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Contents

Page

Foreword ... **iv**

Introduction ... **v**

1 Scope ... **1**

2 Normative references ... **1**

3 Terms and definitions ... **1**

4 Requirements for process measurement frameworks ... **4**
4.1 Conceptualization ... 4
4.1.1 Requirements ... 4
4.1.2 Guidance ... 4
4.2 Construct definition ... 4
4.2.1 Requirements ... 4
4.2.2 Guidance ... 5
4.3 Operationalization ... 5
4.3.1 Requirements ... 5
4.3.2 Guidance ... 5
4.4 Construct specification examination ... 5
4.4.1 Requirements ... 5
4.4.2 Guidance ... 5
4.5 Rating process attributes ... 6
4.5.1 Requirements ... 6
4.5.2 Guidance ... 6
4.6 Aggregation ... 7
4.6.1 Requirements ... 7
4.6.2 Guidance ... 7
4.7 Sensitivity analysis ... 8
4.7.1 Requirements ... 8
4.7.2 Guidance ... 8

5 Requirements for the validation of process measurement frameworks ... **8**
5.1 Requirements ... 8
5.2 Guidance ... 8
5.2.1 Reliability ... 9
5.2.2 Construct validity ... 9
5.2.3 Construct specification ... 9

6 Verifying conformity of process measurement frameworks ... **9**

Annex A (informative) **A terminology map** ... **11**

Annex B (informative) **Construct specification: Reflective or formative** ... **13**

Annex C (informative) **Some statistical validation methods** ... **15**

Annex D (informative) **Methods for implementing the requirements for process measurement frameworks** ... **18**

Bibliography ... **20**

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.

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

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

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

Introduction

This International Standard provides requirements for process measurement frameworks that support and enable the assessment of process quality characteristics, from conceptualization to empirical validation. In process measurement frameworks, measurement of a process quality characteristic produces a composite measure (e.g. process capability levels of ordinal scale in ISO/IEC 33020). Examples of process quality characteristics that are constructs (theoretical concepts) include process capability, process security, process agility, and process safety. The main users of this International Standard are developers of process measurement frameworks and process assessment models. Conformity to this International Standard ensures that any process measurement framework is developed with reliable structures or elements which will generate quality composite measures.

This International Standard is part of a set of International Standards designed to provide a consistent and coherent framework for the assessment of process quality characteristics, based on objective evidence resulting from implementation of the processes. The framework for assessment covers processes employed in the development, maintenance, and use of systems across the information technology domain and those employed in the design, transition, delivery, and improvement of services. The set of International Standards, as a whole, addresses process quality characteristics of any type. Results of assessment can be applied for improving process performance, or for identifying and addressing risks associated with application of processes.

This International Standard provides requirements for the development of process measurement frameworks, such as ISO/IEC 33020. These can then be used to define process assessment models, conformant to ISO/IEC 33004, that can be employed for process assessments conformant with ISO/IEC 33002. The overall architecture and content of the series is described in ISO/IEC 33001.

Several International Standards in the ISO/IEC 330xx family of standards for process assessment are intended to replace and extend parts of the ISO/IEC 15504 series of Standards. ISO/IEC 33001, Annex A provides a detailed record of the relationship between the ISO/IEC 330xx family and the ISO/IEC 15504 series.

Information technology — Process assessment — Requirements for process measurement frameworks

1 Scope

This International Standard sets out the requirements for process measurement frameworks for use in process assessment. The requirements defined in this International Standard form a structure which

a) establish the requirements for process measurement frameworks in the context of process assessment,

b) establish the requirements for the validation of process measurement frameworks for use in process assessment, and

c) establish requirements that are applicable to any process measurement frameworks to develop composite measures across domains.

This International Standard is applicable to the development of process measurement frameworks for any process quality characteristic across all application domains.

Annex A presents a map of terminologies used in this International Standard. Annex B provides an explanation of construct specifications. Annex C reviews statistical validation methods. Annex D provides some methods including references that can be utilized in implementing the requirements for process measurement frameworks. These Annexes will be moved to a guide for constructing process measurement frameworks to be developed as part of the set of International Standards.

NOTE ISO/IEC 33020 is a process measurement framework for assessment of process capability based on this International Standard.

2 Normative references

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

ISO/IEC 15939:2007, *Systems and software engineering — Measurement process*

ISO/IEC 33001:2015, *Information technology — Process assessment — Concepts and terminology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 33001, ISO/IEC 15939, and the following apply:

3.1
aggregation method
method that combines a set of measurement values to create a composite value

Note 1 to entry: Aggregation methods are based on compensatory or non-compensatory models.

3.2
compensatory model
MCDM model in which a composite measure is composed of individually weighted terms and where criteria (also refer to attribute terms) with a high value can compensate for those of a low value in proportion to each weight

Note 1 to entry: A compensatory model suggests that improving the more important measures (those with a higher weighting) is more likely to increase or improve the overall composite value than improving the less important ones. This model assumes that the weight (influence level) of criteria remains the same regardless of the measured level of the criteria.

3.3
composite measure
variable derived from a set of operations of a construct's multi-item measures defined according to construct specification (either reflective or formative) that is the way in which the latent variable representing the construct of interest is linked to its measures

3.4
composite value
value from a composite measure

Note 1 to entry: A composite value can be from an ordinal, interval, or ratio scale.

3.5
construct
concept such as the abstract idea, image, underlying theme, or subject matter that one wishes to measure using process assessments

Note 1 to entry: In process measurement frameworks, constructs (also refers to latent constructs) are theoretical concepts such as the process quality characteristics and process attributes.

Note 2 to entry: The meaning that one assigns to a construct is called theoretical definition, which should explain its meaning, as well as discuss its distinct dimensions (facets).

3.6
dimension
distinct components that a multidimensional construct encompasses

3.7
formative construct
construct that is formed from its observed measures in the relationship between a construct and its measures

Note 1 to entry: The construct is a consequence of its measures and each measure is a determinant of the construct.

3.8
latent variable
variable representing a unidimensional construct

Note 1 to entry: There should be a separate latent variable for each dimension of a construct and a minimum of one measure per latent variable.

3.9
MCDM
Multiple-Criteria Decision Making or Multi-Attribute Decision Making
making preference decisions (e.g., evaluation, prioritization, and selection) of available alternatives characterized by multiple criteria

Note 1 to entry: A criterion in MCDM corresponds to measure.

Note 2 to entry: An MCDM with one alternative is the same as the development of a composite measure.

3.10
measurement model
the implicit or explicit relationship between a latent variable and its (multi-item) measures

Note 1 to entry: The relationship between a reflective (formative) construct and its measure(s) is called a reflective (formative) measurement model.

3.11
multidimensional construct
construct that consists of a number of unidimensional constructs.

Note 1 to entry: Each dimension of a multidimensional construct is called unidimensional and is represented by one latent variable. Each dimension can have multiple measures. In a multidimensional construct, for example, the meaning of capability when it is defined as the common factor underlying its process attributes is different from the case when capability is defined as a simple sum of its process attributes. The former is called a reflective multidimensional construct and the latter is formative. A multidimensional construct can span an indeterminate number of levels.

3.12
non-compensatory model
MCDM model that does not allow criteria to compensate for each other in proportion to their weights

Note 1 to entry: Strongly positive or negative terms influence the overall composite value disproportionately, although the weight stays the same. There are various non-compensatory models depending on the evaluation policy, the purpose of the composite measure, and/or the measurement scale.

3.13
reflective construct

construct that is viewed as the cause of measures in the relationship between a construct and its measures

Note 1 to entry: Reflective construct is an underlying factor of the variation of its measures.

3.14
scale
ordered set of values, continuous, or discrete, or a set of categories to which the attribute is mapped

Note 1 to entry: The type of scale depends on the nature of the relationship between values on the scale. Four types of scales are commonly defined:

Nominal — the measurement values are categorical. For example, the classification of defects by their type does not imply order among the categories.

Ordinal — the measurement values are rankings. For example, the assignment of defects to a severity level is a ranking.

Interval — the measurement values have equal distances corresponding to equal quantities of the attribute. For example, cyclomatic complexity has the minimum value of one, but each increment represents an additional path. The value of zero is not possible.

Ratio — the measurement values have equal distances corresponding to equal quantities of the attribute where the value of zero corresponds to none of the attribute. For example, the size of a software component in terms of LOC is a ratio scale because the value of zero corresponds to no lines of code and each additional increments represents equal amounts of code.

[SOURCE: ISO/IEC 15939:2007]

3.15
unidimensionality
existence of a single trait or construct underlying a set of measures

4 Requirements for process measurement frameworks

This clause defines the requirements for developing process measurement frameworks. Guidance in this International Standard is limited to providing a better understanding of these requirements. Figure A.1 provides a mapping of the relationships between some terms used in this Clause.

NOTE Guidance on achieving conformance to these requirements, including examples and methods, will be provided in a guide for constructing process measurement frameworks to be developed as part of the set of Standards.

4.1 Conceptualization

4.1.1 Requirements

a) A measurement framework shall identify and address a single process quality characteristic;

b) A process quality characteristic in a process measurement framework shall be defined on the basis of a multidimensional construct;

c) A process quality characteristic in a process measurement framework shall be defined as a set of process attributes;

d) Each process attribute shall define a property of the process quality characteristic;

e) Each process attribute that is not directly measurable shall be considered as a construct;

f) Process attributes in a process measurement framework shall be defined as either reflective or formative.

g) The measurement framework shall document the policies and assumptions underlying its use and application;

4.1.2 Guidance

The process of identifying and clarifying concepts is called conceptualization. A concept is an idea or image that unites phenomena of interest (e.g., traits, behaviour traits) under a single term. It is a summarizing device to replace a list of specific traits. Most process quality characteristics (e.g., process capability) are not observable but are theoretical concepts called constructs.

The composite measures (e.g., process capability level) used in process measurement frameworks are defined on the basis of a construct composed of process attributes. A measurement framework may be structured into a series of levels of achievement.

When a process attribute is not directly measurable, it may also be defined as a construct. The set of process attributes for any construct may be either reflective or formative.

Participation of experts and stakeholders can increase the validity of the process quality characteristic and its process attributes; aspects of validity are discussed in C.3.

A multidimensional construct can be depicted with a path diagram including a set of dimensions and their relationships. Use of a path diagram improves the understandability of model scope and structures.

4.2 Construct definition

4.2.1 Requirements

a) The construct definition shall define the meaning of the process quality characteristic and its process attributes in a process measurement framework;

b) The construct definition shall clarify the specification of the process quality characteristic and its process attributes as dimensions;

c) The construct definition shall provide a guide for the operationalization of the process quality characteristic and its process attributes;

d) The construct definition shall state the scales of composite measures such as categorical (e.g., a series of ordinal values such as capability level) or numeric;

e) At least one of the process attributes shall comprise the achievement of the defined process purpose and process outcomes for the process; this is termed the process performance attribute;

4.2.2 Guidance

Although a process quality characteristic or process attribute should convey an intuitive understanding of what it represents, interpretation may vary according to the observer. Thus, a definition is required to explain and provide the meaning of a construct. This is called the construct definition.

Clarification of a construct implies that for example the definition of the process quality characteristic as specified super-ordinate fully covers all of process attributes on the basis of construct specification, where process attributes as sub-ordinates are its distinct dimensions. A latent variable can be assigned to a unidimensional construct in the model. Statistical methods related to dimensionality are introduced in C.1.

4.3 Operationalization

4.3.1 Requirements

a) All process attributes shall be defined according to their construct specification;

b) Achievement of process attributes shall be verifiable through objective evidence.

4.3.2 Guidance

When a process attribute is directly observable through formal assessments, self-reports, surveys (including questionnaires and interviews), observations, or other empirical means, it is a base measure that is functionally independent of other measures. If a process attribute is measured with its several sub-constructs or measures, it can be considered as a construct. Four or more base measures are recommended to measure a construct and perform a set of statistical tests (including model validation and construct specifications) in reflective specification.

NOTE Refer to Clause 6.3.4 of ISO/IEC 33004 for assessment indicators that are utilized for process attribute rating.

4.4 Construct specification examination

4.4.1 Requirements

Construct specifications of the process quality characteristic and its associated process attributes shall be examined through operationalization and with rationale.

4.4.2 Guidance

There are two kinds of construct specifications that refer to the way in which the latent variable representing the construct is linked to its measures (i.e., the relationship between a unidimensional construct and its measures): reflective and formative measurement models. A process quality characteristic or process attribute can be viewed either as underlying factors or indices produced by observed measures. The former is referred to as reflective (effect) constructs or reflective measurement models, and the latter formative (causal) constructs or formative measurement models.

The objective of a reflective measurement model is to measure a single property by using multiple measures, whereas a formative model attempts to summarize multiple properties with a single

composite value. In Annex B, these two specifications can be represented as Figure B.1 (a) and Figure B.1 (b), respectively.

Decision rules to examine reflective or formative, construct specification, are summarized in Table 1. These decision rules can be applied to the process quality characteristic and its associated process attributes. They can be assessed *a priori* statistical validation of construct specification. Annex B provides the construct specification in detail.

Table 1 — Decision rules to examine reflective or formative measurement model

Decision rule	Reflective measurement model	Formative measurement model
Characteristics of measures of the construct	• Measures are manifestations of the construct. • Measures share a common theme. • Measures should be interchangeable. • Measures should have the same or similar content. • Excluding a measure should not alter the conceptual domain of the construct. • Measures are expected to co-vary with one other.	• Measures are defining characteristics (aspects) of the construct. • Measures need not share a common theme. • Measures need not be interchangeable. • Measures need not have the same or similar content. • Excluding a measure may alter the conceptual domain of the construct. • Measures need not co-vary with one another.
Direction of causality between construct and measures	• The direction of causality is from the construct to its multi-item measures. • Changes in a measure should not cause to changes in the construct.	• The direction of causality is from measures to the construct. • Changes in the construct should not cause changes in the measures.

In some instances, the relationships depicted in Figure B.1 (Annex B) can have a higher-order level, i.e., conceptual definitions of constructs are often specified at a more abstract level, which sometimes include multiple reflective and/or formative first-order dimensions. The definition of a higher-order model should be theory-driven in a reflective measure model. Statistical analyses should be used to support or validate the definition.

4.5 Rating process attributes

4.5.1 Requirements

a) The process attributes shall be rated;

b) A measurement scale, i.e., nominal, ordinal, interval, or ratio, shall be defined for the process attributes;

c) A measurement method shall be identified that objectively assigns a value to each process attribute.

4.5.2 Guidance

Some assessments can generate the ratings of for example a process quality characteristic or process attributes for individual process instances assessed. On the other hand, others providing an overall picture without ratings can simultaneously assess a set of process instances under the same context as a process. Rating of process attributes can be based on formal assessments, self-reports, surveys (including questionnaires and interviews), observations, or other empirical means. Thus, a measurement scale for rating base measures should be consistent with the granularity of assessment. Occasionally, rating in self-reports or surveys is on the base of perception rather than objective evidence. Rating scale for the process quality characteristic and its process attributes should be addressed with rationale, consistent with the construct specification (refer to 4.3).

A well-established documented assessment process for rating process attributes provides credible measurement results. The approach to rating the process attributes shall be defined in the documented assessment process, and may depend on the class of the assessment, based on the assessment objectives. Thus, for this purpose, a documented assessment process will guide the process for establishing, planning, performing and evaluating assessment under an integrated assessment scheme. If there

