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Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Measurement of data quality

Ingénierie des systèmes et du logiciel — Exigences et évaluation de la qualité des systèmes et du logiciel (SQuaRE) — Mesurage de la qualité des données

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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, Subcommittee SC 7, *Software and systems engineering*.

The SQuaRE series of standards consists of the following divisions, under the general title *Systems and software Quality Requirements and Evaluation*:

— ISO/IEC 2500n — *Quality Management Division*;

— ISO/IEC 2501n — *Quality Model Division*;

— ISO/IEC 2502n — *Quality Measurement Division*;

— ISO/IEC 2503n — *Quality Requirements Division*;

— ISO/IEC 2504n — *Quality Evaluation Division*;

— ISO/IEC 25050 to ISO/IEC 25099 — *SQuaRE Extension Division*.

Annexes A, B, C, and D are for information only.

Introduction

This International Standard is a part of the SQuaRE series of International Standards. It provides a set of data quality measures that can be used for measuring and evaluating data quality by referring other SQuaRE series of standards, especially ISO/IEC 25012.

The set of data quality measures in this International Standard is selected based on their practical value. They are not intended to be exhaustive and users of this International Standard are encouraged to refine them if necessary.

Quality measurement division

This International Standard is a part of ISO/IEC 2502n series that currently consists of the following International Standards:

— ISO/IEC 25020 — **Measurement reference model and guide:** provides a reference model and guide for measuring the quality characteristics defined in ISO/IEC 2501n.

— ISO/IEC 25021 — **Quality measure elements:** provides a format for specifying quality measure elements and some examples of quality measure elements that can be used to construct software quality measures.

— ISO/IEC 25022 — **Measurement of quality in use:** provides measures including associated measurement methods and quality measure elements for the quality characteristics in the quality in use model.

— ISO/IEC 25023 — **Measurement of system and software product quality:** provides measures including associated measurement methods and quality measure elements for the quality characteristics in the product quality model.

— ISO/IEC 25024 — **Measurement of data quality:** provides measures including associated measurement methods and quality measure elements for the quality characteristics in the data quality model.

Figure 1 depicts the relationship between this International Standard and the other standards in ISO/IEC 2502n.

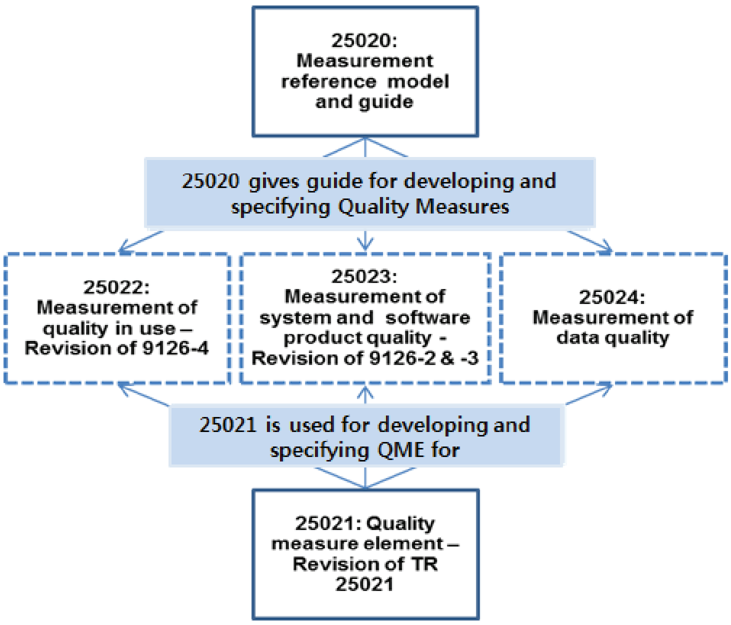

Figure 1 — Structure of the Quality Measurement Division

Outline and organization of SQuaRe series

The SQuaRE series consists of five main divisions and extension division. Outline of each divisions within SQuaRE series are as follows.

— ISO/IEC 2500n — **Quality Management Division**. The standards that form this division define all common models, terms, and definitions referred further by all other standards from SQuaRE series. The division also provides requirements and guidance for the planning and management of a project.

— ISO/IEC 2501n — **Quality Model Division**. The standards that form this division present quality models for system/software products, quality in use, and data. A service quality is under development. Practical guidance on the use of the quality model is also provided.

— ISO/IEC 2502n — **Quality Measurement Division**. The standards that form this division include a system/software product quality measurement reference model, definitions of quality measures, and practical guidance for their application. This division presents internal measures of software quality, external measures of software quality, quality in use measures, data quality measures from “Inherent”, and “System dependent” point of view. Quality measure elements forming foundations for the quality measures are defined and presented.

— ISO/IEC 2503n — **Quality Requirements Division**. The standards that form this division help specify quality requirements. These quality requirements can be used in the process of quality requirements elicitation for a system/software product to be developed designing a process for achieving necessary quality or as inputs for an evaluation process.

— ISO/IEC 2504n — **Quality Evaluation Division**. The standards that form this division provide requirements, recommendations, and guidelines for system/software product evaluation whether performed by independent evaluators, acquirers, or developers. The support for documenting a quality measure as an evaluation module is also presented.

ISO/IEC 25050 to ISO/IEC 25099 are reserved for SQuaRE extension International Standards which currently includes ISO/IEC 25051 and ISO/IEC 25060 to ISO/IEC 25069.

Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Measurement of data quality

1 Scope

This International Standard defines data quality measures for quantitatively measuring the data quality in terms of characteristics defined in ISO/IEC 25012.

This International Standard contains the following:

— a basic set of data quality measures for each characteristic;

— a basic set of target entities to which the quality measures are applied during the data-life-cycle;

— an explanation of how to apply data quality measures;

— a guidance for organizations defining their own measures for data quality requirements and evaluation.

It includes, as informative annexes, a synoptic table of quality measure elements defined in this International standard (Annex A), a table of quality measures associated to each quality measure element and target entitiy (Annex B), considerations about specific quality measure elements (Annex C), a list of quality measures in alphabetic order (Annex D), and a table of quality measures grouped by characteristics and target entities (Annex E).

This International Standard does not define ranges of values of these quality measures to rate levels or grades because these values are defined for each system by its nature depending on the system context and users' needs.

This International Standard can be applied to any kind of data retained in a structured format within a computer system used for any kinds of applications.

People managing data and services including data are the primary beneficiaries of the quality measures.

This International Standard is intended to be used by people who need to produce and/or use data quality measures while pursuing their responsibilities.

— Acquirer (an individual or organization that acquires or procures data from a supplier).

— Evaluator (an individual or organization that performs an evaluation, which can, for example, be a testing laboratory, the quality department of an organization, a government organization, or a user).

— Developer (an individual or organization that performs development activities including requirements, analysis, design, implementation, and testing data during the data-life-cycle).

— Maintainer (an individual or organization that performs operation and maintenance activities of data).

— Supplier (an individual or organization that enters into a contract with the acquirer for the supply of data or service under the terms of the contract).

— User (an individual or organization that uses data to perform a specific function).

— Quality manager (an individual or organization that performs a systematic examination of the data).

— Owner (an individual or organization that takes responsibility for the management and financial value of the data with the legal authority and responsibility to establish for them evaluation, collections, access, dissemination, storage, security, and cancellation).

This International Standard takes into account a large range of data of target entities.

It can be applied in many types of information systems, for example, such as follows:

— legacy information system;

— data warehouse;

— distributed information system;

— cooperative information system;

— world wide web.

The scope does not include the following:

— knowledge representation;

— data mining techniques;

— statistical significance for random sample.

2 Conformance

Any measurement process for requirement, implementation, or evaluation of data quality shall be conformed to this International Standard:

a) selecting data quality characteristics to be specified or evaluated as defined in ISO/IEC 25012;

b) selecting a target entity for which data quality characteristic shall be measured;

c) selecting the appropriate data quality measures defined in Clause 8 by each data quality characteristic concerning a target entity;

d) providing the rationale for any changes when modify the data quality measures;

e) listing any additional quality measures or quality measure elements used that are not included in this International Standard.

Order of items a) and b) can be applied in reverse.

When using modified or new data quality measures, the user shall specify the target entities, measurement method, and related data quality characteristics of ISO/IEC 25012 or specifying any other data quality model that is being used. This International Standard does not provide a complete list of quality measure related to data defined during the data-life-cycle. The user may also identify some other quality measures depending on the technology applied. Even if a number of quality measures included in this International Standard have not been empirically validated and some of them are not based yet on best practices observed in industry, this International Standard is still a good base and an opportunity to improve the data quality measures.

3 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 25000, *Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Guide to SQuaRE*

ISO/IEC 25012:2008, *Software engineering — Software product Quality Requirements and Evaluation (SQuaRE) — Data quality model*

ISO/IEC 25021, *Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Quality measure elements*

4 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 25000, ISO/IEC 25012, ISO/IEC 25021, and the following apply.

NOTE The essential definitions from ISO/IEC 25000 SQuaRE series and the other ISO standards are reproduced here.

4.1
architecture
<system> fundamental concepts or properties of a system in its environment embodied in its *elements* (4.19), relationships, and in the principles of its design and evolution

[SOURCE: ISO/IEC 42010:2011]

Note 1 to entry: In this International Standard, the term "architecture" is intended as "architecture of data", a particular view of the architecture being the work products considered expression of the perspective of a specific system that concerns *data* (4.5). Architecture of data includes architecture elements such as *contextual schema* (4.4), conceptual, logical, physical data models, *data dictionary* (4.6), and documents. In practice architecture of data and data modelling, from the beginning of software engineering, have many levels, such as external model (view), conceptual, and physical (see ANSI/X3/SPARK Three Level Architecture, 1975).

Note 2 to entry: The term "environment" is used in ISO/IEC 42010 to refer (system) context determining the setting and circumstances of all influences upon a system that includes developmental, technological, business, operational, organizational, political, economic, legal, regulatory, ecological, and social influences (in this International Standard, the (system) context, where *data models* (4.10) are applied, can be represented by the *contextual schema* (4.4)).

Note 3 to entry: In ISO/IEC 42010, 4.2.4, Note 1, "the architecture of a system is a holistic conception of that system's fundamental properties best understood via multiple views of that architecture".

4.2
attribute
inherent property or characteristic of a *target entity* (4.36) that can be distinguished quantitatively or qualitatively by human or automated means

[SOURCE: ISO/IEC 25000:2014]

4.3
computer system
system containing one or more components and *elements* (4.19) such as computers (hardware), associated software, and *data* (4.5)

4.4
contextual schema
formal description of the boundary of the context of use where *data models* (4.10) are applied

Note 1 to entry: It is a high-level description of the business' informational needs. It is more general than a conceptual model (see Note 1 in 4.10) as it includes a holistic vision of a (system) context of the *architecture* (4.1).

4.5
data
reinterpretable representation of information in a formalized manner suitable for communication, interpretation, or processing

Note 1 to entry: Data can be processed by humans or by automatic means.

[SOURCE: ISO/TS 19104:2008, B.103]

Note 2 to entry: The definition does not make reference to the one in ISO/IEC 25000 relative to the result of the *measurement* (4.27).

4.6
data dictionary
collection of *information* (4.21) about *data* (4.5) such as name, description, creator, owner, provenance, translation in different languages, and usage

4.7
data file
set of related *data records* (4.15) treated as a unit

Note 1 to entry: In this International Standard, data set is a synonym of data file.

4.8
data format
arrangement of *data* (4.5) for storage or display

Note 1 to entry: Format can be referred to *data type* (4.16) and length of *data item* (4.9).

4.9
data item
smallest identifiable unit of *data* (4.5) within a certain context for which the definition, identification, permissible values, and other *information* (4.21) is specified by means of a set of properties

[SOURCE: ISO/IEC 25021:2012, Annex A]

Note 1 to entry: Field is considered a synonym of data item.

Note 2 to entry: Data item is a physical object “container” of *data values* (4.17).

4.10
data model
graphical and textual representation of analysis that identifies the *data* (4.5) needed by an organization to achieve its mission, functions, goals, objectives, and strategies and to manage and rate the organization.

[SOURCE: ISO/IEC/IEEE 31320-2:2012, 3.1.44]

Note 1 to entry: It is usual to distinguish conceptual model (a model of the concepts relevant to some endeavor), logical, and physical when they represent data at different level of abstraction from high to low.

Note 2 to entry: The formal description of the boundary of the context of use where data models are applied is called *contextual schema* (4.4).

Note 3 to entry: A data model identifies the entities, domains (*attributes*) (4.2), and relationships (associations) with other data and provides the conceptual view of the data and the relationships among data.

4.11
data quality
degree to which the characteristics of *data* (4.5) satisfy stated and implied needs when used under specified conditions

4.12
data quality characteristic
category of data quality attributes that bears on *data quality* (4.11)

[SOURCE: ISO/IEC 25012:2008, 4.4]

4.13
data quality measure
variable to which a value is assigned as the result of *measurement* (4.27) of a *data quality characteristic* (4.12)

[SOURCE: ISO/IEC 25012:2008, 4.5]

4.14
data quality model
defined set of characteristics which provides a framework for specifying data quality requirements and evaluating *data quality* (4.11)

[SOURCE: ISO/IEC 25012:2008, 4.6]

4.15
data record
set of related *data items* (4.9) treated as a unit

[SOURCE: ISO/IEC/IEEE 15289:2015, 5.22]

4.16
data type
categorization of an abstract set of possible values, characteristics, and set of operations for an *attribute* (4.2)

Note 1 to entry: Examples of data types are character strings, texts, dates, numbers, images, sounds, etc.

[SOURCE: ISO/IEC 25012:2008, 4.7]

4.17
data value
content of *data item* (4.9)

Note 1 to entry: In ISO/IEC 25012, 5.1.1, it is specified that from the "Inherent" point of view, *data quality* (4.11) refers to *data* (4.5) itself such as data domain values and possible restrictions.

Note 2 to entry: Number or category assigned to an *attribute* (4.2) of a *target entity* (4.36) by making a *measurement* (4.27).

[SOURCE: ISO/IEC 25000:2005]

4.18
database management system
organized collection of structured data

Note 1 to entry: In order to use database management systems (DBMS), it is necessary to represent *data* (4.5) and the relative operations on it in terms of a *data model* (4.10), a data definition and manipulation language (see Table C.3.1).

4.19
element
smaller part of an *architecture* (4.1)

Note 1 to entry: In this International Standard, the term is used with reference to the architecture of data and to the computer program domain such as *data model* (4.10) or *data dictionary* (4.6).

4.20
form
module or formulary to collect *data* (4.5)

Note 1 to entry: It can be paper-based (paper form) or digital.

4.21
information
in information processing, knowledge concerning objects, such as facts, events, things, processes, or ideas, including concepts, that within a certain context have a particular meaning

[SOURCE: ISO/IEC 25012:2008, 4.10]

Note 1 to entry: Information will necessarily have a representation form to make it communicable. It is the interpretation of this representation (the meaning) that is relevant in the first place.

4.22
information item
separately identifiable body of *information* (4.21) that is produced, stored, and delivered for human use

[SOURCE: ISO/IEC/IEEE 15289:2015, 5.13]

Note 1 to entry: Information product is a synonym.

Note 2 to entry: Information item can be produced in several versions during a project data-life-cycle.

4.23
information item content
information (4.21) included in an *information item* (4.22), associated with a system, product, or service to satisfy a requirement or need

[SOURCE: ISO/IEC/IEEE 15289:2015, 5.14]

4.24
information system
one or more *computer systems* (4.3) and communication systems together with associated organizational resources such as human, technical, and financial resources that provide and distribute *information* (4.21)

[SOURCE: ISO/IEC 25012:2008, 4.14]

4.25
master data
data (4.5) held by an organization that describes the entities that are both independent and fundamental for an enterpirse that it needs to reference in order to perform its transaction

[SOURCE: ISO 22745-2:2010, 14.9, modified]

Note 1 to entry: Master data is a subset of data of a *computer system* (4.3), identified, categorized, and managed that are essential for the core business of an enterprise.

4.26
measure
variable to which a value is assigned as the result of *measurement* (4.27)

Note 1 to entry: The term "measures" is used to refer collectively to base measures, derived measures, and indicators.

[SOURCE: ISO/IEC 25010:2011, 4.4.5]

4.27
measurement
set of operations having the object of determining a value of a *measure* (4.26)

[SOURCE: ISO/IEC 25010:2011, 4.4.7]

4.28
measurement function
algorithm or calculation performed to combine two or more *quality measure elements* (4.32)

[SOURCE: ISO/IEC 25021:2012, 4.7]

4.29
metadata
data (4.5) that describe other data

[SOURCE: ISO/IEC 25012:2008, 4.13]

4.30
presentation device
device used to present *data* (4.5) to the intended user of a system

4.31
quality measure
measure (4.26) that is defined as a *measurement function* (4.28) of two or more values of *quality measure elements* (4.32)

[SOURCE: ISO/IEC 25010:2011, 4.3.10]

4.32
quality measure element
measure (4.26) defined in terms of a property and the measurement method for quantifying it, including optionally the transformation by mathematical function

[SOURCE: ISO/IEC 25021:2012, 4.14]

4.33
quality model
defined set of characteristics, and of relationships between them, which provides a framework for specifying quality requirements and evaluating quality

[SOURCE: ISO/IEC 25010:2011, 4.4.8]

4.34
relational database management system
management system for relational database

Note 1 to entry: In order to use relational data base management systems (RDBMS), it is necessary to represent relational model of data that organizes *data* (4.5) with specific characteristics (tables or relations, unique key, etc.) (see Table C.3.1).

4.35
semantics
meaning of the syntactic components of a language

[SOURCE: ISO/IEC/IEEE 31320-2:2012, 3.1.175]

4.36
target entity
fundamental thing of relevance to the user, about which *information* (4.21) is kept, and need to be measured

[SOURCE: ISO/IEC 25021:2012, 4.17]

Note 1 to entry: Possible synonyms of target entity are input to information product and work product.

Note 2 to entry: Examples of target entities are *architecture* (4.1), *contextual schema* (4.4), conceptual and logical and physical data models, *data dictionary* (4.6), document, *data file* (4.7), database management, relational database management system, *form* (4.20), and *presentation device* (4.30).

Note 3 to entry: Target entities are precisely defined by properties. Examples of properties are *attribute* (4.2), *element* (4.19), information, *metadata* (4.29), *vocabulary* (4.38), *data format* (4.8), *data item* (4.9), *data value* (4.17), *information item* (4.22), *information item content* (4.23), and *data record* (4.15).

4.37
tuple
set of fields or *data items* (4.9)

Note 1 to entry: Tuple can be used in place of record.

4.38
vocabulary
collection of *information* (4.21) related to a specific subset of terms related to a specific domain

Note 1 to entry: Vocabulary is generally used to keep consistency, to avoid duplication, and to support synonyms.

5 Abbreviated terms

The following abbreviations are used in this International Standard.

QM	Quality Measure
QME	Quality Measure Element
DLC	Data-Life-Cycle
DBMS	Database Management System
RDBMS	Relational Database Management System

6 Use of data QMs

6.1 Data quality measurement concepts

Stated and implied needs of system/software quality are represented in the SQuaRE series of standards by quality models that categorise system/software product quality, quality in use and data quality characteristics. The concept of data quality characteristics is defined in ISO/IEC 25012 that categorizes data quality into 15 characteristics.

The measurable quality-related properties of a data are called properties to quantify, with associated QMs. These properties are measured by applying a measurement method. A measurement method is a logical sequence of operations used to quantify properties with respect to a specified scale. The application of a measurement method is called a QME.

The data quality characteristics can be quantified by applying measurement functions. A measurement function is an algorithm used to combine QMEs. The result of applying a measurement function derives QM. In this way, QMs become quantifications of the data quality characteristics. More than one QM can be used for the measurement of a data quality characteristic (see ISO/IEC 25021, Figure 5).

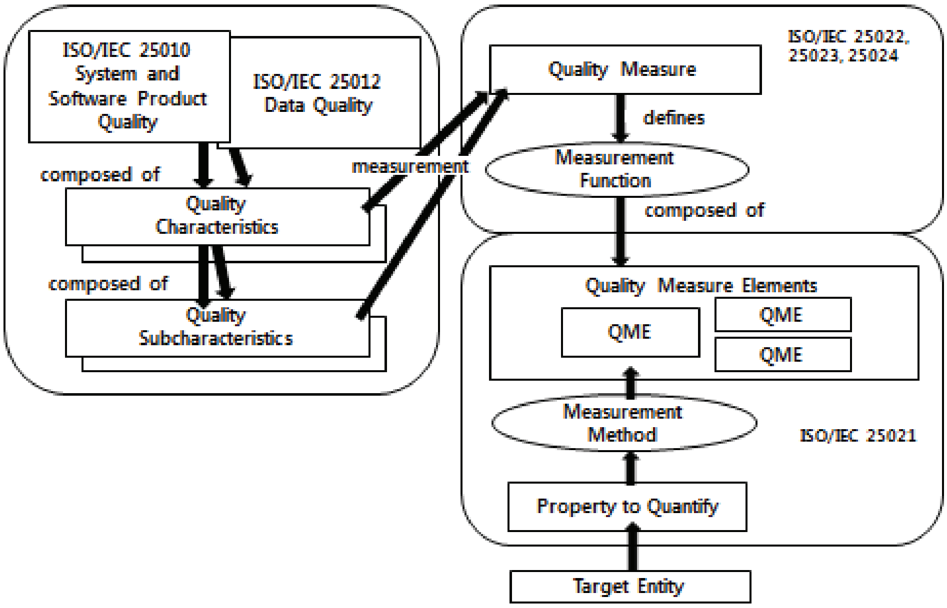

Figure 2 — Relationship among quality models, QM, QME, property to quantify, target entity

Figure 2 describes the relationship among quality models, QMs, QMEs, properties to quantify, and target entities. Referring to the data quality model described in ISO/IEC 25012, the arrows indicate the following:

— data quality model outlines quality characteristics;

— quality characteristics can be evaluated using QMs that are defined by applying a measurement function to QMEs;

— each QME is defined by applying a measurement method to a property to quantify;

— properties are attributes of related target entities.

According to ISO/IEC 25012, data quality can be measured from "Inherent" and "System-dependent" points of view.

The QMs from "Inherent" point of view may be applied to data itself, in particular to the following:

— data domain values and possible restrictions (e.g. business rules governing the quality required for the characteristic in a given application);

— relationships of data values (e.g. consistency);

— metadata.

The QMs from the "System dependent" point of view may be used to quantify the influence on data of computer systems components, such as hardware devices, computer system software and other software.

QMs on data are expected to be correlated with other QMs and other target entities of quality. The relationship between data QMs and other types of QMs related to "process quality" and "quality in use" is shown in Figure 3.

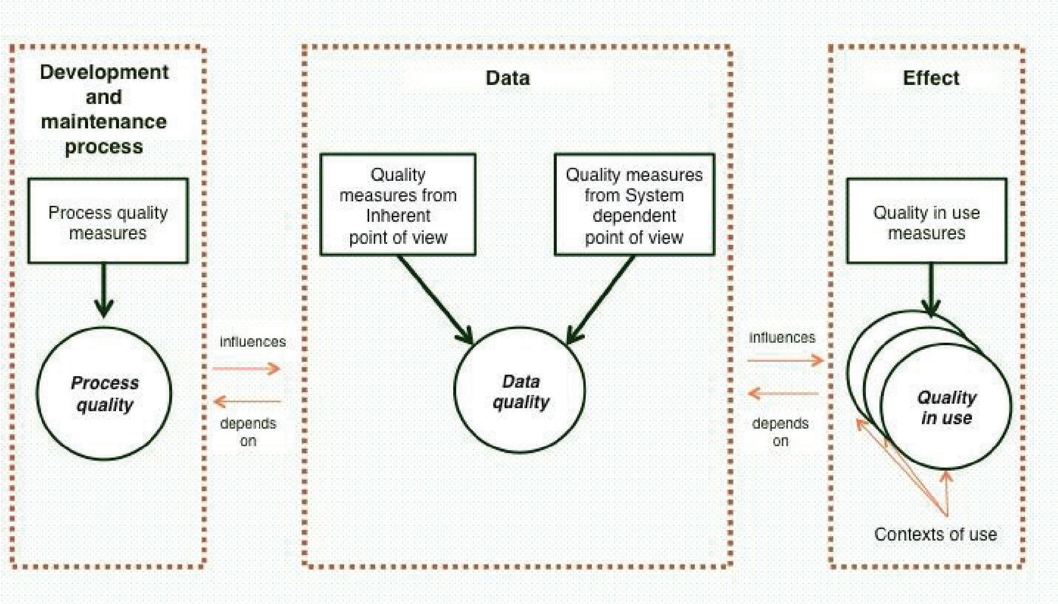

Figure 3 — Relationship between types of QMs

High quality of the development and maintenance process is able to realize high quality of data, considered as a product. Moreover, data quality influences quality in use which represents the effect perceived by the final user.

6.2 Approach to data quality measurement

The QMs described in this International Standard are concerning data and can be used over all DLC stages and for other processes, for example:

— to establish data quality requirements;

— to evaluate data quality;

— to support and implement data governance, data management, data documentation process;

— to support and implement IT services management processes;

— to support improvement of data quality and effectiveness of business decisions process;

— to benchmark data quality of different data management solutions during investigation process;

— to evaluate the quality of system and/or software components that produce data as an outcome.

In each stage of a DLC, data quality can be assessed by measuring characteristics from target entities.

In this International Standard, target entities are the work products of DLC and target entities are precisely defined by properties.

Target entities are represented in different types and they can be managed and stored with different technologies, sometimes they may even be “paper-based”.

Target entities are produced and/or managed by processes in each stage of DLC, as it is for system and software life-cycle.

An example of DLC is represented in Figure 4.

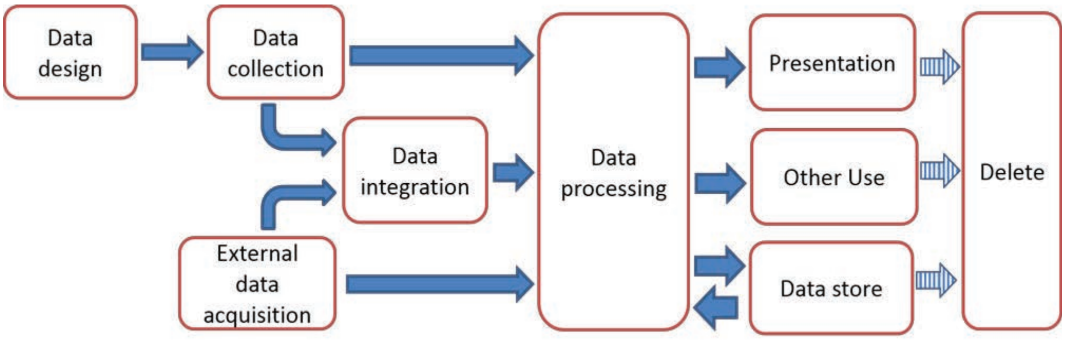

Figure 4 — Example of DLC

The following target entities are considered.

Target entities related to the *Data design* stage:

— architecture;

— contextual schema;

— data models (conceptual, logical, physical);

— data dictionary;

— document.

Properties specified for these target entities:

— attribute;

— element;

— information;

— metadata;

— vocabulary

Target entities related to the other stages of DLC *Data collection, External data acquisition, Data integration, Data processing, Presentation, Other use, Data store, Delete:*

— data file;

— DBMS;

— RDBMS;

— form;

— presentation device.

Properties specified for these target entities:

— data format;

— data item;

— data value;

— information item;

— information item content;

— data record.

The data QMs listed in this International Standard were selected based on the different practices of stakeholders and are related to the following:

— the practical use by organizations;

— innovative perspectives coming from academic institutions, experts, and national regulators;

— the experimental use by researchers.

7 Format used for documenting QMs for data

The data QMs listed in Clause 8 are categorised by the data quality characteristics in ISO/IEC 25012. For each data QM the following information is provided:

a) **ID**: identification code (or identifier) of a data QM; each ID consists of the following three parts:

— abbreviated alphabetic code representing the quality characteristics;

— I ("Inherent") or D ("System dependent") expressing the point of view of data quality characteristics;

— serial number of sequential order within data quality characteristics and point of view;

b) **Name**: QM name related to data;

c) **Description**: the information provided by the data QM and (when useful) the purpose of the measure;

d) **Measurement function**: formula showing how the QMEs are combined to produce the QM;

e) **DLC, Target entities, Properties**: DLC includes stages of the DLC where the data QMEs are applicable, target entities and properties of target entities;

f) **Note**: in the note, additional information such as an acceptable range of values, reference to other standards, explanations or interpretation or criteria, measurement method used to obtain the measures can be defined (i.e. automatic tools, customized software, activities such as inspections, audits, reviews, etc.).

8 Data QMs

8.1 General

This International Standard provides a basic set of data QMs generated by a measurement function applied to the QMEs connected to target entities identified in the DLC.

Generally, the measurement function normalizes the value within a range from 0,0 to 1,0 (or greater); growing values toward 1,0 (or greater value, e.g. in the case of a lack of upper value) means that requirements for better quality are increasingly met. For specific cases, value interpretation is described in a NOTE.

The QMs defined in this clause are listed by data quality characteristics defined in ISO/IEC 25012, in the same order introduced in ISO/IEC 25012. The data QMs listed in ISO/IEC 25012 were only intended as examples; a more extensive list of data QMs is in this International Standard, although it cannot be considered to be an exhaustive set. In this International Standard, all the examples described in ISO/IEC 25012 are taken up again with the necessary changes, quoting in a NOTE the original clause of ISO/IEC 25012. In coherence with ISO/IEC 25012, data QMs, likewise corresponding data quality characteristics, will be varying in importance and priority to different stakeholders, depending on the specific context of use and the DLC stage.

A QME can be considered in more than one QM, with different qualifiers. The same QM can be considered for several entities.

In this Clause, the word "measures" always refers to QMs unless otherwise mentioned.

Additional information and synoptic tables, concerning QMs and QMEs, are in the Annexes.

Annex A provides QMEs used to define data QMs.

Annex B provides for each QME and Target entitiy the correspondent QMs.

Annex C provides QMEs references.

Annex D provides QMs listed in alphabetic order.

Annex E provides QMs identifiers for data quality characteristics and target entities

8.2 QMs for accuracy

Accuracy measures provide the degree to which data has attributes that correctly represent the true value of the intended attribute of a concept or event in a specific context of use.

Accuracy can be measured from the "Inherent" point of view only. Accuracy implies in some cases that the values agree with an identified source of validated information.

Table 1 — Accuracy measures: "Inherent" point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Acc-I-1	**Syntactic data accuracy**	Ratio of closeness of the data values to a set of values defined in a domain	X=A/B A= **number of data items** which have related values syntactically accurate B= **number of data items** for which syntactic accuracy is required	All DLC except Data design Data file Data item, data value
NOTE 1 A single value is considered "syntactically accurate" when it is the same as one from an identified source of validated information: the result is "yes" or "no". NOTE 2 An example of a low degree of syntactic accuracy is when the word Mary is stored as Marj. NOTE 3 See ISO/IEC 25012, 5.3.1.1.				
Acc-I-2	**Semantic data accuracy**	Ratio of how accurate are the data values in terms of semantics in a specific context	X=A/B A= **number of data values** semantically accurate B= **number of data values** for which semantic accuracy is required	All DLC except Data design Data file Data value
NOTE 1 A single value is considered "semantically accurate" when the meaning (the content) corresponds to the reality. NOTE 2 An example of a low degree of semantic accuracy is when the name of John is recorded instead of George; both names are syntactically accurate, so only George is semantically accurate. NOTE 3 See ISO/IEC 25012, 5.3.1.1.				
Acc-I-3	**Data accuracy assurance**	Ratio of measurement coverage for accurate data	X=A/B A= **number of data items** measured for accuracy B= **number of data items** for which measurement is required for accuracy	All DLC except Data design Data file Data item

Table 1 *(continued)*

ID	Name	Description	Measurement function	DLC Target entities Properties
NOTE This measure is relevant to control data quality, if applied on the raw data, especially when a software program for data error attenuation is not available. This QM does not measure the quality of the data, but it measures the thoroughness and application of the accuracy measures. It is a measure of the attention given to the accuracy matter.				
Acc-I-4	**Risk of data set inaccuracy**	The number of outliers in values is indicating a risk of inaccuracy for data values in a data set	X=A/B A= **number of data values** that are outliers B= **number of data values** to be considered in a data set	All DLC except Data design Data file Data value
(To reduce the risk of inaccuracy, outliers shall be validated by humans or instruments.)				
NOTE 1 Outlier: a value that is numerically distant from the rest of values. An outlier is an exception. It can be calculated with different methods (see C.1). NOTE 2 For example, in the following distribution of values concerning the same phenomenon (100, 105, 120, 80, 75, 60, 130, 2000), the last case (2000) represents an outlier that could be convenient to verify. NOTE 3 For X, lower is better.				
Acc-I-5	**Data model accuracy**	Data model describes the system with the required accuracy	X=A/B A= **number of elements** of the data model that accurately describe the system B= **number of elements** of the data model that describe the required accuracy within the requirement specification of the system	Data design Data models Element
NOTE 1 This QM derives from an assessment of the data models. NOTE 2 This QM is based on the subjective opinion of intended users of data models, that reflects the quality (in terms of accuracy) of these artifacts for the user's needs and goals. NOTE 3 This QM is related to the data models that describe the system at the same level of abstraction (definition of data model is in 4.10), related to the same context, developed with the same techniques of rapresentation. NOTE 4 The accuracy of a data model A, compared for example with a previous data model B, depends on the appropriate and detailed graphical representation against the requirements within the specification. NOTE 5 It is intended that a data model describes the system in terms of the objects defined in 4.10. NOTE 6 Generally, 0 < X (X=1 is better). NOTE 7 See Table A.5 and Table B.1.				
Acc-I-6	**Metadata accuracy**	Does metadata describe data with the required accuracy?	X=A/B A= **number of metadata** that provides the appropriate required information B= **number of metadata** defined within the requirement specification of data	Data design Data dictionary Metadata

Table 1 *(continued)*

ID	Name	Description	Measurement function	DLC Target entities Properties
NOTE 1 Accuracy of metadata is relevant for critical data such as data used in GIS data models or e-health. As data moves along DLC, it is used by a number of actors who need interpretable and useful data. NOTE 2 It can be verified by requirement design specification of data. NOTE 3 The citeria of accuracy of metadata is that the degree to which metadata provide a requested information based on the requirement specification of data from the stakeholders and include documentation to interpret the meaning and properties of data correctly. NOTE 4 See Table A.8 and Table B.2.				
Acc-I-7	**Data accuracy range**	Are data values included in the required interval?	X=A/B A= **number of data items** having a value included in a specified interval (i.e. range from minimum to maximum) B= **number of data items** for which can be defined a required interval of values	All DLC except Data design Data file Data item, data value
NOTE Required of value is able to be defined in a requirements specification of the system. The acceptable value of interval is decided by management decision or by statistical analysis from information of QMs or observation of natural phenomena.				

8.3 QMs for completeness

Completeness measures provide the degree to which data associated with a target entity has expected values for all related properties of target entity in a specific context of use.

Completeness can be measured from the "Inherent" point of view only. Completeness can be measured on a single attribute, or on the values of other attributes within a record or message. Completeness is relevant in many cases, for example:

— to measure the presence of a single attribute across all records,

— to measure the presence of attributes of a single record, and

— to measure the presence of records in a data file.

Table 2 — Completeness measures: "Inherent" point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Com-I-1	**Record completeness**	Completeness of data items of a record within a data file	X=A/B A= **number of data items** with associated value not null in a record B= **number of data items** of the record for which completeness can be measured	All DLC except Data design Data file Record, data item, data value
NOTE This QM can be used to calculate average of completeness for different set of records.				
Com-I-2	**Attribute completeness**	Completeness of data items within a data file	X=A/B A= **number of records** with associated values not null for a specific data item B= **number of records** counted	All DLC stages except Data design Data file Record, data item, data value

Table 2 *(continued)*

ID	Name	Description	Measurement function	DLC Target entities Properties
Com-I-3	**Data file completeness**	Completeness of records expected within a data file	X=A/B A= **number of records** contained in a data file B= **number of records** expected	All DLC except Data design Data file Record
Com-I-4	**Data values completeness**	Completeness of values of a data item in a data file	X=A/B A= **number of data values** for a data item in a data file connected to expected values B= **number of data values** expected for a data item in a data file	All DLC except Data design Data file Data item, data value
NOTE See ISO/IEC 25012, 5.3.1.2.				
Com-I-5	**Empty records in a data file**	False completeness of records within a data file	X=1-A/B A= **number of records** where all data items are empty B= **number of records** in a data file	All DLC except Data design Data file Record, data item
NOTE Records exist but are empty.				
Com-I-6	**Conceptual data model completeness**	Completeness of entities described in conceptual data model vs. contextual schema	X=A/B **A= number of entities** of the conceptual data model **B= number of entities** of the conceptual data model that describe the contextual schema completely	Data design Contextual schema, conceptual data model Entity
NOTE 1 This QM is based on the subjective point of view of intended users of a conceptual data model, that reflects the quality (in terms of completeness) of this artifact for the user's needs and present or future goals. NOTE 2 The completeness of the contextual schema characterizes the extend to which the schema represent the corresponding real world or future evolution. The context is determined by circumstances of all influences upon a system that includes developmental, technological, business, operational, organizational, political, economic, legal, regulatory, ecological and social influences. The completeness of conceptual model characterizes the presence/absence of entities included in the model. NOTE 3 This QM does not take into account attributes. NOTE 4 Generally, 0 < X (X=1 is better); a value between 0,1 can indicate a lack of number of entities of the conceptual data models (A) or partial consideration of complete contextual schema, on the other hand, a value > 1 can indicate an overdescription of conceptual data model (A) in comparison with the conceptual data model (B) that describe the contextual schema; completely; this kind of situation may be an excess of specification of the conceptual data model (A). NOTE 5 See Table A.6 and Table B.1.				
Com-I-7	**Conceptual data model attributes completeness**	Completeness of attributes defined for a conceptual data model	X=A/B A= **number of attributes** defined in the conceptual data model B= **number of attributes** defined in the conceptual data model that describe the contextual schema completely	Data design Contextual schema, conceptual data model Attribute

Table 2 *(continued)*

ID	Name	Description	Measurement function	DLC Target entities Properties
NOTE 1 This QM is based on the subjective opinion of intended users of a conceptual data model, that reflects the quality (in terms of completeness) of this artifact for the user's needs and present goals. NOTE 2 For example, "attributes" in the conceptual data model concerns the address in term of "state, city, street and the street number", but in the context of use, it is necessary and defined the geo-localization parameter. NOTE 3 The meaning of attribute is the definition of 4.2. NOTE 4 Generally, 0 < X (X= 1 is better); a value between 0,1 can indicate a lack of number of attributes of the conceptual data models (A); on the other hand, a value >1 can indicate an overdescription of attributes of conceptual data model (A) in comparison with the conceptual data model (B) that describe the contextual schema completely; this kind of situation may be an excess of specification of attributes of conceptual data model (A).				
Com-I-8	**Metadata completeness**	Completeness of attributes for metadata	X=A/B A= **number of attributes** with complete metadata within the data dictionary B= **number of attributes** for which metadata are expected within the data dictionary	Data design Data dictionary Metadata
NOTE 1 The meaning of attribute is the definition of 4.2.				

8.4 QMs for consistency

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

Consistency can be measured from the "Inherent" point of view only. Consistency can be measured in reference to a single computer system or to more computer systems in the same or in different systems.

Measurement context can vary in terms of time (i.e. temporal series of data) and space (i.e. different systems or different sources of data in the same system).

Table 3 — Consistency measures: "Inherent" point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Con-I-1	**Referential integrity**	For each value of one attribute of a table exists the same value of the same attribute in a different table; i.e. there is link between the same attribute represented in different tables and they contain the same values	X=1-A/B A= **number of data items** not consistent by value B= **number of data items** for which referential integrity must be defined	All DLC except Data design Data file, RDBMS Data item, data value

Table 3 *(continued)*

ID	Name	Description	Measurement function	DLC Target entities Properties
NOTE 1 Alternative description for RDBMS: any field in a table that is declared a foreign key can contain either a null value or only values from a parent table's primary key. NOTE 2 Data item is in the same data file or when the same data item is in different tables/data files but related to record with the same primary key values.				
Con-I-2	**Data format consistency**	Consistency of data format of the same data item	X=A/B A= **number of data items** where the format of all properties is consistent in different data files B= **number of data items** for which format consistency can be defined	All DLC except Data design Data file Data item
NOTE It can be applicable to the same data item in the same system or different systems.				
Con-I-3	**Risk of data inconsistency**	Risk of having inconsistency due to duplication of data value	X=A/B A= **Number of data items** where exist duplication in value B= **Number of data items** considered	All DLC except Data design Data file Record, data item, data value
NOTE 1 Risk is considered proportional to the number of duplicates (see C.2). NOTE 2 In case of multiple tables: $A=\sum_j \sum_i D_{ij}$ (j=1...T) where D_{ij} = number of duplications found [in column i of table j (see C.2)]. $B=\sum_j m_j * n_j / T$ (j=1...T) where T = number of tables m_j = number of rows of table j n_j = number of colums of table j In other words B=[[rows*columns] $_{\text{table 1}}$ ...+[rows*columns] $_{\text{table n}}$] / number of tables NOTE 3 For X, lower is better (see examples in C.2).				
Con-I-4	**Architecture consistency**	Degree to which the elements of the architecture have a correspondence in referenced architecture elements	X=A/B **A= Number of elements** of an architecture that have a corresponding referenced elements in the installed architecture B= **Number of elements** of the referenced architecture	Data design Architecture Element
NOTE 1 For example, the elements of the data dictionary do not match with the elements in the conceptual data model. NOTE 2 Particular case of consistency is represented by synonyms: a vocabulary of terms used in a specific domain to define data could be useful to avoid it. NOTE 3 See Table A.5 and Table B.1.				

Table 3 *(continued)*

ID	Name	Description	Measurement function	DLC Target entities Properties
Con-I-5	**Data values consistency coverage**	Coverage of consistency measurement of data values	X=A/B A= **number of data items** considered in consistency measurement of data values B= **number of data items** for which consistency are measured	All DLC except Data design Data file Data item, data value
NOTE QM is not measuring the quality of the data, but it measures the thoroughness and application of the consistency measures.				
Con-I-6	**Semantic consistency**	Degree to which semantic rules are respected	X=A/B A=**number of data items** where values are semantically correct in the data file B=**number of data items** for which semantic rules are defined	All DLC except Data design Data file Data item, data value
NOTE 1 Example: An employee's birth date cannot be later than his "recruitment date". NOTE 2 See ISO/IEC 25012, 5.3.1.3.				

8.5 QMs for credibility

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

Credibility can be measured from the "Inherent" point of view only.

Table 4 — Credibility measures: "Inherent" point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Cre-I-1	**Values credibility**	Degree to which information items are regarded as true, real and credible	X=A/B A= **number of information items** where values are validated/certified by a specific process B= **number of information items** to be validated/certified	All DLC All target entities Information item content, data value
NOTE 1 QM can be applicable to data items (permissible values) and could be extended to evaluate credibility of records, data files, etc. NOTE 2 QME A includes the verification of outliers (see ACC-I-4). NOTE 3 A specific process refers to QMs from inherent point of view and can include evaluation of different sources. NOTE 4 See ISO/IEC 25012, 5.3.1.4. NOTE 5 See Table A.7 and Table B.2.				

Table 4 *(continued)*

ID	Name	Description	Measurement function	DLC Target entities Properties
Cre-I-2	**Source credibility**	Degree to which values are provided by a qualified organization	X=A/B A= **number of data values** provided or validated/certified by a qualified organization B= **number of data values** for which source credibility can be defined	Data collection, External data acquisition Data file Data value
NOTE Data values provided or validated by rightful data owner are considered certified data values.				
Cre-I-3	**Data dictionary credibility**	Degree to which data dictionary provides credible information	X=A/B A= **number of information items** in the data dictionary for which values are validated/certified by a specific process B= **number of information items** in the data dictionary	Data design Data dictionary Information item content, data value
NOTE See Table A.7 and Table B.2.				
Cre-I-4	**Data model credibility**	Degree to which data model provides credible information	X=A/B A= **number of element**s of a data model with appropriate definition validated/certified by a specific process B= **number of elements** of a data model	Data design Data model Element
NOTE See Table A.5 and Table B.1.				

8.6 QMs for currentness

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

Currentness can be measured from the “Inherent” point of view only.

Table 5 — Currentness measures: “Inherent” point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Cur-I-1	**Update frequency**	Degree to which data items are updated with the frequency required.	X=A/B A= **number of data items** updated with the required frequency B= **number of data items** having an update frequency requirement.	Data integration, Data processing, Data store Data file Data item
NOTE 1 For example, the frequency of update can be “daily”. NOTE 2 “A” is valid also for higher frequency. NOTE 3 See ISO/IEC 25012, 5.3.1.5.				

Table 5 *(continued)*

ID	Name	Description	Measurement function	DLC Target entities Properties
Cur-I-2	**Timeliness of update**	Degree to which data items are timely updated	X=A/B A= **number of data items** timely updated B= **number of data items** needing updating.	Data integration, Data processing, Data store Data file Data item
(The timeliness of update shall refer to requirements.)				
Cur-I-3	**Update item requisition**	Degree to which frequency requisition of explicit update data items exists	X=A/B A= **number of information items** with an explicit update requisition B=**number of information items** for which an update requisition is necessary	All DLC All target entities Information item content, data value
NOTE See Table A.7 and Table B.2.				

8.7 QMs for accessibility

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

Accessibility is measured both from “Inherent” and “System dependent” point of view.

Table 6.1 — Accessibility measures: “Inherent” point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Acs-I-1	**User accessibility**	Degree to which data values are considered accessible by intended users	X=A/B A= **number of data items** relevant to the user’s task within a specific context of use having values accessible by intended users B**= number of data items** that are relevant to the user’s task within the context of use having values that are required to be accessible in conformance to specification	Data collection, External data acquisition, Presentation Document, form, presentation device Data item, data value, information items (e.g. images, voice or sounds)
NOTE 1 Particular case of data item accessibility can refer to paper form or screen; the technology can assist users through specific software such as screen reader for the screen (assistive technology). NOTE 2 Example: data (or text) managed by a screen reader cannot be stored as an image. NOTE 3 See ISO/IEC 25012, 5.3.2.1.				

Table 6.2 — Accessibility measures: ”System dependent” point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Acs-D-1	**Device accessibility**	Degree to which accessibility is allowed by a specific device (e.g. voice or sound with textual representation)	X=A/B A= **number of data items** with values accessible through a specific device by intended users B= **number of data items** for which device accessibility can be defined	Data collection, External data acquisition, Presentation Document, form, presentation device Data item, data value, data format, information items (e.g. images, voice or sounds)
NOTE 1 It can be verified by interviews or questionnaire. NOTE 2 See ISO/IEC 25012, 5.3.2.1.				
Acs-D-2	**Data format accessibility**	Degree to which data or information are not accessible by the intended users due to a specific format	X=1-A/B A= **number of data items** not accessible due its format B= **number of data items** for which format accessibility can be defined	Data collection, External data acquisition, Presentation Document, form, presentation device Data item, data format, information items (e.g. images, voice or sounds)
NOTE 1 For example, number of document in PDF not accessible by the screen reader, because of its format not managed by the device. NOTE 2 It can be verified by interviews or questionnaire. NOTE 3 The time (effort) spent to get the information not accessible can be measured by EFF-D-2.				

8.8 QMs for compliance

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

Compliance is measured both from “Inherent” and “System dependent” point of view.

Table 7.1 — Compliance measures: “Inherent” point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Cmp-I-1	**Regulatory compliance of value and/or format**	Degree to which data values and/or format comply with specific standards, conventions or regulations	X=A/B A= **number of data items** that have values and/or format that conform to standards, conventions or regulations B= **number of data items** that shall conform to standards, conventions or regulations due to their value	All DLC except Data design All target entities Data item, data value, format
NOTE See ISO/IEC 25012, 5.3.2.2.				

Table 7.2 — Compliance measures: "System dependent" point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Cmp-D-1	**Regulatory compliance due to technology**	Degree to which data item comply with specific standards, conventions or regulations	X=A/B A= **number of data items** that conforms to standards, conventions or regulations due to technology B= **number of data items** that shall conform to standards, conventions or regulations due to technology	All DLC All target entities Data item
NOTE See ISO/IEC 25012, 5.3.2.2.				

8.9 QMs for confidentiality

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

Confidentiality is measured both from "Inherent" and "System dependent" point of view.

Table 8.1 — Confidentiality measures: "Inherent" point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Cnf-I-1	**Encryption usage**	Degree to which data values are fulfilling the requirement of encryption	X=A/B A= **number of data values** correctly and successfully encrypted and decrypted B= **number of data values** with encryption and decryption requirement	All DLC All target entities Data value
NOTE 1 See ISO/IEC 25012, 5.3.2.3. NOTE 2 Example of data values interested are not limited to personal or confidential information. That is to say any other information can be encrypted based on specification/requirement of a system or compliance to law or regulation.				

Table 8.2 — Confidentiality measures: "System dependent" point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Cnf-D-1	**Non vulnerability**	Degree to which data item defined as confidential can be accessed by authorized users only	X=1-A/B A= **number of accesses** successfully performed during formal penetration attempts by unauthorized users to reach target data item in a specific period of time B= **number of accesses** attempted by unauthorized users to target data item in a specific period of time	All DLC All target entities Data item
NOTE See ISO/IEC 25012, 5.3.2.3.				

8.10 QMs for efficiency

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

Efficiency is measured both from “Inherent” and “System dependent” point of view.

Table 9.1 — Efficiency measures: “Inherent” point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Eff-I-1	**Efficient data item format**	Ratio of using data formats that allows users to perform their operations efficiently	X=A/B A= **number of data items** that are stored in a format that are qualified as efficient B= **number of data items** for which format is tested for efficient operation	Data integration, Data processing, Data store Data file Data item, data format
NOTE 1 See ISO/IEC 25012, 5.3.2.4. NOTE 2 The qualification of format as efficient can derive from international or national regulators, results of tests, etc.				
Eff-I-2	**Usable efficiency**	Ratio of data values that allow intended users to easily use them	X=A/B A= **number of data values** that intended users evaluate as “easily used” B= **number of data values** evaluated by users	Data acquisition, Presentation Form, presentation device Data value, information item content
NOTE 1 For example, in some countries Miles are more usable than Kilometers. NOTE 2 It can be verified by interviews or questionnaire. NOTE 3 “Easily used” can be evaluated comparing the time spent to perform a task by experienced users and novices users: similar result is better.				

Table 9.2 — Efficiency measures: ”System dependent” point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Eff-D-1	**Data format efficiency**	Unnecessary space occupied rate due to data format definition	X=1-A/B A= **size** in bytes of record in a data file unnecessarily occupied due to data format definition B= **size** in bytes of record in a data file due to data format definition	Data store Data file Record, data format
NOTE Unnecessary space derives from the verification that technological alternatives are possibile, producing the same or better results under the same specified conditions.				
Eff-D-2	**Data processing efficiency**	Working time lost due to data item representation (data format)	X=1-A/B A= **time** lost due to data item representation (data format) during a work B= **time** of processing	Data processing, Data store Data file Data item, data format

Table 9.2 *(continued)*

ID	Name	Description	Measurement function	DLC Target entities Properties
NOTE 1 The range of QM values varies depending on the specific context of use. NOTE 2 Processing can be automatic or human. NOTE 3 QM, concerning the time lost to get the information, can be used in conjunction with ACS-D-2. NOTE 4 Time is intended from the point of view of duration (see Annex A).				
Eff-D-3	**Risk of wasted space**	Wasted space in comparison with benchmarked average space	X=SUM (B) – A A= **size** in bytes assumed as target (i.e.: from a benchmark) for efficient data storage of the database B= **size** in bytes used for data in any physical data files of the database	Data store Data file, DBMS Record
NOTE 1 QM can be used also for data items duplication (see Eff-D-4). NOTE 2 See ISO/IEC 25012, 5.3.2.4. NOTE 3 For X lower is better.				
Eff-D-4	**Space occupied by records duplication**	Records duplication space is bigger than the space occupied by deduplicated records	X=A/B A= **size** in bytes of space occupied due to records duplication in a data file B= **size** in bytes of space occupied due to record without duplication in the same data file	Data store Data file, DBMS Record
NOTE 1 The duplication problem is more relevant for data files that do not allow the definition of key constraints. NOTE 2 For example, a typical cost of duplication is the additional mailing cost, for mailing something to customers, when customers are stored more than once in their data base. Example of duplication of a customer, wrongly considered a different person: — Clark Joseph Kent, New York — Clark J. Kent, NY One of these record can be eliminated. NOTE 3 Result value can vary from 1 to infinite. Lower is better.				
Eff-D-5	**Time delay of data update**	Delay between the time at which values of data items change in system A and the time at which values of the same data items change in system B (when system A has to provide values to system B)	X=t2-t1 t1=**time** when data item is updated in system A t2=**time** when data item is updated in system B	Data Integration, Data processing, Data store, Delete Data file Data item, data value
NOTE 1 X can vary from zero to infinite. Lower is better. NOTE 2 The set of measured value of this QM can be applied to introduce the average update time of data item. For example: Average update time for a data item: for i = 1 to n, $Y = (\Sigma X_i/n)$, where n = the number of updates for a data item Average update time for all data items of a dataset: for i = 1 to m, $Z = (\Sigma Y_i/m)$, where m = the number of updates for all data items				

8.11 QMs for precision

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

Precision is measured both from "Inherent" and "System dependent" point of view.

Table 10.1 — Precision measures: "Inherent" point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Pre-I-1	**Precision of data values**	Degree of data values precision according to the specification	X=A/B A= **number of data values** with the requested precision B= **number of data values** with the precision requirement defined	All DLC except Data design Data file Data value
NOTE 1 For example, B is concerning a data file where all data values are supposed to have three decimals. For A is verified that only some data values have the requested precision. X will be less than 1. NOTE 2 See ISO/IEC 25012, 5.3.2.5.				

Table 10.2 — Precision measures: "System dependent" point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Pre-D-1	**Precision of data format**	Degree to which data format keep precision according to the specification	X=A/B A= **number of data items** defined and perceived with the requested precision/data format B= **number of data items** for which precision of format is required	All DLC except Data design Data file Data item, data format
NOTE 1 Data format precision can be verified based on the data format specification. NOTE 2 See ISO/IEC 25012, 5.3.2.5.				

8.12 QMs for traceability

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

Traceability is measured both from "Inherent" and "System dependent" point of view.

Table 11.1 — Traceability measures: “Inherent” point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Tra-I-1	**Traceability of data values**	Degree to which the information of user access to the data value was traced	X=A/B A= **number of data values** for which required access traceability of values exist B= **number of data values** for which access traceability is expected	Data processing Data file, DBMS Data value
NOTE 1 See ISO/IEC 25012, 5.3.2.6. NOTE 2 This QM is not measuring the traceability process; traceability exists and it conforms to the requirements. The result is y/n.				

Table 11.2 — Traceabiliy measures: ”System dependent” point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Tra-D-1	**Users access traceability**	The possibility to keep information about users access to data using system capabilities, for investigating who read/wrote data	X=A/B A= **number of data items** for which user access traceability is expected and realized B= **number of data items** for which user access traceability is expected	All DLC except Data design Data file Data item
NOTE See ISO/IEC 25012, 5.3.2.6.				
Tra-D-2	**Data values traceability**	The possibility to trace the history of a data item value using system capabilities	X=A/B A= **number of data items** for which values are traceable using system capabilities B= **number of data items** for which values are expected to be traceable using system capabilities	Data Processing, Data Store, Delete Data file Data item, data value

8.13 QMs for understandability

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

Understandability is measured both from “Inherent” and “System dependent” point of view.

Table 12.1 — Understandability measures: “Inherent” point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Und-I-1	**Symbols understandability**	Degree to which comprehensible symbols are used	X=A/B A= **number of data values** represented by known symbols B= **number of data values** for which symbols understandabiliy is requested	All DLC All target entities Data value, information item content
NOTE For example, specific symbols include characters or alphabet notation.				
Und-I-2	**Semantic understandability**	Ratio of the common recognized vocabulary which is used in terms of definitions given in the data dictionary	X=A/B A= **number of data values** defined in the data diction-ary by using a common vocabulary B= **number of data values** definded in the data dictionary	All DLC All target entities Data value, information item content, vocabulary
NOTE 1 The “common” vocabulary needs validation by human or instruments. The availability of synonyms can be useful to better understand the meaning. NOTE 2 Example: distance in Miles or Kilometers is always necessary to be specified.				
Und-I-3	**Master data understandability**	Understandability of Master Data is due to metadata definition	X=A/B A=**number of data items** of master data files with existing metadata B=**number of data items** of master data files	All DLC All target entities Data item, information item content
NOTE 1 Metadata are essential to understand the meaning of data items. NOTE 2 See ISO/IEC 25012, 5.3.2.7.				
Und-I-4	**Data values understandability**	Data values are understandable by intended users in the specific context of use	X=A/B A= **number of data values** easily understandable by intended users B= **number of data values** that users attempt to understand during an observation period	All DLC except Data design Data file Data value, information item content
NOTE Example, it can be verified counting number of users’ complaints during an observation period.				

Table 12.2 — Understandability measures: ”System dependent” point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Und-D-1	**Data model understandability**	Degree to which data models provide understandable information	X=A/B A= **number of elements** considered understandable in a data model B= **number of elements** provided by a data model	Data design Data model Element

Table 12.2 *(continued)*

ID	Name	Description	Measurement function	DLC Target entities Properties
NOTE 1 It can be verified by interviews or questionnaire. NOTE 2 Example: this QM can be used when a developer have to read a data model provided by an analyst to realize a software application. NOTE 3 See Table A.5 and Table B.1.				
Und-D-2	**Data representation understandability**	Degree to which data is represented in a comprehensible way to users by system and software	X=A/B A= **number of data items** considered understandable by intended users B= **number of data items** presented in a specific device	Presentation Document, form, presentation device Data item
Und-D-3	**Linked master data understandability**	Understandability of master data is due to linked understandable metadata	X=A/B A=**number of data items** of master data files with automatic linked understandable metadata B=**number of data items** of master data files	All DLC All Target entities Data item, information Item
NOTE 1 This QM reflects the maturity of master data management that allows integration of the system and efficiency of interrelated datasets. NOTE 2 Metadata are linked by the system, using specified software, data formats, data dictionary. NOTE 3 See ISO/IEC 25012, 5.3.2.7.				

8.14 QMs for availability

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

Availability can be measured from the ”System dependent” point of view only.

Table 13 — Availablity measures: ”System dependent” point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Ava-D-1	**Data availability ratio**	Ratio of data items available when required (e.g. during backup/restore procedures)	X=A/B A= **number of data items** available in a specific period of time B= **number of data items** requested in the same period of time	All DLC except Data design All Target entities Data item
NOTE Required specific period or duration can possibly be included during backup or restore procedures, as well as during normal processing. NOTE See ISO/IEC 25012, 5.3.3.1.				

Table 13 *(continued)*

ID	Name	Description	Measurement function	DLC Target entities Properties
Ava-D-2	**Probability of data available**	The probability of successful requests trying to use data items during requested duration	X=A/B A= **number of times** that data items are available for the requested duration B= **number of times** that data items are requested for the requested duration	All DLC except Data design All Target entities Data item
Ava-D-3	**Architecture elements availability**	Degree to which architecture elements are available	X=A/B A=**number of elements** of the architecture available for the intended users B= **number of elements** of the architecture	Data design Architecture Element
NOTE 1 The availability of architecture elements can imply the availability of related target entity. NOTE 2 An example is the availability of information about the data quality rules, that are elements of an architecture. NOTE 3 See Table A.5 and Table B.1.				

8.15 QMs for portability

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

Portability can be measured from the “System dependent” point of view only.

Table 14 — Portability measures: ”System dependent” point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Por-D-1	**Data portability ratio**	Data quality does not decrease after porting (or migration)	X=A/B A= **number of data items** that preserve existing quality after porting B= **number of data items** ported	All DLC except Data design All Target entities Data item
NOTE 1 In this QM, the portability refers to the result of the porting. NOTE 2 See ISO/IEC 25012, 5.3.3.2.				
Por-D-2	**Prospective data portability**	Degree to which portability of data item conforms to requirements	X=A/B A=**number of data items** that can be moved to a target system B= **number of data items** for which portability is expected	All DLC except Data design All Target entities Data item
NOTE This QM refers to the possibility to implement a porting activity.				
Por-D-3	**Architecture elements portability**	Degree to which architecture elements are portable	X=A/B A=**number of elements** of the architecture are portable for a specific user B= **number of elements** of the architecture required	Data design Architecture Element

Table 14 *(continued)*

ID	Name	Description	Measurement function	DLC Target entities Properties
NOTE 1 Example: data models and data dictionary are portable.				
NOTE 2 See Table A.5 and Table B.1.				

8.16 QMs for recoverability

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

Recoverability can be measured from the "System dependent" point of view only.

Table 15 — Recoverability measures: "System dependent" point of view

ID	Name	Description	Measurement function	DLC Target entities Properties
Rec-D-1	**Data recoverability ratio**	Degree to which data stored in a device are successfully and correctly recovered	X=A/B A= **number of data items** successfully and correctly recovered by the system B= **number of data items** that are required to be recovered	All DLC except Data design All Target entities Data item
NOTE See ISO/IEC 25012, 5.3.3.3.				
Rec-D-2	**Periodical backup**	Data is backed up periodically as stated in requirements	X=A/B A=**number of data items** (or data file) successfully backed up periodically B=**number of data items** (or data file) to be backed up	All DLC except Data design All Target entities Data item
Rec-D-3	**Architecture recoverability**	Degree to which architecture elements are recoverable	X=A/B A=**number of elements** of the architecture successfully recovered B=**number of elements** of the architecture that shall be managed by back-up/restore procedures	Data design Architecture Element
NOTE See Table A.5 and Table B.1.				

Annex A
(informative)

QMEs used to define QMs

To each QME, defined in this document, are associated: unique name, target entity, measurement method and a NOTE (see ISO/IEC 25021:2012).

Table A.1 — Number of accesses

QME name	Number of accesses
Target entity	All target entities
Measurement method	The count of attacks
NOTE	The count is registered in a log

Table A.2 — Number of attributes

QME name	Number of attributes
Target entity	Contextual schema, data models, data dictionary
Measurement method	The count of all different attributes (relevant properties of a target entity) that satisfy the condition given in the specific quality requirement definitions
NOTE	e.g. attributes concerning the address in term of “state, city, street and the street number”

Table A.3 — Number of data items

QME name	Number of data items
Target entity	Data file, RDBMS, Document, form, presentation devices
Measurement method	The count of different structures, classes, or formats of data item that satisfy the condition given in the specific requirement definitions.
NOTE	The term field can be a synonym, intended as a smallest identifiable unit of data within a certain context for which the definition, identification, permissible values and other information is specified by means of a set of properties

Table A.4 — Number of data values

QME name	Number of data values
Target entity	All target entities
Measurement method	The count of data values that satisfy a specified condition
NOTE	e.g. number of software faults, amount of software development line of code operational period of system

Table A.5 — Number of elements

QME name	Number of elements
Target entity	Architecture, data model, data dictionary
Measurement method	The count of elements of an architecture, data model or one of the parts into which a property may be subdivided through an analysis

Table A.5 *(continued)*

NOTE	Element of architecture or data model e.g. user-interface, business workflow, data access process, communication process

Table A.6 — Number of entities

QME name	Number of entities
Target entity	Contextual schema, conceptual model
Measurement method	The count of real-world phenomena, fact or concept represented
NOTE	Examples of target entities: data model, contextual schema

Table A.7 — Number of information items

QME name	Number of information items
Target entity	All target entities
Measurement method	The count of information items that satisfy a a specified condition
NOTE	Examples of target entities: data dictionary

Table A.8 — Number of metadata

QME name	Number of metadata
Target entity	Data dictionary
Measurement method	The count of data which describe other data
NOTE	The count of data that describe other data giving information of the context where they are used.

Table A.9 — Number of records

QME name	Number of records
Target entity	Data file, DBMS, RDBMS (tuples)
Measurement method	The count of records of the same structure, class or format that satisfy the conditions given in the specific QME definitions
NOTE	Data items treated as unit or records e.g. deposit record, transaction record, interview result, survey result

Table A.10 — Number of times

QME name	Number of times
Target entity	All target entities
Measurement method	The count of times that a specific periodic phenomenon or action occurs
NOTE	The observation of a phenomenon can provide a probability of an event

Table A.11 — Size

QME name	Size
Target entity	Data file, DBMS, RDBMS
Measurement method	The amount of space used in bytes or multiple of them
NOTE	e.g. the duplication of data is a typical case that can influence the size

Table A.12 — Time

QME name	Time
Target entity	Data file
Measurement method	The calculation of the duration of an event
NOTE	Refers to the interval between a starting time and an end time of any process described in the specific QME definitions (Time (duration) = end time – start time). When it is used, frequency is the number of times in which a specific phenomenon or action occurs per unit-time.

Annex B
(informative)

QMEs, Target entities and QMs

To each QME and Target entity are associated correspondent QMs.

Table B.1 — QMEs (from A.1 to A.6), target entities and QMs

QMEs Target entities	**A.1** number of accesses	**A.2** number of attributes	**A.3** number of data items	**A.4** number of data values	**A.5** number of elements	**A.6** number of entities
Architecture					Con-I-4 Ava-D-3 Por-D-3 Rec-D-3	
Contextual schema		Com-I-7				Com-I-6
Data models					Acc-I-5 Cre-I-4 Und-D-1	
Conceptual data model		Com-I-7				Com-I-6
Logical data model						
Physical data model						
Data dictionary		Com-I-8				
Document			Acs-I-1 Acs-D-1 Acs-D-2 Und-D-2			
Data file			Acc-I-1 Acc-I-3 Acc-I-7 Com-I-1 Con-I-1 Con-I-2 Con-I-3 Con-I-5 Con-I-6 Cur-I-1 Cur-I-2 Eff-I-1 Pre-D-1 Tra-D-1 Tra-D-2	Acc-I-2 Acc-I-4 Com-I-4 Cre-I-2 Pre-I-1 Tra-I-1 Und-I-4		
DBMS				Tra-I-1		
RDBMS			Con-I-1			
Form			Acs-I-1 Acs-D-1 Acs-D-2 Und-D-2	Eff-I-2		

Table B.1 *(continued)*

QMEs / Target entities	**A.1** number of accesses	**A.2** number of attributes	**A.3** number of data items	**A.4** number of data values	**A.5** number of elements	**A.6** number of entities
Presentation device			Acs-I-1 Acs-D-1 Acs-D-2 Und-D-2	Eff-I-2		
All target entities	Cnf-D-1		Cmp-I-1 Cmp-D-1 Und-I-3 Und-D-3 Ava-D-1 Por-D-1 Por-D-2 Rec-D-1 Rec-D-2	Cnf-I-1 Und-I-1 Und-I-2		

Table B.2 — QMEs (from A.7 to A.12), target entities and QMs

QMEs / Target entities	**A.7** number of information items	**A.8** number of metadata	**A.9** number of records	**A.10** number of times	**A.11** size	**A.12** time
Architecture						
Contextual schema						
Data models						
Conceptual data model						
Logical data model						
Physical data model						
Data dictionary	Cre-I-3	Acc-I-6				
Document						
Data file			Com-I-2 Com-I-3 Com-I-5		Eff-D-1 Eff-D-3 Eff-D-4	Eff-D-2 Eff-D-5
DBMS					Eff-D-3 Eff-D-4	
RDBMS						
Form						
Presentation device						
All target entities	Cre-I-1 Cur-I-3			Ava-D-2		

Annex C
(informative)

QMEs references

NOTE Complex QMEs are listed below.

C.1 Outlier

An outlier is a value that is numerically distant from the rest of values. An outlier is an exception.

Outliers can be calculated with many techniques. We reported for example:

C.1.1 Normal distribution

For example, it is possible to have frequency of a phenomenon (weights, revenues, etc.) with a normal distribution (Gauss):

10, 20, 30, 20, 10

where it could be convenient to verify the extreme values.

Similarly, it is possible to have, for a different kind of distribution, the following values:

100, 105, 120, 80, 75, 60, 130, 2000

where the last case (2000) represents an outlier that shall be verified.

The classical parametric method, using average and standard deviation, is concerning the normal (or Gaussian) distribution:

$$f\left(\chi;\mu,\sigma^2\right)=\frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{1}{2}\left(\frac{\chi-\mu}{\sigma}\right)^2} \quad (C.1)$$

The parameter μ is the mean (location of the peak) and σ^2 is the variance (σ is better known as standard deviation).

For the normal (Gaussian) distribution, the interval ($\mu - \sigma$, $\mu + \sigma$) accounts for about 68 % of the set, while two standard deviations from the mean account for about 95 %, and three standard deviations account for about 99,7 %.

C.1.2 Any distribution

For any distribution, the estimation of max number of outlier is:

$$\Pr\left(\left|X-\mu\right|\geq k\sigma\right)\leq\frac{1}{k^2} \quad (C.2)$$

where

X is a random variable;

μ is an expected value;

k is a real number (>0);

σ is the standard deviation.

For any distribution, considering that “nearly all” values should be close to the mean, no more than

$$1 / K^2 \tag{C.3}$$

of the distribution’s values can be more than k standard deviations away from the mean (Bienaymé-Tchebycheff, 1853/1867).

C.1.3 Non-parametric

Non-parametric method (using quantiles) is concerning the use of quantiles.

Quantiles are points taken at regular intervals from a cumulative distribution function of a random variable. Q-quantiles divide ordered data into Q essentially equal-sized data subsets; the quantiles are the data values marking the boundaries between consecutive subsets:

The 2^ quantiles are called the median.

The 3^ quantiles are called tertiles or terciles.

The 4^ quantiles are called quartiles.

...

The 10^ quantiles are called deciles.

...

The 100^ quantiles are called percentiles.

The risk to have inaccurate values is occurring if the data values lie outside the expected limits for the range. It is possible to define an outlier to be any observation outside the range:

$$\left[Q_1 - k\left(Q_3 - Q_1\right), Q_3 + k\left(Q_3 - Q_1\right)\right] \tag{C.4}$$

for some constant, k, where Q_1 and Q_3 are the lower and upper quartiles. In the Interquantile Range Method for K=1,5, the outliers are observations that fall below Q_1-1,5(IQR) or above Q_3+1,5(IQR).

C.2 Duplication

Inconsistency risk is considered proportional to the number of duplicates because update shall be performed to all occurrencies of the same value in order to avoid inconsistencies.

Duplications can be found for each attribute in column i of table j. Duplication score may also be calculated grouping by k attributes and finding duplicates over the records/rows. With this calculation, duplication occurs when, for the set of k attributes selected, two or more records/rows are found equal. With $\binom{n}{k}$ sets of k attributes for a table with n attributes (k=1,..n), the expressions in NOTE 2 of Con-I-3 of 8.4 becomes:

$$A=\sum_k \sum_j \sum_i D_{ijk} \tag{C.5}$$

where D_{ijk} = number of duplications found in set i of k-attributes of table j

In case of multiple tables, also structure of tables impacts inconsistency risk, e.g. a normalized data base leads to better duplication score than a non-normalized one containing the same data. On the other hand, normalization may decrease time efficiency.

In the following example, inconsistency risk is calculated in different data base implementations (Table C.2.1 and Table C.2.2 + Table C.2.3) for k=1 and k=2.

Table C.2.1 — Tournament winners and date of birth

Tournament	Year	Winner	Winner date of birth
Indiana Invitational	1998	Al Fredrickson	21 July 1975
Cleveland Open	1999	Bob Albertson	28 September 1968
Des Moines Masters	1999	Al Fredrickson	21 July 1975
Indiana Invitational	1999	Ship Masterson	14 March 1977

For simplicity, use T for Tournament, Y for Year, W for Winner, wD for winner Date-of-birth.

For Table C.2.1:

Number of duplications (k = 1, T, Y, W, wD) = 2 + 3 + 2 + 2 = 9

Number of duplications (k = 2, TY, TW, TwD, YW, YwD, WwD) = 0 + 0 + 0 + 0 + 0 + 2 = 2

Number of rows = 4, Number of columns = 4, Number of tables = 1

Risk of inconsistency = [(9 + 2)/16]/1 = 0,69

Table C.2.2 — Tournament winners

Tournament	Year	Winner
Indiana Invitational	1998	Al Fredrickson
Cleveland Open	1999	Bob Albertson
Des Moines Masters	1999	Al Fredrickson
Indiana Invitational	1999	Ship Masterson

Table C.2.3 — Player dates of birth

Player	Date of birth
Chip Masterson	14 March 1977
Al Fredrickson	21 July 1975
Bob Albertson	28 September 1968

For simplicity, use T for Tournament, Y for Year, W for Winner, P for Player, D for Date-of-Birth.

For Table C.2.2:

Number of duplications (K = 1, T, Y, W)= 2 + 3 + 2 = 7

Number of duplications (K = 2, TY, TW, YW) = 0 + 0 + 0

Number of rows = 4, Number of colums = 3

For Table C.2.3:

Number of duplications (K = 1, P, D) = 0 + 0

Number of duplications (K = 2, P, D) = 0

Number of rows = 3, Number of columns = 2

Number of tables = 2

Risk of inconsistency = [(7 + 0)/12 + (0 + 0)/6]/2 = 0,29

The implementation with Table C.2.2 + Table C.2.3 has a better score of inconsistency risk than implementation in Table C.2.1 (see Table 3, NOTE 3 “For X, lower is better”).

C.3 Records

Records are collected into a data file and contain set of fields or data items (fields can be a synonym). A set of fields is also called tuple. Table is used to indicate a set of tuples. As a consequence, tuple can be used in place of record; table can be used in place of (structured) data file or data set; a relation or table refers to rows and columns.

Table C.3.1 — Synonims for terms

Generic/original terms	Database	Relational database
(Structured) Data file or data set: contains a set of records	Hierarchical, Network, Relational, Object-oriented Data files with metadata Access paths predefined	Relation or table refers to rows and columns: set of tuples The identifiers is called primary key Integrity constraints Access paths not predefined
Record: contains a set of fields (data items)	Record	Row-Tuple
Field (data item)	Field	Element of tuple

C.4 Size

The amount of space used in bytes or multiple. The most common multiple are the following:

Table C.4.1 — Multiple of bytes

Name	Unit	Multiple
kilobyte	KB	10^3
megabyte	MB	10^6
gigabyte	GB	10^9
terabyte	TB	10^{12}
petabyte	PB	10^{15}
exabyte	EB	10^{18}
zettabyte	ZB	10^{21}
yottabyte	YB	10^{24}

Annex D
(informative)

QMs in alphabetic order

In Table D.1, the following are reported in alphabetic order: QM names, Identifiers, Level of use, Table number where the QMs are defined.

In particular, in the Level of use column: HR = "Highly Recommendable" is indicated according to "practical use by large organizations" (for 19 QMs); R = "Recommendable" is according to "innovative perspectives coming from academic institutions, experts, and national regulators" (for 36 QMs); REF = "for Reference" according to "experimental use by researchers" (for 8 QMs).

Table D.1 — QM list

QM names	Identifiers	Level of use	Table no.
Architecture consistency	Con-I-4	REF	3
Architecture elements availability	Ava-D-3	HR	13
Architecture elements portability	Por-D-3	R	14
Architecture recoverability	Rec-D-3	R	15
Attribute completeness	Com-I-2	R	2
Conceptual data model attributes completeness	Com-I-7	R	2
Conceptual data model completeness	Com-I-6	R	2
Data accuracy assurance	Acc-I-3	R	1
Data accuracy range	Acc-I-7	HR	1
Data availability ratio	Ava-D-1	HR	13
Data dictionary credibility	Cre-I-3	REF	4
Data file completeness	Com-I-3	HR	2
Data format accessibility	Acs-D-2	R	6.2
Data format consistency	Con-I-2	R	3
Data format efficiency	Eff-D-1	R	9.2
Data model accuracy	Acc-I-5	R	1
Data model credibility	Cre-I-4	R	4
Data model understandability	Und-D-1	HR	12.2
Data portability ratio	Por-D-1	R	14
Data processing efficiency	Eff-D-2	HR	9.2
Data recoverability ratio	Rec-D-1	HR	15
Data representation understandability	Und-D-2	R	12.2
Data values consistency coverage	Con-I-5	REF	3
Data values completeness	Com-I-4	R	2
Data values traceability	Tra-D-2	R	11.2
Data values understandability	Und-I-4	R	12.1
Device accessibility	Acs-D-1	R	6.2
Efficient data item format	Eff-I-1	REF	9.1

Table D.1 *(continued)*

QM names	Identifiers	Level of use	Table no.
Empty records in a data file	Com-I-5	R	2
Encryption usage	Cnf-I-1	HR	8.1
Linked master data understandability	Und-D-3	HR	12.2
Master data understandability	Und-I-3	R	12.1
Metadata accuracy	Acc-I-6	R	1
Metadata completeness	Com-I-8	REF	2
Non vulnerability	Cnf-D-1	R	8.2
Periodical backup	Rec-D-2	HR	15
Precision of data format	Pre-D-1	HR	10.2
Precision of data values	Pre-I-1	R	10.1
Probability of data available	Ava-D-2	HR	13
Prospective data portability	Por-D-2	R	14
Record completeness	Com-I-1	R	2
Referential integrity	Con-I-1	R	3
Regulatory compliance due to technology	Cmp-D-1	R	7.2
Regulatory compliance of value and/or format	Cmp-I-1	REF	7.1
Risk of data inconsistency	Con-I-3	R	3
Risk of data set inaccuracy	Acc-I-4	R	1
Risk of wasted space	Eff-D-3	R	9.2
Semantic consistency	Con-I-6	HR	3
Semantic data accuracy	Acc-I-2	HR	1
Semantic understandability	Und-I-2	R	12.1
Source credibility	Cre-I-2	R	4
Space occupied by records duplication	Eff-D-4	REF	9.2
Symbols understandability	Und-I-1	R	12.1
Syntactic data accuracy	Acc-I-1	HR	1
Time delay of data update	Eff-D-5	HR	9.2
Timeliness of update	Cur-I-2	R	5
Traceability of data values	Tra-I-1	REF	11.1
Update frequency	Cur-I-1	HR	5
Update item requisition	Cur-I-3	HR	5
Usable efficiency	Eff-I-2	R	9.1
User accessibility	Acs-I-1	R	6.1
Users access traceability	Tra-D-1	HR	11.2
Values credibility	Cre-I-1	R	4

Annex E
(informative)

QMs identifiers for characteristics and target entities

In the following tables, the data QM identifiers defined in this International standard grouped in DLC, target entities, properties (see 6.2) and data quality characteristics are reported. Some data QMs are applicable to one or more target entities and properties.

Table E.1 — QMs identifiers for I (“Inherent”) data quality characteristics

DLC	**Data design**	**Other stages of DLC**	
Target entities Properties	Architecture, contextual schema, data models (conceptual, logical, physical), data dictionary, document	Data file, DBMS, RDBMS, form, presentation device	
Data quality characteristics	Attribute, element, information, metadata, vocabulary	Data format, data item, information item, record	Data value, Information item content
8.2 Accuracy	Acc-I-5 Acc-I-6	Acc-I-1 Acc-I-3 Acc-I-7	Acc-I-1 Acc-I-2 Acc-I-4 Acc-I-7
8.3 Completeness	Com-I-6 Com-I-7 Com-I-8	Com-I-1 Com-I-2 Com-I-3 Com-I-4 Com-I-5	Com-I-1 Com-I-2 Com-I-4
8.4 Consistency	Con-I-4	Con-I-1 Con-I-2 Con-I-3 Con-I-5 Con-I-6	Con-I-1 Con-I-3 Con-I-5 Con-I-6
8.5 Credibility	Cre-I-3 Cre-I-4	—	Cre-I-1 Cre-I-2 Cre-I-3
8.6 Currentness	Cur-I-3	Cur-I-1 Cur-I-2	Cur-I-3

Table E.2 — QMs identifiers for I (“Inherent”) and D (”System dependent”) data quality characteristics

DLC	**Data design**	**Other stages of DLC**	
Target entities Properties	Architecture, contextual schema, data models (conceptual, logical, physical), data dictionary, document	Data file, DBMS, RDBMS, form, presentation device	
Data quality characteristics	Attribute, element, information, metadata, vocabulary	Data format, data item, information item, record	Data value, Information item content

Table E.2 *(continued)*

DLC	Data design	Other stages of DLC	
8.7 Accessibility	—	Acs-I-1 Acs-D-1 Acs-D-2	Acs-I-1 Acs-D-1
8.8 Compliance	Cmp-D-1	Cmp-I-1 Cmp-D-1	Cmp-I-1
8.9 Confidentiality	Cnf-I-1 Cnf-D-1	Cnf-D-1	Cnf-I-1
8.10 Efficiency	—	Eff-I-1 Eff-D-1 Eff-D-2 Eff-D-3 Eff-D-4 Eff-D-5	Eff-I-2 Eff-D-5
8.11 Precision	—	Pre-D-1	Pre-I-1
8.12 Traceability	—	Tra-D-1 Tra-D-2	Tra-I-1 Tra-D-2
8.13Understandability	Und-I-1 Und-I-2 Und-I-3 Und-D-1 Und-D-3	Und-I-3 Und-D-2 Und-D-3	Und-I-1 Und-I-2 Und-I-3 Und-I-4

Table E.3 — QMs identifiers for D (”System dependent”) data quality characteristics

DLC	Data design	Other stages of DLC	
Target entities Properties	Architecture, contextual schema, data models (conceptual, logical, physical), data dictionary, document	Data file, DBMS, RDBMS, form, presentation device	
Data quality characteristics	Attribute, element, information, metadata, vocabulary	Data format, data item, information item, record	Data value, Information item content
8.14 Availability	Ava-D-3	Ava-D-1 Ava-D-2	—
8.15 Portability	Por-D-3	Por-D-1 Por-D-2	—
8.16 Recoverability	Rec-D-3	Rec-D-1 Rec-D-2	—

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