Software quality, processes, and standards
Basic concepts: requirements

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Moodle: „Software Quality (Tarkvara kvaliteet)”
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Today and the course

Software quality, processes, and standards

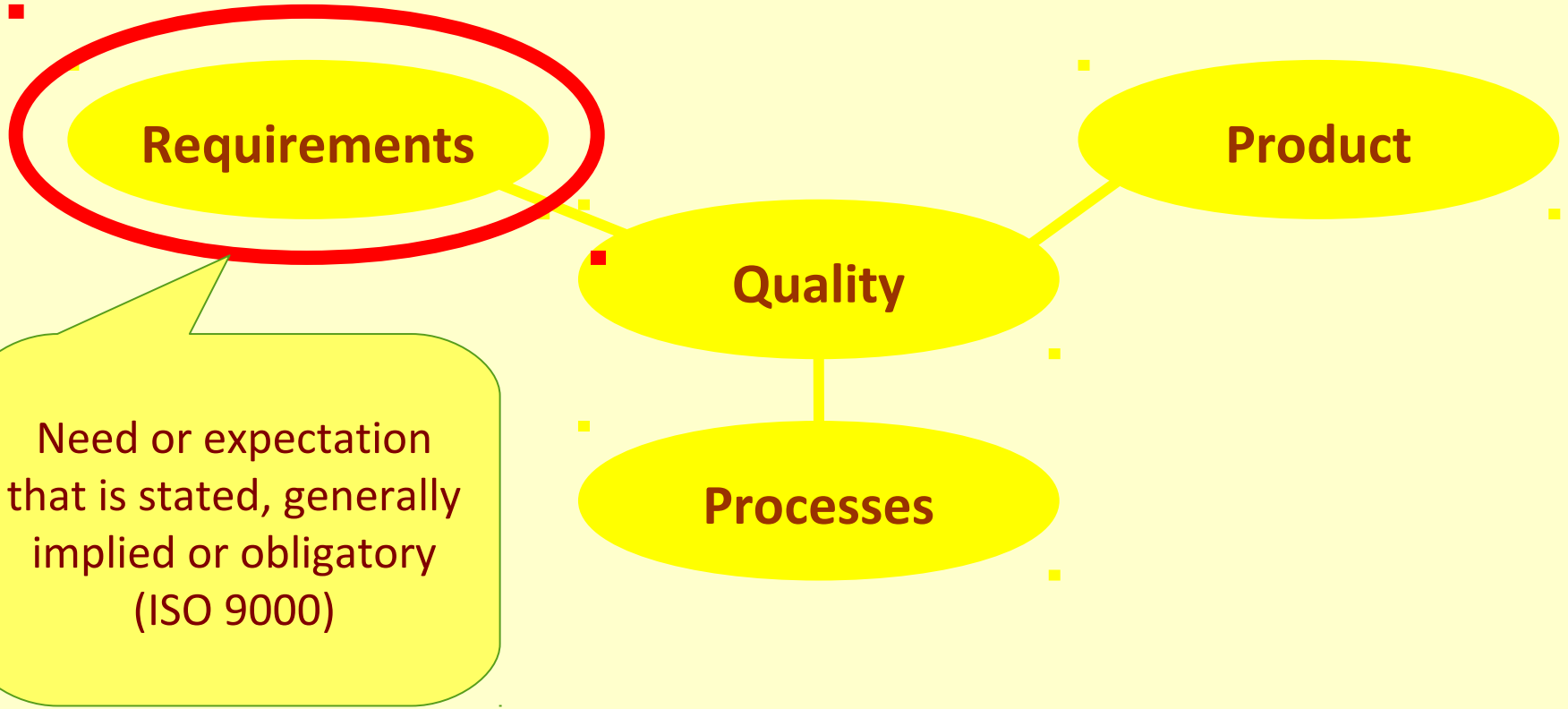
- Quality
  - Why?
  - Three components
  - Three concepts
  - As relative (experiment)
  - As a tradeoff
  - Three SwQ aspects
- V&V
- Quality and processes
- Moodle tepandi.ee

Product
- Software
- Software and system
- Four layers of complexity
- Quality aspects /Sw/system

Requirements
- Why, sources, types
- Properties
- Models =>
  - ISO/IEC 25010
  - ISO/IEC 25012
  - Business

Processes

How can better requirements improve software quality?



Requirements - topics

Motivation and sources. Why? Where do the requirements come from?

Types. Business, process, product, user, data req-s. (Non)functional requirements

Properties. (Non)testable requirements. (Non)realistic. (Non)traceable. Risks.

Models

Quality models. ISO/IEC 25000 series, incl ISO/IEC 25010

Product quality - Select required for the task: functionality, efficiency, reliability, compatibility, usability, security, maintainability, portability

Quality in use, data quality. ISO/IEC 25012

Covered in other courses, not in this one: Requirements elicitation, documentation, management, techniques, tools, software modeling, ...

Project Lab 1 part 2

Why care about better requirements

Requirements appear / evolve during development?

- In practice, requirements change anyway
- Flexible, agile development
- Better customer satisfaction

Need to know at least the main requirements early!

- Business perspective
- Cost, duration, team
- Contracts
- Avoid vendor lock-in possibility
- Some (non-functional) requirements may be very expensive

Sources of requirements

Quality models

- Product quality
- Data quality
- Quality in use
- Process quality

Guide to the Software Engineering Body of Knowledge, SWEBOK, http://www.computer.org/portal/web/swebok/v3guide

ISO/IEC 25010 Software engineering: Software product Quality Requirements and Evaluation (SQuaRE) — Quality model

From quality model to quality requirements

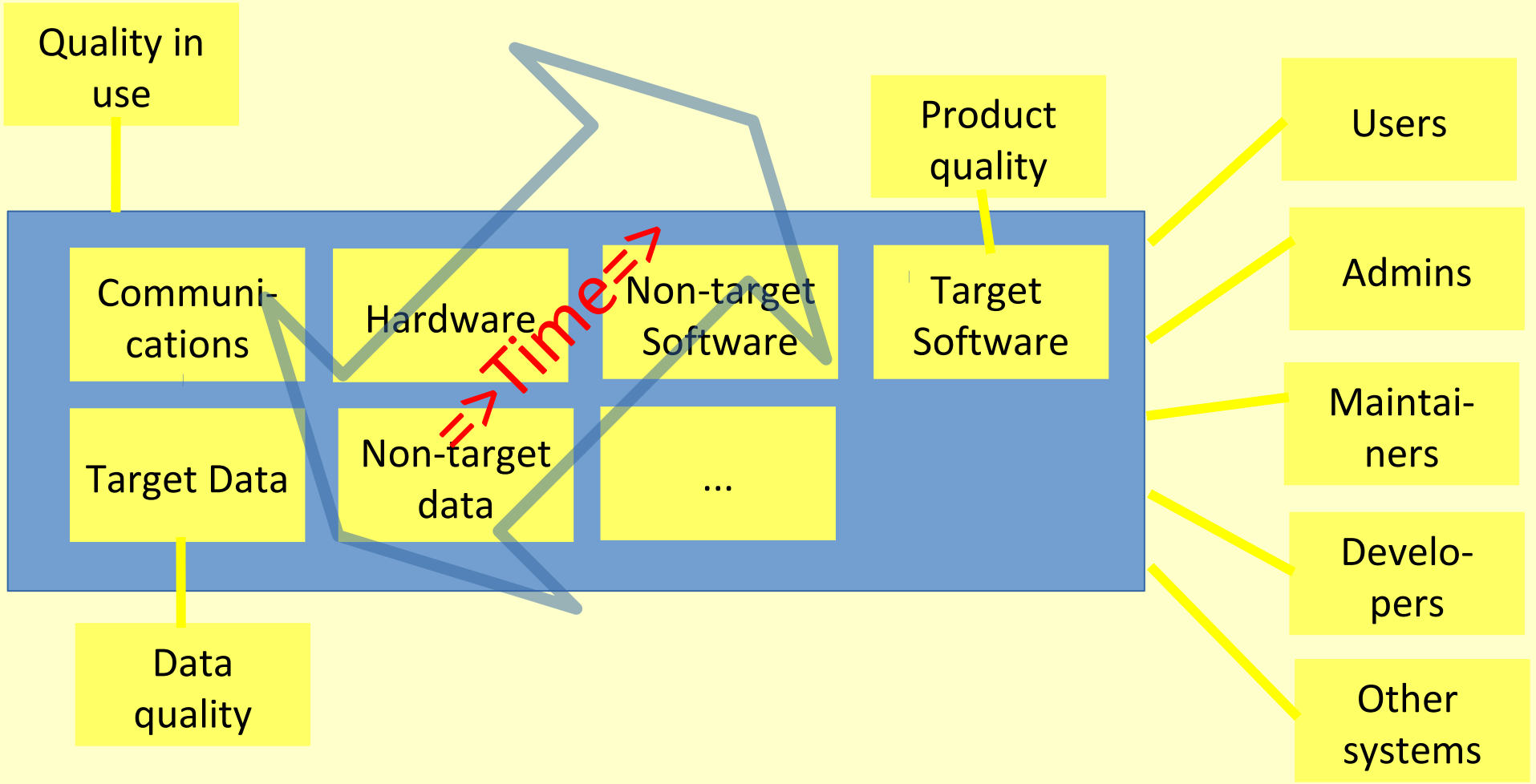
Software quality requirement shall be associated with quality characteristics (or subcharacteristics) as defined in the applied quality model. Note: The quality model can be used as a checklist to ensure coverage of all quality aspects.

Software quality requirements shall be traceable to stakeholder requirements.

If no software quality requirements address a specific characteristic (or subcharacteristic) of the quality model, this shall be documented.

(ISO/IEC 25030)

Quality, system, processes



Product, User, Data, Process quality

Software quality: capability of software product to satisfy stated and implied needs when used under specified conditions

Quality in use: the extent to which a product used by specific users meets their needs to achieve specific goals with effectiveness, productivity, safety and satisfaction in specific contexts of use

Data quality: degree to which the characteristics of data satisfy stated and implied needs when used under specified conditions

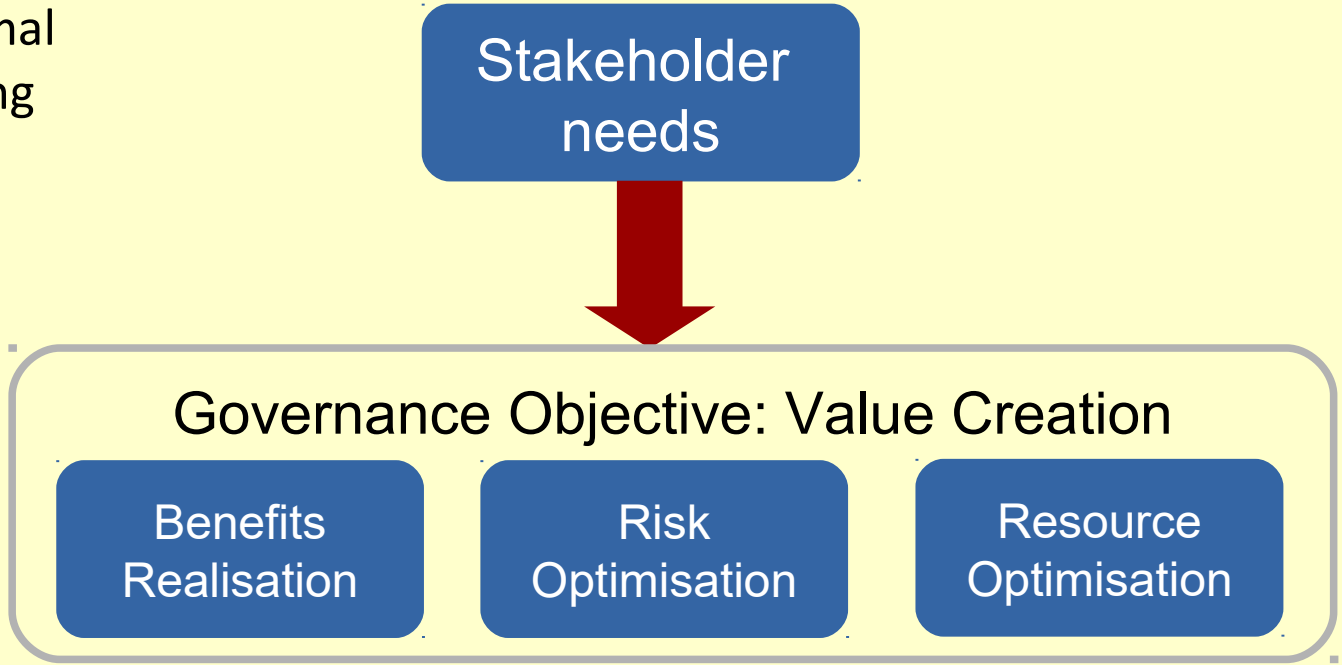
Process quality: the extent to which a process has the capability to consistently produce products of desired quality

Process quality influences product quality, which influences quality in use and data quality

Governance / business objectives (COBIT 5)

Realising benefits at an optimal resource cost while optimising risk

Business quality



Functional / non-functional + Testable / nontestable requirements

- Functional requirements: what the system needs to do?
- Non-functional requirements: How this should be done?
- Testable criteria: it is possible to evaluate whether the actual results confirm to expected results
- Examples: “The system must output the user report in the format defined in Appendix 2”, “The system respond to user queries”, “The system must be reliable”, „Total duration of unplanned system outages must not exceed 2 hours during a 2-month period”

Whose risk?

Realistic / unrealistic, traceable / non-traceable requirements

- Give examples of realistic / unrealistic requirements. Whose risk are they?
  - Examples: “The system must work with the following browsers:...”, “The system must work with all widespread browsers:...”, “The system response time must be under 3 sec” - realistic? problems? risks?
- Software quality requirements must be traceable to stakeholder requirements
  - How ensure traceability? Which risks are associated with non-traceability?
- Compare SMART (*Specific, Measurable, Agreed, Realistic and Time bound*)

Quality models and characteristics

Many models

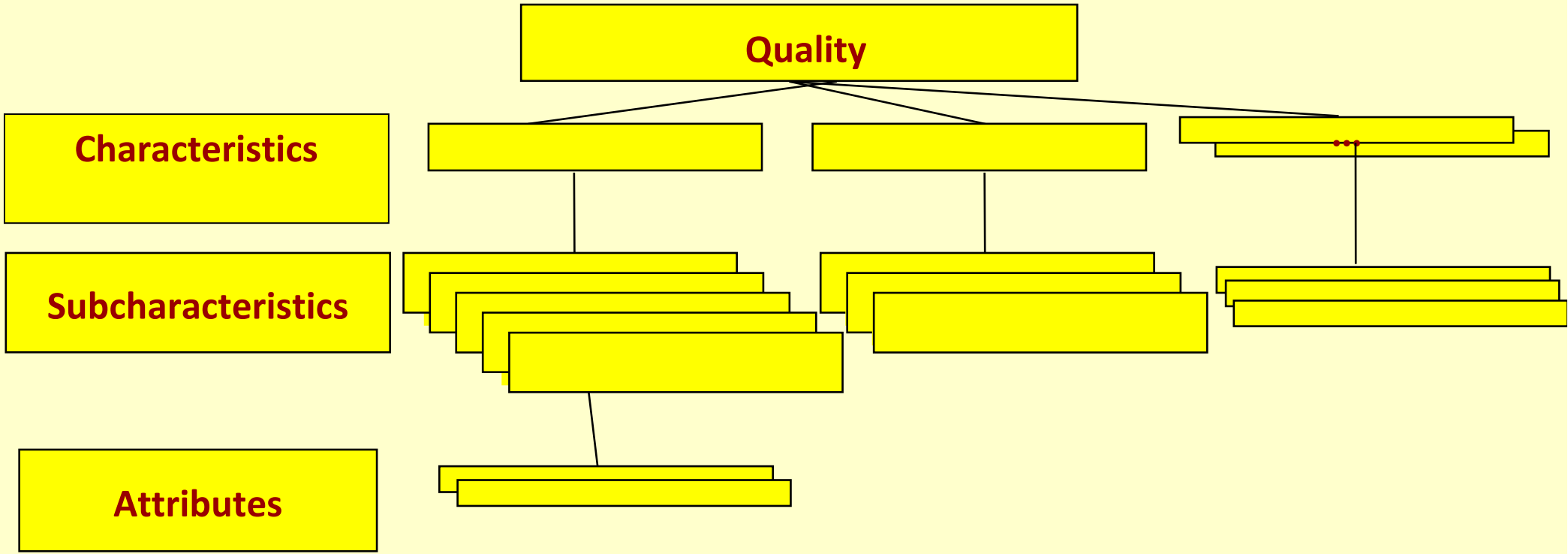
Large number of possible characteristics

Can be combined in different ways, often represented as hierarchy

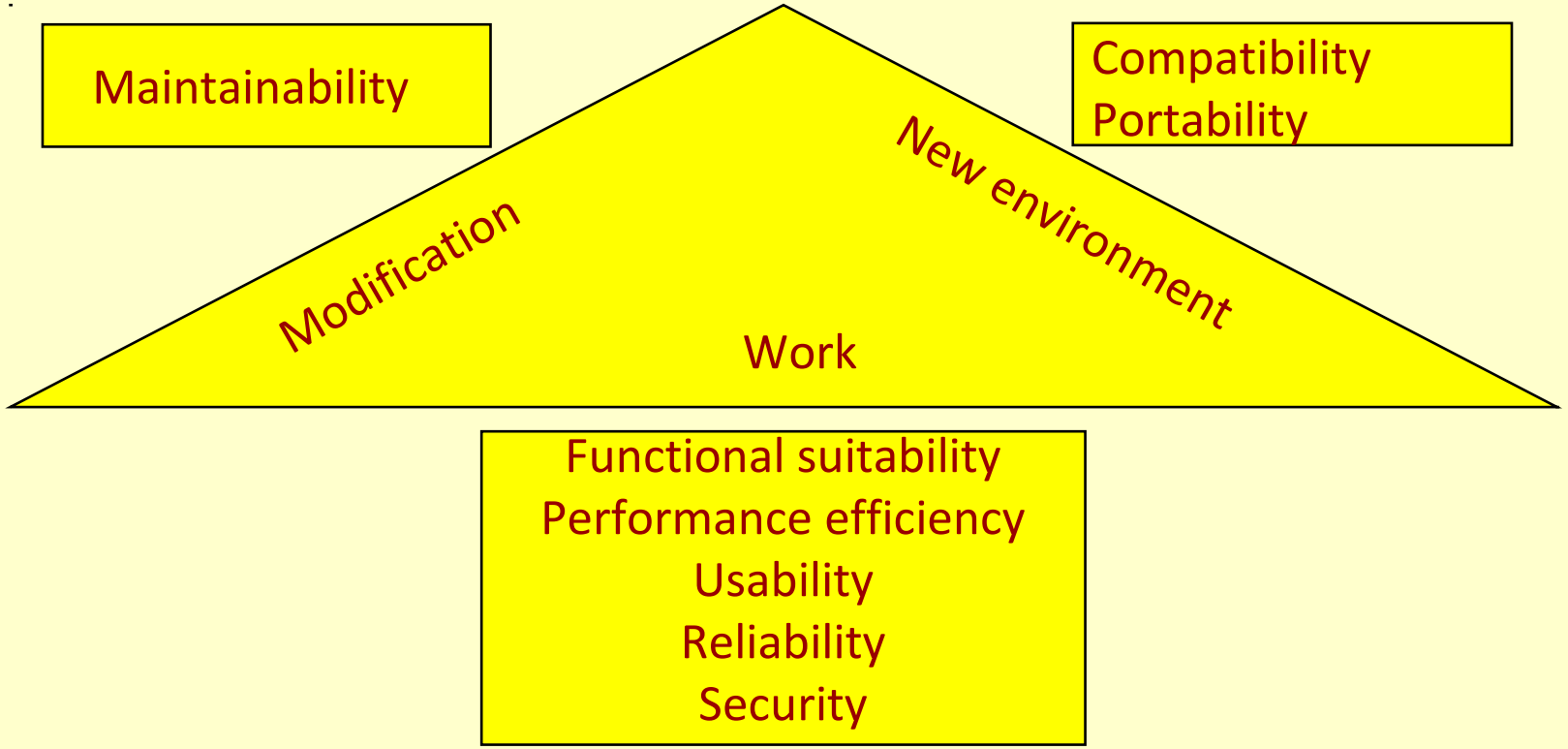
ISO/IEC 25000 series (former ISO/IEC 9126)

Use as a checklist, select those characteristics that are needed for the task

ISO/IEC 25000/ 9126 series



Product quality characteristics (ISO/IEC 25010)



Product quality (ISO/IEC 25010)

ISO/IEC 25010

Functional suitability
Functional completeness
Functional correctness
Functional appropriateness

Performance efficiency
Time behaviour
Resource utilization
Capacity

Compatibility
Co-existence
Interoperability

Usability
Appropriateness recognizability
Learnability
Operability
User error protection
User interface aesthetics
Accessibility

Reliability
Maturity
Availability
Fault tolerance
Recoverability

Security
Confidentiality
Integrity
Non-repudiation
Accountability
Authenticity

Maintainability
Modularity
Reusability
Analysability
Modifiability
Testability

Portability
Adaptability
Installability
Replaceability

https://www.iso.org/obp/ui/#iso:std:iso-iec:25010:ed-1:v1:en

Functional suitability

functional suitability - degree to which a product or system provides functions that meet stated and implied needs when used under specified conditions

functional completeness - degree to which the set of functions covers all the specified tasks and user objectives

functional correctness - degree to which a product or system provides the correct results with the needed degree of precision

functional appropriateness - degree to which the functions facilitate the accomplishment of specified tasks and objectives

Examples

Functional correctness: If the law does not state otherwise, the balances shall be rounded to three decimal places.

Functional appropriateness: If typical input values are required for a task, these values are available to the user automatically as defaults. The user is only presented with the necessary steps to complete a task, excluding any unnecessary steps.

Performance efficiency

performance efficiency - performance relative to the amount of resources used under stated conditions

time behaviour - degree to which the response and processing times and throughput rates of a product or system, when performing its functions, meet requirements

resource utilization - degree to which the amounts and types of resources used by a product or system, when performing its functions, meet requirements

capacity - degree to which the maximum limits of a product or system parameter meet requirements. Note: Parameters can include the number of items that can be stored, the number of concurrent users, the communication bandwidth, throughput of transactions, and size of database.

Compatibility

compatibility - degree to which a product, system or component can exchange information with other products, systems or components, and/or perform its required functions, while sharing the same hardware or software environment

co-existence - degree to which a product can perform its required functions efficiently while sharing a common environment and resources with other products, without detrimental impact on any other product

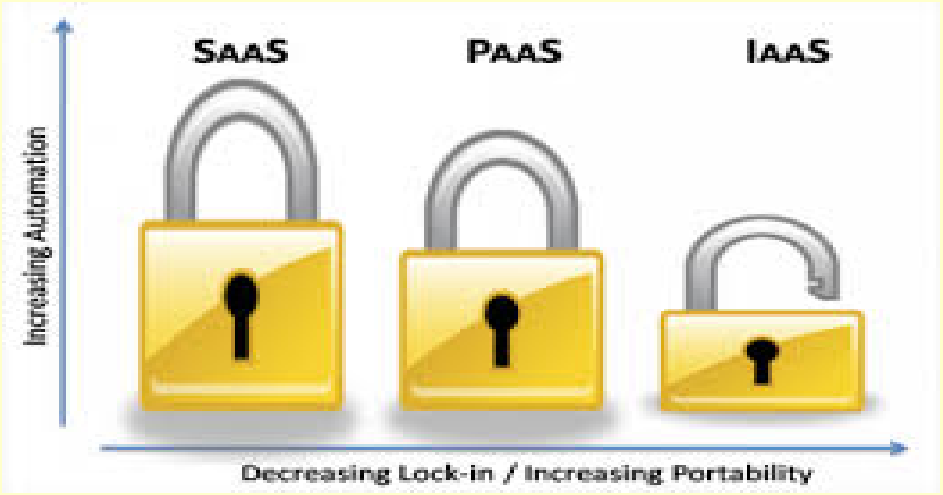
interoperability - degree to which two or more systems, products or components can exchange information and use the information that has been exchanged

Compatibility: uses

Reducing vendor lock-in

Vendor lock-in (proprietary lock-in, customer lock-in), makes a customer dependent on a vendor for products and services, unable to use another vendor without substantial switching costs =>

Cloud Computing Standards, Compatibility and Interoperability: Software /Platform/Infrastructure



Usability 1

usability - degree to which a product or system can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use

appropriateness recognizability - degree to which users can recognize whether a product or system is appropriate for their needs

learnability - degree to which a product or system can be used by specified users to achieve specified goals of learning to use the product or system with effectiveness, efficiency, freedom from risk and satisfaction in a specified context of use

operability - degree to which a product or system has attributes that make it easy to operate and control

Usability 2

user error protection - degree to which a system protects users against making errors

user interface aesthetics - degree to which a user interface enables pleasing and satisfying interaction for the user

accessibility - degree to which a product or system can be used by people with the widest range of characteristics and capabilities to achieve a specified goal in a specified context of use

Examples: Web Content Accessibility Guidelines (WCAG) 2.0

1.1.1 Non-text Content: All non-text content that is presented to the user has a text alternative that serves the equivalent purpose, except for the situations listed below. (Level A)

1.4.1 Use of Color: Color is not used as the only visual means of conveying information, indicating an action, prompting a response, or distinguishing a visual element. (Level A)

1.4.4 Resize text: Except for captions and images of text, text can be resized without assistive technology up to 200 percent without loss of content or functionality

2.1.1 Keyboard: All functionality of the content is operable through a keyboard interface without requiring specific timings for individual keystrokes, except where the underlying function requires input that depends on the path of the user's movement and not just the endpoints. (Level A)

http://www.w3.org/TR/WCAG20/

Reliability

reliability - degree to which a system, product or component performs specified functions under specified conditions for a specified period of time

maturity - degree to which a system, product or component meets needs for reliability under normal operation

availability - degree to which a system, product or component is operational and accessible when required for use

fault tolerance - degree to which a system, product or component operates as intended despite the presence of hardware or software faults

recoverability - degree to which, in the event of an interruption or a failure, a product or system can recover the data directly affected and re-establish the desired state of the system

Three-level IT baseline security system ISKE: availability

K0

K1 – 90% (allowed summary interruption below 24h/week);

K2 – 99% (...about 2h/week);

K3 – 99,9% (...about 10 min/week)

https://www.riigiteataja.ee/akt/13125331

Security 1

security - degree to which a product or system protects information and data so that persons or other products or systems have the degree of data access appropriate to their types and levels of authorization

confidentiality - degree to which a product or system ensures that data are accessible only to those authorized to have access

integrity - degree to which a system, product or component prevents unauthorized access to, or modification of, computer programs or data

Security 2

non-repudiation - degree to which actions or events can be proven to have taken place, so that the events or actions cannot be repudiated later

accountability - degree to which the actions of an entity can be traced uniquely to the entity

authenticity - degree to which the identity of a subject or resource can be proved to be the one claimed

Three-level IT baseline security system ISKE: confidentiality

S0 – public

S1 – internal use

S2 – secret

S3 - top secret

https://www.riigiteataja.ee/akt/13125331

Maintainability

maintainability - degree of effectiveness and efficiency with which a product or system can be modified by the intended maintainers

modularity - degree to which a system or computer program is composed of discrete components such that a change to one component has minimal impact on other components

reusability - degree to which an asset can be used in more than one system, or in building other assets

analysability - degree of effectiveness and efficiency with which it is possible to assess the impact on a product or system of an intended change to one or more of its parts, or to diagnose a product for deficiencies or causes of failures, or to identify parts to be modified

modifiability - degree to which a product or system can be effectively and efficiently modified without introducing defects or degrading existing product quality

testability - degree of effectiveness and efficiency with which test criteria can be established for a system, product or component and tests can be performed to determine whether those criteria have been met

Example: design for maintainability

a. Early planning: anticipating what and how programs might be modified at a later stage.

b. Modular design: defining subsets and simplifying functionality (i.e., one module performs only one function).

c. Object-oriented design: encapsulating both methods and data structures to achieve a higher level of independence than that of modular design.

d. Uniform conventions: facilitating error detection and debugging.

e. Naming conventions: providing understandable codes.

f. Coding standards, comments, and style: enhancing readability of the program.

g. Documentation standards.

h. Common tool sets.

i. Configuration Management

https://oce.jpl.nasa.gov/practices/dfe6.pdf

Portability

portability - degree of effectiveness and efficiency with which a system, product or component can be transferred from one hardware, software or other operational or usage environment to another

adaptability - degree to which a product or system can effectively and efficiently be adapted for different or evolving hardware, software or other operational or usage environments

installability - degree of effectiveness and efficiency with which a product or system can be successfully installed and/or uninstalled in a specified environment

replaceability - degree to which a product can replace another specified software product for the same purpose in the same environment

Compare

compatibility

- co-existence
- interoperability

portability

- adaptability
- installability
- replaceability

Summary: Product quality

ISO/IEC 25010

Functional suitability
Functional completeness
Functional correctness
Functional appropriateness

Performance efficiency
Time behaviour
Resource utilization
Capacity

Compatibility
Co-existence
Interoperability

Usability
Appropriateness recognizability
Learnability
Operability
User error protection
User interface aesthetics
Accessibility

Functional?

Testable?

Realistic?

Traceable?

Risk?

Reliability
Maturity
Availability
Fault tolerance
Recoverability

Security
Confidentiality
Integrity
Non-repudiation
Accountability
Authenticity

Maintainability
Modularity
Reusability
Analysability
Modifiability
Testability

Portability
Adaptability
Installability
Replaceability

https://www.iso.org/obp/ui/#iso:std:iso-iec:25010:ed-1:v1:en

Quality model for quality in use

- Effectiveness
- Efficiency
- Satisfaction
  - Usefulness
  - Trust
  - Pleasure
  - Comfort
- Freedom from risk
  - Economic risk mitigation
  - Health and safety risk mitigation
  - Environmental risk mitigation
- Context coverage
  - Context completeness
  - Flexibility

https://www.iso.org/obp/ui/#iso:std:iso-iec:25010:ed-1:v1:en

Quality in use 1

effectiveness - accuracy and completeness with which users achieve specified goals

efficiency - resources expended in relation to the accuracy and completeness with which users achieve goals

satisfaction - degree to which user needs are satisfied when a product or system is used in a specified context of use

- usefulness - degree to which a user is satisfied with their perceived achievement of pragmatic goals, including the results of use and the consequences of use
- trust - degree to which a user or other stakeholder has confidence that a product or system will behave as intended
- pleasure - degree to which a user obtains pleasure from fulfilling their personal needs
- comfort - degree to which the user is satisfied with physical comfort

https://www.iso.org/obp/ui/#iso:std:iso-iec:25010:ed-1:v1:en

Quality in use 2

freedom from risk - degree to which a product or system mitigates the potential risk to economic status, human life, health, or the environment

- **economic risk mitigation -** degree to which a product or system mitigates the potential risk to financial status, efficient operation, commercial property, reputation or other resources in the intended contexts of use
- **health and safety risk mitigation -** degree to which a product or system mitigates the potential risk to people in the intended contexts of use
- **environmental risk mitigation -** degree to which a product or system mitigates the potential risk to property or the environment in the intended contexts of use

https://www.iso.org/obp/ui/#iso:std:iso-iec:25010:ed-1:v1:en

Quality in use 3

context coverage - degree to which a product or system can be used with effectiveness, efficiency, freedom from risk and satisfaction in both specified contexts of use and in contexts beyond those initially explicitly identified

- **context completeness** - degree to which a product or system can be used with effectiveness, efficiency, freedom from risk and satisfaction in all the specified contexts of use
- **flexibility** - degree to which a product or system can be used with effectiveness, efficiency, freedom from risk and satisfaction in contexts beyond those initially specified in the requirements

https://www.iso.org/obp/ui/#iso:std:iso-iec:25010:ed-1:v1:en

CFP example

- Main functions
- Users
- Inputs, outputs, data exchange forms
- Organisation
- Deadlines
- Existing hardware/software

- OK?

ISO/IEC 9126 => 25010

- + security, +compatibility
- Attribute selection somewhat different
- System and software
- Data quality
- ISO/IEC 9126 still a good example list of quality attributes

See also https://www.iso.org/obp/ui/#iso:std:iso-iec:25010:ed-1:v1:en:term:4.1.3.2

Data quality model characteristics (ISO/IEC 25012)

Inherent:

Accuracy
Completeness
Consistency
Credibility
Currentness

Inherent + System dependent:

Accessibility
Compliance
Confidentiality
Efficiency
Precision
Traceability
Understandability

System dependent:

Availability
Portability
Recoverability

Data quality model 1

Accuracy - The degree to which data has attributes that correctly represent the true value of the intended attributes of a concept or event in a specific context of use. Main aspects: *Syntactic accuracy, Semantic accuracy*

Completeness - The degree to which subject data associated with an entity has values for all expected attributes and related entity instances in a specific context of use.

Consistency - The degree to which data has attributes that are free from contradiction and are coherent with other data in a specific context of use. It can be either or both among data regarding one entity and across similar data for comparable entities.

Credibility - The degree to which data has attributes that are regarded as true and believable by users in a specific context of use.

Currentness - The degree to which data has attributes that are of the right age in a specific context of use.

Data quality model 2

Accessibility - The degree to which data can be accessed in a specific context of use, particularly by people who need supporting technology or special configuration because of some disability.

Compliance - The degree to which data has attributes that adhere to standards, conventions or regulations in force and similar rules relating to data quality in a specific context of use.

Confidentiality - The degree to which data has attributes that ensure that it is only accessible and interpretable by authorized users in a specific context of use.

Efficiency - The degree to which data has attributes that can be processed and provide the expected levels of performance by using the appropriate amounts and types of resources in a specific context of use.

Data quality model 3

Precision. The degree to which data has attributes that are exact or that provide discrimination in a specific context of use.

Traceability. The degree to which data has attributes that provide an audit trail of access to the data and of any changes made to the data in a specific context of use.

Understandability - The degree to which data has attributes that enable it to be read and interpreted by users, and are expressed in appropriate languages, symbols and units in a specific context of use.

Availability - The degree to which data has attributes that enable it to be retrieved by authorized users and/or applications in a specific context of use.

Portability - The degree to which data has attributes that enable it to be installed, replaced or moved from one system to another preserving the existing quality in a specific context of use.

Recoverability - The degree to which data has attributes that enable it to maintain and preserve a specified level of operations and quality, even in the event of failure, in a specific context of use.

More examples - criteria

Interoperability - http://en.wikipedia.org/wiki/European_Interoperability_Framework

Usability - http://www.w3.org/TR/WCAG20/

Usability - http://en.wikipedia.org/wiki/Section_508_Amendment_to_the_Rehabilitation_Act_of_1973

Summary: Business, Process, Product, User, Data quality / requirements

Different requirements from stakeholders: owner, maintainer, user, etc

Business requirements examples: benefits / risk / resource optimisation

Process requirements: constraints on the development of the software

Software product quality: capability of software product to satisfy stated and implied needs when used under specified conditions

Quality in use: the extent to which a product used by specific users meets their needs to achieve specific goals with effectiveness, productivity, safety and satisfaction in specific contexts of use

Data quality: degree to which the characteristics of data satisfy stated and implied needs when used under specified conditions

(SWEBOK, ISO/IEC 25000, ISO/IEC 25012, COBIT)

Key points to know

- Requirements as intrinsic component of quality. Sources of requirements. From quality model to quality requirements.
- Functional / non-functional + Testable / non-testable + Realistic / non-realistic + Traceable / non-traceable requirements. Risks.
- Quality characteristics and subcharacteristics (examples). ISO/IEC 25000 series. Product quality, quality in use, data quality models.

Additional reading - requirements (examples)

Ian Sommerville. Software Engineering. Ninth Edition. Addison-Wesley, Ch 4.

Daniel Galin, Software Quality assurance from theory to implementation, Pearson - Addison-Wesley. Chapter 3.

Guide to the Software Engineering Body of Knowledge (SWEBOK), IEEE. Chapter 1 and Chapter 10 Section 1.3.

Terms and definitions from ISO/IEC 25010, https://www.iso.org/obp/ui/#iso:std:iso-iec:25010:ed-1:v1:en.

Web Content Accessibility Guidelines (WCAG) 2.0, http://www.w3.org/TR/WCAG20/.

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