
- Some metadata kept
- When modified change control procedures need to be applied

Baseline + release it

Durable Work Products

- **Baselined** or **released**
- Full set of metadata must be kept
- Elaborate change process must be followed to change work product

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Work Products in Requirements Engineering

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Characteristics of Work Products

Most work products are **stored** electronically:

- Files
- Databases
- RE tools

- Informal temporary work products may be stored on other media:
- Paper
- Post-its on Kanban board

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Work Products in Requirements Engineering

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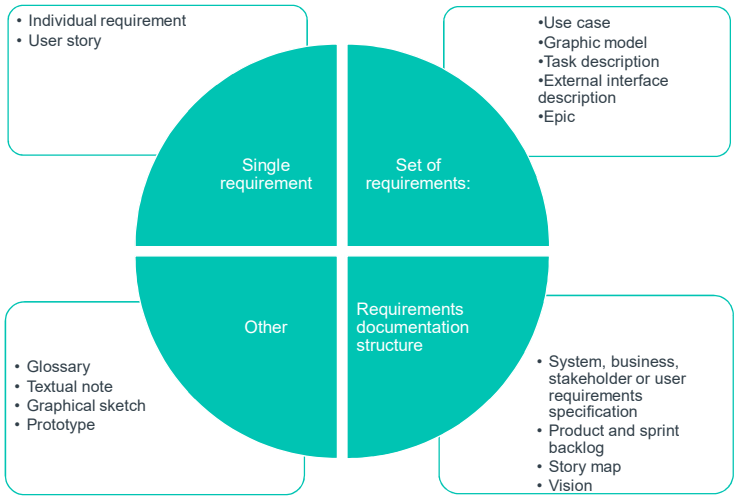
Typical Work Products



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Work Products in Requirements Engineering

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Overview – Single Requirement

Individual requirement	• Single requirement, typical in textual form
User Story	• Function or behavior from a stakeholder's perspective

Overview – Set of Requirements

Use Case	• System function from an actor's or user's perspective
Graphical model	• Various aspects (context, function, behavior, …)
Task description	• Task that system shall perform
External interface description	• Information exchanged between system and actor in the system context
Epic	• High-level view of stakeholder need
Feature	• Distinguishing characteristic of system

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Work Products in Requirements Engineering

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Overview – Documents or documentation structures

Requirements specification(s)	• Comprehensive requirements document
Product and sprint backlog	• List of work items, including requirements
Story map	• Visual arrangement of user stories
Vision	• Conceptual imagination of future system

Overview - Other

Glossary	• Unambiguous and agreed common terminology
Textual note / graphic sketch	• Memo for communication and understanding
Prototype	• Understanding, negotiating, and validating requirement

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Overview

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8. Quality Criteria for Work Products and Requirements

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Work Products in Requirements Engineering

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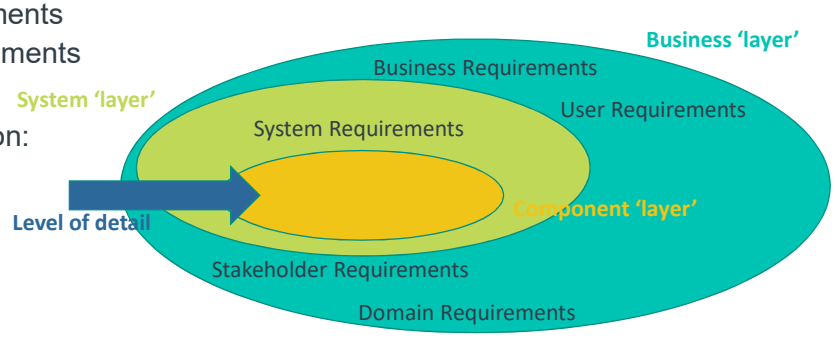
Categories and Abstraction Levels

- **Categories:**
  - System requirements
  - Stakeholders' requirements
  - User requirements
  - Domain requirements
  - Business requirements
- 3 layers of abstraction:
  - Business
  - System
  - Components



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Proper abstraction level

- Depends on what is to be specified
- Do not mix requirements on different abstraction levels

Small (user story)

- More or less same abstraction level

Medium (use case)

- More or less same abstraction level

Large (system reqspec)

- Keep requirements on different abstraction levels separate
- Structure specification document accordingly

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Work Products in Requirements Engineering

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Level of detail

- Depends on several factors

Problem and development context	Degree of shared understanding	Degree of freedom left to designers and programmers
Availability of rapid stakeholder feedback	Cost vs. value of detailed specification	Imposed standards and regulatory constraints

- Greater level of detail:
  - **Lower risk** of getting something unexpected or unspecified
  - **Increased cost** for specification

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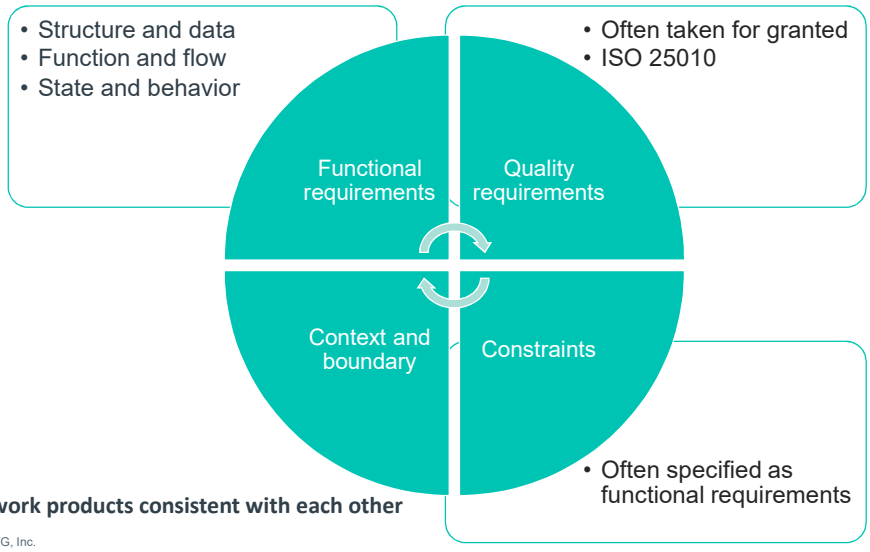
Work Products in Requirements Engineering

Aspects to be considered in Work Products



Keep work products consistent with each other

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Quality Requirement representations

Qualitative

- Ambiguous and thus difficult to achieve and validate

"The system shall be userfriendly."

Quantitative

- Measurable, but sometimes hard to quantify
- Can be quite expensive to specify

"After working 15 minutes with the application, 85% of users give the systems userfriendliness a score of 'good' or 'very good."

Operationalized

- State quality requirements in terms of functional requirements
- Make quality requirements testable but may imply premature design decisions

"When the user hovers over the different fields, the system should display a popup message explaining the expected input."

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When is a qualitative representation sufficient?

- Sufficient implicit shared understanding
- Agreement on solution that satisfies requirements
- Trust in developers to get details right
- Early problem detection (through short feedback loops)

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Quality requirements representation

Situation	Recommended representation
Developers can generalize from examples	1) Quantified examples
	2) Compare with existing system
High risk of not meeting stakeholders's needs	Full quantified/Operationalized representation
Safety-critical quality requirements	Full quantified/Operationalized representation

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Constraints

Technical	• Given interfaces, protocols, components, frameworks that have to be used
Legal	• Restrictions imposed by laws, contracts, standards, or regulations
Organizational	• Organizational structures, processes, or policies that must not be changed by the system
Cultural	• User habits and expectations, shaped by the users' culture(s)
Environmental	• For cyber-physical systems: temperature, humidity, radiation, or vibration, also think of energy consumption or heat dissipation
Physical	• Laws of physics and properties of materials used for physical components that system comprises or interacts with
Particular solutions or restrictions	• Demanded by (important) stakeholders

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Work Products in Requirements Engineering

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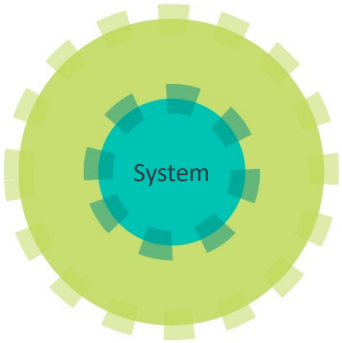
Context and boundary

- Domain requirements and domain assumptions in system context
- External interfaces between system and its environment at the system boundary



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General Documentation Guidelines

- Select work product type that **fits intended purpose**
- **Avoid redundancy** by referencing content instead of repeating same content again
- **Avoid inconsistencies** between work products
- **Use terms consistently** as defined in glossary
- **Structure** work products appropriately – e.g. use standard structures

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Plan the Work Products to be Used

Set of work products must be defined for each endeavor:

- In **which work products** shall the requirements be recorded and for **what purpose**?
- **Which abstraction levels** need to be considered?
- To **which level of detail** must requirements be documented on each abstraction level?
- **How** shall requirements be represented in work products?

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Work Products in Requirements Engineering

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What are advantages of planning work products early in the project?

- Helps plan efforts and resources
- Appropriate use of notations
- Results recorded in right work products
- No major reshuffling of information needed
- No “final editing” needed
- Avoids redundancy
- Less work and better maintainability

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Natural-Language-Based Work Products

Spoken language

- Contextualized
- Interactive
- Immediate feedback

Written language

- No natural means for detecting and correcting ambiguities, omissions and inconsistencies

I didn’t say he killed his wife.

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Natural-Language-Based Work Products

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Advantages

- Extremely expressive and flexible
- Almost any conceivable requirement in any aspect can be expressed
- Used in everyday life: no specific training required to read and understand

Disadvantages

- Can be interpreted in different ways
- Detection of ambiguities, omissions and inconsistencies is difficult and expensive

Natural-language-based work products are a **core means** for specifying requirements

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Natural-Language-Based Work Products

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Simple rules for writing good natural-language-based requirements

Write short and well-structured sentences

- One single requirement in one sentence
- Use phrase templates to achieve a good structure

Define and consistently use a uniform terminology

- Create and use a glossary

Avoid vague or ambiguous terms and phrases

- Avoid fuzzy terms

Know the pitfalls of technical writing

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Natural-Language-Based Work Products

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Avoid fuzzy terms

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Natural-Language-Based Work Products

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Pitfalls of technical writing – To avoid

Incomplete descriptions

- Verbs in natural language typically come with a set of placeholders for nouns or pronouns
- e.g. 'To give' → *Who* gives *what* to *whom*?

Unspecific nouns

- Use more specific nouns, add adjectives or assign a well-defined type
- e.g. 'The data', or 'The user' → Which data? Which user?

Incomplete conditions (If without else)

- Do not only focus on the normal cases, omitting the exceptional cases
- Provide both the then and else clauses

Incomplete comparisons

- Comparisons should include a reference object
- e.g. 'The new video app is much better' → Much better than?

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Natural-Language-Based Work Products

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Pitfalls of technical writing – To use with care

Passive voice

- Sentences in passive voice have no subject
- This may hide who or what is responsible for the action described in the requirement
- e.g. 'The data shall be transferred' → By *whom*?

Universal quantifiers (such as "all" or "never")

- Universal properties are rare
- Is it a true universal property or are exceptions (which have to be specified)?
- e.g. 'Every user always has to pay' → Every user? Always? No exceptions?

Nominalizations (i.e., nouns derived from a verb)

- May hide unspecified requirements
- e.g. 'authentication' or 'administration' → what comprises 'authentication'? What is considered 'administration'

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Template-Based Work Products

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- Used to overcome shortcomings of natural-language-based work products
- Provide predefined structures

Phrase templates

- Syntactic structure of phrase
- Expresses individual requirement or user story in natural language
- Best practice when writing in natural language

Form templates

- Form with predefined fields to be filled in

Document templates

- Predefined skeleton structure for document

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Template-Based Work Products

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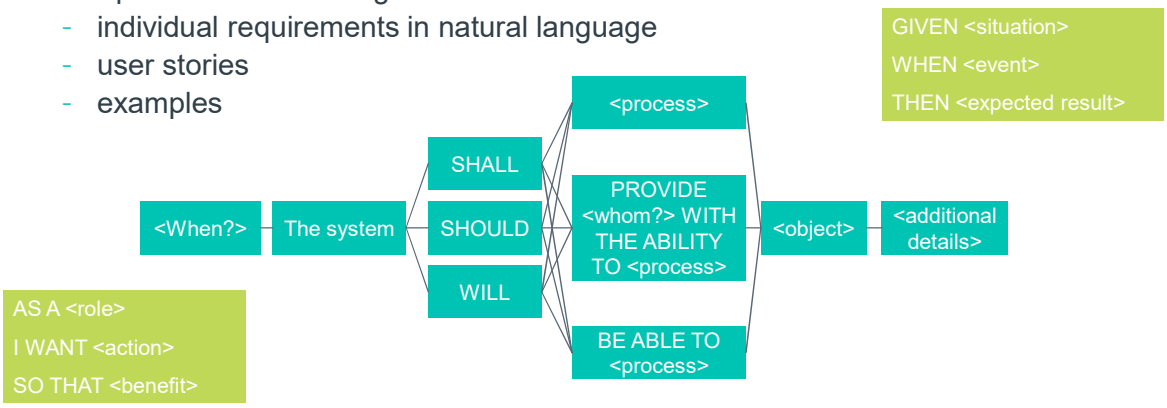
Phrase Templates

- Predefined syntactic structure for a phrase expressing a requirement
- Best practice when writing
  - individual requirements in natural language
  - user stories
  - examples



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Template-Based Work Products

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Boiler plate (for system requirements)

1. Determine legal obligation	2. Determine requirement core	3. Characterize the activity	4. Insert objects	[5. Determine conditions]	[6. Additional details]
• Determine legal relevance • Fixing of liability • If liabilities change, then requirements change too • Use of attributes is another way to document liabilities	• Requirement core requirement is required functionality • *e.g. print, calculate, transfer, store* • Processes are activities or events: they shall be described using verbs • Might be necessary to add (process) verbs to glossary	• How system works closely linked to process words	• Further elements required for completion • Closer or supplementing characterization of process word • What?, Where?	• Functionality only given or provided under certain logical or temporal conditions • 'When', 'While', 'Where', 'If'	• Quality characteristics • Constraints

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Legal Obligation

Must

- Try to avoid the use of 'must'
- Legally required, no discussion about it

Shall

- Mandatory requirement

Should

- Not mandatory but strongly desired

May

- Suggestion

Will

- Future use

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Activity characteristics

Autonomous activity

- System carries out process by itself
- e.g. 'The system should print a receipt'

User interface

- System provides user with process functionality
- e.g. 'The system should provide the client with the ability to print a receipt'

System interface

- System carries out process dependent on a third factor
- Remains passive and waits for an external event
- e.g. 'The system should be able to print a receipt (received from the cashier system)'

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Easy Approach to Requirements Syntax (EARS)

Event-driven requirements

- Triggered by an external event
- WHEN <optional preconditions> <trigger> …

Unwanted behavior

- Describing situations to be avoided
- IF <optional preconditions> <trigger> …

State-driven requirements

- Applies only in certain states
- WHILE <in a specific state> …

Optional features

- Applies only if some feature is included in the system
- WHERE <feature is included> …

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Form Templates

- Predefined fields in a form to be filled in
- Best practice for writing
  - Use cases
  - Measurable quality requirements

Requirements	Description	Value
Name	*The name of the quality requirement*	
Description	*Brief description*	
Focus	*The requirement can affect the end product or the development process.*	
Source	*Source of information (Stakeholder, system, document)*	
Decomposition	*Quality requirements can be decomposed in characteristics and subcharacteristics according to ISO 25010*	
Categorisation	*Quality requirements can be categorised in quality in use, operational quality, external quality & internal quality*	
Priority	*Express the importance of the quality requirement for the stakeholders, the priority can be MAX, LOW, & MIN*	
Obligation	*Optional or mandatory*	
Influence	*Activities of the software process & other categories of requirements (functional, non functional, cognitive) affected by the quality requirement*	
Contribution	*Represents how a quality requirement can be affected buy others quality requirements. This contribution can be (+) or negative (-).*	

Use Case Template:

Template:

ID:	[Unique ID of this use case]
Title:	[Enter the goal of the use case - preferably as a short, active verb-phrase]
Description:	[Describe the goal and context of this use case. This is usually an expanded version of what you entered in the "Title" field.]
Primary Actor:	[A person or a software/hardware system that interacts with your system to achieve the goal of this use case.]
Preconditions:	[Describe the state the system is in before the first event in this use case.]
Postconditions:	[Describe the state the system is in after all the events in this use case have taken place.]
Main Success Scenario:	[Describe the flow of events from preconditions to postconditions, when nothing goes wrong. This is the meat of the use case.]
Extensions:	[Describe all the other scenarios for this use case - including exceptions and error cases.]
Frequency of Use:	[How often will this use case be used?]
Status:	[Development status]
Owner:	[Who owns this use case, in your project team?]
Priority:	[Priority of this use case]

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Document Templates

- Predefined structure for a requirements document e.g. system requirements specification
- **29148**-2018 - **ISO/IEC/IEEE** International Standard - Systems and software engineering -- Life cycle processes -- Requirements engineering. (Chapters 8 & 9)
  - Business requirements specification
  - Stakeholder requirements specification
  - System requirements specification
  - Software requirements specification

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Document Templates

Advantages

- Clear, re-usable structure
- Provide uniform look
- Improve readability
- Capture most relevant information
- Fewer errors of omission
- Improve overall quality of requirements and requirements specifications

Disadvantages

- Focus on formal completion of template rather than on content
- Aspects not included likely to be omitted
- Copy-Paste behaviour

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Exercises

1. Specify an individual requirement using a phrase template
2. Specify a user story using a phrase template
3. Specify a use case using a form template

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Model-Based Work Products

Why use requirement models?

- Loss of insight and overview for textual requirements
  - Number of requirements too big
  - Complexity of requirements
  - Relationship between requirements
  - Abstraction of the requirements
- Read textual requirements several times to get correct and complete picture of system

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Model-Based Work Products

The Role of Models in Requirements Engineering

Model

- Abstract representation of existing part of reality or part of reality to be created
- Notion of reality includes any conceivable set of elements, phenomena, or concepts, including other models.
- With respect to a model, modeled part of reality is called the original

Modeling language

- Consists of grammatical rules and a description of the meaning of the language constructs
- Language rules important to understand model and its nuances

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Syntax

- Describes which notation elements are used in the language
- Describes how these elements can be used in combination

Semantics

- Defines the meaning of the notation elements
- Defines the meaning of the combination of elements
- Understanding is fundamental for preventing the risk of misinterpretation

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Model-Based Work Products

Properties of a model

- Made for a specific purpose
- Gives representation of reality
- Used to reduce information so that we can better understand reality or focus on part of the reality

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Descriptive Models

- Current reality
- Reflects requirements that are met
- If not available yet, result of analysis of current situation
- Also called 'the original'
- AS IS

Prescriptive Models

- Future reality expected or required
- If descriptive model exists, indicates which requirements will be new, changed or are no longer needed.
- Describes ultimate situation desired
- TO BE

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Level of details

Too many details

Hard to grasp
→ Reduce amount of information
→ Omit irrelevant information

- Better understanding of reality
- Understand essence of reality better

Not enough details

Clouded or incorrect image of reality
→ Consider reduction carefully
→ Without distorting reality

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Reduce information

By compression or aggregation

- Make information more abstract
- Information stripped of irrelevant details and therefore more compact
- Information is, as it were, condensed

By selection

- Select only relevant information, not everything
- Indicate subject under consideration
- Focus on specific part (or number of parts) of total

Both can be applied together

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Advantages

Easier to understand and memorize constituting elements and connections

- A picture says more than a 1000 words

Focus on single aspect reduces cognitive load for understanding modeled req's

- Understanding requires less effort

Restricted syntax reduces possible ambiguities and omissions

- Limited number of notation elements + stricter language rules

Higher potential for automated analysis and processing of requirements

- Modeling language more formal than natural language

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Model-Based Work Products

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Perspectives for functional requirements

Structure and data	Function and flow	State and behavior
• **Static structural properties** of system or domain	• **Sequence of actions** to produce required results from given inputs • Actions to execute a (business) process • Including **flow of control** and data between actions and responsible for each action	• **Behavior** of system • Life cycle of business objects • **State-dependent** reactions to events • Dynamics of component interaction

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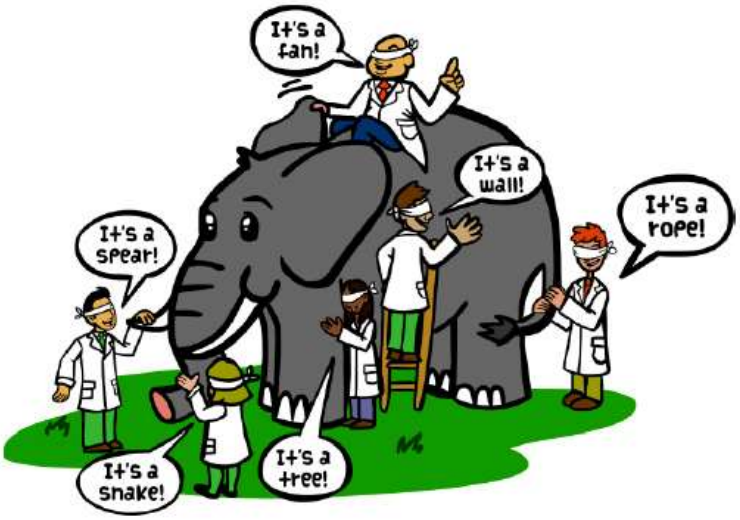
Model-Based Work Products

What are limitations to model-based work products?



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Model-Based Work Products

Limitations

Challenge to keep models focusing on different aspects consistent with each other

- Requires a lot of discipline and coordination between the models

Information from different models needs to be integrated for causal understanding

- All models must be understood well

Focus primarily on functional requirements

- Most quality requirements and constraints not expressable in models with reasonable effort

Not all information can be expressed in model due to restricted syntax

- Models are made for a specific purpose and context
- Not always possible to record all requirements in the model or in multiple models

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Model-Based Work Products

What could you use model-based work products for?

Specifying (primarily functional) requirements, in part or completely
- replacing textual requirements

Decomposing complex reality into well-defined complementing aspects
- each aspect represented by specific model

Paraphrasing textually represented requirements
- to improve comprehensibility
- in particular relationships between them

Validating textually represented requirements
- uncover omissions, ambiguities and inconsistencies

Structuring and **analyzing** knowledge
- Structure your own thoughts to get a better understanding of the system and its context

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Model-Based Work Products

Best of both worlds

- Requirements in textual or visual/graphical form have their advantages and limitations
- Harness power and benefits of both forms of representation

- Amending model with textual requirements
  - Adds more meaning to model
  - Link quality requirements and constraints to model or specific modeling element
  - Provides more complete picture

- Use models to support textual requirements
  - Better understanding
  - Overview

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The Role of Models in Requirements Engineering

- Many modeling languages standardized
- Requirements in non-standard modeling language require a legend

- Many types of models that can be used in RE
- RE must understand which model type best suited to specify requirements in given situation

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Modeling Context

- Models focused on **context aspect:**
- Specify structural embedding of system into its environment
- Specify interaction between system and actors in system context

- **Context Models**
- Specify systems and actors in system context that interact with system
- Sketch interfaces between system and its context
- Not used to describe requirements but to reveal (some) sources of requirements
- Help to identify user interfaces and system interfaces

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Modeling Context

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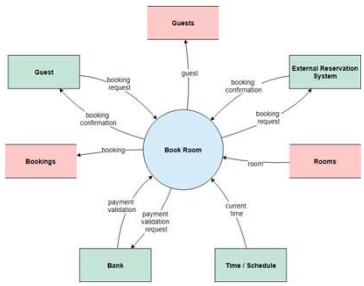
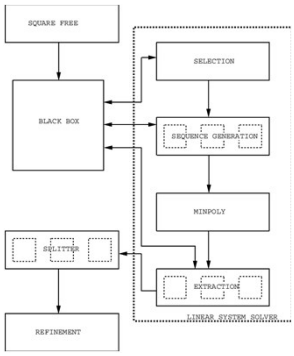
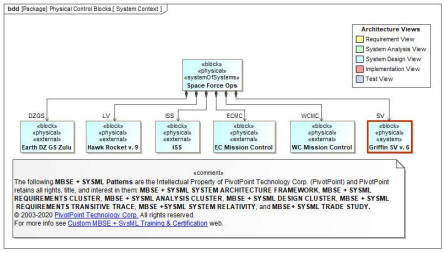
Context Diagrams

- Graphic modeling language for expressing context models
- No standardization
- *e.g. context diagrams from structured analysis, tailored box-and-line diagrams, block definition diagrams*







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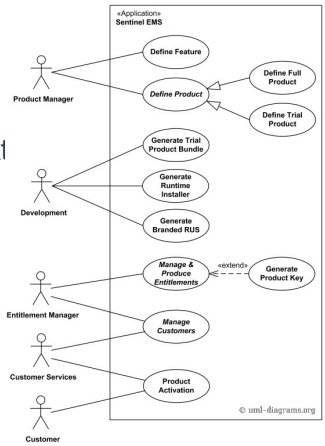
Modeling Context

UML Use Case Diagrams

- Model system and its context
- Model use cases and actors that interact with system through these use cases, in context
- Not complete context! Only specific viewpoint

Use Cases

- Model dynamic interaction between actor in system context and system from perspective of actor
- Mostly written using form templates in natural language
  - UML activity diagram can also be used



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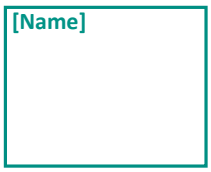
UML Use Case Diagrams

Elements

Use Case (verbs)

Actor: persons and/or other systems that interact with the system



System (Boundary): determines what's inside (the use cases) and outside (persons and other systems)

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UML Use Case Diagrams

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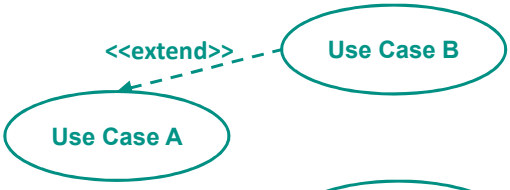
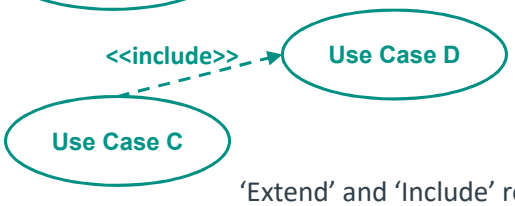
Relations

Communication between actor and use case



Extend: indicates that the behavior of the extension use case may be inserted in the extended use case under some conditions



Include: indicates that the use case to which the arrow points is included in the use case on the other side of the arrow

'Extend' and 'Include' releations usually detected and created later in process

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UML Use Case Diagrams

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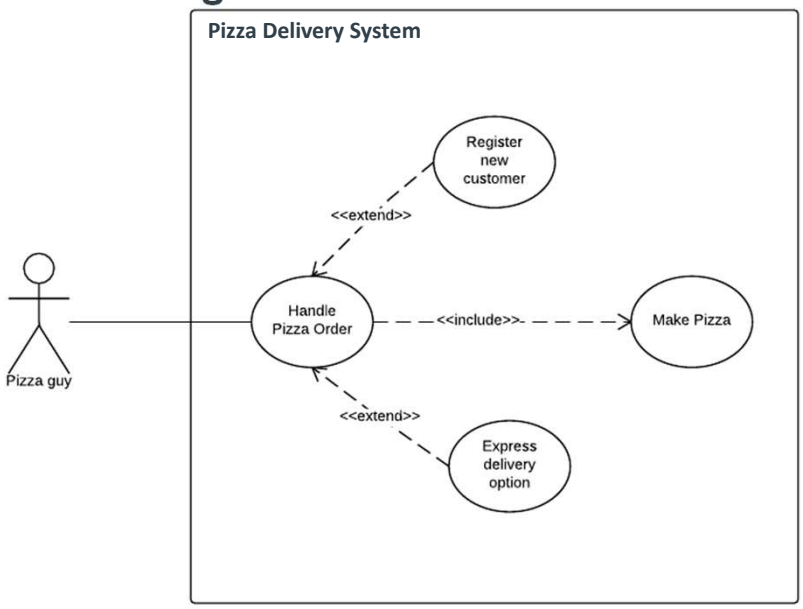
Example



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Modeling Context

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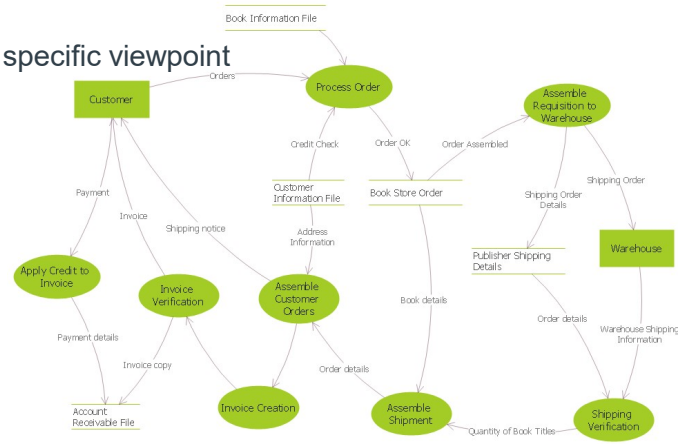
Data Flow Diagrams

- Models flow of data through a process or a system
- No information about the timing or ordering, sequences or parallel behavior
- Multilayered model
- Not complete context! Only specific viewpoint



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Data Flow Diagrams

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Elements

Node: Function / Process

Data store: File / Database

Terminator: Source / Sink

Data flow: Input / Output

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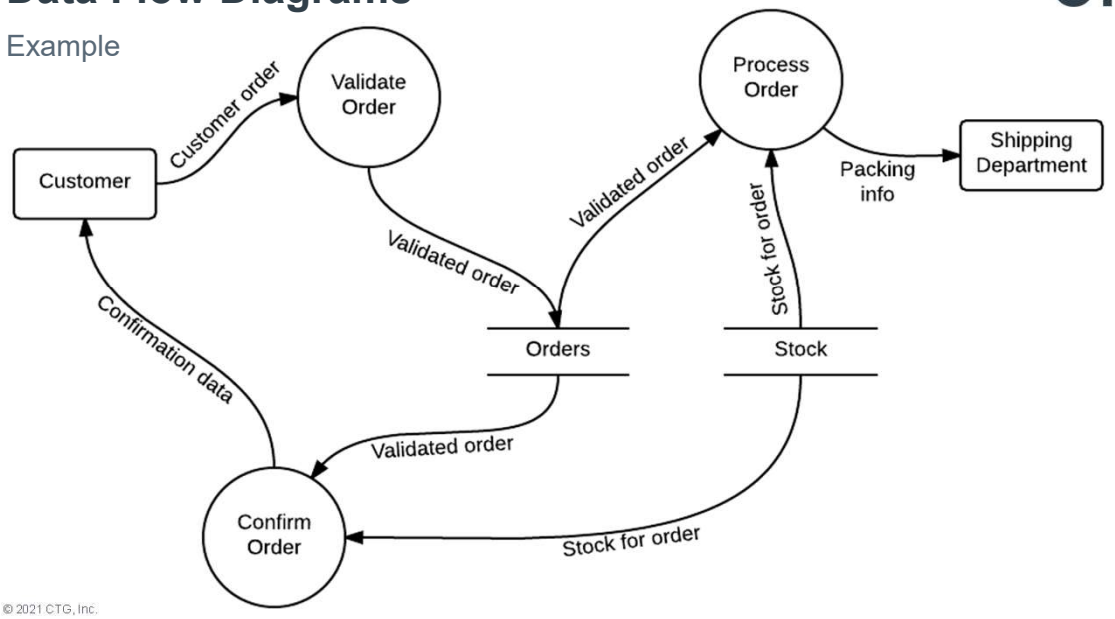
Data Flow Diagrams

Example



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   - Modeling State and Behavior
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Model-Based Work Products

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Modeling Structure and Data

- Models focused on **structure and data:**
- Specify requirements for static structural properties of system or domain

Static Domain Models:

- Specify (business) objects and their relationships in domain of interest
- UML class diagrams can be used

- **(Business) object**
- Tangible: bicycle, book, game console, …
- Intangible: training request, virtual shopping basket, e-book, …

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Modeling Structure and Data

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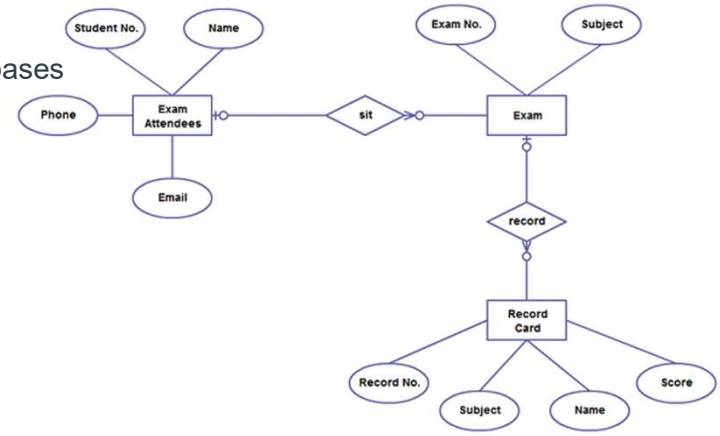
Entity Relationship Diagrams (ERD)

- Models structure of data (static)
- No functions, behavior, control
- Widely used for (relational) databases



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Entity Relationship Diagram

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Elements

[Name] Entity

[Name] Attribute

Generalization

[Name] Relation

(m:n) Cardinality

(m:n)
- Many-to-Many cardinality

(m:1)
- Many-to-One cardinality

(1:n)
- One-to-Many cardinality

(1:1)
- One-to-One cardinality

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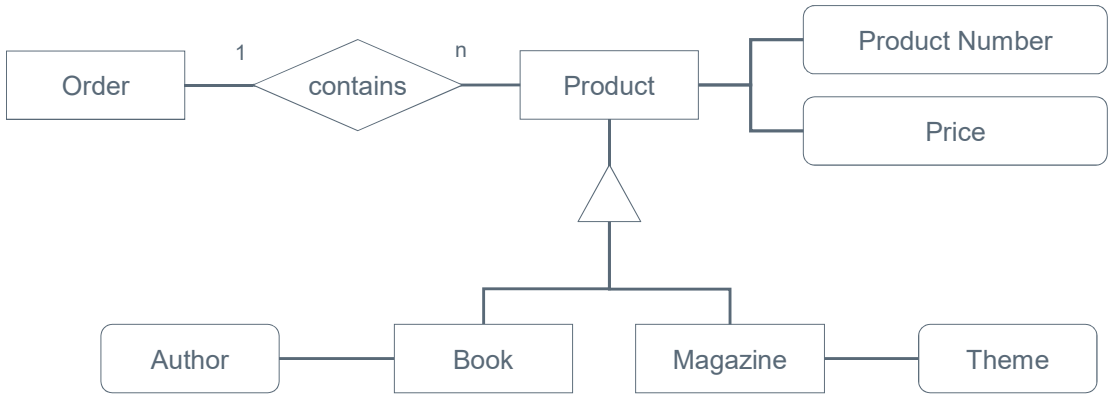
Entity Relationship Diagram

CTG

Example



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Modeling Structure and Data

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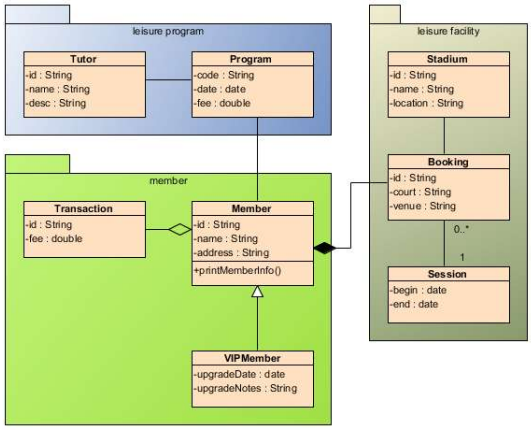
Class Models

- Specify classes of a system and their attributes and relationships
- Classes represent tangible and intangible entities in the real world
- UML class diagrams are typically used



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Class Diagram

CTG

Elements

[Name]
Attribute
Operation

Class

Name

Association

Generalization

Aggregation

Composition

0..1
- Not mandatory, but at most 1

m
- Not more, not less than m

m..n
- Not more than n, not less than m

1..*
- Unlimited, but at least 1

*** (short for 0..*)**
- Unlimited, but not mandatory

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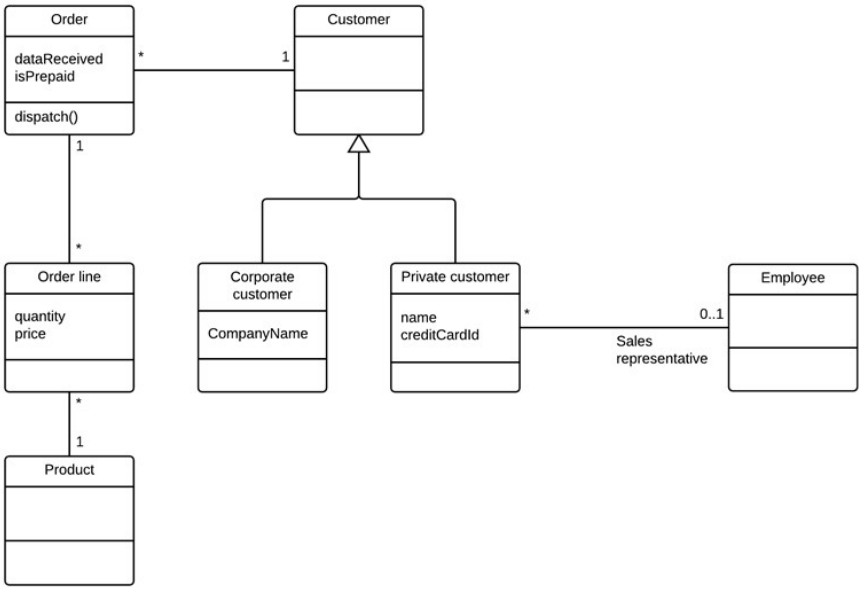
Class Diagram

Example



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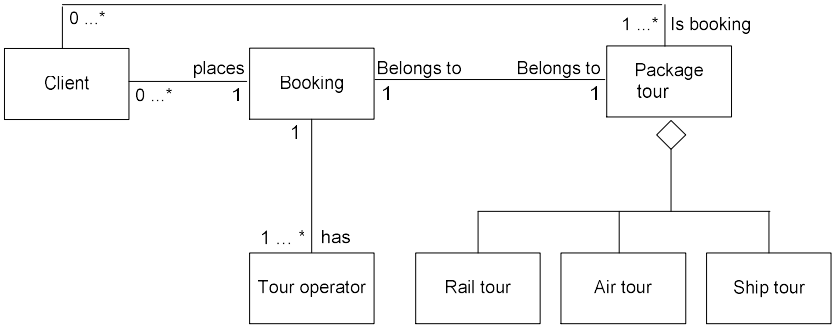
Class Diagram

Exercise: True or False?



- The association between client and package tour is redundant and also inconsistent; it should therefore be removed from the model.
- The association between booking and tour operator makes no sense and should be replaced by an association between package tour and tour operator.
- The client statement that the package tour sold can be either a rail, air or ship tour is correctly modelled.
- The multiplicity of the association between client and booking adequately reflects reality.

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Modeling Structure and Data

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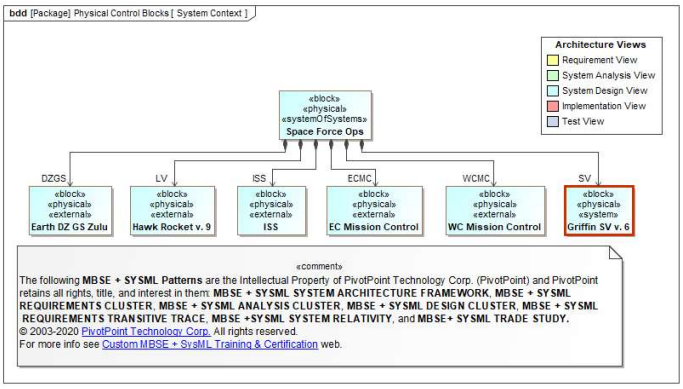
Block Definition Diagram (SysML)

- Model
- conceptual entities that exist in a system
- the relationships between them



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Modeling Structure and Data

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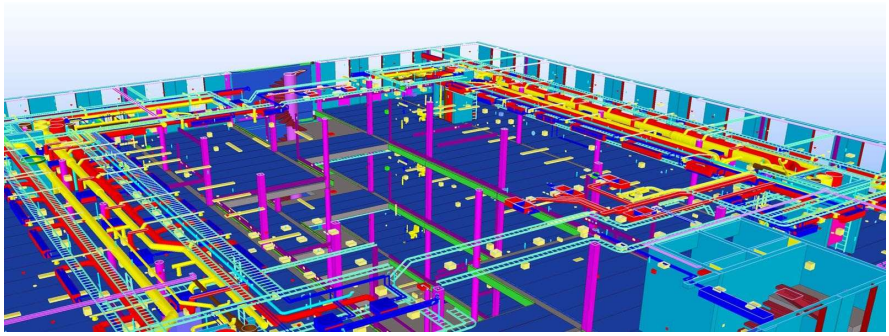
Building Information Models

- Used in building constructions
- Model elements required to plan, build, and manage buildings and other construction elements



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Model-Based Work Products

Modeling Function and Flow

- Models focused on **function and flow** specify:
- Requirements for sequence of actions needed to produce required results from given inputs
- Actions required to execute a (business) process, including
  - flow of control & data
  - who is responsible for which action

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Model-Based Work Products

CTG

Modeling Function and Flow

Activity Models

- Specify system functions

Process Models

- Describe business processes or technical processes
- BPMN language is often used
- Also UML activity diagrams

Domain Story Models

- Specify visual stories about how actors interact with devices, artifacts and other items in a domain
- Typically use domain-specific symbols
- Means to understand the application domain in which a system operates

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Modeling Function and Flow

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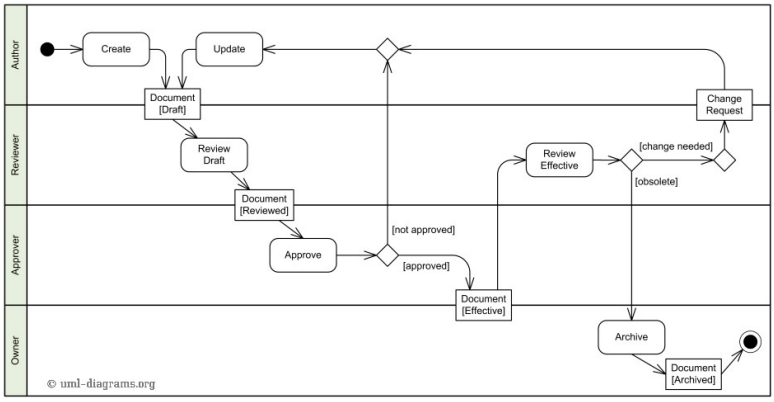
Activity Diagram

- Used to express activity models in UML
- Provide elements for modeling actions and control flow between actions
- Expresses who is responsible for which action



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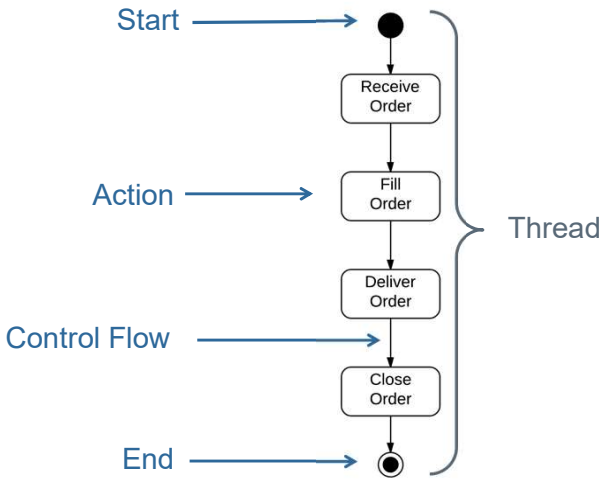
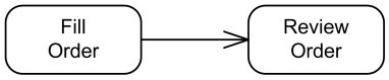
Activity Diagram

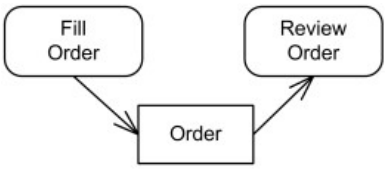
Elements



Control Flow



Object Flow



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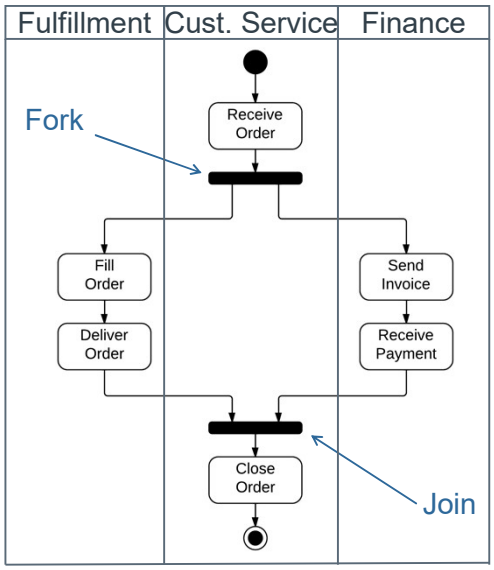
Activity Diagram

Parallel behaviour

Swimlanes



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Activity Diagram

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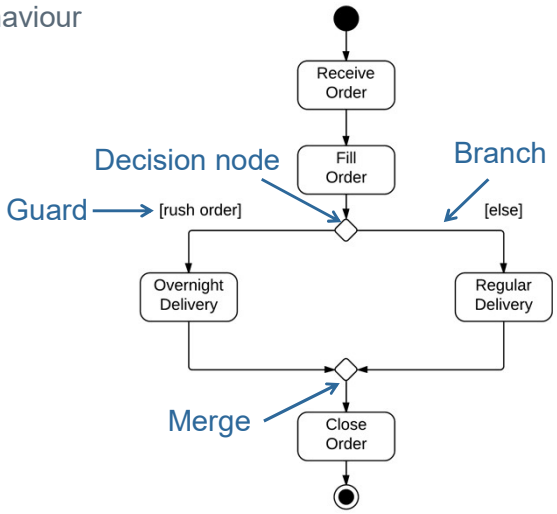
Conditional behaviour



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Modeling Function and Flow

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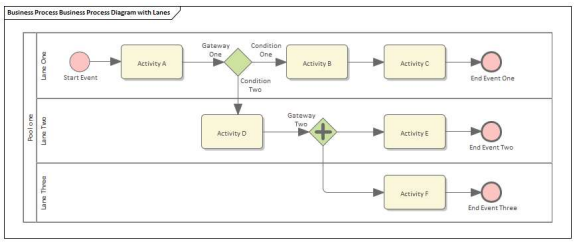
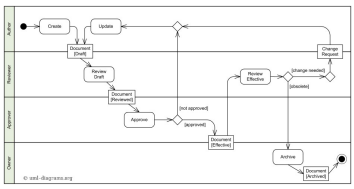
Process Models

- Describe business processes or technical processes
- BPMN language is often used
- Also UML activity diagrams





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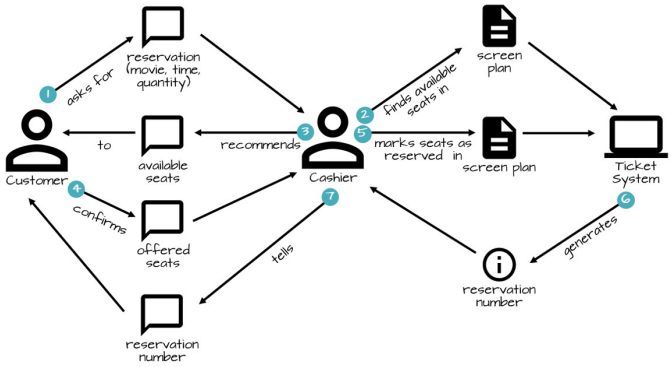
Modeling Function and Flow

Domain Story Models

- Specify visual stories about how actors interact with devices, artifacts and other items in a domain
- Typically use domain-specific symbols
- Means to understand the application domain in which a system operates



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Model-Based Work Products

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Modeling State and Behavior

- Models focused on **state and behavior:**
- Specify requirements for the behavior of a system or domain component in terms of state-dependent reactions to events or the dynamics of component reaction

State Machines model

- Events that trigger transition from one state to another
- Actions that need to be performed when state transaction takes place

State Charts

- State machines with states decomposed hierarchically or orthogonally
- **Interaction Models**
- Model dynamic interactions between objects or actors.

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Modeling State and Behavior

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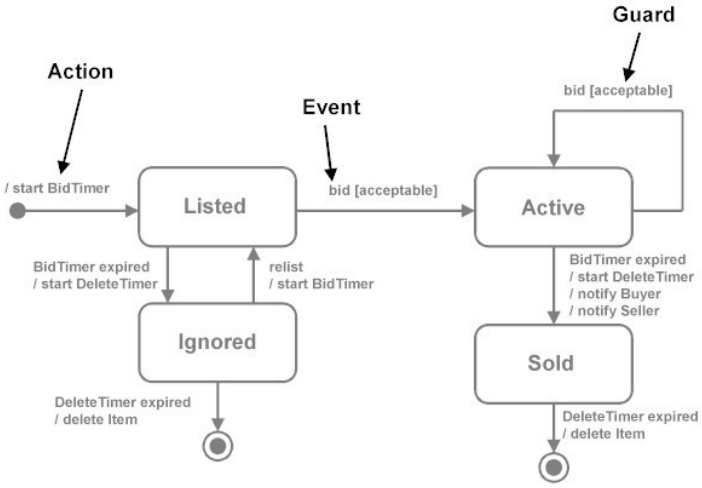
State (Machine) Diagram

- Express statecharts or state machines in UML language



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State (Machine) Diagram

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Elements

- Initial State
- Final State

[Name]

- State

Event[Condition]/ *Action*

- Transition

Event = Input
- Whatever triggers the transition

[Condition]
- Only if 'true', transition takes effect

Action (=Output)
- Whatever action is performed during the transition

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State (Machine) Diagram

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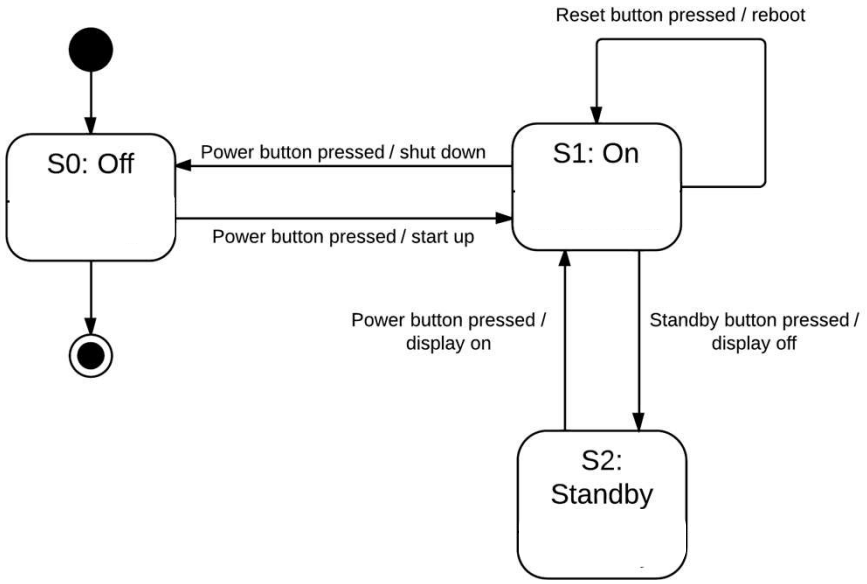
Example



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Modeling State and Behavior

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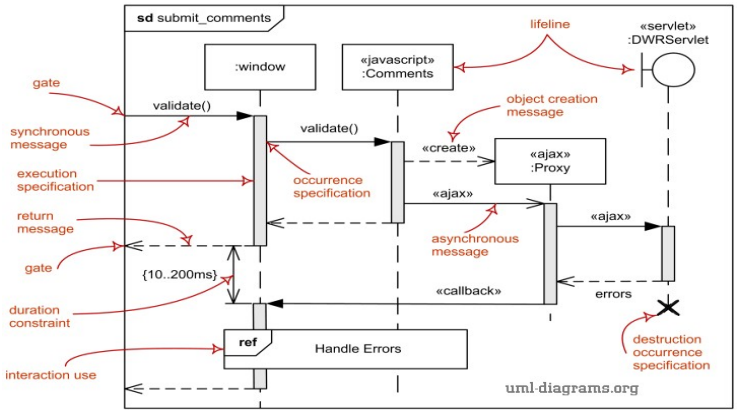
Interaction Model

- Model the dynamic interactions between objects or actors



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Modeling State and Behavior

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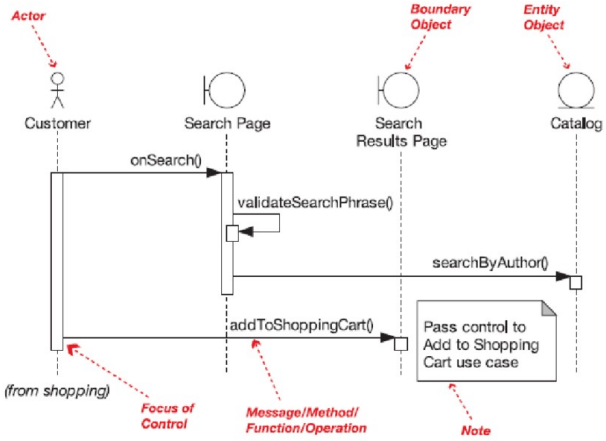
UML Sequence Diagram

- Most common kind of UML interaction diagram
- Represents message flow from one object to another object



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Model-Based Work Products

Exercises

1. Specify a simple model of a system's data or the objects in a model using a UML class diagram
2. Specify a simple system function or business process by a UML activity diagram

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Glossaries

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- Establish shared understanding of terminology
  - People interpret same things differently
- Record common understanding of relevant terms
- Central collection of definitions for:

Context-specific terms

Everyday terms with special meaning in given context

Abbreviations

Acronyms

Synonyms (different term - same meaning)

Homonyms (same term - different meaning)

Match-Match / Right-Right / Rock-Rock / Mean-Mean / Bat-Bat /…

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Glossaries

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Rules for glossaries

Manage glossary centrally

Maintain glossary over entire course of system development

Define a person or small group responsible for glossary

Use uniform style and structure

Involve stakeholders and seek agreement about terminology

Make glossary accessible for everybody involved

Make glossary usage mandatory

Check work products for proper glossary usage

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Requirements Documentation Structures

Requirements specification documents

- Comprise several RE work products
- Organized in well-defined structure
  - Consistent and maintainable collection of requirements
- May contain additional information and explanations
  - *for example: a glossary, acceptance conditions, project information, or characteristics of the technical implementation*
- May also be organized on document structures other than classic documents
- Document templates may help to structure a requirements specification
  - Available in literature and standards
  - Reused from previous, similar projects
  - Imposed by a customer
  - Organization may decide to create template as internal standard

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Requirements Documentation Structures

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Frequently used documents

Vision Document

- Conceptual imagination of future system
- Key characteristics and how it creates value for its users

Business Requirements Specification

- Business goals, objectives and needs of an organization achieved by employing a system

Stakeholder Requirements Specification

- Stakeholders' desires and needs to be satisfied by building a system. Stakeholders' perspective

User Requirements Specification

- Subset of stakeholders' requirements specification
- Only covers requirements of stakeholders who are prospective users

System Requirements Specification

- System to be built and its context, to satisfy stakeholders' desires and needs

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Requirements Documentation Structures

CTG

Frequently used alternative documentation structures

Product backlog

- Prioritized list of work items
- Covering all requirements needed and known for product

Sprint backlog

- Selected subset of product backlog
- Work items that will be realized in next iteration

Story map

- Visual two-dimensional organization of user stories in product backlog
- with respect to time and content

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Requirements Documentation Structures

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Factors for selecting documentation structure and internal organization

Chosen development process

Project type and domain

- e.g. tailor-made solution, product development, standard product customizing …

Contract

- Customer may prescribe use of documentation structure

Document size

- The larger the document, the more structure needed

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Prototypes in Requirements Engineering

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- Specify requirements by example
- Validate requirements

- Used if involved stakeholders do not want to write and review natural-language-based, template-based or model-based work products

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Prototypes in Requirements Engineering

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3 Major purposes

Exploratory prototypes

- Create shared understanding, clarify requirements, validate requirements at different fidelity levels
- Constitute temporary work products discarded after use
- May be used as specification by example → Treated as evolving or durable work products
- Can be expensive depending on degree of fidelity → Trade-off between cost and gained value

Experimental prototypes (also called breadboards)

- Explore technical design solution concepts, in particular with respect to their technical feasibility
- Discarded after use
- Not used in RE

Evolutionary prototypes

- Pilot systems that form core of a system to be developed
- Final system evolves by incrementally extending and improving pilot system in several iterations
- Agile system development frequently employs an evolutionary prototyping approach

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Prototypes in Requirements Engineering

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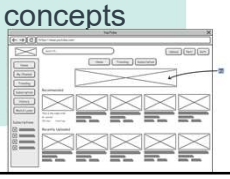
Exploratory prototypes examples

Wireframes	Mock-ups	Native prototypes
• Low fidelity • Built with paper or other simple materials (Digital sketching tools) • Discuss and validate design ideas & user interface concepts	• Medium fidelity • Real screen and click flows, without real functionality • Specify and validate user interfaces • Specific prototyping tools	• High fidelity • Implement critical parts of system to the extent stakeholders can use it • See whether part of the system will work and behave as expected • Explore variants



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Prototypes in Requirements Engineering

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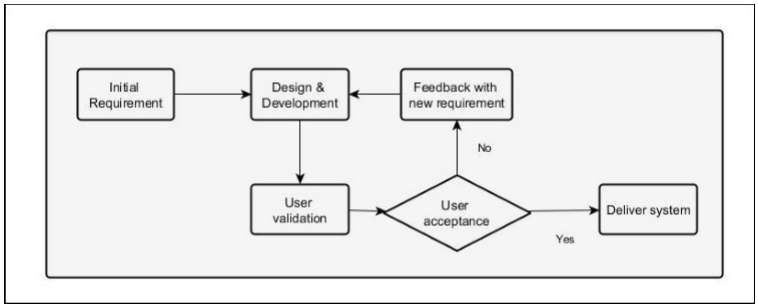
Evolutionary prototypes [LiSZ1994]

- Pilot system forms core of system to be developed
- Final system evolves by incrementally extending and improving pilot system in several iterations



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Quality Criteria Work Documents & Requirements

- Good requirements meet specific **quality criteria**
- **Degree of fulfillment of quality criterion** corresponds to **value created by requirement (cfr Principle 2)**
  - No need to always adhere to all quality criteria completely
  - The higher the value of requirement, the more relevant the quality criteria
    - To reduce risk of failure
- ‘Definition of Ready’ in Agile

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Quality Criteria Work Documents & Requirements

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Quality criteria for single requirements

Adequate
- Describe true and agreed stakeholder needs so stakeholders can judge requirement easily

Understandable
- Comprehensible to target audience. Target audience able to fully understand the requirement

Necessary
- Part of relevant system scope. Contributes to achievement of at least one stakeholder goal or need

Unambiguous
- True shared understanding. Everybody interprets in same way

Complete
- Does not miss any necessary parts

Verifiable
- Fulfillment by implemented system can be checked indisputably

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Quality Criteria Work Documents & Requirements

CTG

INVEST

Independent	• Self-contained
Negotiable	• Leave space for discussion
Valuable	• Deliver value to stakeholder(s)
Estimable	• You must always be able to estimate the size
Small	• Not so big to become impossible to plan/task/prioritize within a level of accuracy
Testable	• Description must provide necessary information to make test development possible

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Quality Criteria Work Documents & Requirements

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Quality criteria for work products covering multiple requirements

Consistent

- No two requirements recorded in one or different work products contradict each other

Non-Redundant

- Each requirement documented only once. No overlap with other requirements

Complete

- Contains all known and relevant requirements (functional, quality, constraints)

Modifiable

- Can be modified without degrading its quality

Traceable

- Trace to origins
- Forward link to implementation (in design, code and test) and to other reqs they depend on

Conformant

- Conform to any applicable mandatory structuring or formatting instructions

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Quiz Questions

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Chapter 4
Practices for Requirements Elaboration

Sources for Requirements,
Elicitation of Requirements,
Conflict Resolution regarding Requirements,
Validation of Requirements

Learning goals

- L3 Determine the boundaries of the system to focus on the relevant requirements
- L1 Remember the relevant sources for the system to be created
- L3 Identify stakeholders and write a stakeholder list
- L2 Understand the benefits of stakeholder management
- L2 Understand how the KANO model can help to elicit the right requirements
- L2 Understand the difference between gathering techniques, design and idea-generating techniques, and thinking tools
- L2 Understand how to choose a proper elicitation technique for a given situation
- L1 Remember the different types of conflict
- L2 Understand what activities are necessary to solve conflicts
- L2 Understand how to apply appropriate conflict resolution techniques
- L2 Understand why requirements documents need to be validated
- L1 Remember the four important aspects for requirements validation
- L2 Understand how to apply appropriate techniques for requirements validation

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Overview

1. Sources for Requirements
2. Elicitation of Requirements
3. Conflict Resolution regarding Requirements
4. Validation of Requirements

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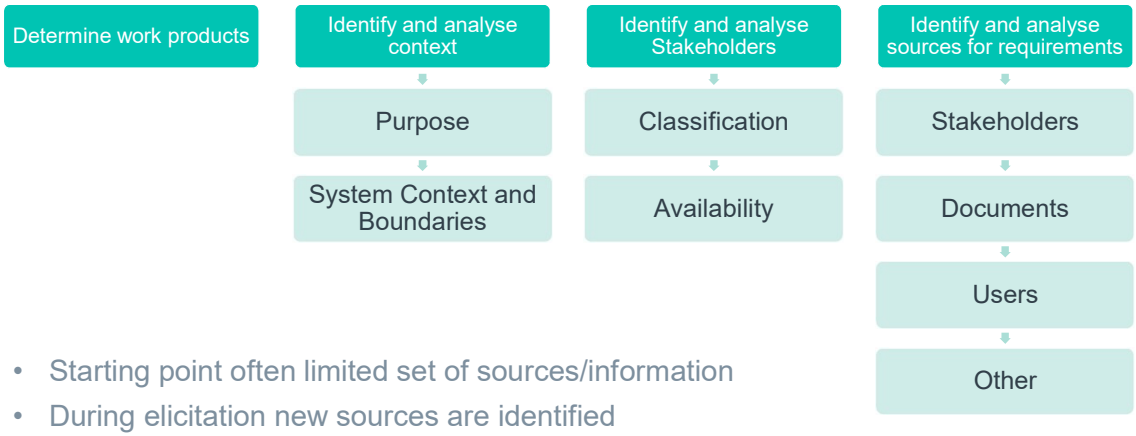
Elicitation process

Pre-Elicitation phase



- Starting point often limited set of sources/information
- During elicitation new sources are identified
- Process repeated over and over again

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Sources for Requirements

- Quality and completeness of requirements depend on sources involved
- Missing relevant sources will lead to
  - incomplete understanding of requirements
  - incomplete requirements
- RE should identify & involve relevant requirements sources
- Identify all relevant requirements sources
  - Iterative and recursive process
  - Requires constant reconsideration

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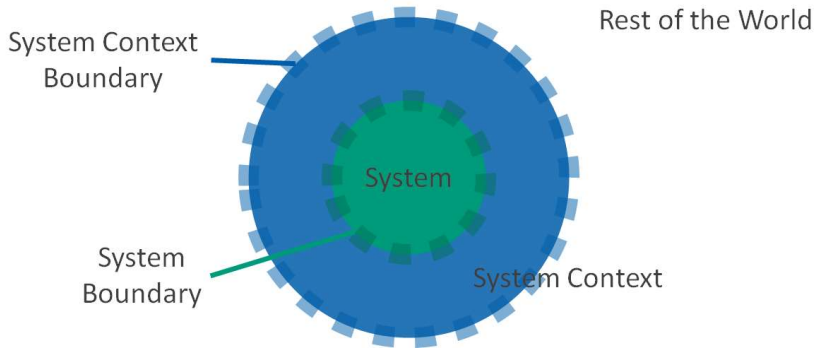
Sources for Requirements

- Shared understanding of system's context required to identify sources
- (System) Context needed
  - To understand nature of requirements to be developed
  - To identify the original sources for requirements



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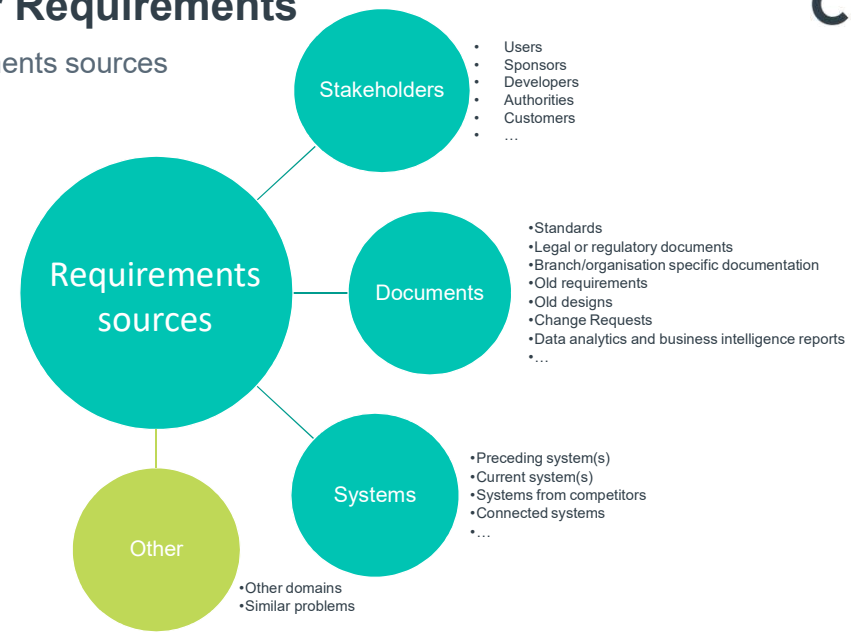
Sources for Requirements

Types of requirements sources



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Sources for Requirements

Stakeholders of a system

- **Main source** for requirements
- Systematic identification of stakeholders should take place at beginning of development
  - Results managed throughout development as a continuous activity

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Sources for Requirements

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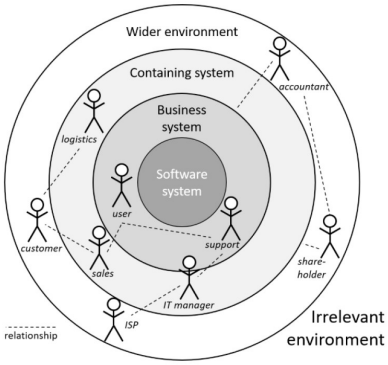
Potential sources to identify relevant stakeholders

- Checklists of typical stakeholder groups and roles
- Organizational structures
  - e.g. organization charts
- Business process documentation
  - e.g. business processes to be supported by the system
- Market reports
  - e.g. identifying trends or competitive products
- Initial stakeholders for identifying additional stakeholders
- Ian Alexander's Onion Model



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Sources for Requirements

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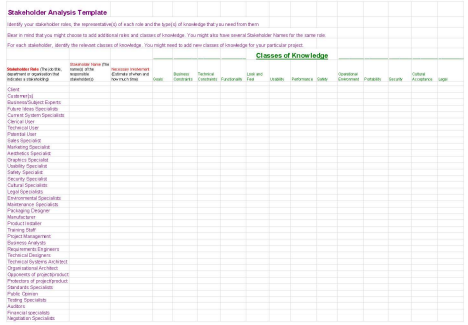
Microsoft Excel-werkblad

Stakeholder List

Up-to-date list containing

- Name
- Function (role)
- Additional personal and contact data
- Temporal and spatial availability during project progress
- Relevance
- Area and extent of expertise
- Goals and interests in terms of the project



Stakeholder Analysis Template

Identify your stakeholder roles, the representative(s) of each role and the type(s) of knowledge that you need from them.

Bear in mind that you might choose to add additional roles and classes of knowledge. You might also have several Stakeholder Names for the same role.

For each stakeholder, identify the relevant classes of knowledge. You might need to add new classes of knowledge for your particular project.

		Classes of Knowledge												
Stakeholder Role (The job title, department or organization that indicates a stakeholder)	**Stakeholder Name** (The name(s) of the person(s) that fill the stakeholder role)	**Resources Involved** (Estimate whether and how much time)	Goals	Business Constraints	Technical Constraints	Functionals	Look and Feel	Usability	Performance	Safety	Operational Environment	Portability	Security	Cultural Acceptance	Legal
Client															
Customer(s)															
Business/Subject Experts															
Future Users Specialists															
Current System Specialists															
Clerical User															
Technical User															
Potential User															
Sales Specialist															
Marketing Specialist															
Aesthetics Specialist															
Human Factors Specialist															
Usability Specialist															
Safety Specialist															
Security Specialist															
Cultural Specialists															
Legal Specialists															
Environmental Specialists															
Maintenance Specialists															
Packaging Designer															
Manufacturer															
Product Installer															
Product Tester															
Project Management															
Business Analysts															
Requirements Engineers															
Technical Designers															
Technical Systems Architect															
Organisational Architect															
Opponents of project/product															
Protectors of project/product															
Standards Specialists															
Public Opinion															
Test Specialists															
Auditors															
Financial specialists															
Negotiation Specialists															

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Sources for Requirements

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Problems with stakeholders

- Rights and obligations not clear
- Needs not sufficiently addressed

- Stakeholder agreement or stakeholder contract can help

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Sources for Requirements

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Stakeholder relationship management

- Effective way to counter problems with stakeholders

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Sources for Requirements

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Exercises

- Identify stakeholders and write a stakeholder list

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Sources for Requirements

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Special Stakeholder: the User

- Stakeholder group in systems with **user interface**
- (Not always most important source of requirements)
- Their acceptance is vital to success of project
  - Prime interest
  - Receive special attention
- There is no such thing as 'The User'
- Number of users does not allow all users to be involved in elicitation
- Can be aggregated into user groups

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Sources for Requirements

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Internal users

- Directly related to organization for which system is being developed (staff, management, subcontractors)
- Mostly limited number, more or less known individually
- Somehow involved in project
- Relatively easy to contact
- They can be reached, influenced, and motivated through formal, existing channels

External users

- Outside company (customers, business partners, civilians)
- Number may be (very) large, in many cases not known individually
- Could be completely unaware of or indifferent to project
- Cannot influence them through formal channels. May need to do special things to motivate them to participate: advertising, promising some reward, giving free access to beta version.
- User panel or addressing crowd (sometimes with payment) can be useful to involve these users

Misusers

- Intentionally try to interact with system in harmful way
- Rarely possible to contact or to influence them

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Personas

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- Fictitious characters representing a group of users with similar characteristics
- For stakeholder roles
  - Too many individuals OR
  - When individuals are unknown

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Sources for Requirements

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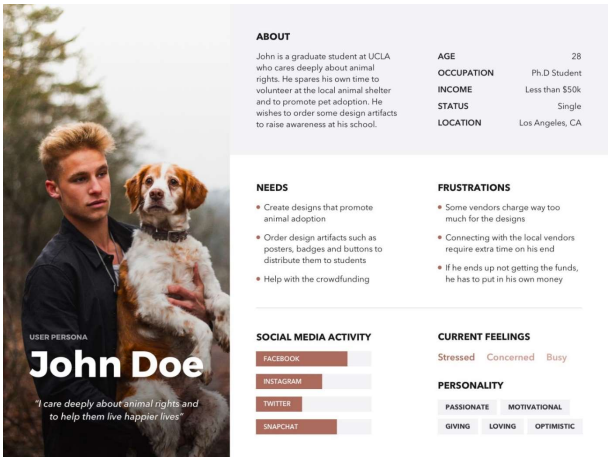
Personas

- Description contains relevant information for development of system
- Usually enriched with additional data like name, picture, hobbies, …
- Give a human face to abstract persona
- Helps understand that it's not only about facts but also about emotions



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Sources for Requirements

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Approaches to create personas

Data-driven

- Developed with marketing techniques
  - Surveys, focus groups, other ethnographic data collection techniques
- "Quantitative personas"

Imagination

- Developed by imagination
  - Brainstorming session with project team
- "Ad hoc personas"
  - Be aware that ad hoc personas are based on imagination and assumptions
  - These assumptions must be checked and confirmed throughout RE process
- Cheaper and quicker alternative

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Overview

1. Sources for Requirements
2. Elicitation of Requirements
3. Conflict Resolution regarding Requirements
4. Validation of Requirements

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Elicitation of Requirements

Task of Requirements Engineer

- Understand stakeholders' desires and needs
- Collect requirements from all relevant requirements sources
- Apply appropriate techniques for elicitation
- Turn implicit demands, wishes and expectations into explicit requirements
- Know nature and importance of each requirement

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Elicitation of Requirements

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Kano Model

- Classifies requirements into 3 categories

Delighters (excitement factors, unconscious requirements)

- Features customers are not aware of
- Customers didn't ask for it because they do not know it is possible
- Skepticism at first but early adapters will spread the word

Satisfiers (performance factors, conscious requirements)

- Something customer explicitly asks for
- The more satisfiers included, the higher the satisfaction
- Finding balance between cost and benefit

Dissatisfiers (basic factors, subconscious requirements)

- Not asked for by customer (obvious)
- Customers won't notice if it's added, but are very upset if it is left out

Noriako Kano

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Elicitation of Requirements

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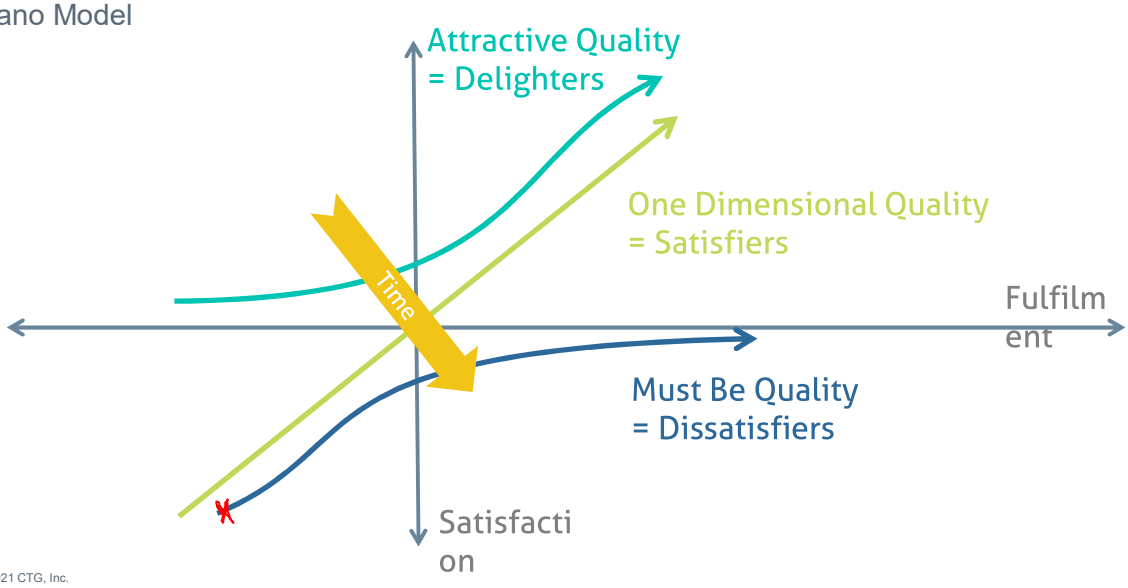
Kano Model



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Elicitation of Requirements

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Kano Model

Actually there are 2 more categories:

Indifferent

- Customers don't care about it

Reject

- Customers hate it

- Classification can be done by asking 2 questions:
  - How would you feel if feature were present in the system?
  - How would you feel if feature were absent from the system?
- Plot it on a 5-point scale

		Feature absent				
		++	+	0	-	--
Feature present	++	?	Delighters			Sat
	+		Indifferent			Dissatisfiers
	0					
	-					
	--	Rejects				?

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Elicitation of Requirements

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Techniques for eliciting requirements

Gathering techniques

- Help elicit satisfiers and dissatisfiers by investigating different sources

Design and idea-generating techniques

- Focus on stimulating creativity
- Create new or innovative requirements that are often delighters
- Create ideas to find solutions for a given question, problem, or goal

Design techniques

- Subsume creativity techniques for idea generation
- Additional explorative, or combined techniques for elaborating ideas and gaining further insights for a given idea

Design thinking

- Different approaches exist (d.school, Designing for Growth, …)
- Formalized process to resolve problems and create solutions
- Solution-focused – starts with a future goal (instead of current problem)

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Gathering techniques

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- Examine different sources and elicit requirements

Questioning techniques	Collaboration techniques	Observation techniques	Artifact-based techniques
Interviews	Workshops	Field observation	System Archaeology
Questionnaires	Crowd-based requirements engineering	Apprenticing	Feedback analysis
			Reuse of requirements

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Gathering Techniques

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Questioning Techniques

- Always in interaction with stakeholders
- Appropriate questions
- Let stakeholder do the thinking
- Receive answers from which requirements can be derived

Qualitative questions

- Open questions
- Start with words like How …, Why …, When …, Where …, What …, Who…
- To extract information

Quantitative questions

- Closed questions
- Start with words like Do …, Is …, Can …, Could …, Will …, Would …, Shall …
- Scoring on a scale, predefined answers, yes/no

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Questioning Techniques

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Interview

- Probably one of most used elicitation techniques
- Does not require specific tools
- Elicit both high-level as very specific requirements
  - Typically satisfiers
- One-on-one between interviewer and interviewee
  - Small group interviewees is also an option → risk of anchoring
- Requires clear goals and good preparation
- Not the sole technique
- Users don't know all the requirements
- Use answers to ask new questions
- Time-consuming

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Questioning Techniques

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Interview preparation

- How will you know that you have been successful? What do you want to achieve?
- Prepare a checklist of topics to be discussed
- Plan the venue of the interview: ideally the stakeholder's workplace
- Plan the boundaries (scope) of your interview (and make this clear at the beginning)
- Ask yourself: Why should the stakeholder care about this interview?

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Questioning Techniques

CTG

Interview process

Getting acquainted	Explain rules	Gather requirements	Summary	Closure
• Introduce yourself and the project • Why do you need to interview this stakeholder?	• Are you going to record the interview? • Stakeholder rights and duties	• Check your observations • Record draft requirements	• "Have we missed anything?"	• "Whom do you recommend I interview next?" • Thank stakeholder • Tell what you will do with the information …

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Questioning Techniques

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Questionnaires

- Large group of stakeholders
- Orally, written, or digitally
- Same set of questions, presented in a structured way
  - Quantitative questions allow quick evaluation and deliver statistical information
  - Qualitative questions tend to deliver complex results
- Designing a good questionnaire involves quite a lot of effort
- Often used to validate first ideas within a larger group

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Collaboration Techniques

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Workshop

- Umbrella term for group-oriented techniques
- From small informal meetings to organized events with hundreds of stakeholders
- Get good global insight in short time
- Use interaction between participants
- Can also be used as creativity technique

"A requirements workshop is a structured meeting in which a carefully selected group of stakeholders and content experts work together to define, create, refine, and reach a closure on deliverables (such as models and documents) that represent user requirements"

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Collaboration Techniques

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Crowd-based Requirements Engineering

- Participatory effort with a crowd of stakeholders (users)
- Leads to more accurate requirements
- Power lies in diversity of talents and expertise within crowd
- Large amount of data obtained → automated data processing platform
- Platform offers
  - Collaboration support
  - Knowledge sharing
  - Foster engagement
    - Collecting, Analyzing, Developing, Validating, Prioritizing requirements

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Observation techniques

- Applied in relation to stakeholders
- Stakeholders observed
  - During their normal (business) processes
  - In their usual context
  - Without direct interference from RE
- Useful to identify dissatisfiers

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Observation techniques

Field observation

- Watching (mostly) end users in their environment
- When interaction would distract users or would interfere with process itself
  - And thus falsify results
- Can even be applied without informing observed subjects
- Detect (often detailed) requirements not easily found with other techniques
  - e.g. behavior too complicated to put into words
- Requires a lot of preparation, sharp eye and lots of time
- Video recording can be helpful for capturing behavior and postprocessing
  - also if your presence is not allowed or desired

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Observation techniques

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Apprenticing

- Participatory
- Experienced users (masters) teach apprentice
  - Kind of internship in environment where system will be used
- Apprentice participates but does not interfere
  - Allowed to make mistakes and ask 'dumb' questions
- Create deep understanding of domain, business and processes
- Optimal duration between one day and several weeks
  - Complexity of the process
  - Repititiveness
  - Time available for master/apprentice
- May be difficult or impossible to organize in certain domains

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Artifact-based techniques

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- Do not use stakeholders (directly)
- Sources are work products like documents, systems, images, audio, video, …
  - Often poorly structured, outdated or partly irrelevant
- Can find (sometimes very detailed) satisfiers and dissatisfiers
- Time-consuming to study in detail
- Useful, particularly when stakeholders not available

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Artifact-based techniques

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System archaeology

- Extract requirements from existing systems
  - Legacy systems
  - Competitor systems
  - Analoguous systems
- Analyze documentation (design, manual …) or implementation (code, comments, scripts, user stories, test cases …)
- Mainly used if new system has to replace existing system and has to cover same functionality
- Time-consuming
- May reveal detailed requirements and constraints not easily detected otherwise
- Other channels needed to validate whether they are still valid and relevant

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Artifact-based techniques

CTG

Feedback analysis

- Collect feedback from (potential) users and customers
  - On existing system or prototype
- Structured (rating in app store) or unstructured data (review comments)
- Gathered through many forms: web surveys, contact forms, during alpha, beta, or A/B testing, social media or remarks received in a call center
- Often large amounts of data
- Time-consuming analysis
- Insight into user's pains and gains
  - Negative scores and critical remarks: unnoticed dissatisfiers
  - Positive scores and compliments: satisfiers
- Occasionally contains innovative ideas

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Artifact-based techniques

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Reuse of requirements

- Existing requirements might be applicable for new systems
- Also requirements from overarching domain model
- Can save lots of time and money
- Existing requirements have to be up-to-date, managed effectively, easily available and documented extensively, which is often not the case.
- Still need to validate with stakeholders whether relevant and valid

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Design and Idea-Generating Techniques

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- New positioning of RE as creative, problem-solving activity
  - Growing influence of software as innovation driver
- Innovative systems need new disruptive features that current stakeholders cannot imagine (yet)
- Promote creativity
- Mostly within teams
- Generation of ideas
- Provide additional ways to elaborate given idea
- Finding delighters

Creativity techniques	Design techniques
Brainstorming	Prototyping
Analogy technique	Scenarios & storyboards

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Creativity techniques

- Stimulate creativity
- Diverse, multi-disciplinary teams
  - IT staff and business
- Stimulate out-of-the-box and borderless thinking
- Elaboration of each other's ideas

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Creativity techniques

Important factors (preconditions) for creativity to emerge

- Techniques do not guarantee success
  - Several mechanisms in our brain have to come together to enable creative ideas

Chance

- (And thus time) for an idea to come up

Knowledge of subject matter

- Raises the odds for an idea that makes the difference

Motivation

- Our brain can only be creative if there is a direct benefit for its owner

Safety and security

- Useless ideas should not have negative consequences

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Creativity techniques

CTG

Brainstorming

- Supports development of new ideas for given question or problem
- Defer judgment by seperating finding ideas from analysing ideas
- Some general guidelines
  - Quantity prevails over quality
  - Free association and visionary thinking is explicitly desired
  - Taking on and combining expressed ideas is allowed and desired
  - Criticizing other participants' ideas is forbidden even if an idea seems to be absurd
- After session, ideas are categorized, assessed and prioritized

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Creativity techniques

CTG

Analogy technique

- Supports development of ideas for critical and complex topics
- Analogies support thinking and generation of ideas
- Success or failure depends on selecting proper analogy for problem
- 2 steps:

Elaborate aspects of selected analogy → Transfer identified aspects

- Without referring to original problem
- Back to original problem

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Design techniques

- Special category of creativity techniques
- Provide additional, explorative, or combinatorial techniques
- Elaborate ideas and gain further insights for a given idea
- Many techniques start from market research or bottleneck analysis
- Relies heavily on visualization, team cooperation, and customer feedback

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Design techniques

Prototypes

- Intermediate work products created to generate feedback
- Range from simple paper sketches to working pre-release versions of a system
- Allow future users to experiment with system in some tangible way
  - Investigate certain, yet unclear, characteristics
- Primarily checking that defined requirements have been implemented correctly
  - Can also be used to derive new requirements
- Useful for detecting non-functional requirements, dissatisfiers and constraints
  - Characteristics not easily understood or defined up front
- Can be applied for (early) validation and (later) validation

- Major risk that users think system is complete

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Design techniques

CTG

Scenarios

- Scenarios describe flow of actions for a system, including involved users (actors)
- Explore alternative ways of realizing a process in a system
- Lightweight structure
  - Easy to develop
  - Changed rapidly
- Can be applied for (early) validation and (later) validation

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Design techniques

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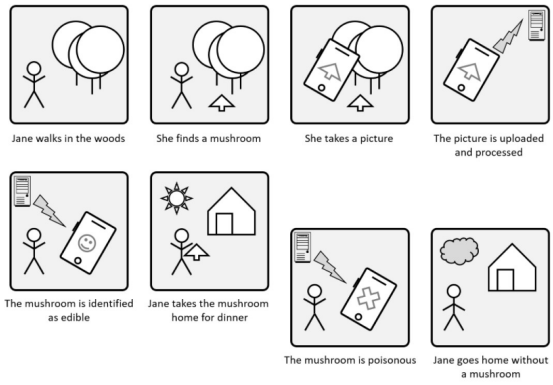
Storyboard

- Scenarios documented in visual form
- Kind of comic strip
- Early elaboration of ideas in terms of processes and activities



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Design Thinking

- Not so much a technique but rather a concept, attitude, philosophy, family of processes
- Focus on innovation and problem solving
- Different variants exist
- 2 basic principles

Empathy

- First step is to find real problem behind given problem
- Understand what stakeholders really think, feel, and do when they interact with system
- Human-centered design
- Common techniques: Personas, empathy mapping, and customer co-creation

Creativity

- Common characteristic of design thinking is the diamond: alternation of divergent and convergent thinking
- Divergent thinking aims at exploring an issue more widely and deeply, generating lots of different ideas
- Convergent thinking focuses, selects, prunes, combines these ideas into a single final delivery

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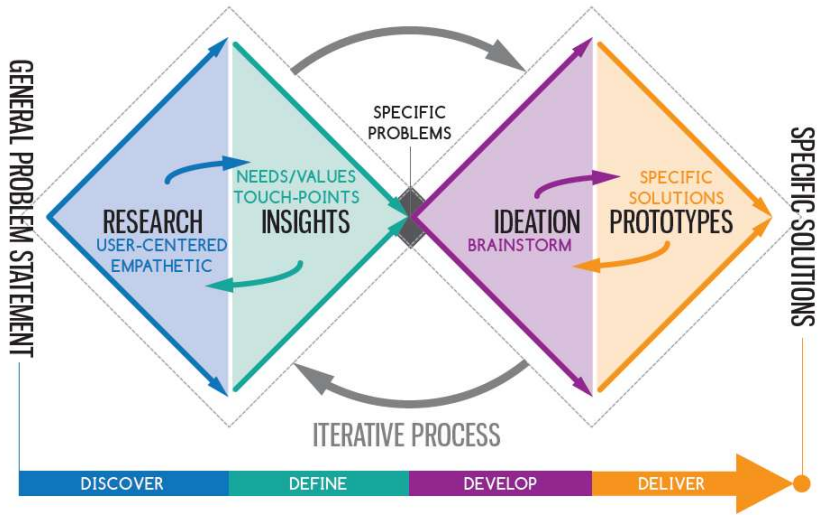
Design Thinking

Double diamond model



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https://www.stanwick.be/nl/blog/design-thinking-creatief-denken-en-doen

Elicitation of Requirements

Elicitation techniques should detect all kinds of requirements:

- Functional requirements
- Quality requirements
- Constraints

In practice quality requirements and constraints get less attention

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Elicitation of Requirements

Picking the right elicitation technique

- Key competence
- Depends on many factors:

Type of system

- e.g. new innovative system or evolution of existing system

Software development life cycle model

- e.g. waterfall, incremental, agile, DevOps

People involved

- e.g. personality, confidentiality, culture, availability

Organizational setup

- e.g. centrally available teams vs. distributed team, government organization vs young startup

- Usually best results with combination of techniques

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Overview

1. Sources for Requirements
2. Elicitation of Requirements
3. Conflict Resolution regarding Requirements
4. Validation of Requirements

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Conflict Resolution regarding Requirements

- Elicitation techniques do not ensure resulting set of requirements as a whole is consistent, complete, conformant, etc.
- All stakeholders must understand and agree on requirements relevant to them
- If some stakeholders do not agree
  - Recognize as a **conflict** and resolve accordingly
- Dealing with conflicts can be difficult, painful and time-consuming
- Denying or ignoring conflicts not an option

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Conflict Resolution regarding Requirements

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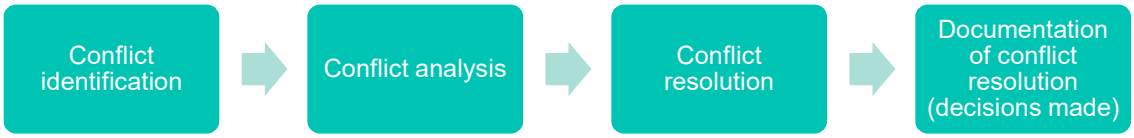
Conflict resolution process



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Conflict resolution process

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Conflict identification

- Conflicts sometimes hard to find
  - Ignored, avoided, denied
- Indicators (even though they do not always 'hide' a conflict')

In communication

- Denial, indifference, pedantry, continuously asking for more details, deliberately incorrect interpretations, concealment, or delegation

In documentation

- Contradictory statements by stakeholders, conflicting results from analysis of documents or systems, inconsistencies across different levels of detail, and inconsistent use of terms

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Conflict resolution process

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Conflict analysis

- Clarify whether it is a requirement conflict or not
  - Other conflicts can be resolved by other participants
- Fully understand nature of requirement conflict before attempting to resolve it
- Collect information about conflict and stakeholders involved
- Determine all conflict type(s)

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Conflict Resolution regarding Requirements

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Conflict Types

Subject matter conflict

- Divergent factual needs (e.g. Legislation in different countries)

Data conflict

- Inconsistent data from different sources
- Same data interpreted in a different way

Interest conflict

- Divergent interests

Value conflict

- Divergent values and preferences

Relationship conflict

- Emotional problems
- Problems in personal relationships between stakeholders

Structural conflict

- Between stakeholders on different hierarchy levels in an organization

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Conflict resolution process

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Conflict resolution

- Select suitable technique to resolve conflict
- Get chosen technique accepted by involved stakeholders before applying it
  - No agreement might lead to not accepting result and thus an unresolved conflict
- In principle the RE is not an involved stakeholder
  - Apply techniques in objective, strictly neutral way
  - Welcome any outcome resulting from the applied technique

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Conflict Resolution regarding Requirements

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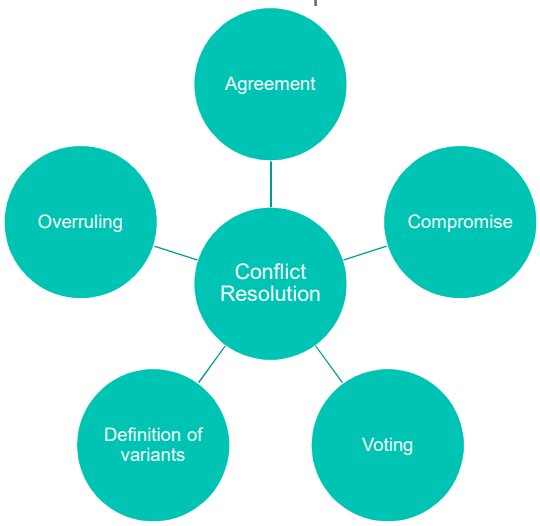
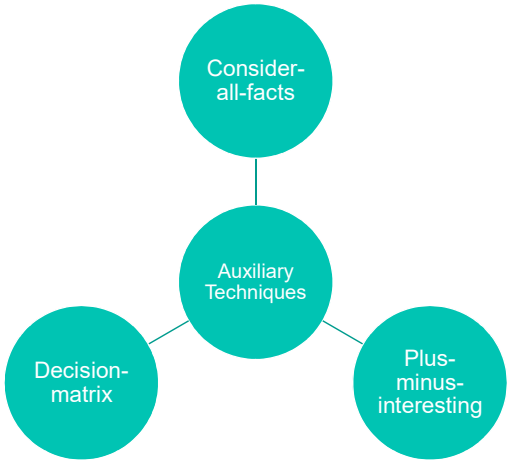
Conflict Resolution Techniques





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Conflict Resolution regarding Requirements

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Conflict Resolution Techniques

Agreement

- Continue discussion between involved stakeholders
- Understand each other's positions and agree to certain option preferred by all parties

Compromise

- Stakeholders agree on option they can live with, but not their preferred option
- Accepting compromise better than continuing conflict

Voting

- Best for simple choice between clear set of conflicting requirements
- Stakeholders should agree on voting procedure before actual voting

Definition of variants

- Build separate solutions for all conflicting requirements
- Develop configurable system to exhibit desired features

Overruling

- Often applied under pressure (not enough time for more convenient techniques)
- Someone higher in authority or hierarchy with enough power to have decision implemented, makes decision

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Conflict Resolution regarding Requirements

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Auxiliary Techniques

Consider All Factors (CAF)

- Score possible alternatives on predefined criteria (cost, time, risk, available resources, …)
- Weighing these criteria provides more clarity about pros and cons of alternatives
- Helps identify *best* alternative

Plus-Minus-Interesting (PMI)

- Identify all positive and negative aspects of alternatives
- Identify interesting points, things that need further investigation
- Most pluses and fewest minuses is preferred

Decision Matrix

- Requirements assessed on (larger) number of criteria to calculate (weighted) final score

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Conflict resolution process

CTG

Conflict documentation

- Resolution might influence requirements in a way not obvious to someone not involved
- Resulting set of requirements may seem illogical or inefficient

→ Properly document and communicate the conflict with respect to

- Assumptions concerning the conflict and its resolution
- Potential alternatives considered
- Constraints influencing chosen technique and/or resolution
- The way the conflict was resolved, including reasons for chosen resolution
- Decision-makers and other contributors

- If resolution not documented
  - Stakeholders might forget or ignore taken decisions
  - Developers might not understand rationale and implement differently

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Overview

CTG

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Validation of Requirements

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- Quality check of set of requirements and its individual requirements
- Important step towards successful system
  - Avoids unsatisfied stakeholders
  - Reduces wasted effort downstream
- Techniques differ in formality and effort
- Selection depends on
  - Software development life cycle model
  - Maturity of development process
  - Complexity and risk level of system
  - Legal or regulatory requirements
  - Need for audit trail
- Often degree of effort and formality increases towards end of project

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Validation of Requirements

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Important aspects

Involve right stakeholders

- Independence between elicitation and validation?
  - Low independence = cheap, but may overlook defects
  - High independence = more time and effort, but might be more effective in long run

Separate identification and correction of defects

- Defects may influence each other
- Later found defect might invalidate earlier fix
- 'Defect' may appear correct after complete validation

Validate from different views

- Always a group effort
- Best to use interdisciplinary team
- Also think of subject matter experts

Repeated validation

- Do not only validate at the end of the elicitation phase
- New insights might lead to updates in initial requirements

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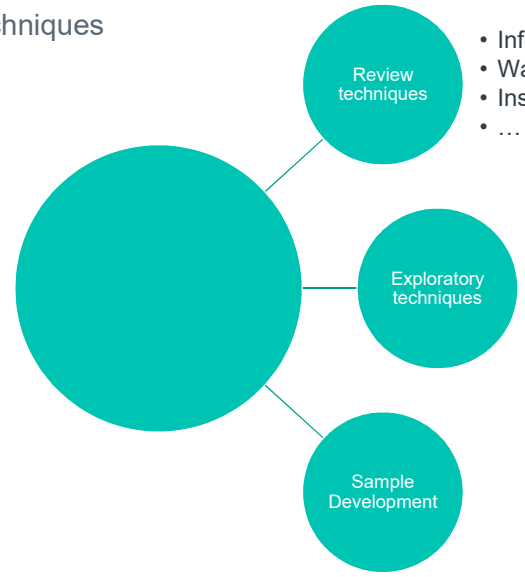
Validation of Requirements

Validation techniques



- Informal review
- Walkthrough
- Inspection
- …

- Prototyping
- Alpha & Beta Testing
- A/B Testing
- Building a MVP
- …

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Validation of Requirements

Review techniques (static)

- Informal review
- Formal review
  - Walkthrough (with or without preparation)
  - Inspection

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Validation of Requirements

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Walkthrough

- Author of work product explains it step by step to audience in interactive session

Without preparation

- During meeting reviewers listen to author and ask ad hoc questions

With preparation

- Reviewers prepare questions for author
  - can make comments, identify flaws, and suggest alternatives.
- Author gives more explanation if necessary
- Author can discuss solutions for weaknesses identified and weigh alternatives against original ideas

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Validation of Requirements

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Inspection

Planning

- Entry check, assignment of roles ("view points")
- Decide on part of document to be inspected
- Gathering of documents / procedures, planning

Kickoff (optional)

- Distributing work product
- Introduce process and / or documents

Individual preparation

- Individually looking for unique defects
- Optimum checking rate (~ 10 pages/hour)
- Pitfall: too many textual defects (highlighter)

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Validation of Requirements

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Inspection

Review Meeting
- Analyze finding
- Assign ownership and determine status
- Decide regarding next steps

Corrections
- Rework (by author)
- Gather metrics and check exit criteria

Follow-up
- Validation of reworked findings

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Validation of Requirements

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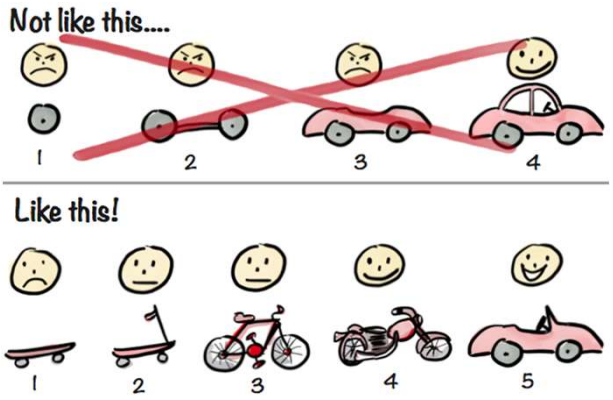
Exploratory techniques (dynamic)

- Hands-on experience with intermediate version of system under development
- Participants report experiences and feedback on current behavior of system
- Common in iterative and design thinking development approaches
- Minimum Viable Product (MVP)



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Validation of Requirements

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Exploratory techniques (dynamic)

Prototyping

- Also used as elicitation technique

Alpha and beta testing

- Acceptance test at development/customer site

A/B testing

- Variants of systems offered to similar user groups

Building a MVP

- Carefully measuring market reactions
- Adjusting system accordingly

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Validation of Requirements

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Sample Development (static)

- Developers produce some common intermediate work products
- May detect flaws that prevent them from producing intended output
  - unclarities, omissions, inconsistencies …
- Quantity and severity of detected flaws indication of quality of requirements

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Quiz Questions

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Chapter 5
Process and Working Structure

Influencing factors, Requirements Engineering Process Facets, Configuring a Requirements Engineering Process

Learning goals

- L1 Know the important factors that influence an RE process
- L2 Understand how and why these factors are influencing
- L2 Understand the facets that influence the configuration of an RE process
- L1 Know typical RE process configurations
- L3 For simple system and project contexts, select and apply an appropriate RE process configuration

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Process and Working Structure

RE Process

- Provides framework for eliciting, documenting, validating, and managing requirements
- Required to shape and structure RE work to be done in given context
- No one-size-fits-all
  - Tailor to given development and system context
- Shapes information flow and communication model between various participants
  - customers, users, Requirements Engineers, developers, testers, …
- Defines work products to be used or produced
- Analysis of influencing factors provides information about how to configure RE process
  - Constrains the space of possible process configurations

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Influencing factors

Factors influencing RE process configuration

- Overall process fit: the RE process must fit the overall system development process
- Development context: customer-supplier relationship, development type, contract, trust
- Capability and availability of stakeholders
- Shared understanding
- Complexity and criticality of the system to be developed
- Constraints
- Available time and budget
- Volatility of requirements
- Experience of Requirements Engineers

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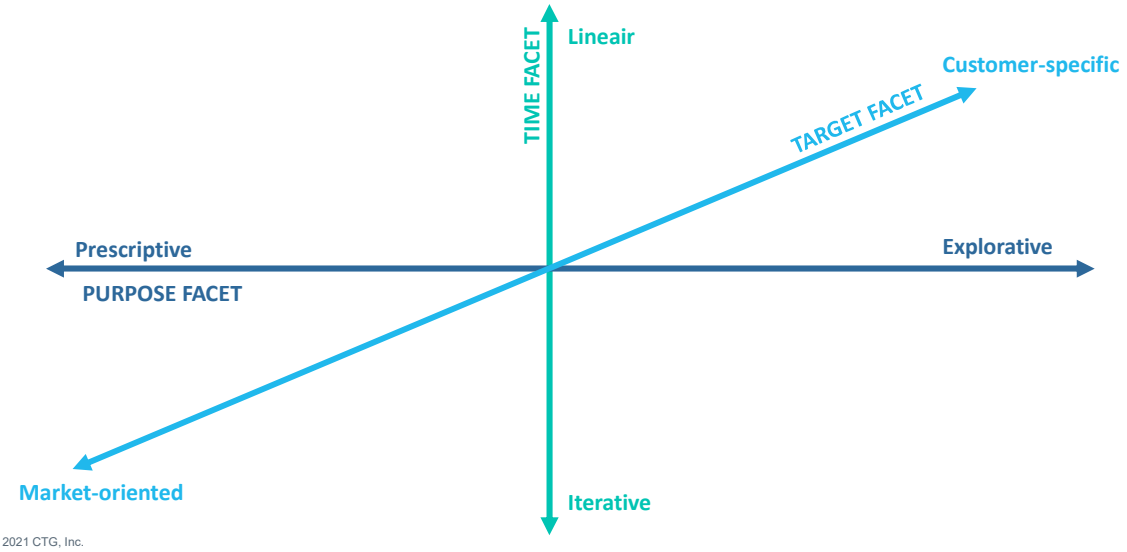
Requirements Engineering Process Facets

3 decisive facets to consider when configuring an RE process



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Requirements Engineering Process Facets

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3 decisive facets to consider when configuring an RE process

Time facet

- **Linear:** requirements specified up front in single process phase
- **Iterative:** requirements are specified incrementally. Starting with general goals and some initial requirements, and then adding or modifying requirements in every iteration

Purpose facet

- **Prescriptive**: requirements specification constitutes a contract: all requirements are binding and must be implemented
- **Explorative:** only goals known a priori, while concrete requirements are explored

Target facet

- **Customer-specific**: system ordered by customer and developed by supplier
- **Market-oriented**: system developed as product or service for a market, targeting specific user segments

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Requirements Engineering Process Facets

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Criteria for choosing a linear process

- Development process is plan-driven and mostly linear
- Stakeholders know their requirements and specify them up front
- Comprehensive reqspec required as contractual basis for outsourcing system design and implementation
- Regulatory authorities require formal requirements freeze at defined process stage

Criteria for choosing an iterative process

- Many requirements not known up front and emerge and evolve during system development
- Short feedback loops established to mitigate risk of developing wrong system
- Project duration allows for more than just one or two iterations
- Ability to change requirements easily is important

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Requirements Engineering Process Facets

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Criteria for choosing a prescriptive process

- Functionality and scope take precedence over cost and deadlines
- Customer requires fixed-price contract for system development with fixed functionality and scope
- Development of specified system may be tendered or outsourced

Criteria for choosing an explorative process

- Stakeholders strongly involved and provide continuous feedback
- Deadlines and cost take precedence over functionality and scope
- Requirements to be implemented need to be negotiated and prioritized

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Requirements Engineering Process Facets

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Criteria for choosing a customer-specific process

- Stakeholders on the customer side are main source for requirements
- Individual persons can be identified for all stakeholder roles
- Contractual relationship between customer and supplier affects RE process

Criteria for choosing a market-oriented process

- Prospective users not individually identifiable
- Requirements specified by organization that develops the system
- Developing organization has to guess/ estimate/elicit needs of envisaged customers/users
- Product owners, marketing people, digital designers, and system architects are primary stakeholders

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Hints and caveats

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- Presented criteria are heuristics rather than fixed rules
- Linear processes work only if sophisticated process for changing requirements is in place
- Linear processes imply long feedback loops
  - To mitigate risks, requirements must be validated intensively
- In market-oriented process, user feedback only way to validate whether product will actually satisfy targeted user segment needs
- In agile setting, an iterative and exploratory RE process fits best

- When defining process, linear and prescriptive are frequently chosen together
- Explorative processes are typically also iterative processes (and vice versa)
- Market-oriented facet does not combine well with linear and prescriptive facets

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Configuring a Requirements Engineering Process

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- Persons responsible for RE configure process to be applied
- Suitable combination of process facets can be used
- Based on analysis of influencing factors

- Three typical combinations

Participatory RE Process

- Iterative & Exploratory & Customer-Specific

Contractual RE Process

- Typically Linear (sometimes Iterative) & Prescriptive & Customer-Specific

Product-Oriented RE Process

- Iterative & Explorative & Market-Oriented

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Configuring a Requirements Engineering Process

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Participatory RE Process: Iterative & Exploratory & Customer-Specific

Main application case	Typical work products	Typical information flow
• Supplier and customer collaborate closely • Stakeholders strongly involved in both RE and development processes	• Product backlog with user stories and/or task descriptions, prototypes	• Continuous interaction between stakeholders, product owners, Requirement Engineers and developers

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Configuring a Requirements Engineering Process

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Contractual RE Process: Linear (sometimes Iterative) & Prescriptive & Customer-Specific

Main application case	Typical work products	Typical information flow
• Reqspec constitutes the contractual basis for the development of a system by people not involved the specification • Little stakeholder interaction after the requirements phase	• Classic system requirements specification • Textual requirements and models	• Primarily from stakeholders to Requirements Engineers

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Configuring a Requirements Engineering Process

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Product-Oriented RE Process: Iterative & Explorative & Market-Oriented

Main application case	Typical work products	Typical information flow
• Organization specifies and develops software in order to sell or distribute it as a product or service	• Product backlog • Prototypes	• Interaction between product owner, marketing, Requirements Engineers, digital designers, developers • Fast feedback from customers/users

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Configuring a Requirements Engineering Process

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- There may be system and development contexts where none of these configurations fit.
  - For example, regulatory constraints may impose use of process that conforms to standards such as ISO/IEC/IEEE 29148
  - RE process has to be created from scratch
  - Or one of 3 mentioned configurations has to be tailored to given situation

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Configuring a Requirements Engineering Process

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Procedure to configure a RE process

Analyze influencing factors
- With respect to list of influencing factors

Assess facet criteria
- Assign each criterion a score

Configure process
- Clear match with one of 3 configuration?
- Else tailor your process
- Mitigating risk should be guiding goal

Determine work products
- Align work products with development process

Select appropriate practices
- Best fit in given situation

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Quiz Questions

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Chapter 6
Management Practices for Requirements

What is Requirements Management, Life Cycle Management, Version Control, Configurations and Baselines, Attributes and Views, Traceability, Handling change, Prioritization

Learning goals

- L1 Know what Requirements Management is about and why it is needed
- L2 Explain why requirements work products need a status/life cycle model
- L2 Set up a versioning concept for requirements in a given project situation
- L1 Know the use of requirements configurations and baselines
- L1 Know the purpose of attributes for requirements
- L2 Define a suitable set of attributes for requirements in a given project situation
- L2 Explain the purpose of view and name the different views of requirements
- L1 Name reasons for requirements traceability
- L1 Summarize the differences between implicit and explicit traceability
- L1 Know how explicit traceability can be documented
- L1 Know how to handle changes in linear (plan-based) and agile approaches
- L1 Know the reason for prioritization and know meaningful assessment criteria
- L1 Name steps to prioritize requirements
- L1 Name different categories of prioritization techniques

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Overview

1. What is Requirements Management?
2. Life Cycle Management
3. Version Control
4. Configurations and Baselines
5. Attributes and Views
6. Traceability
7. Handling Change
8. Prioritization

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What is Requirements Management?

- Process of managing existing requirements recorded in various work products
  - Storing
  - Changing
  - Tracing
- Different ways and at different levels
  - Depending on chosen development process and context
- Maintain requirements so that all roles in project can work effectively and efficiently

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Why manage requirements?

- Requirements are living things
  - Created, used, updated, and deleted during their development and operation
- Make sure parties involved have access to correct versions of all requirements relevant to them
- When not managed properly, risk that some parties may
  - Overlook requirements
  - Stick to outdated requirements
  - Work with wrong versions
  - Overlook relationships
  - …

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Why manage requirements?

- Value lies in improved efficiency and effectiveness of system
  - Both cannot be seperated
- Sometimes neglected in the beginning of project
  - Leads later to loss of overview which results in quality problems and efficiency issues

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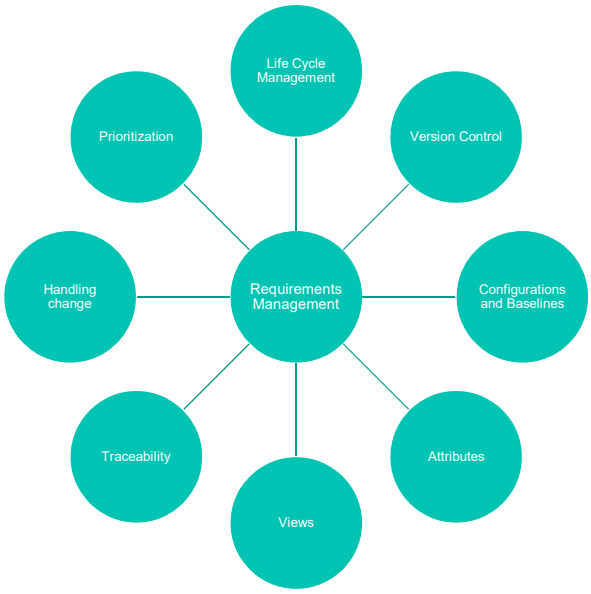
Elements of Requirements Management



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Life Cycle Management

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- Keeping track of all existing work products with respect to their life cycle status
- Allows identification of which work product is in which state
- Defines each allowed life cycle status and state transition

- Actual status of work product should always be clear
  - including history of its transitions

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Life Cycle Management

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Implies

Defining life cycle models for your work products and requirements contained in them with

- States that a work product or requirement can take
- Transitions allowed between these states
- Events that trigger transition from one state to another

Ensuring only explicitly allowed transitions occur

Recording actual states work products and requirements take

Recording actual transitions that occur

Reporting on these states and transitions

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Version Control

- Keep track of all work products during their evolution
- Any change in a work product should be reflected by a new version
- Allows history of work product to be traced back to its origin
- Allows restoring of work product to any earlier version
- Versioning must be considered for all work products

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Version Control

Version numbers

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Version

- Version 0 as long as work product is under development
- Version 1 once formally approved, released and/or launched
- Version X only for major substantive updates

Increment

- Usually starts at 1, incremented with every (externally visible) change
- Sub-increment may be used for corrections of typos only
- Sometimes 9 is used for a final version before release or approval

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Version Control

Versioning strategy

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Identification of each version

- To distinguish between different versions of a work product
- Often version number, supplemented with version date

Clear description of each change

- Tell and understand the difference between a certain version and its predecessor
- Change description must be clearly linked to the version number

Strict policy on storage of versions

- Locate and retrieve old versions
- Preserve all previous versions of all work products
- Archiving and cleaninp up work products no longer needed

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Configurations and Baselines

Requirements configuration

- Consistent set of work products that contain requirements
- Each configuration defined for specific purpose
- Each configuration contains at most one version of each work product

Baseline

- Stable, change-controlled configuration of work products
- Represent stable starting point for next phase
- Often frozen and set aside as an anchor
- Used for release planning or other delivery milestones in project
- Sprint backlog serves as baseline for next iteration

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Configurations and Baselines

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Properties for configurations

Logically connected

- Set of requirements in configuration belongs together in view of certain goal

Consistent

- Set of requirements has no internal conflicts and can be integrated in a system

Unique

- Both configuration and its constituent requirements are clearly and uniquely identified

Unchangeable

- Configuration composed of selected requirements
- Each with specific version that will never be changed in this configuration

Basis for reset

- Configuration allows fallback to previous configuration if any undesired changes occur

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Configurations and Baselines

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Product dimension

- Indicates which requirements are included in specific configuration
- Sometimes, configuration will contain all available requirements. Usually, a certain selection

Version dimension

- In specific configuration, every selected requirement is present in exactly one, and only one, version
- latest version or earlier one, depending on purpose of configuration itself
- Single different version of single requirement forms new configuration

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Attributes

- Characteristics of requirements, required information
- Required to document important metadata for a work product
- Typically used to answer important questions during project or product life cycle
  - *Which work products are planned for a release?*
  - *How much effort is a release likely to incur overall?*
  - *How many work products have a high priority?*
- Enables team members and other stakeholders to get information about requirements
  - at any point during the project
- Relevant set of attributes depends on information needs of stakeholders in project
- ISO 29148 provides overview of most relevant attributes

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Attributes

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ISO 29148

Identification
- Each requirement should have a unique, immutable identifier
- Without proper identification, requirements management is impossible

Stakeholder priority
- The (agreed) priority of requirement from stakeholder's viewpoin

Dependency
- A low-priority requirement should be implemented first because another, high-priority requirement depends on it

Risk
- Potential that implementation of requirement will lead to problems, such as damage, extra costs, delays, legal claims
- Estimate, to be based on consensus among stakeholders

Source
- Origin of requirement, where did it come from?
- Information needed for validation, conflict resolution, modification, or deletion.

Rationale
- reason why requirement is needed
- Stakeholder's objectives that should be fulfilled

Difficulty
- Estimate of effort needed to implement requirement
- Needed for project planning and estimation

Type
- Indicates whether requirement is a functional requirement, quality requirement or constraint

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Views

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- Allows adjusting reports on information needs of target audiences
- Delivers relevant information for a specific target group
- Excerpt from total set of requirements
- Combination of filter and sort settings
  - Can be made available or reusable to other participants by storing selected combination

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Views

3 types of views

Selective views

- give information on deliberate selection of requirements instead of all requirements

Projective views

- shows selection from all data (attributes) of requirements

Aggregating views

- summaries, totals, or averages, calculated from set of requirements

Projective view (only 4 attributes)

Selective view (only sales dept)

ID	Version	Name	Type	Source	Difficulty (1..5)
1	2.0	Calculate	Functional	Sales	3
2	1.0	Response	Quality	Sales	2
3	1.2	VAT	Constraint	Sales	1
4	0.2	Foreign VAT	Constraint	Sales	4
5	2.0	Delivery date	Functional	Logistics	2
6	0.1	Track & trace	Functional	Logistics	5
7	1.1	Courier	Functional	Logistics	1
8	0.2	Routing	Functional	Logistics	4
9	1.2	Accessi-bility	Quality	Logistics	3

Aggregating view

Functional	5	Quality	2	Constraint	2

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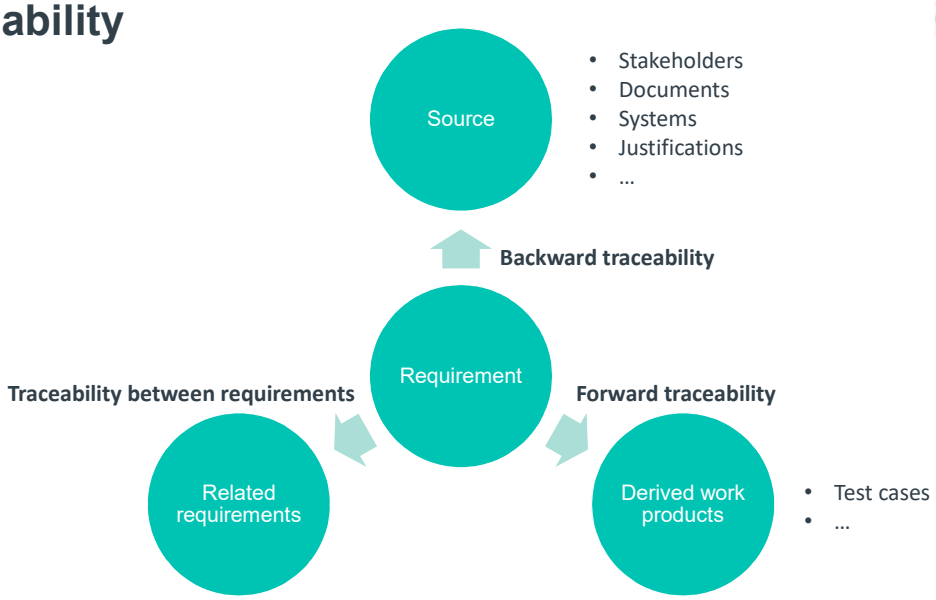
Traceability



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Traceability

- Prerequisite for requirements management
- Often explicitly demanded by standards, laws and regulations
- Maintaining dependencies for analysis, compliancy and information
  - Between different work products at requirements level
  - Relationships with predecessors and successors
- Good tools are indispensable

Implicitly

- Using structured and standardized work products
- Naming conventions (Req-xxx-nnn)

Explicitly

- Relate work products to each other based on their UID

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Traceability

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Reasons for requirements traceability

- Provide evidence that certain requirement is satisfied
- Prove that requirement is implemented and by what means
- Show product compliance with applicable laws and standards
- Look for missing work products
  - (e.g., find out whether test cases exist for all requirements)
- Analyze effects of a change to requirements

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Traceability

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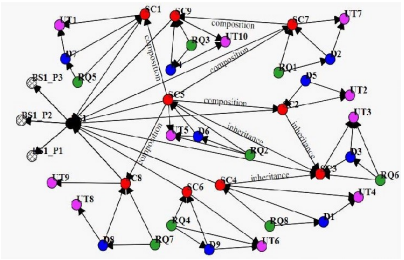
Common representation forms

- Hyperlinks
- References
- Matrices
- Tables
- Graphs



Requirements Traceability Matrix

Requirements Traceability Matrix			Root folder: Contract processing	Requirement	Agree on	Check	Create contact	Determine	See customer off	Send contact	Sign contact	Determine net price	Inform customer	Send original	Contract processing	Check if	Develop proposal	Explain contact	Quotation	Sales order
				#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		Total	Req		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Root Folder: Modeling			Covered		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Test	#	Test		Relate	4	4	4	4	4	4	4	2	2	2	1	0	0	0	0	0
Contact processing - path 2	1	1	X	10	X	X	X					X	X							
Contact processing - path 1	2	1	X	8				X	X	X	X									
Agree on	3	1	X	2	X															
Check	4	1	X	2		X														
Create contact	5	1	X	2			X													
Determine	6	1	X	2				X												
See customer off	7	1	X	2					X											
Send contact	8	1	X	2						X										
Send original	9	1	X	2										X						
Sign contact	10	1	X	2							X									
Contact processing	11	1	X	1											X					

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Handling change

Approximately 1 out of 3 requirements will change during the project

- Requirements will change, whether you like it or not
- Agile manifesto: 'Welcome changing requirements, even late in development'
- Change should be seen as an opportunity
  - To get a better system
  - To create more value to users

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Handling change

Every change is a risk

- Can introduce defects, leading to system failure
- Can delay project progress
- Can take more effort and money than foreseen
- Users may not like it and refuse to work with it
- Things can go wrong and disturb a previously stable project or system

→ Handle changes with care to get optimal value at acceptable cost and minimal risk

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Handling change

Reasons for changes in requirements

- Changes in the system context
  - New insights of stakeholders
  - Behavior of competitors
- New constraints to the system
  - Laws becoming effective
- Performance has to be improved due to growing market demand
- Competitor system is launched with some delighter features that your client wants too
- Incorrect requirements
- Extended scope
- Defects

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Handling change

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Change enablement (ITSM)

- Ensures that changes are implemented effectively, safely, and in timely manner
  - To meet stakeholders' expectations
- Balances effectiveness, throughput, compliance, and risk control
- Focuses on three aspects:
  - All risks have been accurately assessed
  - Authorizing changes to proceed
  - Managing change implementation
- Implies that organization
  - Assigns a change authority to decide on the changes
  - Defines a process for handling them
- Tuned to development approach and point in time where change occurs

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Handling change

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- Impact analysis before deciding on implementation of change
  - Clarify value, efforts and risk of change

Linear RE process

- Decision on change usually taken by change control board

Iterative (agile) RE process

- Product owner has authorization to include changes in product backlog
- Product owner prioritizes changed item

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Prioritization

- Not all requirements equally important
- What are most relevant requirements for next product release or increment?

- Assessment
- Basis for prioritization
- Determined by using multiple assessment criteria
  - Business value
  - Urgency
  - Effort
  - Dependencies
  - others

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Prioritization

Priority

- Describes importance of a single requirement
- Compared to other requirements
  - Product/Sprint backlog
- According to certain criteria
  - Single criterion
  - Multiple criteria
  - Depends on chosen prioritization technique

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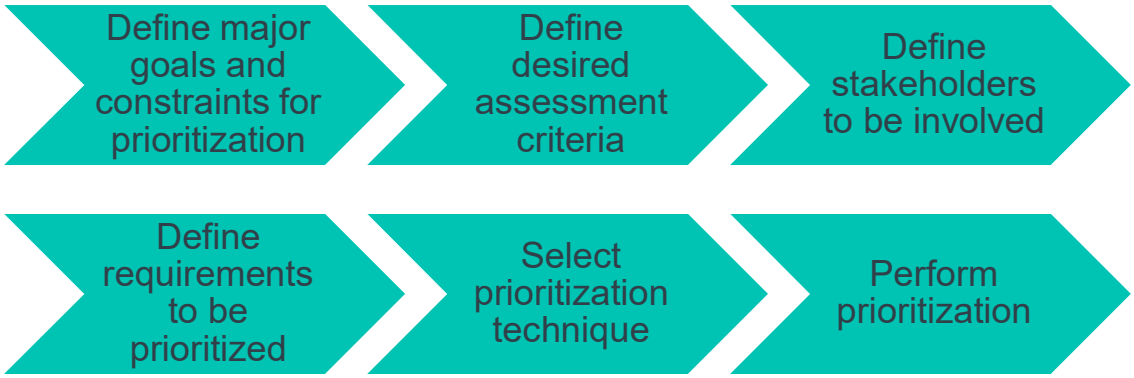
Prioritization

Steps for prioritization



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Prioritization

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Define major goals and constraints for prioritization

- Project and system context determine reason for prioritization
- Technical or legal constraints might limit choices to be made

- Examples:

Goal	Focus
Which features to implement in next release	Business value
Select users stories for next iteration	Story points and technical dependencies

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Prioritization

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Define desired assessment criteria

- Goals and constraints dictate criteria to be used
- Commonly used criteria
  - business value for stakeholders
  - urgency perceived by users
  - effort to implement
  - risks for usage
  - logical and technical dependencies
  - legally binding nature of a requirement,
  - (inter-) subjective preference of relevant stakeholders
- Single criterion or balanced selection of relevant criteria

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Prioritization

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Define stakeholders that have to be involved

- Goals and constraints influence which stakeholders to involve
- Certain stakeholders set these goals, so be aware of interdependency

- Examples

Subject	Stakeholders
Launch of new system	Business representatives Panel of future customers
Product backlog to decide on next iteration	Scrum team

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Prioritization

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Define requirements that have to be prioritized

- Unlikely whole set has to be prioritized
  - Depends on goals and constraints
  - Constraints might dictate certain requirements as must-haves
- Only prioritize those requirements for which you have the choice to include them or not
  - Project phase is also an important factor
    - Early phase: include draft versions
    - Late phase: only stable requirements
- Requirements to be prioritized should be on comparable abstraction level
  - Early phase: themes of features
  - Iteration planning: user stories

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Prioritization

Microsoft Excel-werkblad

Select prioritization technique

- Goals and constraints set the stage
- Several techniques available
  - Differ in effort, thoroughness, level of detail
- Important that stakeholders agree on technique

Ad-hoc prioritization techniques

Expert assigns value to every requirements (based on experience)

+ quickly

- depends on expert's actual experience

Analytical prioritization techniques

Systematic process to assign priorities

- e.g. assign weights to certain criteria (benefit, cost, risk, time implement)

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Prioritization

Perform prioritization

- Assess all selected requirements on defined criteria
- Apply selected techniques
  - With stakeholders involved
- Result is a prioritized list of requirements

- Different stakeholders might have different priorities → Requirements conflict

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Quiz Questions

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Chapter 7
Tool Support

Tools in Requirements Engineering,
Introducing Tools

Learning goals

- L1 Know the different types of RE tools
- L2 Explain what to consider when introducing RE tools

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Tools in Requirements Engineering

- Can support RE process
- Support dedicated tasks and activities
- Often focus only on certain aspects in RE
  - Rarely support all activities
  - RE processes are quite individual
- Different tools might be combined

- Other kind of tools (office or issue tracking tools) have limitations
  - RE and stakeholders should be in control of process
  - Requirements should be aligned and quite stable

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Tools in Requirements Engineering

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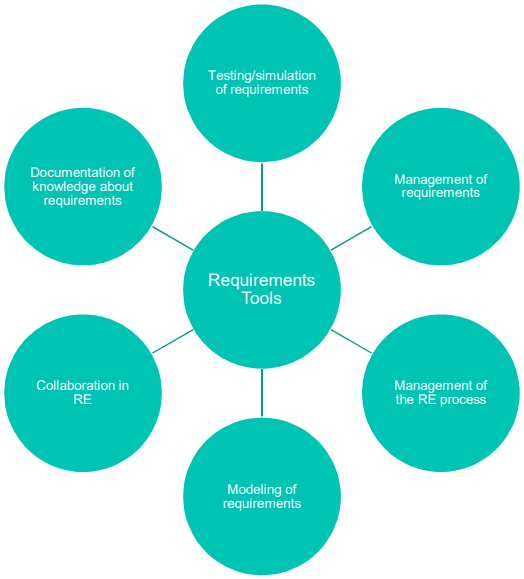
Tools support

- Sharing requirements
- Creating a shared understanding of the requirements



- Defining and storing requirements attributes
- Prioritizing requirements
- Managing versions and configurations
- Tracking and tracing requirements
- Managing changes to requirements

- Measuring and reporting on the RE process
- Measuring and reporting on the product quality
- Managing the RE workflow

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Tool Selection and Introduction

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Important aspects

Consider all life cycle costs beyond licence costs

- Also take into account less visible costs

Consider necessary resources

- For selection process, but also for maintenance and user support after introduction

Avoid risks by running pilot projects

- Apply tool to a non-critical project/system
- Use the tool redundantly alongside an existing project
- Import/copy the requirements of a completed project

Evaluate the tool according to defined criteria

- Make the right choice

Instruct employess on use of tool

- If users are not sufficiently trained, not all benefits are used
- Create new (agreed) procedures, templates, changes to working method

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Tool Selection and Introduction

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All life cycle costs

Initial

- Knowledge acquisition
- Costs for purchase, adaptation or development
- Selection, implementation, integration process
- Training

Recurring

- Ownership (maintenance, license fees, support fees, sustaining knowledge levels)
- Portability
- Availability and dependencies

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Tool Selection and Introduction

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Criteria for tool evaluation

Project perspective	• Project management aspects • *Does the tool support the project and the information required in the project?*
Process perspective	• Support of Requirements Engineering process • *Does the tool sufficiently support the RE process? Can it be sufficiently adapted to the existing RE process and working method?*
User perspective	• Degree of application by the users of the tool • Important because if users are not satisfied with the tool, the risk of the tool not being accepted increases. • *Does the tool sufficiently support the authorization of users and groups? Is it sufficiently user-friendly and intuitive?*
Product perspective	• Functionalities offered by the tool • *Are the requirements sufficiently covered by the tool? Where is the data stored? Is there a roadmap with the functional extensions for the tool? Is the tool still supported by the supplier for the time being?*
Supplier perspective	• Service and reliability of the supplier. • *Where is the supplier located? How is the support for this tool arranged?*
Economic perspective	• Business case • *Does the tool deliver sufficient benefits in relation to the costs? What are the (management) costs for the purchase and maintenance? What does the tool provide for the RE process? Is a (separate) maintenance contract required?*
Architecture perspective	• How tool fits into the (IT) organization. • *Does the technology applied suit the organization? Can the tool be sufficiently linked with other systems? Does the tool fit into the IT landscape and does it comply with the architectural constraints?*

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Quiz Questions

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