
**Software engineering — Software product
Quality Requirements and Evaluation
(SQuaRE) — Quality measure elements**

*Ingénierie du logiciel — Exigences de qualité et évaluation du produit
logiciel (SQuaRE) — Éléments de mesure de la qualité*

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

In exceptional circumstances, the joint technical committee may propose the publication of a Technical Report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC TR 25021, which is a Technical Report of type 2, was prepared by Joint Technical Committee 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 *Software product Quality Requirements and Evaluation*:

- Quality Management Division,
- Quality Model Division,
- Quality Measurement Division,
- Quality Requirements Division, and
- Quality Evaluation Division.

Introduction

The purpose of this Technical Report is to define an initial set of quality measure elements to be used throughout the software product life cycle for the purpose of Software Product Quality Requirement and Evaluation (SQuaRE). While the quality measure elements can be used for standalone measurement, their main purpose is to be used as the building blocks for other SQuaRE measures as described in ISO/IEC TR 9126-2, ISO/IEC TR 9126-3 and ISO/IEC TR 9126-4. The content of this Technical Report constitutes the link between ISO/IEC 9126 and the subsequent SQuaRE series of standards (Figure 1).



Figure 1 — Organization of SQuaRE series of standards

During the period of transition from a Technical Report to an International Standard, the intention of this Technical Report is to be only a source of support for the collection of quality measure elements. During this trial period, the applicability of this Technical Report and its content will be evaluated in the user environment. The support provided by this Technical Report for the measurement of software product quality is twofold: (a) assist in the selection of the required quality measure elements for a given quality measure, and (b) provide guidance for collecting the selected measurements.

The set of quality measures listed in this Technical Report arise from surveys involving several large commercial and academic institutions conducted during the following research projects:

- Quality Measure Validation Survey (Prague University of Economics research project GACR 201/06/0175 and Czech University of Life Sciences in Prague research projects MSM6046070904 and 2C06004);
- Conformity of Industrial Software to International Standards ES (Excellent Software) Mark (Korean Agency for Technology and Standards, Korea);
- Project for Development fund of MII (China Ministry of Information Industry): software engineering standardization.

NOTE This set does not contain quality measure elements for all ISO/IEC 9126-1 Quality Model subcharacteristics. Some subcharacteristics were omitted because survey results did not find evidence of their use. It does not imply the ISO/IEC 9126-1 Quality Model should be changed, but rather new quality measures may need to be defined in the future.

Subsequently the quality measure elements necessary for measurement of the above quality measures set have been identified and documented. These quality measure elements represent an initial set of measures which can be used during the construction of quality measures referenced in ISO/IEC TR 9126-2, ISO/IEC TR 9126-3 and ISO/IEC TR 9126-4, as well as other measures for other purposes. Quality measures described in the SQuaRE series (Figure 2) are derived from one or more quality measure elements described in this Technical Report. When evaluating a selected quality measure, the user should first review and evaluate the relevant quality measure element(s) listed in this Technical Report.

Some important benefits from using the measures in this Technical Report are the following.

- To improve measurement productivity and consistency which will minimize measurement effort: When using quality measures such as internal, external and quality in use, there is a possibility of duplicating the attribute measurement tasks, because they are usually performed as separate activities. However by identifying the set of quality measure elements that are uniquely required to derive all the quality measures for a given product, these measurements need to be performed only once at the attribute level. This approach will improve the productivity of the measurement processes.
- Usability (guidance, cross reference): This Technical Report allows users to identify the possible indicators of quality (quality measures) that can be derived by measuring one or more measures from a selected set of quality measure elements, and thereby maximizing the benefits from the measurement process.

The quality measure elements are the common components of quality measures. The intention here is that users of this Technical Report will select measures from quality measure elements for the purpose of defining internal, external or quality-in-use measures. These are then used for the definition of quality requirements (ISO/IEC 25030), software product evaluation (ISO/IEC 2504n), quality assessment and other purposes. It is therefore strongly recommended to use this Technical Report and the other documents in the Quality Measurement Division together with the other relevant documents in the ISO/IEC 25000 series.

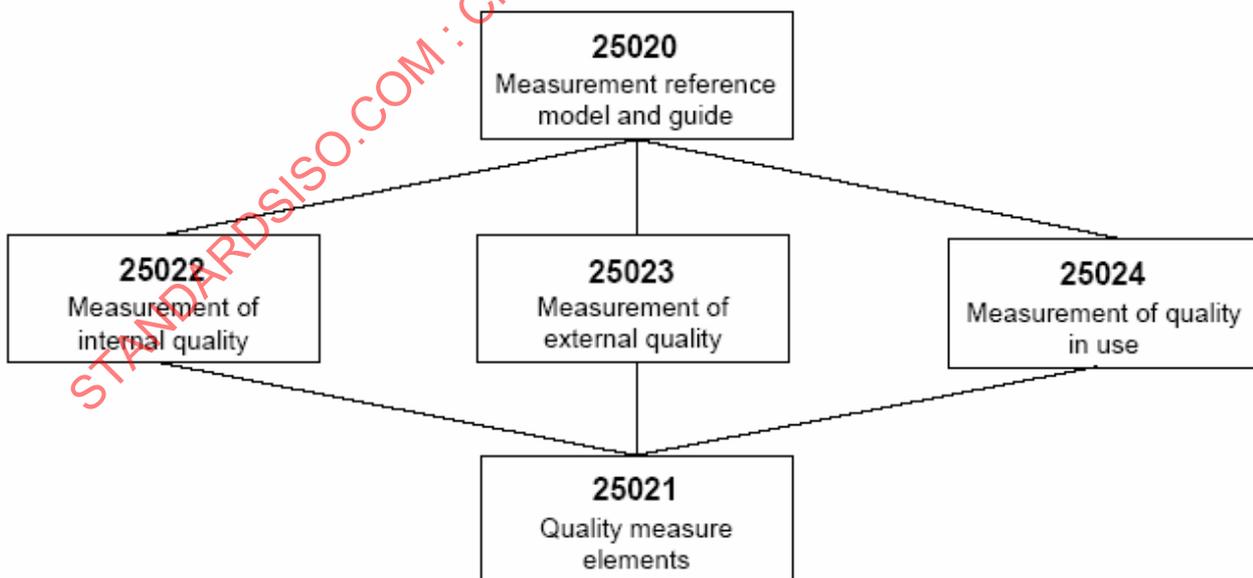


Figure 2 — Structure of the Quality Measurement Division

Quality measure elements, together with the other support documentation offered in this Technical Report, provide added value to the ISO/IEC 9126 Technical Reports and International Standards by making them more understandable to users by clearly defining the relevant quality measure elements (Figure 3). In this sense, this Technical Report acts effectively as the common link between ISO/IEC 9126 and its follower, the SQuaRE series.

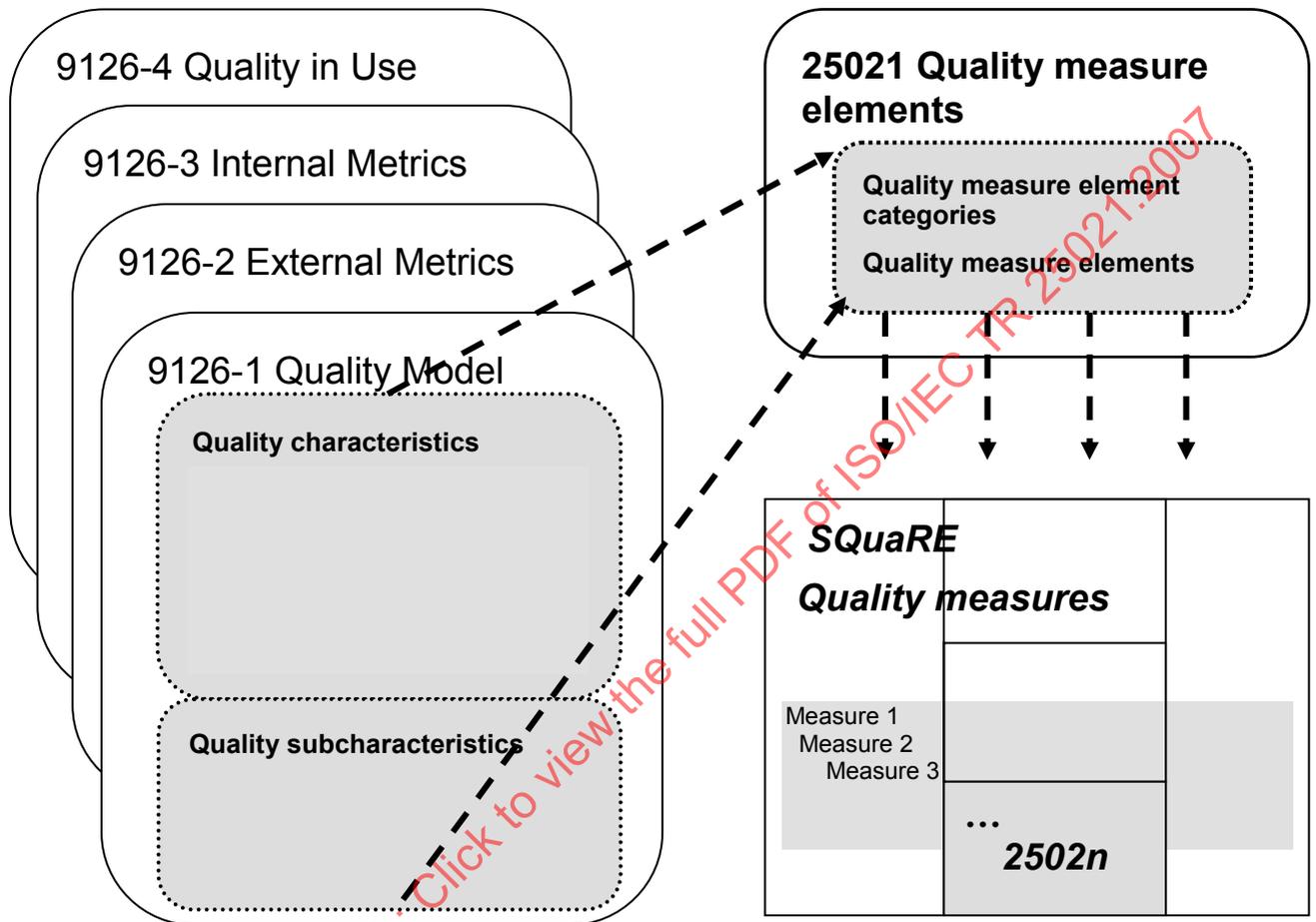


Figure 3 — The relationship of ISO/IEC TR 25021 as a link between the ISO/IEC 9126 and the SQuaRE series of standards

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Software engineering — Software product Quality Requirements and Evaluation (SQuaRE) — Quality measure elements

1 Scope

This Technical Report specifies an initial set of quality measure elements in order to assist users of ISO/IEC TR 9126-2, ISO/IEC TR 9126-3 and ISO/IEC TR 9126-4 and users of the SQuaRE series of quality measurement standards ISO/IEC 2502n in the selection and use of the quality measures for software product quality evaluation and in the selection of the entities to be measured in the software product lifecycle.

This Technical Report contains

- a) a description of the concept of quality measure elements,
- b) considerations for using quality measure elements,
- c) a set of quality measure elements.

This Technical Report is intended for, but not limited to, developers, acquirers and independent evaluators of software product, particularly those responsible for defining software product quality requirements and for software product evaluation.

2 Conformance

There are no conformance requirements in this Technical Report.

3 Normative references

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

ISO/IEC 25000, *Software Engineering – Software product Quality Requirements and Evaluation (SQuaRE) – Guide to SQuaRE*

ISO/IEC 25020, *Software engineering – Software product Quality Requirements and Evaluation (SQuaRE) – Measurement reference model and guide*

ISO/IEC 15939, *Systems and software engineering – Measurement process*

ISO/IEC TR 9126-2, *Software engineering — Product quality — Part 2: External metrics*

ISO/IEC TR 9126-3, *Software engineering — Product quality — Part 3: Internal metrics*

ISO/IEC TR 9126-4, *Software engineering — Product quality — Part 4: Quality in use metrics*

4 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 25000, ISO/IEC 25020 and ISO/IEC 15939 apply.

NOTE The following definitions are replicated here for the convenience of the user.

4.1 attribute

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

NOTE 1 Based on ISO/IEC 15939:2007.

NOTE 2 ISO 9000 distinguishes two types of attributes: a permanent characteristic existing inherently in something; and an assigned characteristic of a product, process or system (e.g. the price of a product, the owner of a product). The assigned characteristic is not an inherent quality characteristic of that product, process or system.

4.2 base measure

measure defined in terms of an attribute and the method for quantifying it

NOTE A base measure is functionally independent of other measures.

[ISO/IEC 15939:2007, based on the definition in the International Vocabulary of Basic and General Terms in Metrology, 1993]

4.3 derived measure

measure that is defined as a function of two or more values of base measures

[ISO/IEC 15939:2007, based on the definition in the International Vocabulary of Basic and General Terms in Metrology, 1993]

NOTE A transformation of a base measure using a mathematical function can also be considered as a derived measure.

4.4 external software quality

capability of a software product to enable the behaviour of a system to satisfy stated and implied needs when the system is used under specified conditions

NOTE Attributes of the behaviour can be verified and/or validated by executing the software product during testing and operation.

EXAMPLE The number of failures found during testing is an external software quality measure related to the number of faults present in the program. The two measures are not necessarily identical since testing may not find all faults, and a fault may give rise to apparently different failures in different circumstances.

4.5 indicator

measure that provides an estimate or evaluation of specified attributes derived from a model with respect to defined information needs

[ISO/IEC 15939:2007]

NOTE In ISO/IEC 14598, this definition of "indicator" was: "a measure that can be used to estimate or predict another measure".

4.6**information need**

insight necessary to manage objectives, goals, risks and problems

[ISO/IEC 15939:2007]

4.7**internal software quality**

capability of a set of static attributes of a software product to satisfy stated and implied needs when the software product is used under specified conditions

NOTE 1 Static attributes include those that relate to the software architecture, structure and its components.

NOTE 2 Static attributes can be verified by review, inspection and/or automated tools.

EXAMPLE The number of lines of code, complexity measures and the number of faults found in a walk through are all internal software quality measures made on the product itself.

4.8**measure, noun**

variable to which a value is assigned as the result of measurement

NOTE The term “measures” is used to refer collectively to base measures, derived measures, and indicators.

[ISO/IEC 15939:2007]

4.9**measure, verb**

make a measurement

[ISO/IEC 14598-1:1999]

4.10**measurement**

set of operations having the object of determining a value of a measure

[ISO/IEC 15939:2007, based on the definition in the International Vocabulary of Basic and General Terms in Metrology, 1993]

NOTE Measurement can include assigning a qualitative category such as the language of a source program (ADA, C, COBOL, etc.).

4.11**measurement function**

algorithm or calculation performed to combine two or more base measures

[ISO/IEC 15939:2007]

4.12**measurement method**

logical sequence of operations, described generically, used in quantifying an attribute with respect to a specified scale

[ISO/IEC 15939:2007, based on the definition in the International Vocabulary of Basic and General Terms in Metrology, 1993]

4.13**quality in use (measure)**

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

4.14

quality measure element

base measure or derived measure that is used for constructing software quality measures

NOTE The software quality characteristics or subcharacteristics of the entity are derived afterwards by calculating a software quality measure.

5 Symbols and abbreviated terms

For the purposes of this Technical Report, the symbols and abbreviations given in ISO/IEC 25000, ISO/IEC 25020 and the following apply.

QME Quality Measure Element

SPQM-RM Software Product Quality Measurement Reference Model

6 Quality measure elements concept

Quality measure elements are used throughout the software product lifecycle as an input for the internal, external and quality in use measures listed in ISO/IEC TR 9126-2, ISO/IEC TR 9126-3 and ISO/IEC TR 9126-4. They measure:

- Attributes of resources consumed, or activities performed during the software product development, testing, and maintenance that relate to software product quality.
- Attributes of the software product itself,
- Attributes of the specific context of use,
- Attributes of the software product when used in a specific context of use, and the effects connected with such use (effects on the user and the result of their task).

6.1 Quality measure elements in the Software Product Quality Measurement Reference Model (SPQM-RM)

International Standard ISO/IEC 25020 defines the Software Product Quality Measurement Reference Model (SPQM-RM) to be used for the software product quality requirements specification process (top-down approach) and for the software product quality evaluation process (bottom-up approach).

SPQM-RM (Figure 4) defines the position of quality measure elements in the software product quality measures definition process. Any single quality measure element by itself generally will not indicate the quality of the measured entity. The quality measure is derived afterwards by computing the results of quality measure element values as stated in the formula of the quality measure that is being measured.

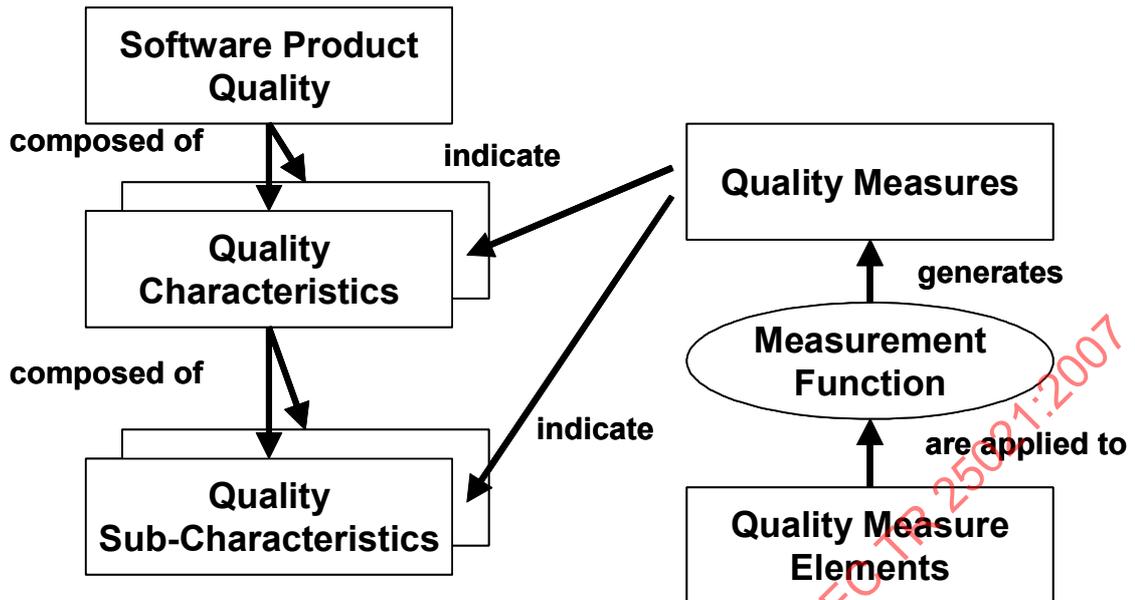


Figure 4 — Quality measure elements concept in SPQM-RM

A quality measure is derived from one or more quality measure elements. A quality measure element can be an input to more than one quality measure. This relationship can be represented in the form of a two-dimensional cross-reference table, which allows a user of this Technical Report to select the proper quality measure elements that are necessary for measuring an individual set of quality measures. It also allows the user of this Technical Report to identify quality measures, which could be derived from a given set of quality measure elements.

The layout of the cross-reference table is shown in Table 1. In this table the quality measures and quality measure elements can be any of those stated in this document. This table works in both ways: by row, a cross associates a quality measure element to all the quality measures where its usage applies; by column, all the crosses indicate the quality measure elements that are required for the quality measure in that column.

Table 1 — Layout of the cross-reference table representing the relationship between QMEs and quality measures

| | Quality measure 1 | Quality measure 2 | Quality measure 3 |
|---------------------------|-------------------|-------------------|-------------------|
| Quality measure element 1 | X | X | |
| Quality measure element 2 | X | | X |
| Quality measure element 3 | | | X |

When evaluating the quality measure elements, a user should be familiar with the information given in the quality measure element table and consider all the limitations and rules given for a listed quality measure element, prior to applying the formula to obtain the value of the quality measure.

6.2 Quality measure elements and their categories

Quality measures in ISO/IEC TR 9126-2, ISO/IEC TR 9126-3 and ISO/IEC TR 9126-4 are described in different level of detail. Some of them are specified precisely, such that the QME and their measurement methods could be easily derived from them; others are described in a way that permits different QME and measurement methods to be used. The concept of the QME Category is used to indicate this difference.

6.3 Aspects of quality measure elements

Users of this Technical Report should consider each of the aspects listed in this section (while evaluating the quality measure elements) in order to avoid accidental misuse of the measurement process, and possible omission of essential measurement steps.

The purpose of quality measure elements is to measure different attributes of a software product or process at any stage during the software product lifecycle. This requires consideration of different aspects of the quality measure elements construction and application of specific practices, such as data selection, measurement process, documentation, arithmetic operations, etc. that are described in each clause.

For the purpose of this Technical Report these aspects are:

- Measurement scale type – the scale type used for measurement,
- Measurement focus in the software product quality lifecycle – the scope and objective of the measurement (e.g. the software product itself, software product in a system, software product in a system used by a specified user in a specified scenario),
- Measurement method type – the measurement method type relating to the quality measure element used for measurement.

These aspects are followed with an essential, but not exclusive set of considerations. While measuring any quality measure element a user of this Technical Report should examine relevant considerations from all the above listed aspects.

NOTE 1 The following aspects and considerations relate to common issues that are relevant to the collection or measurement of (non-exclusive) sets of QMEs.

NOTE 2 Some of the described considerations (e.g. nominal scale etc.) are not relevant for any of the QME listed in this Technical Report. They have been included to bring the complete description of each aspect and allow measurement of QMEs not listed in this Technical Report.

6.3.1 Measurement scale type

The type of scale depends on the nature of the relationship between values on the scale. Five types of scales are commonly used and connected considerations are:

NOTE Scale is defined in ISO/IEC 25000. The following are examples of types of scale.

Nominal scale - The purpose of nominal scale type measures is to classify measured attributes. No ordering is implied even if numbers are used. The numbers assigned to measures in nominal scale type measurement identify only the category (type) of measured attribute. Therefore the order, minimum, maximum, median, arithmetic mean, percentage, etc. derived from these numbers do not have any empirical meaning.

EXAMPLE Software product fault types or categories. Type of function based on the software product quality model (e.g., type of quality characteristics or subcharacteristics)

Ordinal scale - The purpose of ordinal scale type measures is to assign an order to measured attributes. The ordinal scale is often useful to augment the nominal scale with information about an ordering of the classes or categories. The minimum, maximum and median derived from the measures in the ordinal scale type

measurement have empirical meaning. The arithmetic mean, percentage etc. do not have an empirical meaning.

EXAMPLE Software product failure by severity (e.g. negligible, marginal, critical, catastrophic)

Interval scale - The purpose of interval scale type measures is to measure a difference between measures. If a ratio is calculated from the quality measure elements of the same type, it does not have an empirical meaning.

EXAMPLE Cyclomatic complexity has a minimum value of one, but each increment represents an additional path. The value of zero is not possible.

Ratio scale - The ratio scale is similar to the interval scale but includes the value zero, representing total lack of an attribute. Ratio scale quality measure elements include ordered rating scales, where the difference between two measures, and the ratio of two measures, has the same empirical meaning. Ratio and average are giving meaning to the values.

EXAMPLE Effort (time) spent to change, Buffer size, Number of detected faults

Absolute scale - The purpose of absolute scale type measures is to measure a proportion between measures with the same units. Absolute scale quality measure elements include measures resulting from dividing one ratio scale measure to another ratio scale measure where the measurement unit is the same in both cases.

EXAMPLE Number of comment lines divided by total lines of code

6.3.2 Measurement focus in software product quality lifecycle

NOTE ISO/IEC 25020 defines the relationship between the software product quality lifecycle and the quality measures. A short summary of these relationships is also described in clause 6.1 Quality measure elements in the Software Product Quality Measurement Reference Model (SPQM-RM).

Internal software quality measure - The purpose of internal software quality measures is to measure internal attributes of a software product. Internal attributes are those that can be measured in terms of the software product itself, i.e., separate from its behaviour. Internal software quality measures provide the users with the ability to measure the internal quality characteristics of the intermediate deliverables and thereby manage the development of the product to achieve the specified quality requirements. The quality measure element can be measured only if the user has access to the software product structure (source code, design specifications etc.).

NOTE Internal software quality is defined in ISO/IEC 25000

EXAMPLE The number of lines of code, complexity measures and the number of faults found in a walk through are all internal software quality measures made on the product itself.

External software quality measure - The purpose of external software quality measures is to measure external attributes of a software product. External attributes are those that can be measured only with regard to how the product relates to its environment, i.e., by observing its behaviour in the system environment in which it is intended to operate, or in a similar environment. External software quality measures provide users, evaluators, testers, and developers with the insight into the quality of the software product by collecting measures during the execution of the software product. The value of a quality measure element of that type is influenced either by the attributes of the product itself or by the attributes of the process of using it.

NOTE External software quality is defined in ISO/IEC 25000

EXAMPLE The number of failures found during testing – it could be influenced by quality of the software product but also by the testing process.

Quality in use measure - The purpose of quality in use measures is to measure quality in use attributes. Quality in use attributes are those that can be measured when executing the software product in a specified

context of use. Quality in use measures provides users with the benefit that they are able to evaluate the results of using the software product rather than the properties of the software product itself. The value of the quality measure element is influenced by the context of use, which includes skills of the user who is using the software product. The context of use has to be stated while presenting the measurement results.

NOTE Quality in use (measure) is defined in ISO/IEC 25000

EXAMPLE Number of times that specific software product functions/applications/systems are used to fulfil a specific user task, expert user's task efficiency

6.3.3 Measurement method type

Considerations related to the measurement method type with regard to the quality measure element used for measurement are:

Subjective measurement method - Subjective measurements are those where quantification is influenced by human judgment. Subjective measures are used when no formal objective procedures of measurement can be applied. The value of the quality measure element is influenced by human judgment as an evaluator. Therefore it is necessary to interpret the results with respect to the number of evaluators and statistical methods used for the measurement result calculation. Both should be stated while presenting the measurement results.

EXAMPLE Number of times the user pauses for a long period, expert user's task efficiency

Objective measurement method - Objective measurements provide quantification that is based on numerical rules for selection, such as counting. The application of these rules may be implemented via human or automated means. When using this type of measures, no additional considerations are necessary.

EXAMPLE Number of lines of code, total number of tasks tested

6.4 Table format of quality measure elements

The following information is given in this Technical Report for each quality measure element in the form of a table:

- a) QME category name: Name of quality measure element category, measured by this QME,
- b) QME name: Name of quality measure element,
- c) QME ID: Unique Identification of quality measure element,
- d) Detail: Detail specification of measurement method,
- e) Input: Source of data which could be used to measure the quality measure element,
- f) Documentation: Documentation which should be prepared in order to measure the quality measure element. This is also used while interpreting the measurement for proper justification of measurement results (e.g. for justification of type of functions counted),
- g) Considerations connected with the quality measure element use:
 - Measurement concept,
 - Measurement scale,
 - Measurement focus in Software Product Quality Lifecycle,
 - Measurement method type.

NOTE A more detailed explanation is given in clause 6.2 Quality measure elements and their categories

- h) Used for: Specifies the relevant internal, external, or quality in use characteristics, subcharacteristics and measure where a given QME is used.

NOTE Mapping of QME or QME Category to specific quality characteristics or subcharacteristics is not provided in this table; they are in special annexes of this TR (**Error! Reference source not found.** and 0).

7 Quality measure element categories

Quality measure element categories are listed in the following table:

Table 2 — Quality measure element categories

| Quality measure element category name | Description |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Data size</u> | The number of records of the same structure, class or format that satisfy the conditions given in the relevant QME definitions. This number of records can be expressed as: — Count of records, — Size in bytes. |
| <u>Number of Data Items</u> | The count of different types of structures, classes, or formats of data that satisfy the condition given in the relevant QME definitions. |
| <u>Number of Failures</u> | The count of all failures which occur in a given time span and which also satisfy the condition given in the relevant QME definitions. EXAMPLE # of expected failures, # of detected failures, # of resolved failures, # of failures of a given severity level. |
| <u>Number of Faults</u> | The count of software product faults detected (or estimated) in a given software product component and satisfy the condition given in the relevant QME definitions. NOTE # fault of a given category, # faults of a given severity, # faults successfully corrected, etc. |
| <u>Number of Functions</u> | The count of all the functions that satisfy the condition given in the relevant QME definitions. NOTE Functions can be for example, required, implemented, tested, essential, optional, or any combination of these and more. |
| <u>Number of I/O Events</u> | The count of the number of I/O events that satisfy the condition given in the relevant QME definitions. NOTE We can distinguish between messages from the system to the observer - Interaction between observer and the system e.g. a dialogue, - Transaction: the sequence of interactions between the observer and system which must be executed atomically to accomplish an operation, e.g. a wizard (with options). |

| Quality measure element category name | Description |
|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Number of Requirements</u> | <p>The count of requirement clauses that satisfy the condition given in the relevant QME definitions.</p> <p>NOTE Requirements can be i.e. essential, optional, validated, or any combination of these and more.</p> |
| <u>Number of Restarts</u> | <p>The count of the number of attempts for a system to resume computation after a critical failure, and satisfies the condition given in the relevant QME definitions. We distinguish between System restart Recover</p> |
| <u>Number of System Operations</u> | <p>The count of complete operations performed by the system that satisfy the condition given in the relevant QME definitions.</p> <p>NOTE We count the number of complete operations, not the individual steps required in each operation.</p> |
| <u>Number of Tasks</u> | <p>A Task is the set or sequence of activities required to achieve a given goal. The number of tasks is the count of tasks that satisfy the condition given in the relevant QME definitions. We distinguish between</p> <ul style="list-style-type: none"> — User tasks: activities performed by the user (using software product) towards a specified goal, — System tasks: activities performed by the system to support user tasks. |
| <u>Number of Test Cases</u> | <p>Refers to the count of different test input data and scenarios that satisfy the condition given in the relevant QME definitions, e.g. test cases designed, required, executed (successfully or failed), etc.</p> |
| <u>Number of Trials</u> | <p>The count of attempts to perform the same operation to satisfy the condition given in the relevant QME definitions. These attempts can be</p> <ul style="list-style-type: none"> — Evaluation: iterations with same input and same scenario (e.g. stress testing), — Cases: iterations with different input and/or different scenarios. |
| <u>Number of User Operations</u> | <p>The count of number of operations performed by the user that satisfy the condition given in the relevant QME definitions, where an operation is a sequence of steps required to perform a task.</p> |

| Quality measure element category name | Description |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Product Size</u> | <p>The count of software product components according to a desired criterion. This can be lines of code (LOC), function points (see note), modules, classes, or visual structures such as diagrams or their parts.</p> <p>NOTE 1 Software product components can be counted only if some additional properties are satisfied e.g. only executable lines of code, lines of code which also contain commenting, only comment lines, declaration or type casting, bracket/braces only, etc.</p> <p>NOTE 2 There are four ISO/IEC standards defining the function point product size.</p> |
| <u>Time Duration</u> | <p>Refers to the interval between a starting time and an end time of any process described in the relevant QME definitions (Time duration = end time – start time). We distinguish between</p> <ul style="list-style-type: none"> — Execution Time: Refers to time measured internally by the computer clock, e.g. CPU time, I/O time, etc., or any time measured via inserted code or software tools (e.g. test suites), — Observation time: Refers to time measured externally by the observer, using an external clock, e.g. time to finish a transaction or user task, — Set time: A fixed time process or observation, but meaningful for a measure evaluation that is independent of action, e.g. required response time. |

8 Set of quality measure elements

8.1 Data Size

8.1.1 Number of change log data actually recorded

| | |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Data Size |
| QME Name | Number of change log data actually recorded |
| QME ID | QME0101 |
| Detail | Count the number of change log data that have been actually recorded (as internal files, as database records) during the software product change. |
| Input | Maintenance report |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | External |

| | |
|---------------------------|------------------------------------|
| Measurement method | Objective |
| Used for | Software change control capability |

8.1.2 Number of change log data planned to be recorded as sufficient to trace software changes

| | |
|---------------------------|------------------------------------------------------------------------------------------|
| QME Category | Data Size |
| QME Name | Number of change log data planned to be recorded as sufficient to trace software changes |
| QME ID | QME0102 |
| Detail | Derive from specification of required change log data items to be recorded. |
| Input | REQ Spec. |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Software change control capability |

8.1.3 Number of data actually recorded during operation

| | |
|---------------------------|-----------------------------------------------------------------------|
| QME Category | Data Size |
| QME Name | Number of data actually recorded during operation |
| QME ID | QME0103 |
| Detail | Document the data size that has been recorded during operation items. |
| Input | Test report |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Audit trail capability |

8.1.4 Number of data planned to be recorded as sufficient to monitor status of software during operation

| | |
|---------------------------|----------------------------------------------------------------------------------------------------|
| QME Category | Data Size |
| QME Name | Number of data planned to be recorded as sufficient to monitor status of software during operation |
| QME ID | QME0104 |
| Detail | Count the number of data items to be recorded during operation as specified in requirements. |
| Input | Requirements |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Subjective |
| Used for | Audit trail capability |

8.2 Number of Data Items

8.2.1 Number of data formats to be exchanged as in the specifications

| | |
|---------------------------|----------------------------------------------------------------------------|
| QME Category | Number of Data Items |
| QME Name | Number of data formats to be exchanged as in the specifications |
| QME ID | QME0201 |
| Detail | Count the number of data formats to be exchanged as in the specifications. |
| Input | REQ spec. |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Data exchangeability (Data format based) |

8.2.2 Number of data items implemented with specific levels of precision, confirmed in evaluation

| | |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Data Items |
| QME Name | Number of data items implemented with specific levels of precision, confirmed in evaluation |
| QME ID | QME0202 |
| Detail | Count the number of data items that meet the requirements of specific levels of precision. Data items are various formats used in input and/or output operations - input or output windows on the screen, output files etc. |
| Inputs | REQ spec. Design spec. Source code Review report |
| Documentation | List of data items reviewed |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Precision |

8.2.3 Number of data items that require specific levels of precision

| | |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Data Items |
| QME Name | Number of data items that require specific levels of precision |
| QME ID | QME0203 |
| Detail | Count the total number of data items with specific level of precision defined in requirements or design specification. Data items are various formats used in input and/or output operations - input or output windows on the screen, output files etc. |
| Input | REQ spec. Design spec. |
| Documentation | List of data items reviewed |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Precision |

8.2.4 Number of data structures, which are operable and have no limitation after adaptation

| | |
|---------------------------|---------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Data Items |
| QME Name | Number of data structures, which are operable and have no limitation after adaptation |
| QME ID | QME0204 |
| Detail | Count the number of data structures which are operable and has no limitation after adaptation, confirmed in review. |
| Inputs | REQ spec. Design spec. Review report |
| Documentation | List of data items reviewed |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Adaptability of data structures |

8.2.5 Number of input and output data items available from the interface

| | |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Data Items |
| QME Name | Number of input and output data items available from the interface |
| QME ID | QME0205 |
| Detail | Count the number of input and output data items available for user from the interface as described in the user manual. Data items are various formats used in input and/or output operations - input or output windows on the screen, output files etc. |
| Input | User manual |
| Documentation | List of input data items List of output data items |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Understandable input and output |

8.2.6 Number of input and output data items which user successfully understands

| | |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Data Items |
| QME Name | Number of input and output data items which user successfully understands |
| QME ID | QME0206 |
| Detail | Conduct user test and interview user with questionnaire or observe user behaviour and count data items classified as understood. Data items are various formats used in input and/or output operations - input or output windows on the screen, output files etc. |
| Inputs | User manual Operation report |
| Documentation | List of input data items List of output data items Criteria (method) used for understandability classification |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Subjective |
| Used for | Understandable input and output |

8.2.7 Number of interface data formats that have been implemented correctly as in the specifications

| | |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Data Items |
| QME Name | Number of interface data formats that have been implemented correctly as in the specifications |
| QME ID | QME0207 |
| Detail | Count the number of interface data formats that have been implemented correctly in the source code with respect to the interface. |
| Inputs | REQ spec. Design spec. Source code Review report |
| Documentation | List of interface data formats List of incorrectly implemented data formats |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Data exchangeability (Data format based) |

8.2.8 Total number of data structures requiring adaptation capability

| | |
|---------------------------|---------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Data Items |
| QME Name | Total number of data structures requiring adaptation capability |
| QME ID | QME0208 |
| Detail | Count the total number of data structures requiring adaptation capability, confirmed in review, design or REQ spec. |
| Inputs | REQ spec. Design spec. Review report |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Subjective |
| Used for | Adaptability of data structures |

8.3 Number of Failures

8.3.1 Number of detected failures

| | |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Failures |
| QME Name | Number of detected failures |
| QME ID | QME0301 |
| Detail | Count the number of detected failures during defined trial period of using the software product. Each failure has to be categorized and weighted by its importance. |
| Inputs | Test report Operation report Problem report |
| Documentation | List of test cases applied List of failures with their categories List of failures categories and their weights |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Failure density against test cases |

8.3.2 Number of resolved failures

| | |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Failures |
| QME Name | Number of resolved failures |
| QME ID | QME0302 |
| Detail | Count the number of failures that did not reoccur during defined trial period under the similar conditions (e.g. under same test cases executed). |
| Inputs | Test report Operation report |
| Documentation | List of failures categories and their weights List of resolved failures and their categories |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Failure resolution |

8.3.3 Number of transmission related error messages and failures

| | |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Failures |
| QME Name | Number of transmission related error messages and failures |
| QME ID | QME0303 |
| Detail | Emulate a condition where by the system reaches a situation of expected load. Run the application and record the number of error messages and failures related to transmission. |
| Inputs | Operation report showing elapse time Test report |
| Documentation | Measurement Tool name and version Computer HW specification Operating system name and version |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Mean occurrence of transmission error |

8.3.4 Total number of actually detected failures

| | |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Failures |
| QME Name | Total number of actually detected failures |
| QME ID | QME0304 |
| Detail | Count the total number of actually detected failures during observed operation time. Create and maintain a problem resolution report describing status of all the failures. |
| Inputs | Operation report Test report |
| Documentation | List of test cases applied List of failures categories and their weights List of failures with their categories |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Failure resolution Mean time between failures (MTBF) |

8.4 Number of Faults

8.4.1 Number of corrected faults in design/coding

| | |
|---------------------------|----------------------------------------------------------------------------------------------|
| QME Category | Number of Faults |
| QME Name | Number of corrected faults in design/coding |
| QME ID | QME0401 |
| Detail | Count the number of faults corrected (removed) during design/coding. |
| Input | Fault removal report |
| Documentation | List of fault categories and their weights List of corrected faults with their categories |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Fault removal |

8.4.2 Number of detected faults

| | |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Faults |
| QME Name | Number of detected faults |
| QME ID | QME0402 |
| Detail | Count the number of detected faults during defined trial period of using software product. Each fault has to be categorized and weighted by its importance. Source of each fault has to be identified (e.g. design, code, etc.) |
| Inputs | Operation report Test report Problem report Source code Review report REQ spec. |
| Documentation | List of test cases applied List of fault categories and their weights Lists of detected faults and their categories |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Fault removal |

8.4.3 Number of faults detected in review

| | |
|---------------------------|---------------------------------------------------------------------------------------------|
| QME Category | Number of Faults |
| QME Name | Number of faults detected in review |
| QME ID | QME0403 |
| Detail | Count the numbers of faults detected in review, during design/coding. |
| Input | Review report |
| Documentation | List of fault categories and their weights Lists of detected faults and their categories |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Fault removal |

8.5 Number of Function

8.5.1 Number of functions

| | |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Number of functions implemented |
| QME ID | QME0501 |
| Detail | Count the number of functions implemented, (both correctly and incorrectly implemented). Each reviewed function has to be categorized and weighted by its importance. |
| Inputs | REQ spec. Design spec. Review report |
| Documentation | List of functions implemented |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Completeness of user documentation and/or help facility Physical accessibility Completeness of description |

8.5.2 Number of functions (or types of functions) described in the product description

| | |
|---------------------------|-------------------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Number of functions (or types of functions) described in the product description |
| QME ID | QME0502 |
| Detail | Count the number of functions, which are adequately described in the product description. |
| Inputs | REQ spec. Design spec. Review report Product description (documentation) |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Subjective |
| Used for | Completeness of description Completeness of user documentation and/or help facility |

8.5.3 Number of functions reviewed

| | |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Number of functions reviewed |
| QME ID | QME0503 |
| Detail | <p>Count the number of implemented functions that were reviewed during the validation process. The following may be measured :</p> <ul style="list-style-type: none"> — all or parts of design specifications, — completed modules/parts of software products. <p>Each counted function has to be categorized and weighted by its importance.</p> |
| Inputs | <p>Review report</p> <p>Test report</p> |
| Documentation | List of functions reviewed |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Functional adequacy |

8.5.4 Number of functions described in requirement specifications

| | |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Number of functions described in requirement specifications |
| QME ID | QME0504 |
| Detail | Count the number of functions described in the requirement specifications. Each reviewed function has to be categorized and weighted by its importance. |
| Input | REQ spec. |
| Documentation | List of functions required |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | <p>Functional implementation completeness</p> <p>Functional implementation coverage</p> |

8.5.5 Number of functions for which specific accuracy requirements need to be implemented

| | |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Number of functions for which specific accuracy requirements need to be implemented. |
| QME ID | QME0505 |
| Detail | Count the number of functions with specific accuracy requirements needs to be implemented and listed the specific accuracy requirements according specification. Each counted function has to be categorized and weighted by its importance. |
| Inputs | REQ spec. Design spec. Source code |
| Documentation | List of accuracy requirements |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Computational Accuracy |

8.5.6 Number of functions in which problems are detected in evaluation

| | |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Number of functions in which problems are detected in evaluation |
| QME ID | QME0506 |
| Detail | Count the number of functions in which problems are detected during evaluation. The following may be measured: <ul style="list-style-type: none"> — all or parts of design specification, — completed modules/parts of software products. Each counted function has to be categorized and weighted by its importance. |
| Inputs | REQ spec. Design spec. Source code Review report Test report |
| Documentation | List of problem categories and their weights List of problems with their categories List of functions, which have problems |
| Measurement scale | Ratio |

| | |
|---------------------------|---------------------|
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Functional adequacy |

8.5.7 Number of functions in which specific accuracy requirements had been implemented, confirmed in evaluation

| | |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Number of functions in which specific accuracy requirements had been implemented, confirmed in evaluation |
| QME ID | QME0507 |
| Detail | Count the number of functions that have implemented the accuracy requirements and that were confirmed during the evaluation process. Each counted function has to be categorized and weighted by its importance. |
| Inputs | REQ spec. Design spec. Source code Test report |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Computational Accuracy |

8.5.8 Number of functions, which can be customized

| | |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Number of functions, which can be customized |
| QME ID | QME0508 |
| Detail | Count the number of implemented functions, which can be customized. Each reviewed function has to be categorized and weighted by its importance. The meaning of "customization" has to be also defined and documented before starting each measurement. |
| Inputs | REQ spec. Review report |
| Documentation | List of customizable functions |

| | |
|---------------------------|------------------------|
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Physical accessibility |

8.5.9 Number of implemented functions, which are capable of achieving, required results in specified multiple HW environments as specified

| | |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Number of implemented functions, which are capable of achieving, required results in specified multiple HW environments as specified |
| QME ID | QME0509 |
| Detail | Count the number of implemented functions, which are capable of achieving, required results in specified multiple HW environments as specified, confirmed in review. Each counted function has to be categorized and weighted by its importance. |
| Inputs | REQ spec. Design spec. Review report |
| Documentation | List of implemented functions, which have H/W portability |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Hardware environmental adaptability (adaptability to hardware devices and |

8.5.10 Number of implemented functions, which are capable of achieving, required results in specified multiple system software environments as specified

| | |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Number of implemented functions, which are capable of achieving, required results in specified multiple system software environments as specified |
| QME ID | QME0510 |
| Detail | Count the number of implemented functions, which are capable of achieving, required results in specified multiple system software environments as specified, confirmed in review. Each counted function has to be categorized and weighted by its importance. |

| | |
|---------------------------|------------------------------------------------------------------------------------------------------------------------|
| Inputs | REQ spec. Design spec. Review report |
| Documentation | List of implemented functions, which have S/W portability |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | System software environmental adaptability (adaptability to OS, network software and co-operated application software) |

8.5.11 Number of incorrectly implemented or missing functions detected

| | |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Number of incorrectly implemented or missing functions detected |
| QME ID | QME0511 |
| Detail | Count the number of incorrectly implemented or missing functions detected in validation, in comparison to the actual version of requirements or design specifications. Each counted function has to be categorized and weighted by its importance. |
| Inputs | REQ spec. Design spec. Source code Review report |
| Documentation | List of incorrectly implemented or missing functions with their categories |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Functional implementation coverage |

8.5.12 Number of missing functions detected in evaluation

| | |
|---------------------|----------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Number of missing functions detected in evaluation |
| QME ID | QME0512 |

| | |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Detail | Count the number of missing functions detected in evaluation in comparison to the requirements or design specifications. Each counted function has to be categorized and weighted by its importance. |
| Inputs | REQ spec. Design spec. Source code Review report |
| Documentation | List of missing functions with their categories |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Functional implementation completeness |

8.5.13 Number of user interface functions

| | |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Number of user interface functions |
| QME ID | QME0513 |
| Detail | Count the number of implemented user interface functions. Each counted function has to be categorized and weighted by its importance. |
| Inputs | REQ spec. Design spec. Review report User manual |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Function understandability |

8.5.14 Number of user interface functions where the purpose is understood by the user

| | |
|---------------------|--------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Number of user interface functions where the purpose is understood by the user |
| QME ID | QME0514 |

| | |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Detail | Count the number of user interface functions where the purposes are understandable to the user. Each counted function has to be categorized and weighted by its importance. |
| Inputs | REQ spec. Review report |
| Documentation | List of user interface functions Description of the method for assessing understandability |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Subjective |
| Used for | Function understandability |

8.5.15 Total number of functions with H/W environment adaptation capability requirements

| | |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Total number of functions with H/W environment adaptation capability requirements |
| QME ID | QME0515 |
| Detail | Count the total number of functions with H/W environment adaptation capability requirements. Each counted function has to be categorized and weighted by its importance. |
| Inputs | REQ spec. Design spec. Review report |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Hardware environmental adaptability (adaptability to hardware devices and network facilities) |

8.5.16 Total number of functions with system software environment adaptation capability requirements

| | |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Functions |
| QME Name | Total number of functions with system software environment adaptation capability requirements |
| QME ID | QME0516 |
| Detail | Count the total number of functions with system software environment adaptation capability requirements. Each counted function has to be categorized and weighted by its importance. |
| Inputs | REQ spec. Design spec. Review report |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | System software environmental adaptability (adaptability to OS, network software and co-operated application software) |

8.6 Number of I/O Events

8.6.1 Number of I/O messages during evaluation

| | |
|---------------------------|-----------------------------------------------------------------------------------------------------|
| QME Category | Number of I/O Events |
| QME Name | Number of I/O messages during evaluation |
| QME ID | QME0601 |
| Detail | Run application and monitor result(s) I/O messages for specific evaluation. |
| Input | Operation report |
| Documentation | Measurement tool name and version Computer HW specification Operating system name and version |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | I/O loading limits |

8.6.2 Required maximum number of I/O messages

| | |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of I/O Events |
| QME Name | Required maximum number of I/O messages |
| QME ID | QME0602 |
| Detail | Required maximum number of I/O messages can be derived from specification of required real-time processing, user expectation of business needs, or observation of user reaction. A user cognitive aspect of human ergonomics may be considerable if required maximum number of I/O messages is not specified in requirements. Take into account that it can be different number for different user. |
| Inputs | Testing report Operation report showing elapse time |
| Documentation | Prediction model applied Historical data used |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Subjective |
| Used for | I/O loading limits |

8.6.3 Required maximum number of transmission related error messages and failures

| | |
|---------------------------|-----------------------------------------------------------------------------|
| QME Category | Number of I/O Events |
| QME Name | Required maximum number of transmission related error messages and failures |
| QME ID | QME0603 |
| Detail | This should be derived from requirements specifications |
| Input | REQ spec. |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Subjective |
| Used for | Maximum transmission utilization |

8.7 Number of Requirements

8.7.1 Number of access controllability requirements implemented correctly as in the specifications

| | |
|---------------------------|--------------------------------------------------------------------------------------------------------|
| QME Category | Number of Requirements |
| QME Name | Number of access controllability requirements implemented correctly as in the specifications. |
| QME ID | QME0701 |
| Detail | Count the number of access controllability requirements implemented correctly as in the specification. |
| Inputs | REQ spec. Design spec. Source code Review report |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Access controllability |

8.7.2 Number of access controllability requirements in the specifications

| | |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Requirements |
| QME Name | Number of access controllability requirements in the specifications |
| QME ID | QME0702 |
| Detail | Count the number of access controllability requirements in the specifications. Each counted requirement has to be categorized and weighted by its importance. |
| Input | REQ spec. |
| Documentation | List of access controllability requirements |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Access controllability |

8.8 Number of Restarts

8.8.1 Number of restarts which met required time during testing or user operation support

| | |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Restarts |
| QME Name | Number of restarts which met required time during testing or user operation support |
| QME ID | QME0801 |
| Detail | Count the number of attempts for a system to resume computation after a critical failure or system start, which met the set, required time. It means the number of system restart providing service to users within a required time. |
| Inputs | Test report Operation report REQ spec. |
| Documentation | Set time - time required to restart |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Restartability |

8.8.2 Total number of restarts during testing or user operation support

| | |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Restarts |
| QME Name | Total number of restarts during testing or user operation support |
| QME ID | QME0802 |
| Detail | Count the number of attempts for a system to resume computation after a critical failure or system start during the trial period |
| Inputs | Operation report Test report |
| Documentation | List of restart times and their reasons |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Restartability |

8.9 Number of Tasks

8.9.1 Number of accesses to help until a user completes his/her task

| | |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Tasks |
| QME Name | Number of accesses to help until a user completes his/her task |
| QME ID | QME0901 |
| Detail | Conduct user test and observe user behaviour. Count the number of cases that user accesses help to complete his/her task. All these counts must be performed with in the context of a proper experiment, where both tasks and subjects are a random selection from their respective populations. |
| Inputs | Operation report or Test report User monitoring record |
| Documentation | List of user tasks tested Record of accesses to help |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Help frequency |

8.9.2 Number of completed tasks

| | |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Tasks |
| QME Name | Number of completed tasks |
| QME ID | QME0902 |
| Definition | The total number of user tasks, which have been successfully completed during testing or operation. |
| Detail | Conduct user test and observe user behaviour or observe user behaviour during operation. Count the number of user tasks successfully completed. All these counts must be performed with in the context of a proper experiment, where both tasks and subjects are a random selection from their respective populations. |
| Inputs | Operation report or Test report User monitoring record |
| Documentation | List of user tasks successfully completed |
| Measurement scale | Ratio |
| Measurement focus | External |

| | |
|---------------------------|------------------------------------------------------------|
| Measurement method | Objective |
| Used for | Effectiveness of the user documentation and/or help system |

8.9.3 Number of tasks successfully completed after accessing online help and/or user documentation

| | |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Tasks |
| QME Name | Number of tasks successfully completed after accessing online help and/or user documentation |
| QME ID | QME0903 |
| Detail | Conduct user test and observe user behaviour or observe user behaviour during operation. Count the number of user tasks successfully completed after accessing online help and/or user documentation. All these counts must be performed with in the context of a proper experiment, where both tasks and subjects are a random selection from their respective populations. |
| Inputs | Operation report or Test report User monitoring record |
| Documentation | List of user tasks tested Record of completed tasks after accessing online help and/or user documentation. |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Effectiveness of the user documentation and/or help system |

8.9.4 Throughput

| | |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Tasks |
| QME Name | Throughput |
| QME ID | QME0904 |
| Detail | Execute a number of concurrent tasks. Count the number of job tasks completed in a given time period. Keep a record of each attempt. This QME needs to part of an experiment where operational profiles are used to determine appropriate task mixed. |
| Inputs | Testing report Operation report showing elapse time |
| Documentation | List of tasks executed during the testing Record of completed number of tasks for each time period |

| | |
|---------------------------|----------------------------------------------------------------|
| Measurement scale | Ratio |
| Measurement focus | External, Quality In Use |
| Measurement method | Objective |
| Used for | Mean throughput (mean amount of throughput) Task completion |

8.9.5 Total number of tasks tested

| | |
|---------------------------|-----------------------------------------------------------------------------------------------------|
| QME Category | Number of Tasks |
| QME Name | Total number of tasks tested |
| QME ID | QME0905 |
| Detail | Count the total number of user tasks tested. |
| Input | User monitoring record or Operation report |
| Documentation | List of user tasks tested |
| Measurement scale | Ratio |
| Measurement focus | External, Quality In Use |
| Measurement method | Objective |
| Used for | Effectiveness of the user documentation and/or help system Help accessibility Task completion |

8.10 Number of Test Cases

8.10.1 Number of passed test cases during testing or operation

| | |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Test Cases |
| QME Name | Number of passed test cases during testing or operation |
| QME ID | QME1001 |
| Detail | Count the number of test cases passed (with no deviations from the expected test case results) which have been actually executed during testing or operation. |
| Input | Test report |
| Documentation | List of test cases passed |
| Measurement scale | Ratio |

| | |
|---------------------------|---------------|
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Test maturity |

8.10.2 Number of performed test cases

| | |
|---------------------------|-----------------------------------------------------------------------------------------------|
| QME Category | Number of Test Cases |
| QME Name | Number of performed test cases during testing or operation |
| QME ID | QME1002 |
| Detail | Count the number of test cases which have been actually executed during testing or operation. |
| Input | Test report |
| Documentation | List of test cases applied |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Test maturity |

8.10.3 Number of test cases required

| | |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Test Cases |
| QME Name | Number of test cases required |
| QME ID | QME1003 |
| Detail | Count the number of test cases to be performed as per requirements. If the number of test cases is not defined in requirements specification, it should be defined in the test plan (covering all requirements). It is recommended to perform stress testing using live historical data especially from peak periods. It is also recommended to ensure that the following test types are executed and passed successfully: <ul style="list-style-type: none"> - User operation scenario; - Peak stress; Overloaded data input. |
| Input | REQ spec. Test plan |
| Documentation | List of test cases to be applied per requirement |

| | |
|---------------------------|---------------|
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Test maturity |

8.11 Number of Trials

8.11.1 Number of cases which a user succeeded to change install operation for his/her convenience

| | |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Trials |
| QME Name | Number of cases which a user succeeded to change install operation for his/her convenience |
| QME ID | QME1101 |
| Detail | Observe user's or maintainer's behaviour when user is trying to install software in operation environment. Count the number of cases, when user successfully installed the software product as expected. |
| Input | Test report |
| Documentation | List of test cases to be applied per requirement |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Ease of installation |

8.11.2 Number of evaluations

| | |
|----------------------|---------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Trials |
| QME Name | Number of evaluations |
| QME ID | QME1102 |
| Detail | Count the number of attempts to perform the iterations with same input under same scenario containing the system response |
| Inputs | Test spec. Operation report Test report |
| Documentation | Executed scenario Input to scenario |

| | |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | I/O loading limit Maximum memory utilization Maximum transmission utilization Mean occurrence of transmission error Mean response time (Mean time to response) Mean throughput (Mean amount of throughput) Mean turnaround time (Mean time for turnaround) |

8.11.3 Total number of cases which a user attempted to change install operation for his/her convenience

| | |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Number of Trials |
| QME Name | Total number of cases, which a user attempted to change install operation for his/her convenience |
| QME ID | QME1103 |
| Detail | Observe user's or maintainer's behaviour when user is trying to install software to operation environment. Count the number of cases, when user tried to install the software product. |
| Input | Test report |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Ease of installation |

8.12 Product Size

8.12.1 Product Size

| | |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Product Size |
| QME Name | Non-comment source statements (NCSS) Product Size |
| QME ID | QME1201 |
| Detail | Count the non-comment source statements (NCSS) that include executable statements and data declaration statements with logical source statements. |

| | |
|---------------------------|--------------------------------------------------|
| Inputs | Source code |
| Documentation | Programming language |
| Measurement scale | Ratio |
| Measurement focus | Internal |
| Measurement method | Objective |
| Used for | Estimated latent fault density, Fault Density |

8.13 Time Duration

8.13.1 Failure resolution time

| | |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Time Duration |
| QME Name | Failure resolution time |
| QME ID | QME1301 |
| Detail | Time measured externally by the observer, using an external clock, identifying the duration of the failure resolution (the time duration between failure occurrence and its final resolution). |
| Inputs | Operation report Test report |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Mean time between failures (MTBF) |

8.13.2 Operation time

| | |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Time Duration |
| QME Name | Operation time |
| QME ID | QME1302 |
| Detail | Time measured externally by the observer, using an external clock, identifying the duration when the software is under discrete operation or continuous operation. In intermittent operation mode, it should be assumed that the time measurement is done only for the period when the software is active. |

| | |
|---------------------------|--------------------------------------------------------------------------|
| Inputs | Operation report |
| Documentation | |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Computational accuracy Mean time between failures (MTBF) Precision |

8.13.3 Response time

| | |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Time Duration |
| QME Name | Response time |
| QME ID | QME1303 |
| Detail | Execution time (or observation time) interval between user action and system response for specific user operation. Response time is usually a measure of an interactive system's efficiency that tracks the speed with which the system will respond to a user's command. |
| Inputs | Test report Operation report Special computer message |
| Documentation | Measurement method (execution or observation time) User operation identification Record of response time for each user operation |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Mean response time (Mean time to response) |

8.13.4 Task time

| | |
|---------------------|-----------------------------------------------------------------------------------|
| QME Category | Time Duration |
| QME Name | Task time |
| QME ID | QME1304 |
| Detail | Task time is usually a measured for a user attempting to fulfil a specified task. |

| | |
|---------------------------|------------------------------------------------------------------------------------------------------|
| Inputs | Test report Operation report |
| Documentation | Task description User operation identification Record of response time for each user operation |
| Measurement scale | Ratio |
| Measurement focus | Quality in Use |
| Measurement method | Objective |
| Used for | Task time |

8.13.5 Turnaround time

| | |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QME Category | Time Duration |
| QME Name | Turnaround time |
| QME ID | QME1305 |
| Detail | Emulate a condition where a load is placed on the system by executing a number of concurrent tasks (sample shot). Measure the time it takes to complete the selected job task in the given traffic with given input data. Keep a record of each attempt. |
| Inputs | Operation report showing elapse time Test report |
| Documentation | List of tasks executed during the testing Record of turnaround time for each task |
| Measurement scale | Ratio |
| Measurement focus | External |
| Measurement method | Objective |
| Used for | Mean turnaround time (Mean time for turnaround) |

Annex A
(informative)

Selected quality measures

Listed quality measures arise from research projects described in Introduction. They represent a default kernel of quality measures, which are proven to be used in common practice. They are also used and described in other documents, together with a wide range of other measurements that are required for more specific purposes. These documents are the ISO/IEC TR 9126-2, ISO/IEC TR 9126-3 and ISO/IEC TR 9126-4.

NOTE This set does not contain information for all ISO/IEC 9126-1 Quality Model subcharacteristics. Some subcharacteristics were omitted, because survey results did not find evidence of their use. It does not imply the ISO/IEC 9126-1, Quality Model should be changed, but rather the new quality measures should be defined in the future.

Table A.1 — Set of Quality Measures

| Document | Quality Characteristics | Quality Subcharacteristics | Quality Measure Name | Number of QME defined for this Quality Measure |
|----------------------------------------------------|-------------------------|----------------------------|------------------------------------------|------------------------------------------------|
| External Quality Measures ISO/IEC TR 9126-2 | Functionality | Suitability | Functional implementation completeness | 2 |
| | | | Functional adequacy | 2 |
| | | | Functional implementation coverage | 2 |
| | | Accuracy | Computational accuracy | 3 |
| | | | Precision | 3 |
| | | Interoperability | Data exchangeability (Data format based) | 2 |
| | | Security | Access controllability | 2 |
| | Reliability | Maturity | Estimated latent fault density | 3 |
| | | | Failure density against test cases | 1 |
| | | | Failure resolution | 2 |
| | | | Fault density | 2 |
| | | | Fault removal | 3 |
| | | | Mean time between failures (MTBF) | 2 |

| Document | Quality Characteristics | Quality Subcharacteristics | Quality Measure Name | Number of QME defined for this Quality Measure |
|----------|-------------------------|----------------------------|------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|
| | | | Test maturity | 2 |
| | | Recoverability | Restartability | 2 |
| | Usability | Understandability | Completeness of description | 2 |
| | | | Function understandability | 2 |
| | | | Understandable input and output | 2 |
| | | Learnability | Effectiveness of the user documentation and/or help system | 2 |
| | | | Help accessibility | 1 |
| | | Operability | Physical accessibility | 2 |
| | Efficiency | Time Behaviour | Mean response time (Mean time to response) | 3 |
| | | | Mean throughput (Mean amount of throughput) | 2 |
| | | | Mean turnaround time (Mean time for turnaround) | 3 |
| | | Resource Utilization | I/O loading limits | 3 |
| | | | Maximum memory utilization | 1 |
| | | | Maximum transmission utilization | 2 |
| | | | Mean occurrence of transmission error | 3 |
| | Maintainability | Analyzability | Audit trail capability | 2 |
| | | Changeability | Software change control capability | 2 |
| | Portability | Adaptability | Adaptability of data structures | 2 |
| | | | Hardware environmental adaptability (adaptability to hardware devices and network facilities) | 2 |
| | | | System software environmental adaptability (adaptability to OS, network software and co-operated application software) | 2 |
| | | Installability | Ease of installation | 2 |

| Document | Quality Characteristics | Quality Subcharacteristics | Quality Measure Name | Number of QME defined for this Quality Measure | |
|----------------------------------------------------|--------------------------------------------------|----------------------------|------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|---|
| Internal Quality Measures ISO/IEC TR 9126-3 | Functionality | Suitability | Functional implementation completeness | 2 | |
| | | | Functional adequacy | 2 | |
| | | | Functional implementation coverage | 2 | |
| | | Accuracy | Computational accuracy | 3 | |
| | | | Precision | 3 | |
| | | Interoperability | Data exchangeability (Data format based) | 2 | |
| | | Security | Access controllability | 2 | |
| | Reliability | Maturity | Fault removal | 3 | |
| | Usability | Understandability | Completeness of description | 2 | |
| | | | Function understandability | 2 | |
| | | Learnability | Completeness of user documentation and/or help facility | 2 | |
| | | Operability | Physical accessibility | 2 | |
| | Portability | Adaptability | Adaptability of data structures | 2 | |
| | | | Hardware environmental adaptability (adaptability to hardware devices and network facilities) | 2 | |
| | | | System software environmental adaptability (adaptability to OS, network software and co-operated application software) | 2 | |
| | Quality in Use Measures ISO/IEC TR 9126-4 | Effectiveness | | Task completion | 2 |
| | | Productivity | | Task time | 1 |

Annex B (informative)

Cross reference table between quality measures and quality measure element categories

Following table depicts the relationship (cross-reference) between quality measures and quality measure element categories listed in this Technical Report. Values in columns are showing the number of quality measure elements in relevant QME category defined for each quality measure.

NOTE This set does not contain information for all ISO/IEC 9126-1 Quality model subcharacteristics. Some subcharacteristics were omitted, because survey results did not find evidence of their use. It does not imply the ISO/IEC 9126-1 Quality model should be changed, but rather the new quality measures should be defined in the future.

Table B.1 — Cross Reference table between quality measures and quality measure element categories

| Document | Quality Characteristics | Quality Subcharacteristics | Quality Measure Name | Data Size | Number of I/O | Number of Data Items | Number of Failures | Number of Faults | Number of Functions | Number of Requirements | Number of Restarts | Number of Tasks | Number of Test Cases | Number of Trials | Product Size | Time Duration | |
|------------------------------------------------|-------------------------|----------------------------|------------------------------------------|-----------|---------------|----------------------|--------------------|------------------|---------------------|------------------------|--------------------|-----------------|----------------------|------------------|--------------|---------------|---|
| External Quality Measures ISO/IEC TR 9126-2 | Functionality | Suitability | Functional implementation completeness | | | | | | 2 | | | | | | | | |
| | | | Functional adequacy | | | | | | 2 | | | | | | | | |
| | | | Functional implementation coverage | | | | | | | 2 | | | | | | | |
| | Accuracy | | Computational accuracy | | | | | | | 2 | | | | | | | 1 |
| | | | Precision | | | | | | | | | | | | 2 | | 1 |
| | Interoperability | | Data exchangeability (Data format based) | | | 1 | | | | | | | | | 1 | | |
| | | | Access controllability | | | | 2 | | | | | | | | | | |

| Document | Quality Characteristics | Quality Subcharacteristics | Quality Measure Name | Data Size | Number of I/O | Number of Data Items | Number of Failures | Number of Faults | Number of Functions | Number of Requirements | Number of Restarts | Number of Tasks | Number of Test Cases | Number of Trials | Product Size | Time Duration |
|----------|-------------------------|----------------------------|------------------------------------------------------------|-----------|---------------|----------------------|--------------------|------------------|---------------------|------------------------|--------------------|-----------------|----------------------|------------------|--------------|---------------|
| | Reliability | Maturity | Estimated latent fault density | | | | 2 | | | | | | | | 1 | |
| | | | Failure density against test cases | | | | 1 | | | | | | | | | |
| | | | Failure resolution | | | | 2 | | | | | | | | | |
| | | | Fault density | | | | 1 | | | | | | | | 1 | |
| | | | Fault removal | | | | 3 | | | | | | | | | |
| | | | Mean time between failures (MTBF) | | | | 1 | | | | | | | | 1 | |
| | | | Test maturity | | | | | | | | | | 2 | | 1 | |
| | | Recoverability | Restartability | | | | | | | | 2 | | | | | |
| | Usability | Understandability | Completeness of description | | | | | 2 | | | | | | | | |
| | | | Function understandability | | | | | 2 | | | | | | | | |
| | | | Understandable input and output | | | | | | | | | | | | | |
| | | Learnability | Effectiveness of the user documentation and/or help system | 1 | | 2 | | | | | | | | | | |
| | | | Help accessibility | | | | | | | 1 | | | | | | |
| | | Operability | Physical accessibility | | | | | 2 | | | | | | | | |
| | Efficiency | Time Behaviour | Mean response time (Mean time to response) | | | | | | | | | 1 | | | | 2 |

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