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Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Quality-in-use model

Ingénierie des systèmes et du logiciel — Exigences de qualité et évaluation des systèmes et du logiciel (SQuaRE) — Modèle de qualité de fonctionnement

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html. In the IEC, see www.iec.ch/understanding-standards.

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

This first edition of ISO/IEC 25019, together with the first edition of ISO/IEC 25002 and the second edition of ISO/IEC 25010, cancels and replaces ISO/IEC 25010:2011, which has been technically revised.

The main changes are as follows:

— stakeholders influenced by use of system or product are classified and explicated;

— aspects of interest for each stakeholder are integrated and shown as quality characteristics;

— context coverage which was shown as quality characteristics in the quality-in-use model of the previous version is removed.

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

As information system (ICT products, software, data) and IT services are widely used, the target of their effect and influence of using them can extend from their direct users to organizations and the society. To control the effect and influence as much as possible is a social responsibility of enterprises and public/society administrations.

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 th 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 purpose of the "quality-in-use" model is to represent the effects and influences that can be experienced by using information system and IT service system; that is, to define, measure, evaluate and improve the quality of systems and software products and IT services when using them. Quality-in-use can be influenced by many factors including the quality of software, data and IT services.

If context of use changes, effect and influence on a stakeholder also changes.

Such context of use changes are monitored through quality evaluations of quality-in-use characteristics/ sub-characteristics so that changes/gaps from initially specified context of use are identified and fed back to the next quality improvement cycle.

Full details of the changes to the quality-in-use model are in Annex A. 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 agreed quality characteristics and their measurement, the SQuaRE family of standards provides a framework for reliable development and delivery of information systems and IT services.

This document introduces the structure of SQuaRE quality models and provides requirements for developing them. ISO/IEC 25002 describes how SQuaRE quality models in the quality model division (2501n) can be used in conjunction with other SQuaRE standards to guide quality-related activities across the information system lifecycle regardless of the development methodology. 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. 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.

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.

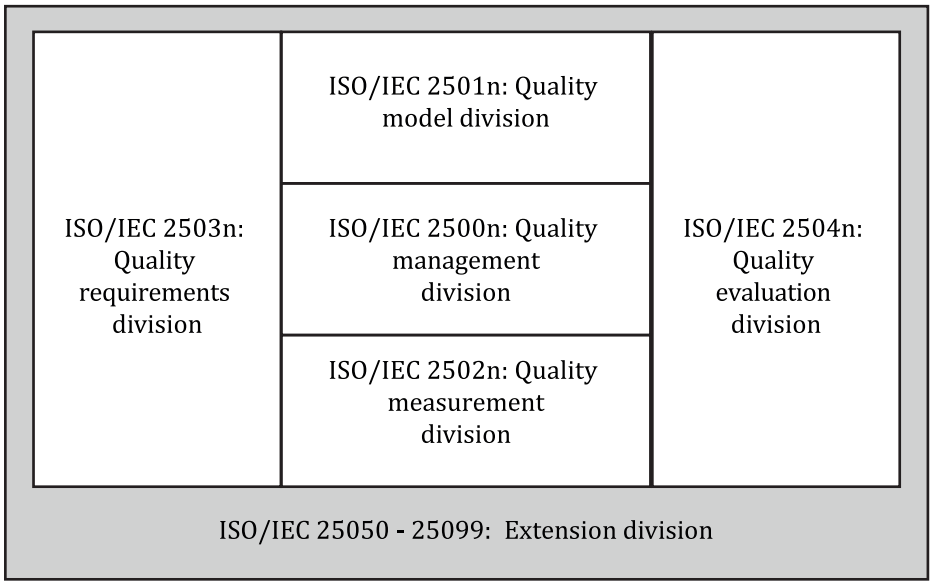


Figure 1 — Organization of SQuaRE family of International Standards

The divisions within the SQuaRE family are:

— ISO/IEC 2500n - 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. The 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 2501n - 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. This document belongs to the quality model division. This document is aligned with ISO/IEC 25002 on quality models overview and usage.

  — ISO/IEC 25010: Product quality model

  — ISO/IEC 25011: IT service quality models

  — ISO/IEC 25012: Data quality model

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

— ISO/IEC 2502n - 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 property of product, data, IT services and quality-in-use. Quality measure elements (QME) forming foundations for quality measures for internal and external property of product are defined and presented.

— ISO/IEC 2503n - 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 2504n - 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), commercial off-the-shelf software and 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 12207 and 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 system and software quality evaluation.

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

— a framework for quality requirements 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 and ISO/IEC/IEEE 90003 (which are concerned with quality assurance processes) to provide:

— support for setting quality goals (and certification where applicable);

— support for design review, verification, and validation.

Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Quality-in-use model

1 Scope

This document defines a quality-in-use model composed of three characteristics (which are further subdivided into sub-characteristics) that can influence stakeholders when products or systems are used in a specified context of use. This model is applicable to the entire spectrum of information system and IT service system, including both computer systems in use and software products in use.

This document provides a set of quality characteristics for specifying, measuring, evaluating and improving quality-in-use.

In this document, because context of use is specified as prerequisite of quality-in-use, context of use is necessary to be re-specified to change prerequisite when a product or service intend to fulfil to context of use changes.

The model can be applied, in particular, by those responsible for specifying and evaluating software product quality, such as developers, acquirers, quality assurance and control staff, and independent evaluators. Activities during product development that can benefit from the use of the quality model can include, but are not limited to:

— identifying requirements for information system and IT service system in use;

— validating the comprehensiveness of a quality-in-use requirements specification;

— identifying information system and IT service system design objectives for quality-in-use;

— identifying quality-in-use control criteria as part of overall quality assurance;

— identifying acceptance criteria for information system and IT service system or information systems;

— establishing measures to address the consequences of using products in specified context-of -use;

— presenting evaluation items for ethics considerations when using information system and IT service system;

— supporting governance of digitalization activities.

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 Quality-in-use

3.1.1
affect
change the attitude of a *user* (3.1.31) or other *stakeholder* (3.1.26) regarding a decision to acquire or use a *system* (3.1.29)

3.1.2
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.]

3.1.3
component
entity with discrete structure, such as an assembly or software module, within a *system* (3.1.29) considered at a particular level of analysis

3.1.4
context of use
combination of *users* (3.1.31), goals and tasks, resources, and environment

Note 1 to entry: The "environment" in a context of use includes the technical, physical, social, cultural and organizational environments.

[SOURCE: ISO 9241-11:2018, 3.1.15]

3.1.5
customer
organization (3.1.13) or person that receives a *product* (3.1.14) or service

Note 1 to entry: In interactive *system* (3.1.29), customers are sometimes the same as *operators* (3.1.12).

[SOURCE: ISO/IEC/IEEE 12207:2017, 3.1.16, modified — The original note 1 to entry and EXAMPLE has been removed; a new note to entry has been added.]

3.1.6
data quality
capability of the characteristics of data to satisfy stated and *implied needs* (3.3.3) 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".]

3.1.7
developer
individual or *organization* (3.1.13) that performs development activities [including *requirements* (3.1.21) analysis, design, testing through acceptance] during the *system* (3.1.29) or software life cycle process

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

3.1.8
direct user
person who directly interacts with the *product* (3.1.14)

Note 1 to entry: This definition of the term "direct user" is originally for the term "user" that is defined in ISO/IEC 9241-11:2018, 3.1.7. In this document, the term "direct user" is addressed to distinguish from "*indirect user*" (3.3.4).

3.1.9
information system
system (3.1.29) that comprises *ICT products* (3.3.2), ICT environment, and the people who use them or are impacted by them which become a combination of interacting elements organized to achieve one or more stated purposes

Note 1 to entry: While information systems can be part of larger systems that include other electro-mechanical products and their *users* (3.1.31), this document considers these *components* (3.1.3) as part of the *context of use* (3.1.4) of the system only if they have a direct relevant relationship to the ICT products and users who are part of the information system. However, many of the quality *attributes* (3.1.2) can be applied to these larger systems of systems as well.

Note 2 to entry: Information system in this document can be recognized as a system of interest with the other interacting systems comprising the operational environment. An individual system is the same as the system defined in ISO/IEC/IEEE 15288, i.e. “a combination of interacting elements organized to achieve one or more stated purposes”.

Note 3 to entry: An embedded software system is not an information system for the purpose of this document. information system in this usage is intended to describe a scope for quality concerns that include the *target entities* (3.1.30) effect on each other. The target entities included under the term information system include *ICT products* (3.3.2), IT services and their operational environment comprised of one or more systems.

3.1.10
measure, noun
variable to which a value is assigned as the result of *measurement* (3.1.11)

Note 1 to entry: The plural form “measures” is used to refer collectively to base measures, derived measures, and indicators.

[SOURCE: ISO/IEC/IEEE 15939:2017, 3.15]

3.1.11
measurement
set of operations having the object of determining a value of a *measure* (3.1.10)

Note 1 to entry: Measurement can include assigning a qualitative category such as the language of a source program (C, C++, Ruby, etc.).

[SOURCE: ISO/IEC/IEEE 15939:2017, 3.17, modified — The original note 1 to entry has been replaced by a new one.]

3.1.12
operator
individual or *organization* (3.1.13) that performs the operations of a *system* (3.1.29)

[SOURCE: ISO/IEC/IEEE 12207:2017, 3.1.29, modified — Notes 1 to 3 to entry have been removed.]

3.1.13
organization
group of people and facilities with an arrangement of responsibilities, authorities and relationships

EXAMPLE company, corporation, firm, enterprise, institution, charity, sole trader, association, or parts or combination thereof, whether incorporated or not, public or private.

[SOURCE: ISO/IEC/IEEE 12207:2017, 3.1.30, modified — "whether incorporated or not, public or private" has been added in the EXAMPLE; note 1 to entry has been removed.]

3.1.14
product
artefact that is produced, is quantifiable, and is deliverable to *user* (3.1.31) as either an end item in itself or a *component* (3.1.3) item

Note 1 to entry: In this document, product refers to an *ICT product* (3.3.2) that is part of an *information system* (3.1.9). 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.]

3.1.15
quality-in-use
extent to which the *system* (3.1.29) or *product* (3.1.14), when it is used in a specified *context of use* (3.1.4), satisfies or exceeds *stakeholders'* (3.1.26) needs 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* (3.1.22).

Note 2 to entry: The quality-in-use model can be used as a guide to represent the *user's* (3.1.31) expectations about the system's behaviour.

Note 3 to entry: Users of the quality-in-use includes direct and *indirect users* (3.3.4). When applied to *direct users* (3.1.8), quality-in-use appears as "effect", and to other stakeholders it appears as "influence".

3.1.16
quality measure
derived *measure* (3.1.10) that is defined as a *measurement* (3.1.11) function of two or more values of *quality measure elements* (3.1.17)

[SOURCE: ISO/IEC 25020:2019, 3.13, modified — The abbreviated term "QME" has been removed.]

3.1.17
quality measure element
measure (3.1.10) defined in terms of a property and the *measurement* (3.1.11) method for quantifying it, including optionally the transformation by a mathematical function

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

3.1.18
quality property
property of a target entity that is related to a *quality measure element* (3.1.17), and which can be quantified by a *measurement* (3.1.11) method

3.1.19
quality requirement
requirement (3.1.21) for *quality properties* (3.1.18) or *attributes* (3.1.2) of an *information system* (3.1.9) and IT service system that satisfy needs which ensue from the purpose for which that information system and IT service system is to be used

[SOURCE: ISO/IEC 25030:2019, 3.15, modified — "ICT product, data or service" has been replaced by "information system and IT service system" twice.]

3.1.20
quality sub-characteristics
set of one or more *quality properties* (3.1.18) that represent a unique aspect of a *quality characteristic* (3.3.12)

3.1.21
requirement
statement which translates or expresses a need and its associated constraints and conditions

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

3.1.22
risk
effect of uncertainty on objectives

Note 1 to entry: An effect is a deviation from the expected — positive and/or negative. In this document the focus is on negative deviations leading to adverse consequences.

Note 2 to entry: Risk is often characterized by reference to potential events and consequences, or a combination of these.

Note 3 to entry: Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated likelihood of occurrence. In this document risk is characterized as the combination of the severity of the adverse consequence and the likelihood of an adverse consequence occurring.

Note 4 to entry: Objectives can have different aspects, such as financial, health and safety, and environmental goals and can apply at different levels, such as strategic, organization-wide, project, *product* (3.1.14), and process.

Note 5 to entry: Uncertainty is the state, even partially, of deficiency of information related to, understanding or knowledge of, an event, its consequence, or likelihood.

[SOURCE: ISO/IEC/IEEE 15026-1:2019, 3.4.2]

3.1.23
society
people in general, living together in communities or in geo-political defined areas

Note 1 to entry: Society means civil society used in Sustainable Development Goals (SDGs) and geo-political society, i.e. society at large.

3.1.24
software product
set of computer programs, procedures, and possibly associated documentation and data

Note 1 to entry: *Products* (3.1.14) include intermediate products, and products intended for *users* (3.1.31) such as *developers* (3.1.7) and *maintainers* (3.3.6).

Note 2 to entry: In SQuaRE standards, *software quality* (3.1.25) has the same meaning as software *product quality* (3.3.9).

[SOURCE: ISO/IEC 25000:2014, 4.31]

3.1.25
software quality
capability of *software product* (3.1.24) to satisfy stated and *implied needs* (3.3.3) when used under specified conditions

Note 1 to entry: This definition differs from the definition of quality in ISO 9000:2015 in that it refers to the satisfaction of stated and implied needs, while the ISO 9000:2015, 3.6.2, quality definition refers to the fulfilment of *requirements* (3.1.21); i.e. quality is defined as extent to which a set of inherent characteristics of an object fulfils requirements.

[SOURCE: ISO/IEC 25000:2014, 4.33; modified — Note 1 to entry has been rephrased.]

3.1.26
stakeholder
individual or *organization* (3.1.13) having a right, share, claim, or interest in a *system* (3.1.29) or in its possession of characteristics that meet their needs and expectations

EXAMPLE End *users* (3.1.31), end user organizations, supporters, *developers* (3.1.7), *customers* (3.1.5), producers, trainers, *maintainers* (3.3.6), disposers, acquirers, suppliers, regulatory bodies, and people influenced positively or negatively by a 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]

3.1.27
stakeholder need
prerequisite identified as necessary for a *stakeholder* (3.1.26), or a set of stakeholders, to achieve an intended outcome, implied or stated within a specific *context of use* (3.1.4)

3.1.28
sub-sub-characteristic
subdivision of a *quality sub-characteristic* (3.1.20) established by the *user* (3.1.31) of a *quality model* (3.3.10) to provide more granular representation of the quality *attributes* (3.1.2) of a *target entity* (3.1.30)

3.1.29
system
combination of interacting elements organized to achieve one or more stated purposes

Note 1 to entry: A system is sometimes considered as a *product* (3.1.14) 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 associated 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.

3.1.30
target entity
fundamental thing of relevance to the *user* (3.1.31), about which information is kept, and which needs to be *measured* (3.3.7)

Note 1 to entry: Target entities include *ICT products* (3.3.2) and their *components* (3.1.3) for ISO/IEC 25010, IT services for ISO/IEC IS 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.]

3.1.31
user
individual or group that interacts with a *system* (3.1.29) or benefits from a system during its utilization

Note 1 to entry: *Primary users* (3.3.8) and *secondary users* (3.3.11) interact with a system, and primary, secondary, and *indirect users* (3.3.4) can benefit from a system.

[SOURCE: ISO/IEC/IEEE 12207:2017, 3.1.70, modified — The original note to entry has been replaced by a new one.]

3.2 Quality-in-use characteristics and sub-characteristics

3.2.1
beneficialness
extent of benefit resulting from the use of a *product* (3.1.14), *system* (3.1.29) or service

3.2.1.1
usability
extent to which a *system* (3.1.29), *product* (3.1.14) or service can be used by specified *users* (3.1.31) to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified *context of use* (3.1.4)

[SOURCE: ISO 9241-11:2018, 3.1.1, modified — Notes to entry have been removed.]

3.2.1.2
accessibility
extent to which *products* (3.1.14), *systems* (3.1.29), services, environments and facilities can be used by people from a population with the widest range of *user* (3.1.31) needs, characteristics and capabilities to achieve identified goals in identified *contexts of use* (3.1.4)

Note 1 to entry: Context of use includes direct use or use supported by assistive technologies.

[SOURCE: ISO 9241-112: 2017, 3.15]

3.2.1.3
suitability
extent to which behaviours or outcomes, or both, of a *product* (3.1.14) meet (satisfy) specified *quality requirements* (3.1.19) when used

Note 1 to entry: When a product or *system* (3.1.29) is especially recognized as an *information system* (3.1.9) and an IT service, suitability, which is a kind of sub-characteristic in *quality-in-use* (3.1.15), is important because it *affects* (3.1.1) the gain or loss of opportunities for a more diverse and broader group of *stakeholders* (3.1.26) to obtain valuable benefits of use.

3.2.2
freedom from risk
extent to which a *product* (3.1.14) or *system* (3.1.29) mitigates the potential *risk* (3.1.22) to economic status, human life, health, *society* (3.1.23), financial values, enterprise activities, or the environment

Note 1 to entry: Risk includes economic risk, health risk, human life risk and environmental and societal risk.

3.2.2.1
freedom from economic risk
extent to which a *product* (3.1.14) or *system* (3.1.29) mitigates the potential *risk* (3.1.22) to financial status, efficient operation, commercial property, reputation, or other aspects in the intended *contexts of use* (3.1.4)

Note 1 to entry: When a product or system is especially recognized as an *information system* (3.1.9) and IT service, there is concern that the economic risk has more impact to the economics in a more diverse and broader group of *stakeholders* (3.1.26) so that the risk monitoring used is often considered to be more focused in addition to risk mitigation.

3.2.2.2
freedom from environmental and societal risk
extent to which a *product* (3.1.14) or *system* (3.1.29) mitigates the potential *risk* (3.1.22) to the environment and *society* (3.1.23) at large in the intended *contexts of use* (3.1.4)

Note 1 to entry: When a product or system is especially recognized as an *information system* (3.1.9) and IT service, there is concern the environmental and societal risk impacts on public properties in societies, and on environments including societal or natural ecology systems in a diverse and broad group of *stakeholders* (3.1.26) so that the risk monitoring used is often considered to be more focused in addition to risk mitigation.

3.2.2.3
freedom from health risk
extent to which a *product* (3.1.14) or *system* (3.1.29) mitigates the potential *risk* (3.1.22) to people's health in the intended *contexts of use* (3.1.4)

3.2.2.4
freedom from human life risk
extent to which a *product* (3.1.14) or *system* (3.1.29) mitigates the potential *risk* (3.1.22) to people's lives in the intended *contexts of use* (3.1.4)

3.2.3
acceptability
extent to which a human response is favourable when accepting or installing a *product* (3.1.14), *system* (3.1.29) or service software tool designed to perform some frequently used function

3.2.3.1
experience
extent to which *users* (3.1.31) or *stakeholders* (3.1.26) accumulate knowledge or skill acquired over time, especially that gained in a particular profession

EXAMPLE Data analyses or replaying, simulating, or detecting similar/different patterns based on recorded weather data can help weather monitoring users to improve their knowledges or skills for a weather forecasting.

3.2.3.2
trustworthiness
extent to which *users* (3.1.31) or *stakeholders* (3.1.26) have confidence that their expectations are met in a verifiable way

Note 1 to entry: Aspects to ensure trustworthiness can include, for example, reliability, availability, resilience, security, privacy, safety, accountability, transparency, integrity, authenticity, quality, and usability.

Note 2 to entry: Trustworthiness is an *attribute* (3.1.2) that can be applied to services, *products* (3.1.14), technology, data and information as well as, in the context of governance, to *organizations* (3.1.13).

EXAMPLE When purchasing a product from a seller through an online shopping *system* (3.1.29), information such as product specifications, previous transaction history, comments or rating by the purchasers, description of return and refund procedures, and ratings or warnings by the online store operation service site, as well as product photos, are used to determine the extent to which the product and seller will meet potential *customer* (3.1.5) expectations for the purchase.

[SOURCE: ISO/IEC TR 24028:2020, 3.42, modified — "ability to meet stakeholders' expectations" has been changed to "extent to which users or stakeholders have confidence that their expectations are met"; the original notes 1 and 2 to entry has been removed; the original note 3 to entry has become note 2 to entry; 2 new notes to entry have been added.]

3.2.3.3
compliance
extent to which a *user* (3.1.31) or other *stakeholder* (3.1.26) has confidence that a *product* (3.1.14), *system* (3.1.29), software, or service in use meets requirements, as required by rules or laws

3.3 Related SQuaRE concepts

3.3.1
evaluator
individual or *organization* (3.1.13) that performs an evaluation

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

3.3.2
ICT product
product (3.1.14) which uses information and communication technologies (ICTs) and can be a part of *information system* (3.1.9)

Note 1 to entry: ICT product can constitute other ICT products (sub-products) and sometimes a *component* (3.1.3) of an ICT product can also be considered as ICT products by themselves. Examples of ICT products includes computer hardware, *software products* (3.1.24), software components, 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* (3.1.13) 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 firmware, sensors, and communicators, but not the *users* (3.1.31).

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.]

3.3.3
implied needs
needs that may not have been stated but are actual needs

Note 1 to entry: Some implied needs only become evident when the *software product* (3.1.24) is used in particular conditions (context of use).

EXAMPLE Implied needs include needs not stated but implied by other stated needs, and needs not stated because they are considered to be evident or obvious.

[SOURCE: ISO/IEC 25000:2014, 4.12]

3.3.4
indirect user
person who receives output from a *system* (3.1.29), but does not interact with the system

EXAMPLE Business managers, acquirers, product managers

[SOURCE: ISO/IEC 25030:2019, 3.9, modified — EXAMPLE has been replaced.]

3.3.5
IT service quality
capability of an IT service 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* (3.3.3), while the ISO 9000 quality definition refers to the satisfaction of *requirements* (3.1.21).

[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"; note 1 to entry has been added.]

3.3.6
maintainer
individual or organization that performs maintenance activities

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

3.3.7
measure, verb
make a *measurement* (3.1.11)

[SOURCE: ISO/IEC 25000:2014, 4.18, modified — Note 1 to entry has been removed.]

3.3.8
primary user
person or entity who interacts with the *system* (3.1.29) to achieve the primary goals

[SOURCE: ISO/IEC 25030:2019, 3.11, modified — "user" has been changed to "person or thing"; note 1 to entry has been removed.]

3.3.9
product quality
capability of an *ICT product* (3.3.2) or its *components* (3.1.3) to satisfy stated and implied quality needs when used under specific conditions

Note 1 to entry: This definition differs from the ISO 9000:2015 quality definition mainly because the *software quality* (3.1.25) definition refers to the satisfaction of stated and *implied needs* (3.3.3), while the ISO 9000 quality definition refers to the satisfaction of *requirements* (3.1.21).

Note 2 to entry: Typically, *users* (3.1.31) do not consider *systems* (3.1.29) that only satisfy requirements as high-quality systems. Quality is related to satisfying and even surpassing expectations with associated constraints and conditions.

3.3.10
quality model
defined set of characteristics, and the relationships between them, which provides a framework for specifying *quality requirements* (3.1.19) and evaluating quality

3.3.11
secondary user
user (3.1.31) who interacts with the *product* (3.1.14) to support the *primary users* (3.3.8)

EXAMPLE:

a) content provider, *system* (3.1.29) manager, administrator, security manager;

b) *maintainer* (3.3.6), analyser, porter, installer.

[SOURCE: ISO/IEC 25030:2019, 3.17, modified — More examples have been added.]

3.3.12
quality characteristic
category of *quality* (3.1.25) *attributes* (3.1.2) that bears on the quality of the *ICT product* (3.3.2) or information system

Note 1 to entry: Quality characteristics can be further divided into *quality sub-characteristics* (3.1.20). While characteristics typically represent one aspect of quality that is of interest to stakeholders, quality sub-characteristics can help subdivide quality characteristics into individual aspects that help in mapping them to *quality properties* (3.1.18).

3.3.13
validation
confirmation, through the provision of objective evidence, that the *requirements* (3.1.21) 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.

3.3.14
verification
confirmation, through the provision of objective evidence, that specified *requirements* (3.1.21) 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.

4 Quality-in-use model

4.1 General

The target of quality-in-use is not limited to direct interaction. It also includes any stakeholders and societal elements that are influenced indirectly by the use of systems, software products and/or IT services.

There are three main quality characteristics in the quality-in-use model: beneficialness, freedom from risk, and acceptability. These three quality characteristics are chosen to represent all stakeholder needs.

As system and software products are widely used, they can affect and influence not only direct users but also organizations and elements of society at large. Quality-in-use can be considered a result that is affected and influenced not only by the quality of the system's software products, but also by the management principles and practices adopted by the stakeholders who govern them.

Manufacturers have a responsibility to society at large to provide means to allow for controlling, as much as possible, the effects and influences of using the system’s software products.

Therefore, quality-in-use can be regarded as the effect and influence on stakeholders resulting from the use of systems software products and/or IT services. The purpose of the quality-in-use model is to help improve quality-in-use by measuring and evaluating its influence.

4.2 Stakeholder

The targets that are influenced by using systems and software are not only their direct users but can also include various kinds of stakeholders. The influences (quality characteristics) are differentiated by the difference of the targets. Accordingly, this document classifies these targets into the following four groups; and the aspects of interest for the quality-in-use model for each group is defined.

— Operator of system and/or software (primary user and secondary user which are affected by system and software)

— Organization which is responsible for the system and/or software management (secondary user which is affected by system/software and indirect user which is influenced by system/software)

— Customer using system and/or software (primary user, secondary user, and indirect user)

— Public and societal elements influenced by the existence and use of the system and/or software (non-user)

4.3 Quality-in-use in context

When developing a system or product, context of use is closely analysed because understanding how a target system or product is used by various stakeholders is very important information in deciding user system interactions and the user interface specification.

Therefore, systems or products are developed based on an assumed or specified context of use, which is a prerequisite. As systems or products are used under the context of use, quality-in-use is also measured and evaluated accordingly.

When evaluating quality-in-use, it is necessary to identify deviations or changes from the initially assumed and specified context of use during actual use, and to distinguish between cases in which the user's intended goal is not fully satisfied even if it is a specified context, and cases in which it is not satisfied because it is not a specified context.

Without a timely cycle that monitors, evaluates, and identifies actual deviations or changes in the context of use, and reflects the results in the improvement of the product, the risk of frequently failing to achieve the user's goals during use will increase. This can cause risks (e.g. economic, trustworthiness) to users themselves, including operators and societal public stakeholders.

When improving the product, improvement to quality (sub-)characteristics such as inclusivity, adaptability or other quality characteristics can be achieved through the application of an iterative development process, a maintenance process in a timely manner (e.g. perfective or preventive maintenance), or concurrent development and operation processes (e.g. DevOps) to the initially specified context of use and/or to the re-specified extended context to cover the deviated or changed context of use.

4.4 Quality-in-use model structure

Quality-in-use is the extent that the IT system or ICT product satisfies the stakeholder needs when in operation under the specified context of use.

Stakeholder needs are classified as “beneficialness”, “freedom from risk” and “acceptability”, when their needs correspond to quality characteristics. The quality-in-use model is shown in Figure 2.

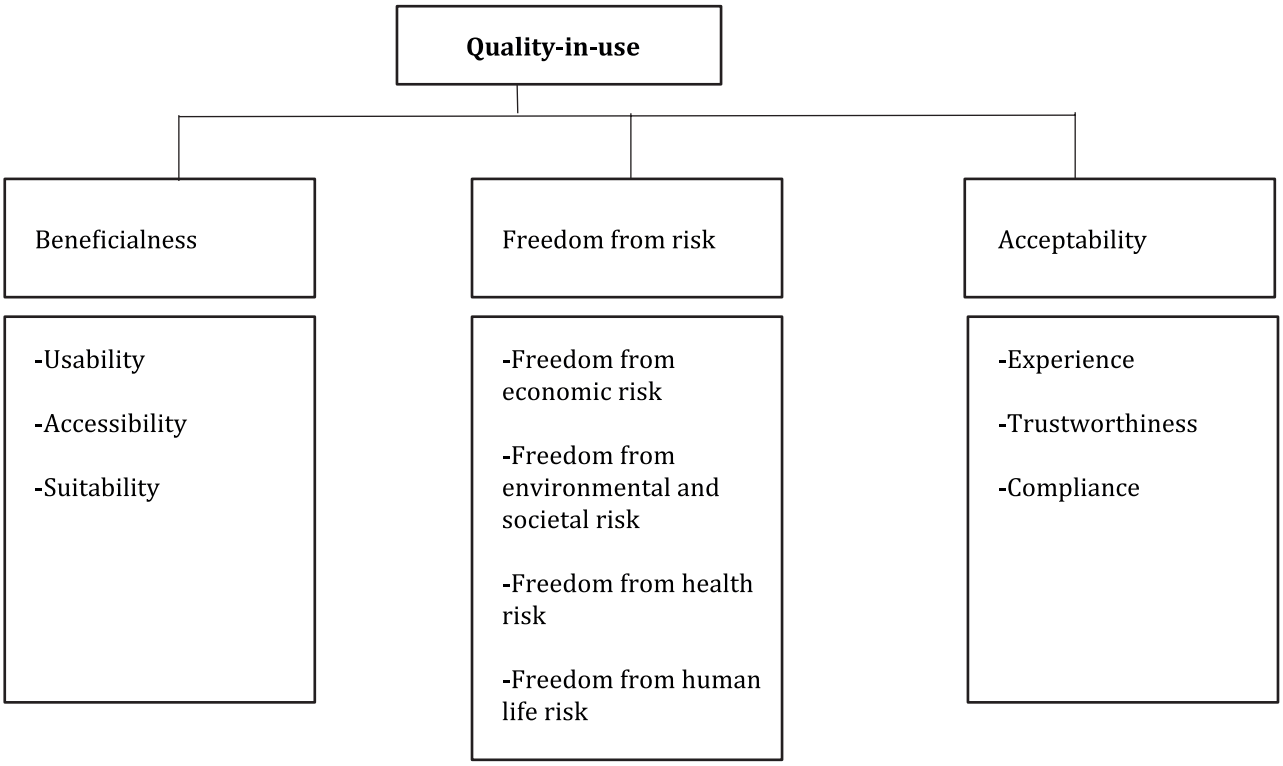


Figure 2 — The quality-in-use model

In Figure 2, "beneficialness", "freedom from risk" and "acceptability" are the quality-in-use characteristics. The boxes below each quality-in-use characteristic show the corresponding sub-characteristics.

According to 4.2, stakeholders are divided into four groups: "operators", "customers", "responsible organizations" and "society". The relationship between characteristics, sub-characteristics, stakeholders, and their aspects of interest is shown in Annex B; examples of quality characteristics and sub-characteristics are shown in Annex C.

4.5 Target of the quality-in-use model

Figure 3 illustrates the quality models and their target entities.

The quality-in-use model focuses on information system and IT service system that includes ICT product and IT service under specified context of use.

The target information system and IT service system also include hardware and communication facilities, as well as data which are the subject of the data quality model.

The information system is within a wider human-computer system (such as an enterprise system, embedded system, or large-scale control system) and can include users and the technical and physical usage environment.

The evaluation scope can be determined by the user requirements or needs. Although the quality of the system results from the aggregated quality of each component, the users generally perceive the quality of the system as a whole instead of the individual components the system comprises.

EXAMPLE If the users of an aircraft with a computer-based flight control system are considered to be the passengers, then the system upon which they depend includes the flight crew, the airframe and propulsion systems, and the hardware and software in the flight control system; whereas if the flight crew are considered to be the users, then the system upon which they depend consists only of the airframe and propulsion systems, and the flight control system.

Other stakeholders, such as software developers, system integrators, acquirers, owners, maintainers, contractors, quality assurance and control professionals, are also concerned with the quality.

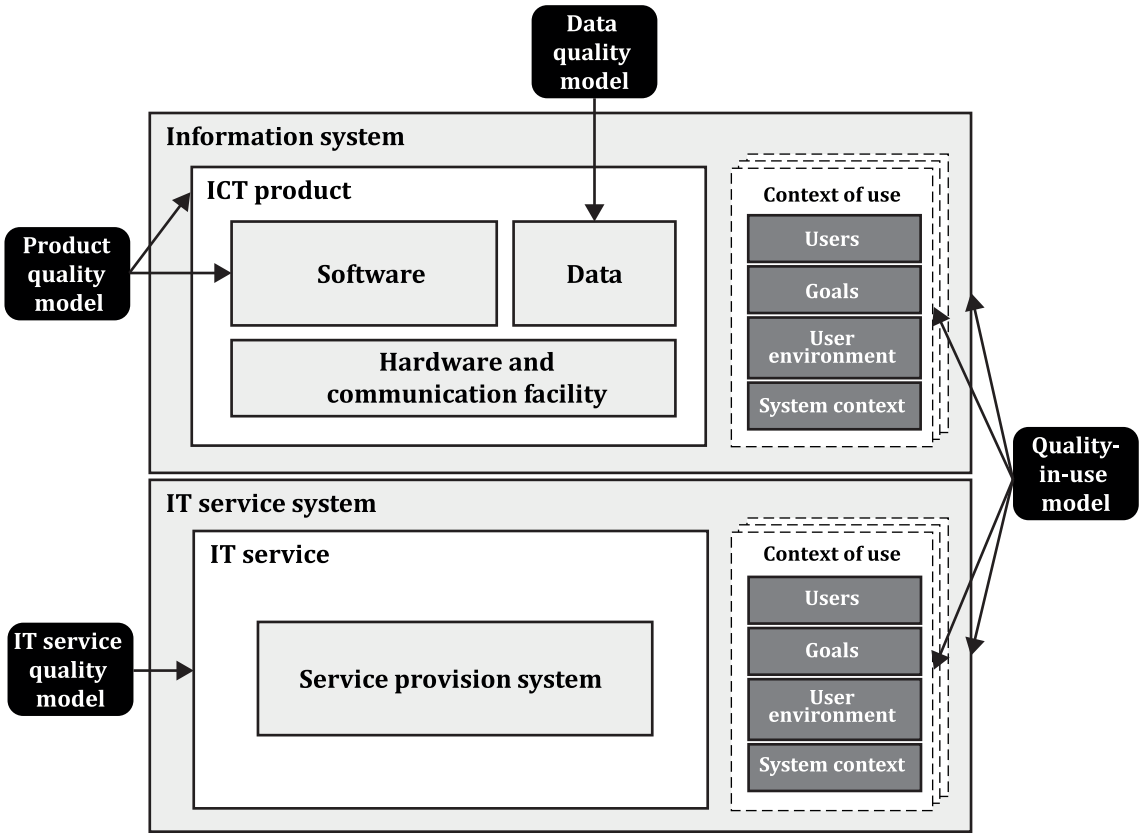
Figure 3 depicts how different quality models apply to different components of an information system or IT service system. The quality models together serve as a framework to ensure that all relevant aspects of quality are considered in specifying requirements, developing, or evaluating information systems, 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 or entities 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.



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

Figure 3 — Quality models and their target entities

NOTE 1 When an IT service does not contain an ICT product and its components, the IT service is evaluated separately from them.

NOTE 2 The product quality model is indirectly applied to hardware and communication facilities when they are a component of an ICT product.

NOTE 3 Service provision system is an information system to provide IT service to users, including people, processes, technology, facilities and information.

4.6 Using the quality-in-use model

The purpose of the "quality-in-use" model is to characterize the effects and influences that can be experienced by using information system and IT service system; that is, to define, measure, evaluate and improve the quality of systems and software products and IT services when using them. Characteristics and sub-characteristics of quality-in-use models cannot be represented as specifications because they are affected and influenced by the result of use by humans or other entities.

Annex D shows examples of applying the quality-in-use model for certain kinds of systems.

This SQuaRE family of International Standards includes some standards about design and evaluation. ISO/IEC 25030 and ISO/IEC 25040 can be referred to for design and evaluation of quality-in-use at the system level; ISO/IEC 25022 can be referred to for detail and measurement of quality characteristics; and ISO/IEC 25062, ISO/IEC 25063, ISO/IEC 25064, ISO 25065 and ISO/IEC 25066 can be referred to for common industry format for usability-related information.

Annex A
(informative)

Comparison with the quality-in-use model in ISO/IEC 25010:2011

Figure A.1 shows the quality-in-use model defined in ISO/IEC 25010:2011.

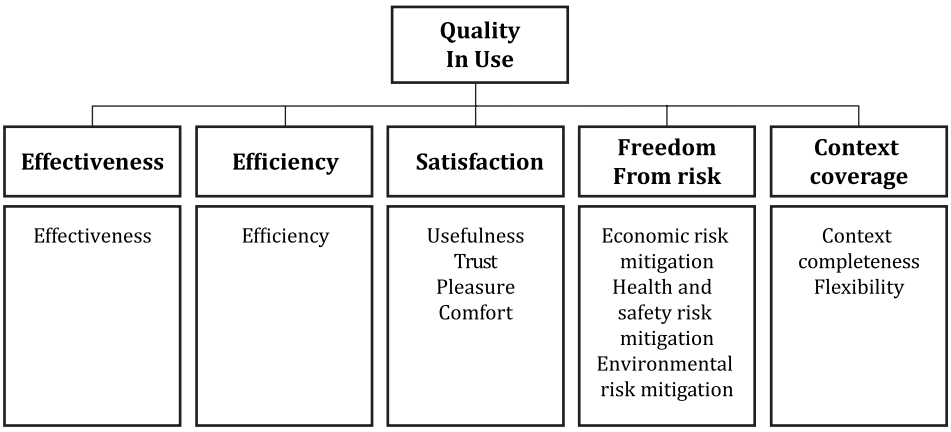


Figure A.1 — Quality-in-use model in ISO/IEC 25010:2011

After this model was defined, as system and software products are widely used, their effect and influence can extend from their direct users to organizations and society at large.

On the other hand, Figure A.2 shows the usability concept and definition described in ISO 9241-11:2018. Figure A.2 shows that usability which consists of "effectiveness", "efficiency" and "satisfaction" is the outcome by "use" of the product, system and service under the identified context of use. As "effectiveness", "efficiency" and "satisfaction" are parts of quality characteristics in the quality-in-use model defined in ISO/IEC 25010: 2011, this model is mainly focused on "use", that is, direct users.

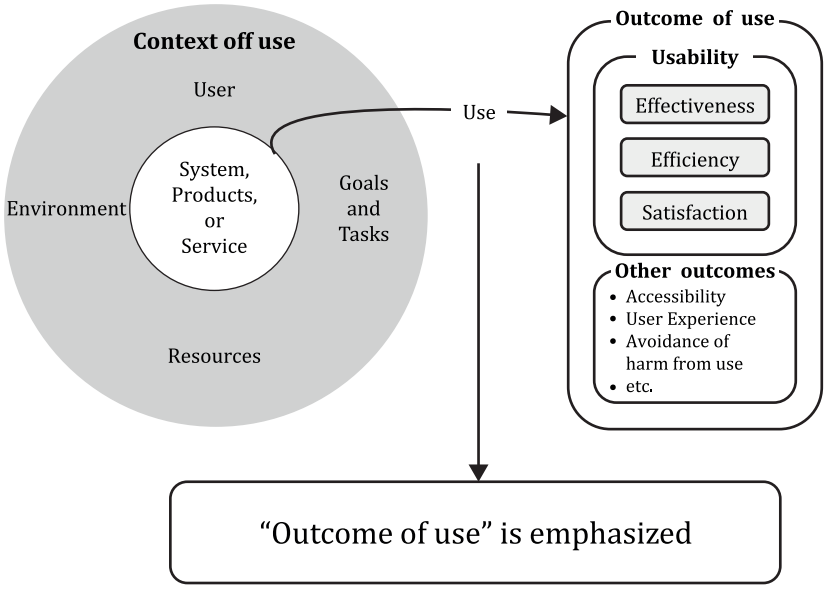


Figure A.2 — the usability that results from use of a system, product, or service in a context of use in ISO 9241-11:2018

To expand the target of quality-in-use to not only direct users but also indirect users and other stakeholders, the quality-in-use model has been revised. Figure 2 shows the revised quality-in-use model in this document.

The major changes are the range of quality characteristics and sub-characteristics. Concretely, the following changes have been made.:

a) As a kind of quality characteristic, “beneficialness” which includes “usability” as a sub-characteristics is defined.

b) Though “freedom from risk” remains as a quality characteristic, the range of sub-characteristics are wider.

c) As a kind of quality characteristic, “acceptability” is defined. These characteristics and sub-characteristics did not appear in the previous model. However, they are very important characteristics to explain the influence on not only direct users but also organizations and society at large (see Annex B).

d) The range of context of use is based on the prerequisite of context coverage. So, in this document, context coverage is not a quality characteristic.

In Figure A.1 and Figure A.2, the term “effectiveness”, “efficiency” and “satisfaction” appear. They are still usable as elements of usability which is one of the quality sub-sub-characteristics in this document.

These can be described as follows, similar to ISO/IEC 25010:2011.

— Effectiveness: accuracy and completeness with which identified goals are achieved.

— Efficiency: resources used in relation to the results achieved.

  Typical resources include time, human effort, costs, and materials, e.g., information system and IT service system satisfaction.

— Satisfaction: extent to which a user or other stakeholder perceives the results of use of a system, product, or service to meet their needs and expectations.

For a user who directly interacts with the product or system, effortless (i.e. physically comfortable without fatigue) and enjoyability (i.e. psychologically comfortable with positive feelings or motivations) and usefulness (i.e. useful to achieve its own purpose) are relevant to satisfaction. For a user who does not directly interact with the product or system, only usefulness is relevant.

These are referring to and modified from ISO 9241-11:2018.

In ISO/IEC 25010:2011, “context coverage” is defined as follows:

“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”.

This quality characteristic has two sub-characteristics. Their titles and definitions are as follows:

— 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 requirement.

From these definitions, context coverage is defined as whether or not the target information system and IT service system can be used under the assumed context of use.

Firstly, as these definitions focus on the previous quality-in-use description, the range of targets is narrow.

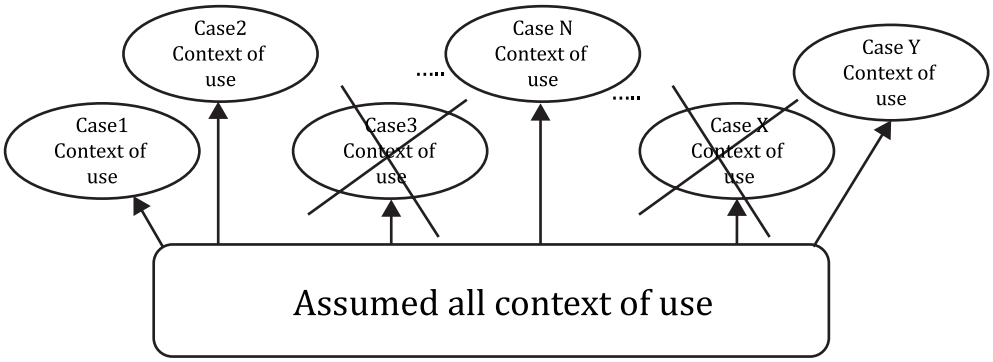


Figure A.3 — Concept of context coverage

Secondly, Figure A.3 illustrates the concept of context coverage; that is, the relationship between assumed all possible contexts of use (*N*) and each context of use which can actually be used. In Figure A.3, case 3 and case X are contexts which actually cannot be used. So, the degree of context coverage is (*N*-2)/*N*. However, as the proposed quality-in-use model focuses on the effect and influence of usage, contexts which cannot be used are not included in the target. This means that assumed contexts are a prerequisite. If the context changes and the target information system and IT service system cannot be used, quality-in-use cannot be measured because "use" is a prerequisite in quality-in-use. When considering "use", a context of use is predefined. So, when context changes, the context is a predefined context of use.

However, responding to the change of context is important. This issue can be resolved by iterative quality improvements to "user assistance" of "interaction capability" and/or "adaptability" of "flexibility" defined in the product quality model in the ISO/IEC 25010 revision. The product then has better "maintainability". Whether information system and IT service system can be used under assumed context or not is dependent on their specification. So, context coverage can be one of sub-characteristics in product quality.

Annex B
(informative)

The relationship between quality characteristics, quality sub-characteristics, and their stakeholder's needs

Table B.1 shows the relationship among quality characteristics, quality sub-characteristics, and their stakeholder's needs.

Table B.1 illustrates the example of clustering and naming each stakeholder's needs for reference because each stakeholder's needs can be clustered into four groups, and hard to define uniquely for every group. From the description of stakeholders' needs in each group, their quality-in-use characteristics, sub-characteristics, and measures are defined as requirements.

Aspects of interest represent various concerns of stakeholders who are involved in the products-in-use; and they are sources of stakeholder's needs. They are described and named differently or similarly depending on various types of stakeholders. It is difficult to define such aspects of interests consistently across these different stakeholders. However, it can be considered to describe most of aspects of interests by using quality-in-use sub-characteristics or their combinations that are defined in this document. Similarly, it can be considered to adapt measures for quality-in-use sub-characteristics and to describe quantitatively aspects of interests.

Table B.1 — An example of the relationship between quality characteristics, quality sub-characteristics, stakeholders, and their aspects of interest

Scope of needs to be satisfied		Aspects of interests (as sources of needs) for each stakeholder's type			
Characteristics	**Sub-characteristics**	**Responsible organization**	**Operator**	**Customer**	**Public and society**
beneficialness	— usability — accessibility — suitability	— cost and benefit — man-hour for management — man-hour for operation — stock price — advantage	— effectiveness — efficiency — Satisfaction	— effectiveness — efficiency — Satisfaction	— tax revenue — stock price Index — employ people
freedom from risk	— freedom from economic risk — freedom from health risk — freedom from environmental and societal risk — freedom from human life risk	— reliability — accountability — safety — privacy — security — availability — confidentiality — maintainability	— safety — privacy — self-authority — reliability	— safety — privacy — self-authority — reliability	— atmospheric temperature — amount of COx exhaust — noise — water quality — the number of accidents or matters — damage cost — crime

Table B.1 *(continued)*

Scope of needs to be satisfied		Aspects of interests (as sources of needs) for each stakeholder's type			
Characteristics	**Sub-characteristics**	**Responsible organization**	**Operator**	**Customer**	**Public and society**
acceptability	— experience — trustworthiness — compliance	— trust — transparency — brand image — corporate identification — loyalty — traceability — service support — no previous conviction — ethics	— trust — transparency — ethics — good tools — good manuals — good training	— trust — transparency — ethics	— trust — transparency — ethics — fair trade — consideration to nature

Annex C
(informative)

Example of quality-in-use characteristics and their effect and influence

Table C.1 shows examples of different stakeholder needs and quality-in-use characteristics. These examples describe a case of goods delivery by using a drone. In this example, activities of each stakeholder, each stakeholder's needs, and their details are shown.

Table C.1 — Examples of different stakeholder needs and quality-in-use characteristics

Quality-in-use characteristics corresponding to stakeholder needs	**Beneficialness**	**Freedom from risk**	**Acceptability**
Operators **EXAMPLE:** When a delivery service operator sets up to use multiple drones to deliver commodities by air to customers, the operator intends to complete a successful delivery service.	**Usability (effectiveness and efficiency of usability)** — Easy to pick up a designated commodity correctly, to input and check delivery address, set flight route, and load it on the drone to be ready to fly and be sent to its customer. — Easy to set flight delivery route within a short time with the drone able to automatically adjust its flight route in real time. — Free from operational mistakes when inputting and checking the destination address and command as to when and where to depart from. — Easy to check the current location and status (e.g. flying attitude, speed, directions, height) of a flying drone. — Easy to check potential malfunctions of an individual drone and a drone delivery system throughout the process when the drone is prepared to depart, is flying, and is returning. **Usability (satisfaction)** — Not feeling tired and stressful and feeling comfortable physically and mentally during daily operations. **Accessibility** — Easily operable from multiple places and able to take over monitoring and controlling of flying drone at any time. — Operable by disabled operator. **Suitability** — Easy to make sure the drone completely and successfully delivered the commodity to the designated customer (e.g. personal identification, address or place).	**Freedom from economic risk** — Sustainable enough, with highly successful ratio of delivery with very few incident occurrences in order to continue working operations jobs with stable incomes. **Freedom from environmental and societal risk** — Sufficient and certain operations to prevent the working environment from deteriorating for the operator (e.g. noisy, longer working hours). **Freedom from risk to human life** — Sufficient automatic accidental collision avoidance with operators and people. — Sufficiently secured against unauthorized access to avoid high jacking of the control operation for intentional attacks against operators and people. — Sufficiently capable to continuously provide operations jobs that ensure low physiological and psychological loading during operation of the system and service (e.g. reduce stress of drone operators by ensuring delivery job with fewer incidents).	**Experience** — Learnable about what is the faster route and how long it takes for delivery and return. — Learnable regarding the commanding or helping the machine learning of the drone, about the places to be avoided in the flying routes and dangerous behaviours to be prevented. **Trustworthiness** — Availability to monitor and record accurate information on the actual status of the drone transparently in real time (e.g. flying to geometric points, attitude, speed, acceleration, directions, height). — Availability to monitor and record accurate information of the actual status of the drone sufficiently transparent to demonstrate that the drone completely avoids prohibited behaviours in routine and emergency operation, even when the drone operates autonomously or receives instructions or commands from the operator. **Compliance** — Availability to monitor and record accurate information on the actual status of the flying drone to determine the following: whether it conforms to what is agreed with the customer; whether it automatically selects its flying route through only allowable flight areas according to regulations or laws.

Table C.1 *(continued)*

Quality-in-use characteristics corresponding to stakeholder needs	**Beneficialness**	**Freedom from risk**	**Acceptability**
Customers (Person who purchased a commodity and is going to use the flying drone delivery service) **EXAMPLE:** When a customer decides to request delivery using the flying drone, the customer can purchase the commodity and request with necessary input information for the flying drone delivery service.	**Usability (effectiveness and efficiency of usability)** — Easy to order without mistakes in inputting of delivery information. — Easy to change where and when the customer can receive products even after the drone departs. — Can receive a commodity without any damage. — Easy to make sure the drone is approaching to deliver the commodity and to prepare to receive in a timely manner. **Usability (satisfaction)** — Deliverable on desired date and time without damages frequently enough to feel comfortable. — Sufficiently affordable and cost-effective performance when using the flying drone delivery service compared to other methods. **Accessibility** — Can request changing the destination. — Can monitor where the drone is flying and change the destination from anywhere. — Can use regularly or emergently from anywhere in wide areas and locations with high successful ratio of delivery with few incident occurrences. — Operable by disabled employees. **Suitability** — Can regularly and emergently receive commodities on desired date and time without damages. — Can receive commodities with flying drone with negotiation to operators even under bad weather conditions.	**Freedom from economic risk** — Demonstrable convincing data that there are very few occurrences of damage or loss of the purchased commodity (e.g. drop to a wrong address, send to a wrong person who is not the customer, collide with something during the flight). — Customers are well informed on provision of insurance to waiver of payment or compensation for damages to commodity or other entities or peoples caused by an accident or incident during the delivery to the customer. **Freedom from environmental and societal risk** — Demonstrable convincing data that there are very few accidents or incidents that adversely affect the environment around the customer (e.g. noise of approaching drone, collision with trees, flowers, pollution of natural resources such as water, soil or air used by customer). **Freedom from risk to human life** — Demonstrable convincing data of automatic avoidance of t accidental collisions with the customer. — Sufficiently secured against unauthorized access in order to highjack the control operation for intentional attacks against operators and people.	**Experience** — Learnable from usage records about the cost versus convenient performance and improvement determinations whether to use the flying drone delivery service or other methods. **Trustworthiness** — Convincingly clear that, through the use of the service, the flying drone delivery is sufficiently available correctly and punctually as requested by the customer. **Compliance** —Convincingly clear that, through the use of the service, the system and service are operated in adherence to agreements between the customer and the service provider.

Table C.1 *(continued)*

Quality-in-use characteristics corresponding to stakeholder needs	**Beneficialness**	**Freedom from risk**	**Acceptability**
Responsible organization **EXAMPLE:** A delivery service provider intends to demonstrate advantages, to extend service available areas and to increase customer of an accelerated delivery service using flying drones at the customer's request.	**Usability (effectiveness and efficiency of usability)** — Easy to pick up a designated commodity and load it on the drone to be ready to fly and send to its customer within a short lead time. — Can deliver a lot of commodities to the customers within a short delivering time. — Can optimize or decrease efforts of operations and administration to continue to business operation. **Usability (satisfaction)** — Justification that the system and service are competitive enough to attract customers compared to other delivery service methods by demonstrating with operations data that these are able to deliver commodities by fulfilling various customer requests, and continuing distant and just in time delivery within acceptable delay and tolerable damage parameters. **Accessibility** — Easily operable from multiple places and locations for extendable service areas. — Can employ disabled personnel as operators. — In order to perform one of societal responsibilities, the system and its service can be capable of delivering essentials with flying drones even when it is under difficult circumstances such as support materials that are requested to be carried in for recovery from accidents or natural disasters. **Suitability** — Continuously operate the flying drone delivery service with sufficiently successful delivery ratio in maximum available circumstances (e.g. under bad weather, natural disasters, accidents) to earn a good reputation from customers and the public and to gain beneficial revenue enough to continue the delivery service business.	**Freedom from economic risk** — Recoverable within a sufficiently short duration to mitigate compensation liability when system failure occurs. **Freedom from environmental and societal risk** — Sufficiently capable to continuously minimize incident occurrences which adversely affect the environment or societal properties (e.g. the drone crashes possibly igniting a fire on a mountain, in a forest, or a person's house). **Freedom from risk to human life** — Sufficient automatic accidental collision avoidance with operators and people. — Sufficiently secured against unauthorized access in order to highjack the control operation for intentional attacks against operators and people. — Sufficiently capable of continuously assigning employees to jobs that assure low physiological and psychological loading during operation of the system and service (e.g. reduced stress of employees by ensuring delivery jobs with fewer incidents, reduced effort to check and clean the drone when returned to base).	**Experience** — Learnable regarding preventing accidents and incidents that can possibly cause expensive compensation, from records of incidents experienced during operation of the flying drone delivery service. **Trustworthiness** — Availability of monitoring and recording reliable information on the actual status of the drone transparently enough to demonstrate that the drone completely avoids prohibited behaviours and follows instructions or commands from the operator, even when the drone can automatically do machine learning or operate autonomously. — Ease of analysing performance data of the system and its service to determine successful delivery ratio including information for improving business processes, such as time to delivery, idle time, damaged levels of commodities and frequency and severity of incidents. — Certainty of sustainable delivery service business without critical incidents, problems or accidents by demonstrating the reliable daily operation of system and its service. — Accountability to problem/incident reports by responding and publishing them quickly. — Available to access feedback information on the voice of the customer to know whether service operation provides good correspondence for customers and society at large or not (e.g. status of resolutions for customer claims or negative opinions, reputation among customers and society at large). **Compliance** —Convincingly reliable daily operations to evidently conform to global, or local regulations or laws (e.g. flying routes, areas, altitudes, drone behaviour in the vicinity of people).

Table C.1 *(continued)*

Quality-in-use characteristics corresponding to stakeholder needs	**Beneficialness**	**Freedom from risk**	**Acceptability**
Public and society **EXAMPLE People 1:** People who are potential customers, i.e. possibly intend to use the flying drone delivery service but not yet, because they are living or staying in the places where transportation is inconvenient (e.g. mountainous areas, islands, destructed areas by disaster), or because they are difficult to get out of their homes by medical reasons.	**Usability (effectiveness and efficiency of usability)** — Can recognize that it is at least one method of efficient delivery service in the society at large. **Usability (satisfaction)** — Can feel continuously convenient and comfortable sufficiently to sustain a reliable livelihood. **Accessibility** — Can request the flying drone conduct the delivery service of essentials even when it is under difficult circumstances (e.g. recovery from accidents or natural disasters, bad weather like heavy rain or strong wind, locked down city by medical reason). **Suitability** — Can regularly and emergently use the system and service within acceptable duration with tolerable damages.	**Freedom from economic risk** — Demonstrable convincing information from historical operational data that very few problems occur that cause economic loss (e.g. lost or damaged commodities, wrong address delivery, collision with people, building or facilities). **Freedom from environmental and societal risk** — Demonstrable convincing data that very few accidents or incidents occur that adversely affect the environment or cause damage around the places where people are residing (e.g. noise, damage to landscape). **Freedom from risk to human life** — Demonstrate convincingly that the flying drone can take emergent actions to avoid a collision severe enough to harm a person.	**Experience** — Learnable regarding the helpfulness of the flying drone delivery **Trustworthiness** — Apparently reliable daily performance which demonstrates that the system and its service sufficiently maintain the flying drone delivery service. **Compliance** — Apparently reliable enough to be strictly operated in order to meet the agreement between the service provider and customer.
Public and society **EXAMPLE People 2:** People who live around a route or in area, where a drone possibly flies.	**Usability (effectiveness and efficiency of usability)** — Can recognize that the flying drone delivery service is one of selectable delivery ways without additional concern. **Usability (satisfaction)** — Feel comfortable without disturbance from a flying drone delivery service even around a route that a drone possibly flies. **Accessibility** — Easy to contact the delivery service to send claims from the people who live around a route that a drone possibly flies. **Suitability** — Live their own daily life without disturbance from the flying drone delivery service even around a route that a drone possibly flies.	**Freedom from economic risk** — Demonstrate convincingly that the drone can avoid collisions with facilities in vicinity of their flying routes (e.g. buildings, houses, vehicles, antennas, electric cables). **Freedom from environmental and societal risk** — Demonstrate convincingly that very few accidents or incidents that cause environmental damage (e.g. noise of flying drone, pollution of natural resources such as air, water and soil caused by spread of leaked chemical or bio products from lost or damaged commodities). **Freedom from risk to human life** — Demonstrate convincingly that the flying drone is capable of taking emergent actions to avoid collisions with people in vicinity of their flying routes.	**Experience** — Learnable regarding how to live with the flying drone delivery service without problems, through the information (data) provided by the system and its service. **Trustworthiness** — Apparently reliable daily performance which demonstrate that the system and its service have sufficient integrity to address and resolve problems including concerns raised by people around the route of the flying drone delivery. — Apparently reliable daily performance which demonstrates that the system and its service are operated carefully enough to avoid carrying dangerous commodities (e.g. explosive, poisonous chemical) and to have threat movements (e.g. flying too low over people **Compliance** — Apparently reliable daily performance which demonstrates that the system and its service are operated in accordance with global and local regulations or laws (e.g. allowable flight routes, areas).

Annex D
(informative)

Example of applying the quality-in-use model to an application

D.1 Example 1: Electric power supply company

— Objectives: supply electric power stably.

— "use": operation by operator (in the public utility or power company central control room).

See Table D.1.

Table D.1 — An example of the result applying an electric power supply system to quality-in-use model

	Operator (Operator for control system)	Customer (People in the area like residence, shop, etc.)	Responsible organization (Electric power supply company)	Public and society at large (Local government, traffic control system, street lighting
Beneficialness	Usability	Ability to use electricity when desired	Achieve the purpose of cost benefit	Employment rate, tax revenue
Freedom from risk	Low error rate, less fatigue	Safety, reliability	Avoid stop supplying electric	Suitable for environment or society at large
Acceptability	Trust in operation	Trust in use	Compliance, brand, trust for their management	Fair and stable supply

D.2 Example 2: self-driving public bus

— Objectives: to transfer passengers to destination bus stop safely.

— "use": operation by operator (in the central control room).

See Table D.2.

Table D.2 — An example of the result applying a self-driving bus system to quality-in-use model

	Operator (Self-driving bus Operator)	Customer (Passenger, sponsor)	Responsible organization (Operation company, government)	Public and society at large (Local government, pedestrian, other vehicular traffic)
Beneficialness	Usability	Easy to use (daily use, easy to ride on/off), reduce time, merit for investment	Achieve the purpose (contribution to society at large, cost benefit), stock price	Employment rate, tax revenue, admirable company
Freedom from risk	Low error rate, less fatigue, self- control	Fall prevention reasonable costs, on-time performance, certain advertising	On-time performance, no accidents, maintain safe operation	Suitable to environment or society at large (reduction in CO_2), reduction in traffic accidents
Acceptability	Trust in operation, ethics and compliance	Trust in use, avoidance of antisocial force	Compliance (traffic low, government regulation), well-known brand,	Fair trade (compatibility to the other traffic methods)

D.3 Example 3: Retail system (e.g. convenience store system)

— Objectives: to manage, sell or buy commodities easily.

— "use": operation by store clerk using cashier system or order terminals, or by customer using self-register system.

See Table D.3.

Table D.3 — An example of the result applying a retail system (like convenience store system) to quality-in-use model

	Operator (Store clerk, shoppers using self-register system)	Customer (Shopper, supplier)	Organization (Convenience store)	Public and society (Residence, school in the area)
Beneficialness	Usability	Ease of transactions between supplier and customers	Achieve sales target	Employment rate, tax revenue, high availability in operating hours, commodity being changed according to some event in the near area
Freedom from risk	Low error rate, easy to redo	Safety, reliability	Prevent shortages of goods, Continue to open the shop	Suitable to environment or society at large
Acceptability	Trust in operation	Trust in transactions	Compliance, Brand, trust in management (exclusion of antisocial forces from using the parking area)	Fair and stable supply of goods, reliable garbage collection

D.4 Example 4: Banking system (e.g. online banking system)

— Objectives: to transact by customer, to manage transaction by a banker.

— "use": operation by customer using online banking system, or operation by banker using a system in a bank.

See Table D.4.

Table D.4 — An example of the result of applying an online or physical banking system to quality-in-use model

	Operator (Banker using in bank system, customer using an online banking system)	Customer (Customer using an online banking system)	Organization (Bank)	Public and society [Residence, local government, small and medium enterprise (SME) in the area]
Beneficialness	Usability	Usability, ability to successfully conduct desired transactions	Assure the accuracy of the transaction amount	Employment rate, tax revenue
Freedom from risk	Low error rate, less fatigue	Safety, reliability	Avoid transactions that cause the mission critical system to stop or fail	Suitable to environment or society at large
Acceptability	Trust in operation	Trust in use	Compliance, Brand, trust for management	Fair and stable market

D.5 Example 5: Hospital system (e.g. electronic medical report system)

— Objectives: to manage unified patient data correctly and in high security.

— "use": operation by a doctor, a nurse or a management staff.

See Table D.5.

Table D.5 — An example of the result of applying an electronic hospital system to quality-in-use model

	Operator (A doctor, a nurse, a management staff)	Customer (Patients, their family, a pharmacist, medical supplier)	Organization (A hospital)	Public and society at large (Residence, local government)
Beneficialness	Usability	Less waiting time, stable transaction	Stable bed utilization rate	Employment rate, tax revenue, easy to use/visit
Freedom from risk	Low error rate, less fatigue	Safety, reliability, transparency of the medical care system	Avoiding medical accidents, especially human safety critical ones	Avoid medical accidents for citizens
Acceptability	Trust in operation	Trust in use	Compliance, Brand, trust in management	Trustable and stable management

D.6 Example 6: Enterprise system (e.g. in-house procurement system)

— Objectives: to be more efficient for an in-house procurement system.

— "use": operation by employee or staff dealt with data from system.

See Table D.6.

Table D.6 — An example of the result of applying an in-house procurement system to quality-in-use model

	Operator (An employee, a staff dealt with data from system)	Customer (Supplier)	Organization (Company)	Public and society (Residence, local government)
Beneficialness	Usability, accessibility	Correct order	Work efficiency, reduce work time	Employment rate, tax revenue
Freedom from risk	Low error rate, less fatigue, less stress, easy to redo	Safety, reliability	Avoid increased network load due to access concentration	Suitable for environment or society at large by paperless or low electricity consumption
Acceptability	Trust in operation	Trust in order details	Compliance, trust for their management	Local reputation

D.7 Example 7: University system (e.g. lecture management system)

— Objectives: to be more efficient for lecture management.

— "use": operation by university student, university staff and university lecturer (professor, assistant professor).

See Table D.7.

Table D.7 — An example of the result applying a lecture management system to quality-in-use model

	Operator (University student, university staff and university lecturer)	Customer [Family, (university) student, (university) lecturer and equipment supplier]	Organization (University)	Public and society (Residence, commercial district, local government)
Beneficialness	Usability, accessibility	Correct information for application, the number of students who need a text or equipment	Work efficiency, reduce work time	Ordering according to the time when people gather
Freedom from risk	Low error rate, less fatigue, correct application, easy to check application statue, information leakage prevention	Safety, reliable data.	Safety, reliable data.	Suitable for environment or society at large, traffic control in the surrounding area
Acceptability	Trust in operation	Trust in use	trust in management	Local reputation

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