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Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Quality model overview and usage

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Foreword

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 7, *Software and systems engineering.*

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

A wide variety of organizational functions and personal activities are increasingly performed by information systems and IT services. Therefore, high-quality information systems and IT services are essential to providing value and avoiding potential negative consequences for their stakeholders. Unfortunately, quality assurance has traditionally focused primarily on functional requirements, giving far less attention to the non-functional attributes of a system/product. Comprehensive specification, design, and evaluation of all quality attributes of information systems and IT services are critical to optimizing the value of information systems to their stakeholders.

The comprehensive specification of quality characteristics associated with a specific type of information system is represented in a quality model. A quality model can be used as an objective reference supporting requirements definition, evaluation, and validation/verification. By establishing an international agreement on quality characteristics and their measurement, the SQuaRE family of standards provides a framework for reliable world-wide development and delivery of information systems and IT services.

This document is intended to provide guidelines for interpreting and using ISO/IEC 25010, ISO/IEC TS 25011, ISO/IEC 25012, ISO/IEC 25019, and other SQuaRE quality models to be published in the future. Quality models in the SQuaRE family can guide the development of quality measures and evaluation processes used to provide evidence that information systems, ICT products, data, and IT services have the capability to perform their role in achieving the sustainable development goals of SDGs 4, 9, and 11.

This document introduces the structure of SQuaRE quality models and provides requirements for developing them. This document describes how SQuaRE quality models in the quality model division (ISO/IEC 2501n) can be used in conjunction with other SQuaRE standards to guide quality-related activities across the information system lifecycle. These quality models can guide the development of measures for evaluating the quality of information systems and IT services to meet the requirements of their stakeholders. These models provide a common language for describing quality characteristics that can be understood by all stakeholders and should be considered in defining product requirements. They also provide a basis for defining standard quantitative measures of quality characteristics for evaluating the quality properties of a target entity.

The complexity of information systems has grown exponentially with the advent of modern digital technologies. This complexity elevates the importance of non-functional requirements and qualities. SQuaRE quality models can help guide the development of modern digital technologies that are trustworthy and that delight their users.

This document is a part of the SQuaRE series of International Standards, which consists of the following divisions:

— quality management division;

— quality model division;

— quality measurement division;

— quality requirements division;

— quality evaluation division;

— SQuaRE extension division.

Figure 1 (adapted from ISO/IEC 25000) illustrates the organization of the SQuaRE family of International Standards. Similar standards are grouped into divisions. Each division provides guidance and resources for performing a different function in ensuring system and software product quality.

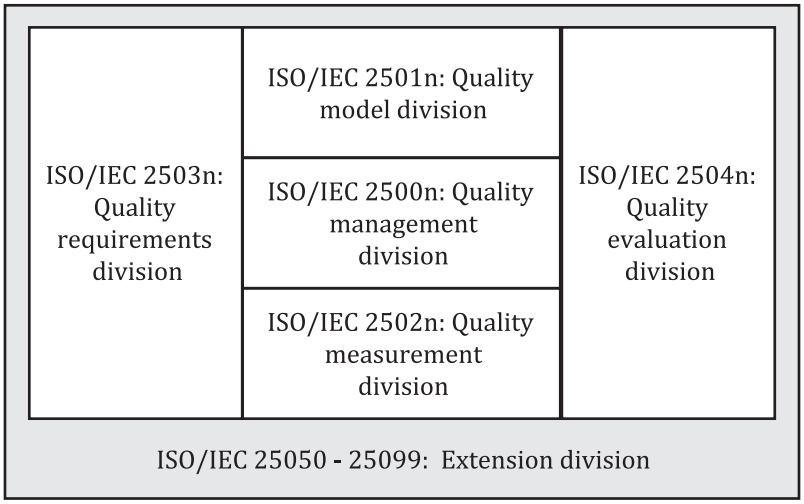

Figure 1 — Organization of SQuaRE family of International Standards

The divisions within the SQuaRE family are:

— ISO/IEC 25000 to ISO/IEC 25009 - quality management division. The International Standards that form this division define all common models, terms, and definitions referred to by all other International Standards from the SQuaRE family. This division also provides requirements and guidance for a supporting function that is responsible for the management of the requirements, specification, and evaluation of software product quality. Practical guidance on the use of the quality models is also provided.

  — ISO/IEC 25000: Guide to SQuaRE

  — ISO/IEC 25001: Planning and management

  — ISO/IEC 25002: Quality models overview and usage

— ISO/IEC 25010 to ISO/IEC 25019 - quality model division. The International Standards that form this division present detailed quality models for computer systems and software products, data, IT services and quality-in-use.

  — ISO/IEC 25010: Product quality model

  — ISO/IEC TS 25011: IT service quality model

  — ISO/IEC 25012: Data quality model

  — ISO/IEC 25019: Quality-in-use model

— ISO/IEC 25020 to ISO/IEC 25029 - quality measurement division. The International Standards that form this division include a quality measurement framework, mathematical definitions of quality measures, and practical guidance for their application. Examples are given of quality measures for internal and external properties of products, data, IT services and quality-in-use. Quality measure elements (QME) forming foundations for quality measures for internal and external properties of products are defined and presented.

— ISO/IEC 25030 to ISO/IEC 25039 - quality requirements division. The International Standards that form this division help specify quality requirements based on quality models and quality measures. These quality requirements can be used in the process of eliciting quality requirements for information systems and IT services to be developed or as input for an evaluation process.

— ISO/IEC 25040 to ISO/IEC 25049 - quality evaluation division. The International Standards that form this division provide requirements, recommendations and guidelines for software product evaluation,

whether performed by evaluators, acquirers or developers. The guideline for documenting a measure as an evaluation module is also provided.

— ISO/IEC 25050 to ISO/IEC 25099 - SQuaRE extension division. These International Standards currently include requirements for quality of ready-to-use software product (RUSP), Common Industry Formats for usability reports, and quality models and measures for new technologies such as cloud services and artificial intelligence.

The SQuaRE standards can be used in conjunction with ISO/IEC/IEEE 15288, particularly the processes for the specification and evaluation of quality requirements. ISO/IEC 25030 describes how quality models can be used for systems and software quality requirements; and ISO/IEC 25040 describes how the quality models can be used for systems and software quality evaluation.

The SQuaRE standards can also be used in conjunction with ISO/IEC 33000 family of International Standards which are concerned with software process assessment to provide:

— a framework for software product quality definition in the customer-supplier process;

— support for quality review, verification, and validation, as well as a framework for establishing quantitative quality characteristics;

— support for setting organizational quality goals in the management process.

The SQuaRE standards can be used in conjunction with ISO 9001 (which is concerned with quality assurance processes) to provide:

— support for setting quality goals;

— support for design review, verification, and validation.

Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Quality model overview and usage

1 Scope

This document establishes a framework for defining quality models which are composed of quality characteristics and sub-characteristics. In particular, this document provides:

— the concept of a quality model;

— the structure and semantics of quality models;

— the relationship between quality models and the other concepts, including measurement, requirement definition, and evaluation;

— guidelines, requirements and examples for using quality models.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
attribute
inherent property or characteristic of an entity that can be distinguished quantitatively or qualitatively by human or automated means

[SOURCE: ISO/IEC 25000:2014, 4.1, modified — Notes to entry have been removed.]

3.2
component
entity with discrete structure, such as an assembly or software module, within a *system* (3.29) considered at a particular level of analysis

Note 1 to entry: *ICT products* (3.8) are composed from multiple entities including sub-ICT products, hardware, firmware, communication infrastructure, software, software components, and data

[SOURCE: ISO/IEC 19770-5:2015, modified — The term has been changed from "software component" to "component"; the original note 1 to entry has been replaced by a new one.]

3.3
context of use
users (3.31), tasks, equipment (hardware, software and materials), and the physical and social environments in which a *product* (3.15) is used

[SOURCE: ISO/IEC 25000:2014, 4.2]

3.4
data quality
capability of the characteristics of data to satisfy stated and implied needs when used under specified conditions

[SOURCE: ISO/IEC 25000:2014, 4.5, modified— "degree to which the characteristics of data satisfy" has been changed to "capability of the characteristics of data to satisfy".]

3.5
developer
individual or organization that performs development activities [including *requirements* (3.25) analysis, design, testing through acceptance] during the *system* (3.29) or software life cycle process

[SOURCE: ISO/IEC 25000:2014, 4.6]

3.6
direct user
person who interacts with the *product* (3.15)

Note 1 to entry: This includes primary *users* (3.31) who use the *system* (3.29) to achieve their goals and secondary users like content providers, system managers, administrators, operators and installers.

3.7
evaluator
individual or organization that performs an evaluation

[SOURCE: ISO/IEC 25000:2014, 4.10]

3.8
ICT product
product (3.15) which uses information and communication technologies (ICTs) and can be a part of *information system* (3.10)

Note 1 to entry: ICT product can constitute other ICT products (sub-products) and sometimes a *component* (3.2) of an ICT product can also be considered as ICT products by themselves. Examples of ICT products includes computer hardware, software *products* (3.15), and data.

Note 2 to entry: ICT product refers to combination of one or more technology components (e.g. cloud, internet, data, multimedia, communication, hardware, firmware, software, and middleware) that enables modern computing and allows people and organizations to interact and operate in the digital world.

Note 3 to entry: ICT product does not include people, machines, infrastructure, and other facilities which are independent from communication and data. ICT product includes hardware with embedded computer, such as sensors and communicators, but not the *users* (3.31).

Note 4 to entry: While many artefacts like data sheets, user manuals, installation manuals, operations guides, and configuration guides contribute to the quality of an ICT product and the information system that constitutes it, they are not ICT products by themselves.

[SOURCE: ISO/IEC 25030:2019, 3.8, modified — The original note 1 to entry has been removed; 4 new notes to entry have been added.]

3.9
indirect user
person who receives output from a *system* (3.29), but does not interact with the system

EXAMPLE business managers, acquirers, product managers

3.10
information system
system (3.29) that comprises software, hardware, communication facility, data, and the people who use it [*users* (3.31)] in a given (user and system) environment to satisfy their information processing needs (goals)

Note 1 to entry: While information systems can be part of larger systems that include other electro-mechanical *products* (3.15) and their users, this document considered these *components* (3.2) as part of the *context of use* (3.3) of the system only if they have a direct relevant relationship to the *ICT products* (3.8) and users who are part of the information system. However, many of the quality *attributes* (3.1) can be applied to these larger systems of systems as well.

Note 2 to entry: The *quality-in-use* (3.18) model can be used as a guide to represent the user's expectations about the system's behaviour.

Note 3 to entry: Users of the quality-in-use includes *direct* (3.6) and *indirect users* (3.9). When applied to direct users, quality-in-use appears as "effect"; and when applied to other *stakeholders* (3.26) it appears as "influence".

[SOURCE: ISO/IEC 25030:2019, 3.10, modified — "(users)", "(user and system)" and "(goals)" have been added; the original note 1 to entry has been removed; 3 new notes to entry have been added.]

3.11
IT service
service that makes use of IT *systems* (3.29) as tools to provide value to an individual *user* (3.31) or a business by facilitating results the user or business wants to achieve

Note 1 to entry: Users include customers and service providers.

[SOURCE: ISO/IEC TS 25011:2017, modified — The preferred term "information technology service" has been removed; the original note 1 to entry has been replaced by a new one.]

3.12
IT service system
system (3.29) that is comprised of an *IT service* (3.11) and the people who use it [*users* (3.31)] in a given (user) environment to satisfy their service needs

3.13
IT service quality
capability of an *IT service* (3.11) to satisfy stated and implied quality needs when delivered under specified conditions

Note 1 to entry: This definition differs from the ISO 9000:2015 quality definition mainly because the IT service quality definition refers to the satisfaction of stated and implied needs, while the ISO 9000 quality definition refers to the satisfaction of *requirements* (3.25).

Note 2 to entry: Typically, *users* (3.31) do not consider IT services that only satisfy delivery requirements as high-quality IT services. Quality relates to satisfying and even surpassing expectations within associated constraints and conditions.

[SOURCE: ISO/IEC TS 25011:2017, 3.3.10, modified — "degree to which an IT service satisfies" has been changed to "capability of an IT service to satisfy"; "quality" has been added; "used" has been changed to "delivered"; notes 1 and 2 to entry have been added.]

3.14
maintainer
individual or organisation that performs maintenance activities

[SOURCE: ISO/IEC 25000:2014, 4.17, modified — Note 1 to entry has been removed.]

3.15
product
artefact that is produced, is quantifiable, and is deliverable to *user* (3.31) as either an end item in itself or a *component* (3.2) item

Note 1 to entry: In this document, product refers to an *ICT product* (3.8) that is part of an *information system* (3.10). ICT product components include subsystems, software, firmware, hardware, data, communication infrastructure, and other elements that are part of the ICT product.

[SOURCE: ISO/IEC 25030:2019, 3.12, modified — The original notes 1 and 2 to entry have been replaced by a new note to entry.]

3.16
product quality
capability of a *system* (3.29) or its *components* (3.2) to satisfy stated and implied quality needs when used under specific conditions

Note 1 to entry: This quality definition is semantically similar to the ISO 9000:2015 quality definition. This software quality definition refers to the satisfaction of stated and implied needs, and the ISO 9000 quality definition refers to fulfil requirements (ISO 9000:2015, 3.6.4) defined as “need or expectation that is stated, generally implied or obligatory”.

Note 2 to entry: Product quality model refers to the system and software product quality model defined in ISO/IEC 25010.

Note 3 to entry: Typically, *users* (3.31) do not consider *systems* (3.29) that only satisfy requirements as high-quality systems. Quality is related with satisfying and even surpassing expectations with associated constraints and conditions.

[SOURCE: ISO/IEC 25020:2019, 3.17, modified — The preferred term "system and software product quality" has been removed; "system and/or software" has been replaced by "system or its components"; "implied needs" has been replaced by "implied quality needs"; notes 1 and 3 to entry have been added.]

3.17
quality characteristic
category of quality *attributes* (3.1) that bears on the quality of the *ICT product* (3.8) or *information system* (3.10)

Note 1 to entry: Quality characteristics can be further divided into *quality sub-characteristics* (3.24). While characteristics typically represent one aspect of quality that is of interest to *stakeholders* (3.26), quality sub-characteristics can help subdivide quality characteristics into individual aspects that help mapping them to *quality properties* (3.22).

[SOURCE: ISO/IEC 25000:2014, 4.34, modified — The term has been changed from "software quality characteristic" to "quality characteristic", the definition has been adapted to apply to a larger scope of products and systems; the original note 1 to entry has been replaced by a new one.]

3.18
quality-in-use
extent to which the *system* (3.29) or *product* (3.15), when it is used in a specified *context of use* (3.3) satisfies or exceeds *stakeholders' needs* (3.27) to achieve specified beneficial goals or outcomes

Note 1 to entry: Beneficial goals can be stated as targets, in predefined conditions with managed economic, environmental, organizational, and societal risks.

Note 2 to entry: The *quality-in-use* (3.18) model can be used as a guide to represent the *user's* (3.31) expectations about the system's behaviour.

Note 3 to entry: Users of the quality-in-use includes *direct* (3.6) and *indirect users* (3.9). When applied to direct users, quality-in-use appears as “effect”; and when applied to other *stakeholders* (3.26) it appears as “influence”.

3.19
quality measure
derived measure that is defined as a measurement function of two or more values of *quality measure elements* (3.20))

Note 1 to entry: Quality measures can be considered as derived properties of an *ICT product* (3.8) or *information system* (3.10).

Note 2 to entry: Inherent (structural) quality measures quantify structural properties of the ICT product or information system, while behavioural quality measures quantify properties that can be identified and measured on the ICT product or information system as a whole and its behaviour in a *context of use* (3.3).

[SOURCE: ISO/IEC 25021:2012, 4.13, modified — Notes 1 and 2 to entry have been added.]

3.20
quality measure element
measure defined in terms of a property and the measurement method for quantifying it, including optionally the transformation by a mathematical function

[SOURCE: ISO/IEC 25020:2019, 3.14, modified — The abbreviated term "QME" and note 1 to entry have been removed.]

3.21
quality model
defined set of *characteristics* (3.17) and of relationships between them, which provides a framework for specifying *quality requirements* (3.23) and evaluating the quality

[SOURCE: ISO/IEC 25000:2014, 4.27]

3.22
quality property
property of a *target entity* (3.30) that is related to a *quality measure element* (3.20) and which can be quantified by a measurement method

Note 1 to entry: Quality properties can be used either in measurement of quality or just for providing qualitative feedback.

Note 2 to entry: The term “quality property” is regarded as the same to the term “property to quantify” when describing quality. Then, the definition is the same to the one that is originally for the term “property to quantify” of ISO/IEC 25020:2019, 3.11.

3.23
quality requirement
requirement (3.25) for *quality properties* (3.22) or *attributes* (3.1) of an *ICT product* (3.8), data, or service that satisfy needs which ensue from the purpose for which that ICT product, data, or service is to be used

[SOURCE: ISO/IEC 25030:2019, 3.15, modified —note 1 to entry has been removed.]

3.24
quality sub-characteristic
set of one or more *quality properties* (3.22) that represent a unique aspect of a *quality characteristic* (3.17)

3.25
requirement
statement which translates or expresses a need and its associated constraints and conditions

[SOURCE: ISO/IEC/IEEE 15288:2023, 3.36]

3.26
stakeholder
individual or organisation having a right, share, claim, or interest in a *system* (3.29) or in its possession of characteristics that meet their needs and expectations

EXAMPLE Stakeholders include customers, *users* (3.31), *developers* (3.5), *maintainers* (3.14), system integrators, business analysts, vendor and acquisition managers, product managers, business managers and responsible parties, independent *evaluators* (3.7), data owners, *IT service* (3.11) providers, trainers, auditors, regulatory bodies, and other people affected by the system.

Note 1 to entry: Some stakeholders can have interests that oppose each other or oppose the system.

[SOURCE: ISO/IEC/IEEE 15288:2023, 3.44, modified — The EXAMPLE has been updated.]

3.27
stakeholder need
prerequisite identified as necessary for a *stakeholder* (3.26), or a set of stakeholders, to achieve an intended outcome, implied or stated within a specific *context of use* (3.3)

3.28
sub-sub-characteristic
subdivision of a *quality sub-characteristic* (3.24) established by the *user* (3.31) of a *quality model* (3.21) to provide more granular representation of the quality *attributes* (3.1) of a *target entity* (3.30)

3.29
system
arrangement of parts or elements that together exhibit a stated behaviour or meaning that the individual constituents do not

Note 1 to entry: A system is sometimes considered as a *product* (3.15) or as the services it provides.

Note 2 to entry: In practice, the interpretation of its meaning is frequently clarified by the use of an associative noun, e.g. aircraft system. Alternatively, the word “system” is substituted simply by a context-dependent synonym (e.g. aircraft), though this potentially obscures a system principles perspective.

Note 3 to entry: A complete system includes all of the associated equipment, facilities, material, computer programs, firmware, technical documentation, services, and personnel required for operations and support to the degree necessary for self-sufficient use in its intended environment.

[SOURCE: ISO/IEC/IEEE 15288:2023, 3.46]

3.30
target entity
fundamental thing of relevance to the *user* (3.31), about which information is kept, and which needs to be measured

Note 1 to entry: Target entities include *ICT products* (3.8) and their *components* (3.2) for ISO/IEC 25010, *IT services* (3.11) for ISO/IEC TS 25011, and data for ISO/IEC 25012.

[SOURCE: ISO/IEC 25021:2012, 4.17, modified — "need" has been changed to "which needs"; note 1 to entry has been added.]

3.31
user
individual or group that interacts with a *system* (3.29) or benefits from a system during its utilization

Note 1 to entry: *Direct users* (3.6) interact with a system; and direct and *indirect users* (3.9) can benefit from a system.

[SOURCE: ISO/IEC/IEEE 15939:2017, 3.40, modified — Note 1 to entry has been added.]

3.32
validation
confirmation, through the provision of objective evidence, that the *requirements* (3.25) for a specific intended use or application have been fulfilled

Note 1 to entry: The objective evidence needed for a validation is the result of a test or other form of determination such as performing alternative calculations or reviewing documents.

Note 2 to entry: The word "validated" is used to designate the corresponding status.

Note 3 to entry: The use conditions for validation can be real or simulated.

[SOURCE: ISO 9000:2015, 3.8.13]

3.33
verification
confirmation, through the provision of objective evidence, that specified *requirements* (3.25) have been fulfilled

Note 1 to entry: The objective evidence needed for a verification can be the result of an inspection or of other forms of determination such as performing alternative calculations or reviewing documents.

Note 2 to entry: The activities carried out for verification are sometimes called a qualification process.

Note 3 to entry: The word "verified" is used to designate the corresponding status.

[SOURCE: ISO 9000:2015, 3.8.12]

4 Abbreviated terms

ICT information and communication technology

IT information technology

5 Guidance for using SQuaRE quality models

Quality models in the quality model division and quality extension division of SQuaRE are aligned with quality model structures enumerated in this document. The SQuaRE quality models in the quality model division and quality extension division are elaborated with a structure of quality characteristics and sub-characteristics that provide a basis for quantifying them with quality measures in the quality measurement division.

Users of SQuaRE quality models should abide by the following guidelines when interpreting and modifying quality models for specific applications.

— Quality model: When quality models presented in the quality model division and quality extension division are modified for application to niche products, services, or contexts of use, the modified models should adopt the relevant quality characteristics as defined in an existing quality model division and quality extension division quality model. Modifications and interpretations of the quality characteristics and sub-characteristics for the niche application should be documented.

— Quality characteristic: Interpretations of quality characteristics for a specific information system or context of use should not differ conceptually from the definition of the quality characteristics in the relevant quality model from the quality model division or quality extension division.

— Quality sub-characteristic: When a quality model is applied to a specific ICT product, definitions of quality sub-characteristics may be modified or customized to fit unique stakeholder requirements, ICT product properties, or the context of use. The modified sub-characteristics should be documented and conceptually consistent with the definition of the sub-characteristics in the relevant quality model. To support traceability and consistency in applying a modified quality model, interpretations and modifications to sub-characteristics should be documented in all guidelines developed locally for using

or applying or interpreting the modified quality model in a specific context of use. Interpretations and modifications should also be included in any document reporting results using measures derived from the model for purposes such as selection, benchmarking, or validation.

6 Quality model overview

A quality model is a defined set of characteristics and sub-characteristics that are quantified by quality measures that can be used to define quality requirements and evaluate the quality properties of target entities. Each quality model provides a framework for specifying quality requirements and measuring the capability of a target entity. SQuaRE quality models are designed to apply to all types of target entities and stakeholders. These models categorize the quality properties of target entities into different quality characteristics and sub-characteristics that can be prioritized, defined, measured, evaluated, and managed on behalf of multiple stakeholders. Quality characteristics can be used to guide the definition of quality requirements derived from stakeholder needs and goals.

The quality models included in the quality model division enable both quantitative and qualitative evaluation and feedback about target entities that can be provided to business and IT stakeholders. Quality models are used for specifying quality requirements (quality requirements division), establishing quality measures (quality measurement division), and performing quality evaluations (quality evaluation division).

The quality models include quality characteristics and sub-characteristics which are associated with the quality properties of target entities. Thus, quality characteristics in these quality models can be used to evolve checklists for ensuring a comprehensive evaluation of whether quality requirements are satisfied. These evaluations provide feedback to system development, integration, maintenance, and other lifecycle processes.

Quality models can be applied to target entities that are developed from scratch, acquired ready to use, customized on a vendor system, integrated from open source, or in operation needing maintenance or enhancement. Quality models are independent of development methods since they apply to quality properties of all ICT products and IT services. Thus, measures of quality characteristics and sub-characteristics can help quantify the satisfaction of stakeholder needs and requirement for a wide range of ICT systems and IT services. When used with target entities in operation, measures derived from quality models quantify the effect target entities have on stakeholders.

7 Quality model framework

7.1 Quality model structure

SQuaRE quality models in the the SQuaRE family of standards exhibit the following structural attributes.

— The quality model is focused on a clearly defined target entity representing a cohesive domain of artefacts.

— The quality model is composed from a set of quality characteristics that collectively cover the measurable quality properties of the target entity.

— When the number or complexity of a quality characteristic's attributes justify it, a quality characteristic is partitioned into a set of quality sub-characteristics that collectively cover the range of quality attributes normally associated with that quality characteristic.

— The quality sub-characteristics associated with the quality characteristics relevant to a target entity collectively cover the full set of measurable quality properties relevant to the target entity.

— To the extent possible, quality sub-characteristics are associated with measures that are mutually exclusive in quantifying the quality properties of a target entity.

— Each quality characteristic or sub-characteristic is related to one or more quality measures whose definition and calculation are described in the quality measurement division.

In some instances, a sub-characteristic may need to be represented in finer granularity to be applied in a specific context of use. In such cases, the sub-characteristic may be subdivided into sub-sub-characteristics that are documented for a specific use. However, sub-sub-characteristics are not included as elements in a quality model standard in the quality model division since they are defined only for a specific scenario of use. The sub-sub-characteristics are exhaustive in covering the full domain of measurable quality properties related to their sub-characteristic in the context of use. The sub-sub-characteristics are also mutually exclusive in covering the quality properties related to their associated sub-characteristic. Measures appropriate to the context of use can be defined for each of the sub-sub-characteristics.

Figure 2 depicts the structure of a SQuaRE quality model and relationships between different model elements. Each SQuaRE quality model focuses on a class of target entities such as ICT products, IT services, or data. A SQuaRE quality model presents a structured representation of the quality characteristics of its target entity. These quality characteristics can be decomposed into one or more sub-characteristics, each of which can be measured by one or more quality measures. For instance, the quality properties of ICT products can be quantified with quality measures related to the quality characteristics and sub-characteristics associated with stakeholder requirements.

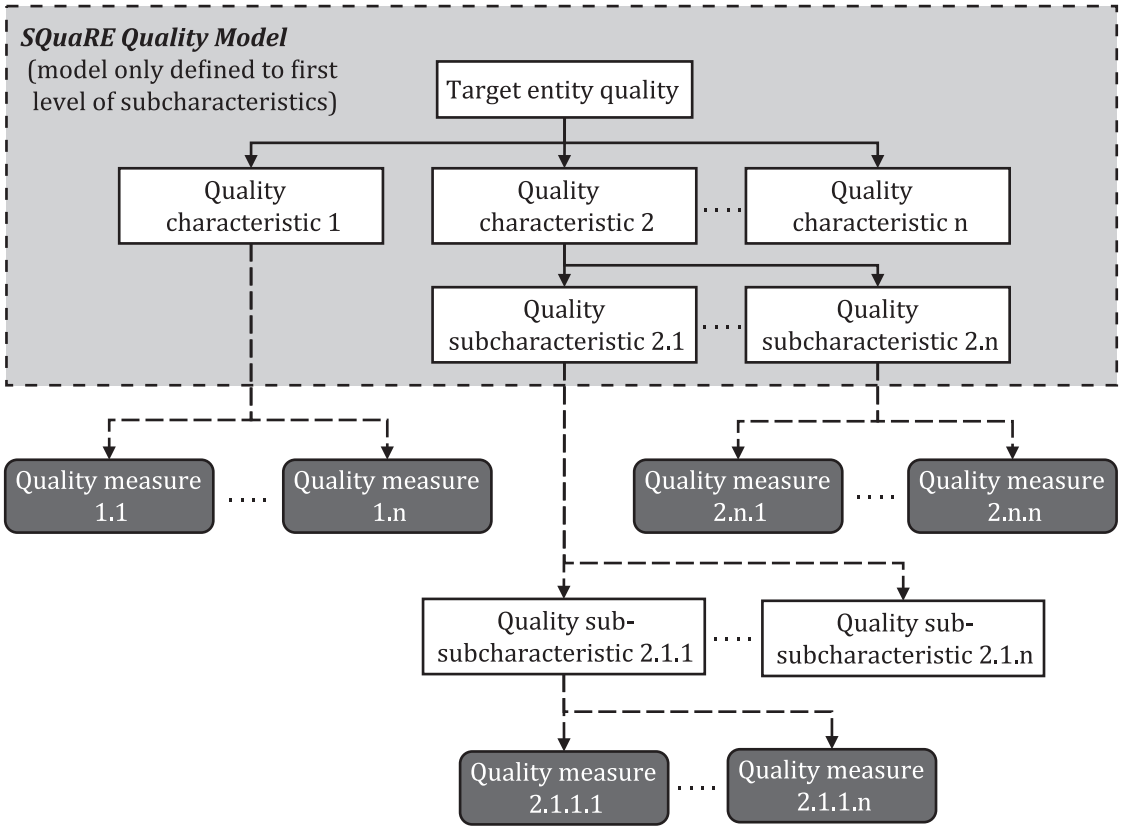

Figure 2 — Structure of quality models in the quality model division

NOTE Further elaboration on the 'measure' aspects of this figure can be found in quality measurement division standards.

Quality characteristics and sub-characteristics represent various needs and quality requirements that affect the capabilities of a target entity. These characteristics and sub-characteristics can be measured by quality measures as described in the quality measurement division. While characteristics and sub-characteristics of a quality model are common to all types of target entities, their importance can depend on the specific type of target entity under evaluation. Some quality characteristics and sub-characteristics may only be important for certain types of target entities. There may be trade-offs where enabling one quality characteristic impacts another, such as the negative effect on usability from increased security, or the negative effect on maintainability from the increased complexity that often results from designing software for performance efficiency.

Quality characteristics and sub-characteristics are associated with quality measures that are used to evaluate the capability of a system to determine whether it meets quality requirements. Users of quality models and their measures should define relationships and build traceability from quality characteristics, sub-characteristics, and measures to the quality properties of the target entity under evaluation. This traceability allows other stakeholders to understand how the target entity was evaluated and how to interpret the quantitative results. Quality models may be modified or customized at the sub-characteristic level (but not the characteristic level) for application in a specific context of use.

7.2 Quality model categories

There are two primary quality perspectives:

— quality of the ICT product, data, or IT service required to meet the needs of stakeholders (e.g. ICT product security);

— quality-in-use as affecting users or other stakeholders in a specific context of use (e.g. satisfaction with an interaction).

The quality of an ICT product is affected by the quality of its subsystems and components. An ICT product's software or firmware components share similar quality characteristics with the overall ICT product. Although data quality affects the quality of ICT products, the quality model for data is defined by a different set of quality characteristics than ICT products. Therefore, multiple quality models are needed to address different contributors to information system and ICT product quality. the quality-in-use model (ISO/IEC 25019) includes quality characteristics that describe the information system's effects on users or other stakeholders in a specific context of use.

— The product quality model (ISO/IEC 25010) includes a set of quality characteristics for an ICT product incorporating its software, hardware, and communication components that guides requirements specification, development, and evaluation of an ICT product.

— The data quality model (ISO/IEC 25012) includes a set of quality characteristics of data and technology managing the data that guides requirements specification, development, and evaluation of data.

— The IT service quality model (ISO/IEC TS 25011) includes a set of quality characteristics of IT services that guides requirements specification, provision, and evaluation of IT services.

— The quality-in-use model (ISO/IEC 25019) includes quality characteristics related to the behavioural attributes of an ICT product or IT service when in use.

Figure 3 depicts how different quality models apply to different components of an information system or IT service system. The quality models together serve as a framework to ensure that all relevant aspects of quality are considered in specifying requirements, developing, or evaluating information systems, ICT products, data, or IT services. However, the priorities assigned to the quality characteristics in each model depend on the context in which the information system is used. The context of use represents a collection of interacting factors including:

— users: types of people who will be using the system;

— goals: users' intention to achieve by using the system;

— user environment: situation in which users are using the system;

— system context: nature and technical context of the system being used.

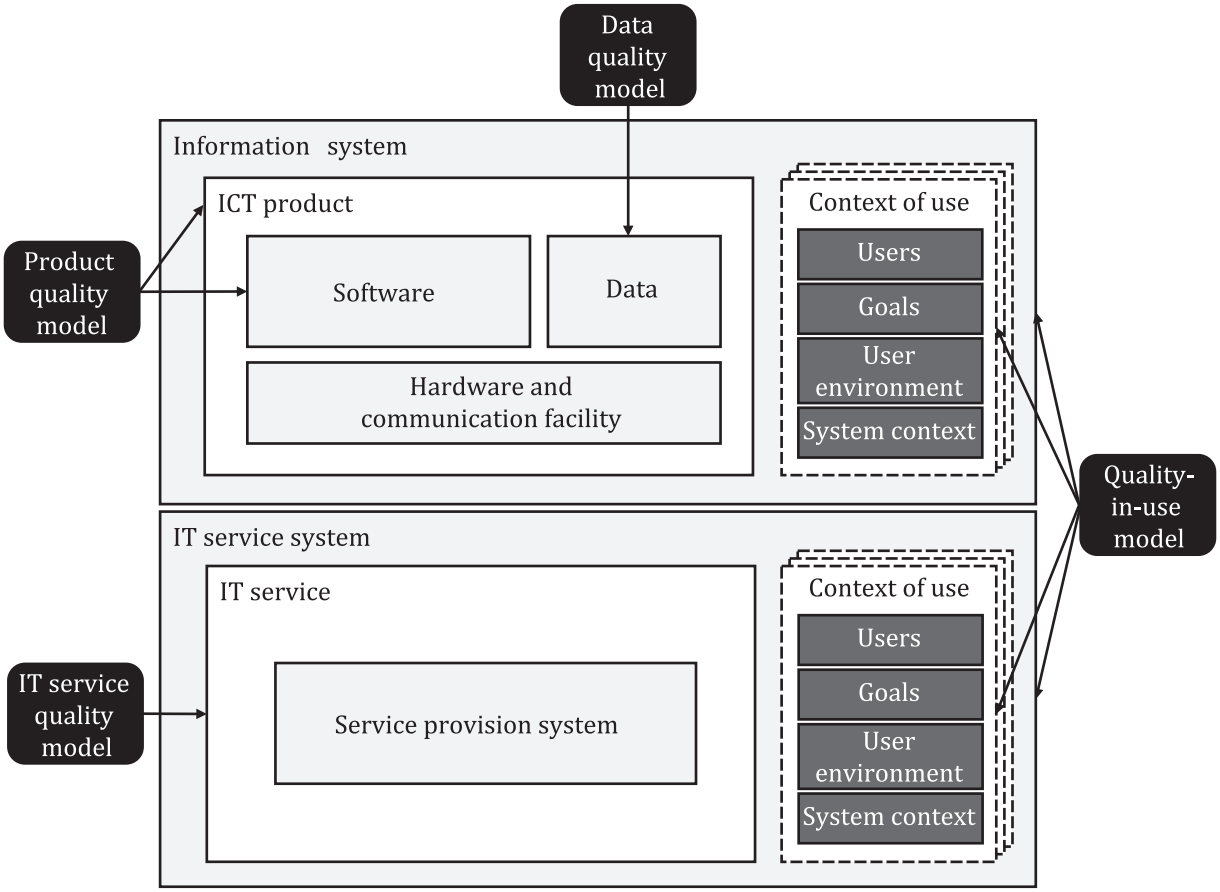

Figure 3 — Quality models and their target entities

NOTE 1 Arrows indicate the target entities within information systems or IT services to which SQuaRE quality models apply.

NOTE 2 When an IT service does not contain an ICT product and its components, the IT service can be evaluated separately from them.

NOTE 3 The product quality model is indirectly applied to hardware and communication facilities when they are a component of an ICT product.

NOTE 4 Service provision system is an information system to provide IT service to users, including people, processes, technology, facilities, and information.

7.3 Ontology of quality model concepts

As displayed in Figure 4, quality models are positioned within an ontology for representing quality concepts relating to a target entity (ICT product, data, or IT service) and its effect on stakeholders experience (quality-in-use). Quality models are constructed from quality characteristics and sub-characteristics that help define quality objectives that are stated and often quantified in quality requirements. The process of applying a quality model's concepts to a target entity is initiated by deriving quality requirements from stakeholder goals and needs. These quality goals and needs represent the functionality and operational attributes stakeholders expect an information system to possess. Quality requirements can then be derived from the stakeholder quality goals and needs. The quality requirements state what and how the information system should perform in relation to quality characteristics.

Quality characteristics and sub-characteristics help define quality objectives which can be quantified by quality measures. Quality objectives can be used to set target values for quality measures. The quality measures are used to measure the quality properties of a target entity to verify that its capability satisfies quality objectives and requirements.

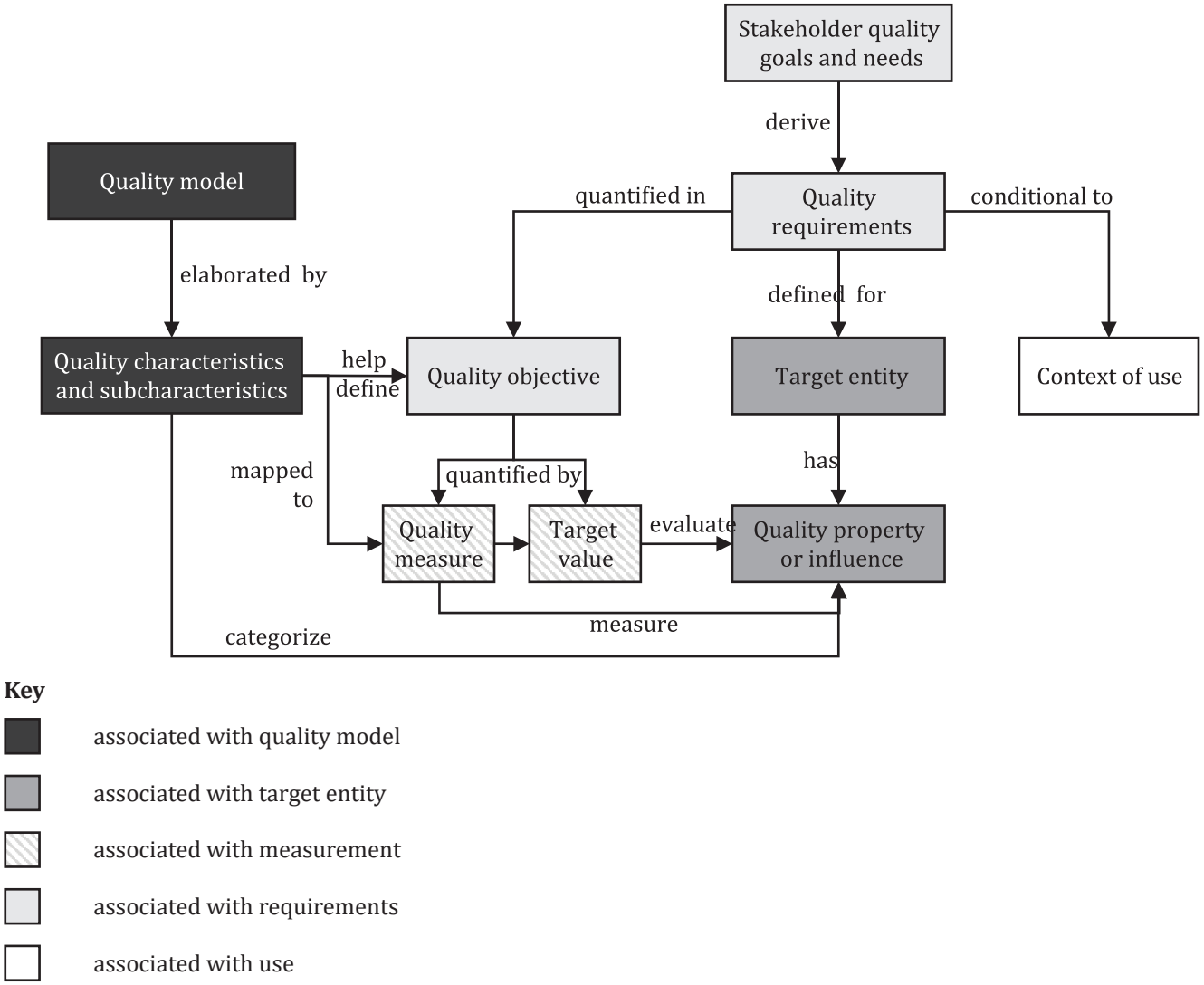

Figure 4 — Ontology of quality model concepts

7.4 Quality requirement priorities and conditions

Within this quality model ontology, variations in the context of use can prioritize different quality requirements for different systems or parts of a system. For example, certain quality requirements such as reliability and security can be prioritized for all online transactions. Quality requirements related to maintainability, flexibility, and compatibility can be prioritized for enterprise IT services. Still other quality requirements such as performance efficiency and interaction capability can be prioritized for user interfaces. Quality requirements can become conditional under different contexts of use. For example, response time can include conditional criteria to specify needs for different types of consumers with varying internet connection bandwidths or accessibility needs. An IT service level agreement can contain conditional quality requirements such as constraining recovery times for different subscription levels.

7.5 Applying and extending quality models

Information systems and their constituent ICT products may be structured in complex hierarchies as systems of systems. The quality of the overall system is dependent on the subsystems that constitute it. The boundary of an ICT product or information system where the quality model is applied depends upon the design and usage of the ICT product and the context of use applicable to the target information system. How a quality model is applied also depends on the target users and business stakeholders. Hence not every part of an information system can be considered a target entity of the product quality model because some

parts of the system can be considered as a target entity of the quality use in model, which is measured in the context of use. Similarly, some components of a larger system in which an ICT product is contained can be part of the context of use if they have a direct bearing on the quality of the target information system or ICT product.

EXAMPLE 1 If the users of an aircraft with a computer-based flight control system are defined to be the passengers, then the system on which they depend includes the flight crew, the airframe, and the hardware and software in the flight control system. However, if the uses are only defined to be the flight crew, then the system on which they depend consists only of the airframe and flight control system.

Quality guidelines that extend the use of quality models beyond a single target entity can expand the boundary of their application across part or all of an organization.

EXAMPLE 2 Guidelines can be developed for extending the use of quality models across all target entities in an entire product line. Similarly, a consumer organization can establish common quality guidelines as part of their enterprise architecture strategy or customer experience strategy for all ICT products that they acquire or build.

Quality models should be extended when there are advances in technologies and usage patterns that drive new quality requirements and goals.

EXAMPLE 3 For cognitive systems, self-learning capability and self-learning speed can be newer sub-characteristics that can be added to quality models as the use of quality models is extended into the knowledge systems domain.

The quality-in-use model (ISO/IEC 25019) can be modified or extended to include responsiveness to changes in the context or state of the ICT product or IT service being used.

EXAMPLE 4 When the environment where an ICT product is used changes from atmospheric environments to space environments, new quality sub-sub-characteristics can be developed for supporting weightless users, users undergoing rapidly increasing G-forces, users experiencing extended isolation, or other conditions unique to space flight.

8 Quality model usage

8.1 Stakeholders

Throughout an information system's lifecycle, different stakeholders have different quality goals related to their responsibilities and roles. For example, the functional suitability, interaction capability, and performance efficiency of a system can be critical to a direct user of the system. Many aspects like security and reliability are important for all stakeholders.

Quality models can be used for multiple purposes that can differ across various stakeholders (users, business functions, job types, etc.) associated with an information system. These stakeholders include but are not limited to the following categories related to system development:

— customers and business stakeholders - who specify their quality requirements and work with business analysts to translate these needs into system requirements;

— business analysts - who elicit develop system requirements, and in many cases should anticipate non-functional quality requirements based on stakeholder needs and contexts of use;

— vendor and acquisition managers - who manage external suppliers on behalf of their organization and ensure that the quality of delivered ICT products satisfies quality targets and contractual agreements;

— regulators - who establish rules, regulations, or standards that target entities are required to satisfy in a specific domain;

— users - who use target entities to satisfy their goals;

— society - when an information system affects the environment, finances, safety, or other significant outcome in the community affected by its operations;

— architects, developers, maintainers, and system integrators - who design, implement, maintain, measure, evaluate, and manage the quality of ICT products for internal or external customers, as well as the information systems or systems of systems that incorporate them;

— product managers - who ensure that quality requirements and expectations are addressed during development and maintenance to produce an ICT product that meets customer needs and goals;

— quality management professionals - who establish organizational standards for quality, test and evaluate ICT products for their achievement of quality objectives, and in some cases approve ICT products for release into production; they may also adapt and extend the quality models, quality measures, and checklists to best fit their context of use;

— independent evaluators - who evaluate the quality of information systems and ICT products independent of the development organization;

— ICT product operators - who oversee the operation of ICT products in production and respond to operational incidents.

8.2 Use of quality models within quality processes

8.2.1 Introduction to quality model usage examples

This clause describes five quality processes in which quality models can be applied. For each quality process, examples will be presented for how quality models for ICT products, data, IT services, and quality-in-use can be applied. The five processes in which the quality models can be applied to achieve stakeholders' quality goals include:

— quality requirements definition;

— quality engineering;

— quality evaluation;

— quality measurement;

— quality management.

Examples from the next five clauses demonstrate how SQuaRE quality models combine to form a wholistic approach to ensuring that quality meets or exceeds customer requirements and expectations.

8.2.2 Quality requirements definition

Stakeholder needs should be translated into quality requirements to achieve their quality goals. Business analysts, users, acquisition managers, and other stakeholders can be involved in this translation. Quality requirements division standards help specify quality requirements based on quality models and measures. Quality requirements can be defined qualitatively with quality models from quality model division standards and defined quantitatively with quality measures from quality measurement division standards. The more rigor with which these requirements can be defined quantitatively, the greater assurance stakeholders can have in the system's capability to meet their needs. Each of the quality models can be used to guide the definition of quality requirements for information systems that are built internally, purchased ready to use, or outsourced. For example:

— ICT product quality requirements can be documented as measurable attributes related to response times, protection from unauthorized use, allowable downtime, capability to scale with increasing use, or capability to interoperate with other systems.

— Data quality requirements can be documented for accuracy, accessibility, or traceability of data.

— IT service quality requirements can be documented for the continuity, professionalism, or adaptability of a service using an information system.

— Quality-in-use requirements can be documented for effectiveness of the system, the satisfaction of users, or the environmental consequences of system use.

8.2.3 Quality engineering

Architects, developers, and others involved in architecting, designing, coding, or integrating an ICT product should translate stakeholder quality requirements into verifiable quality properties of the system and its use. Stakeholder quality requirements are an important input to architectural, platform, framework, design, and coding decisions that ensure information systems and ICT products satisfy stakeholder quality requirements. However, those designing and constructing an ICT product should also ensure that its architectural and coding properties are engineered to provide the structural foundation needed to support the stakeholder's non-functional as well as functional quality requirements. Stakeholder requirements create priorities among quality characteristics and sub-characteristics that can guide design and coding decisions, evaluate architectural trade-offs, and identify components that should be added to the system to ensure stakeholder quality requirements are satisfied. For example:

— ICT products can be designed and coded to improve security by eliminating security weaknesses, improving maintainability through reduced coupling among components, or improving safety by implementing failsafe mechanisms in the system.

— Data can be structured to support efficient and secure processing, be automatically checked for completeness, or be presented in formats accessible to a broader range of stakeholders.

— IT services can be designed in cooperation with service providers to ensure the service is customizable to the client, can be recovered quickly after an interruption, and can be learned with minimal effort.

— ICT products and IT services can be constructed to enhance quality-in-use by designing for efficient operations, optimizing business outcomes, and providing satisfying user experiences.

8.2.4 Quality evaluation

Quality assurance professionals, acceptance testers, independent evaluators, acquisition managers, and other stakeholders can design test cases and conduct a suite of quality assurance procedures. Quality evaluation division standards provide requirements and recommendations for quality evaluation processes to ensure ICT products and IT services satisfy all the quality requirements of the system, both functional and non-functional. To ensure the full set of quality characteristics and sub-characteristics are verified and validated, quality evaluation processes can employ a combination of functional testing, static and dynamic analysis, penetration testing, user labs, proof of correctness, user acceptance tests, operational assessment, and other techniques selected to ensure the quality requirements of the system are satisfied. Each of the quality models can guide the assembly of test suites that fully exercise and evaluate the quality attributes of an information system. For example:

— the non-functional, structural attributes of ICT product quality can be evaluated through static analysis of the code, penetration testing, and load testing to determine if there are reliability flaws that could crash the system, security vulnerabilities that allow unauthorized access to data, or efficiency problems under heavy processing loads;

— data quality can be evaluated for data completeness, data consistency, and the credibility of the data source through automated and manual data checks and determining provenance of data sources;

— IT service quality can be evaluated for the timeliness of responses from the system, the usability of the service by customers, or the extent to which the system is able to react to different stakeholder needs through dynamic analysis and usability lab evaluations;

— quality-in-use of ICT products and IT services can be evaluated in follow-up questionnaires, interviews, or other assessment methods to assess user-perceived effectiveness, user satisfaction, and business consequences.

8.2.5 Quality measurement

Measurement and quality assurance staff can use quality measurement division quality measurement standards based on quality model division quality models for selecting quality measures to evaluate whether quality requirements and criteria have been satisfied. These quality measurement standards enumerate measures for each quality characteristic and sub-characteristic in quality models. Measurement and quality assurance staff can use quality measurement standards to guide the selection and definition of quality measures and measurement methods that are best suited to evaluate quality properties of target entities. For example:

— ISO/IEC 25023 enumerates measures for the quality characteristics and sub-characteristics in ISO/IEC 25010 related to quality properties of ICT products. This document defines primarily behavioural measures for such properties as system availability, modularity, and portability between platforms. ISO/IEC 25023 measures can be supplemented with structural products measures based on the Common Weakness Enumeration (cwe.mitre.org), MISRA (www.misra.org.uk), or ISO/IEC 5055 automated source code quality measures.

— ISO/IEC 25024 enumerates measures for the quality characteristics and sub-characteristics in ISO/IEC 25012 related to the quality properties of data. This document can guide definition of measures related to such quality properties as the completeness, consistency, and correctness of data.

— ISO/IEC TS 25025 enumerates measures for the quality characteristics and sub-characteristics in ISO/IEC TS 25011 related to the quality properties of IT services. This document can guide definition of measures related to such quality properties as reliability, tangibility, responsiveness and adaptability of IT services.

— ISO/IEC 25022 enumerates measures for the quality characteristics and sub-characteristics in ISO/IEC 25019 related to the quality-in-use properties of ICT products and IT services. This document can guide definition of quality-in-use measures collected from user surveys, clinical data regarding health consequences, business outcome data regarding effectiveness, and similar experiences with and outcomes of ICT products and IT services.

8.2.6 Quality management

Quality managers (roles that can involve other positions in the organization) can use quality models to manage the quality of information systems across various stages of development and operations. They can use quality characteristics and sub-characteristics to set objectives, make decisions, track quality growth, manage vendors, measure outcomes, assess technical risk, and support other management tasks. Each of the quality models can be used to select and weight quality characteristics and sub-characteristics from which quality targets can be established for accepting or improving information systems. For example:

— Quality information such as quality ratings, measures, and historical performance on ICT products can be used to select among alternative systems or suppliers, decide which systems should be modernized, allocate resources to systems, decide whether to retire a system, conduct due diligence on ICT products during an acquisition or merger, and perform other management functions and decisions.

— Quality information on data can be used to select data sources, decide when data should be cleaned, determine if existing data protections are sufficient to satisfy industry regulations, and make other decisions regarding data.

— Quality information on IT services can be used to provide additional training, redesign the service or its method of delivery, or improve availability or performance.

— Quality information on Quality-in-use can be used to anticipate customer complaints, evaluate the risk to which a system exposes the business, identify aspects of the product or service that need to be improved, or select among multiple vendor systems that perform the same function.

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