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Information technology — Process assessment — Process measurement framework for assessment of process capability

Technologies de l'information — Évaluation du processus — Cadre de mesure du processus pour évaluer la capacité du processus

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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.

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) or the IEC list of patent declarations received (see http://patents.iec.ch).

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

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

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

This second edition cancels and replaces the first edition (ISO/IEC 33020:2015), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the definitions of process capability levels and process attributes in 5.2, to improve consistency with ISO 9001:2015;

— two additional annexes are included, following Annex A; these are numbered as Annex B (Indicators of process capability) and Annex C (Guidance on the process assessment framework);

— the original Annex B has been relocated as Annex D (Example of a process performance model).

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

Introduction

This document defines a process measurement framework for the process quality characteristic of process capability. The process measurement framework in this document conforms to the requirements of ISO/IEC 33003 and is applicable to any domain. The process measurement framework can be included in any process assessment model for the assessment of process capability, as specified in ISO/IEC 33004.

This document is primarily addressed to developers of process assessment models for the process quality characteristic of process capability. It is also addressed to the lead assessor and other stakeholders, such as the sponsor of the assessment, who need to be assured that the requirements of this process measurement framework have been met.

This document 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 set of International Standards, as a whole, addresses process quality characteristics of any type. Results of assessment can be applied for improving process performance, benchmarking, or for identifying and addressing risks associated with application of processes.

The set of International Standards ISO/IEC 33001 to ISO/IEC 33099, termed the ISO/IEC 330xx family, defines the requirements and resources needed for process assessment. The overall architecture and content of the series is described in ISO/IEC 33001. General issues relating to the application of conformity assessment to the assessment of process quality characteristics and organizational process maturity are addressed in ISO/IEC 29169.

Several standards in the ISO/IEC 330xx family for process assessment are intended to replace and extend parts of the ISO/IEC 15504 series. This document is intended to replace ISO/IEC 15504-2:2003, Clause 5. ISO/IEC 33001:2015, 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 — Process measurement framework for assessment of process capability

1 Scope

This document defines a process measurement framework that supports the assessment of process capability, in accordance with the requirements of ISO/IEC 33003. The process measurement framework provides a schema that can be used to construct a process assessment model conformant with ISO/IEC 33004 which can be used in the performance of assessment of process capability according to the requirements of ISO/IEC 33002. In the context of this document and related standards, process capability is a process quality characteristic related to the ability of a process to consistently meet current or projected business goals.

The process measurement framework defined in this document forms a structure which

a) facilitates self-assessment,

b) provides a basis for use in process improvement and process quality determination,

c) is applicable across all application domains and sizes of organization,

d) produces a set of process (capability) attribute ratings (process profile), and

e) derives a process capability level.

This document also includes as informative annexes a set of assessment indicators of process capability that can be used in the construction of a process assessment model using this process measurement framework, and guidance on the meaning of the process capability levels and the achievement of the process attributes.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO/IEC 33003, *Information technology — Process assessment — Requirements for process measurement frameworks*

3 Terms and definitions

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

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

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

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

3.1
conformity
fulfilment of a requirement

Note 1 to entry: In English the word "conformance" is synonymous but deprecated. In French the word "compliance" is synonymous but deprecated.

[SOURCE: ISO 9000:2015, 3.6.11, modified — Note 2 to entry has been removed.]

3.2
documented information
information required to be controlled and maintained by an organization and the medium on which it is contained

Note 1 to entry: Documented information can be in any format and media and from any source.

Note 2 to entry: Documented information can refer to:

— the management system, including related processes;

— information created in order for the organization to operate (documentation);

— evidence of results achieved (records).

Note 3 to entry: This constitutes one of the common terms and core definitions for ISO management system standards given in Annex SL of the Consolidated ISO Supplement to the ISO/IEC Directives, Part 1.

[SOURCE: ISO 9000:2015, 3.8.6]

3.3
nonconformity
non-conformity
non-fulfillment of a requirement

[SOURCE: ISO/IEC/IEEE 24765:2017, 3.2615, modified — The admitted term "non-conformity" has been added.]

3.4
process capability
characterization of the ability of a process to meet current or projected business goals

3.5
process capability level
characterisation of a process on an ordinal measurement scale of *process capability* (3.4)

4 Overview

The process measurement framework for assessment of process capability described in this document is expressed in terms of a set of process attributes. Each process attribute is defined in terms of a set of process attribute outcomes which can be evaluated to indicate the extent of achievement of the process attribute. The process attributes are organised into process capability levels, ranging from Incomplete (in which the process does not achieve its defined process outcomes) to Innovating (in which the process is continually improved to respond to organizational change). The process measurement framework for assessment of process capability shall be conformant with the requirements for process measurement frameworks in ISO/IEC 33003. Annex A documents the conformance of the measurement framework.

In addition to the definitions of process capability levels and process attributes, this document contains in Annex B, a set of assessment indicators of process capability comprising generic practices for each process attribute. The document also includes, in Annex C, detailed guidance on the use and application of the measurement framework, and in Annex D, an example of a process performance model.

The result of an assessment, using a process assessment model that incorporates this process measurement framework, will be a set of process profiles — ratings of the achievement of the set of process attributes for each process in the scope of the assessment. The result can also be expressed in terms of the capability level ratings achieved for each process in the assessment scope. A capability level rating does not guarantee that an organization will perform its processes at any given process capability level, simply that it is capable of performing its processes at that level.

Users of this document may reproduce 5.2, 5.3, 5.4, 5.6 and Annex B as part of any process assessment model or maturity model so that it can be used for its intended purpose.

5 A process measurement framework for process capability

5.1 General

This clause defines a process measurement framework for the assessment of process capability, conformant with the requirements of ISO/IEC 33003. This process measurement framework provides a schema that can be used to construct a process assessment model for assessing process capability.

Within this process measurement framework, the measure of capability is based upon a set of process attributes. Each process attribute defines a measurable property of process capability. The extent of process attribute achievement is characterised on a defined rating scale. The process capability level for an assessed process is derived from the set of process attribute ratings represented in the process profile.

The achievement of one process attribute may be associated with the achievement of another process attribute within the process measurement framework.

5.2 Process capability levels and process attributes

5.2.1 General

Process capability is defined on a six-point ordinal scale that enables capability to be assessed from the bottom of the scale, **Incomplete**, through to the top end of the scale, **Innovating**. The scale represents increasing capability of the implemented process, from failing to achieve the process purpose through to continually improving and able to respond to organizational change.

5.2.2 Process capability Level 0: Incomplete process

The process is not implemented or fails to achieve its process purpose.

At this level there is little or no evidence of any systematic achievement of the process purpose.

5.2.3 Process capability Level 1: Performed process

5.2.3.1 General

The implemented process achieves its process purpose. The following process attribute demonstrates the achievement of this level.

5.2.3.2 PA 1.1 Process performance process attribute

The process performance process attribute is a measure of the extent to which the process purpose is achieved. As a result of full achievement of this process attribute:

a) The process achieves its defined process outcomes.

5.2.4 Process capability Level 2: Managed process

5.2.4.1 General

The previously described *Performed process* is now implemented in a managed fashion (planned, monitored and adjusted) and its documented information are appropriately established, controlled and maintained.

The following process attributes, together with the previously defined process attribute, demonstrate the achievement of this level.

5.2.4.2 PA 2.1 Performance management process attribute

The performance management process attribute is a measure of the extent to which the performance of the process is managed with necessary resources and competences. As a result of full achievement of this process attribute:

a) results to be achieved are determined and communicated;

b) risks that can affect performance of the process are determined and addressed;

c) performance of the process is planned, monitored, measured, evaluated and adjusted (as needed);

d) responsibilities and authorities for performing the process are determined, assigned and communicated;

e) resources necessary for performing the process are determined, provided and maintained (as needed);

f) person(s) performing the process are competent on the basis of appropriate education, training, or experience;

g) interfaces between the involved parties are managed to ensure both effective communication and the level of control expected.

NOTE 1 Results to be achieved can include quality criteria for documented information, process cycle time or frequency, resource usage and boundaries of the process.

NOTE 2 Techniques for progress monitoring and evaluation can include milestone achievement and percentage complete towards next milestones, elapsed time compared to estimated time of activities, actual resource usage compared against planned requirements, experienced people estimate of percentage complete of activities or work packages, burn down charts representing measurable progress such as outstanding work (or backlog) over time (or story points).

NOTE 3 Resources include people, infrastructure, and environment for the operation of processes. Infrastructure can include buildings and associated utilities, equipment (including hardware and software), transportation resources and information and communication technology. A suitable environment can be a combination of human and physical factors including social and psychological environmental factors. Resources include internal and external resources and can include customers and users. The term 'resources' is defined in ISO/IEC/IEEE 24765.

NOTE 4 Applicable actions to acquire necessary competences can include, for example, the provision of training to, the mentoring of, or the re-assignment of persons, or the hiring or contracting of competent persons.

NOTE 5 Addressing risk establishes a basis for achieving improved results and preventing negative effects. Actions taken to address risks should be proportionate to the potential impact. Options to address risk can include avoiding the risk, taking risk in order to pursue an opportunity, eliminating risk source, changing the likelihood or consequences, sharing the risk, or retaining risk by informed decision.

5.2.4.3 PA 2.2 Documented information management process attribute

The documented information management process attribute is a measure of the extent to which the documented information produced internally, or acquired from an external source when performing the process is appropriately managed. As a result of full achievement of this process attribute:

a) requirements for the documented information of the process are determined;

b) requirements for control of the documented information are determined;

c) documented information is appropriately identified, and controlled according to requirements;

d) documented information is reviewed and approved for suitability and adequacy in accordance with planned arrangements and adjusted as necessary to meet requirements;

e) documented information is determined, maintained and retained to the extent necessary to have confidence that the process has been performed as planned and to demonstrate the conformity of products and/or services to their requirements.

NOTE 1 Requirements for the control of documented information can include requirements for the identification and description, format and media, and control of changes (e.g. version control), distribution, retrieval and use, storage and preservation, including preservation of legibility, retention and disposition, and for making it available and suitable for use when and where it is needed.

NOTE 2 The documented information referred to in this clause is that which results from the achievement of the process purpose through the process outcomes.

5.2.5 Process capability Level 3: Established process

5.2.5.1 General

The previously described *Managed process* is now implemented using a defined process which is assured and continually improved.

The following process attributes, together with the previously defined process attributes, demonstrate the achievement of this level.

5.2.5.2 PA 3.1 Process definition process attribute

The process definition process attribute is a measure of the extent to which a standard process is established and maintained. As a result of full achievement of this process attribute:

a) a standard process, including appropriate tailoring guidelines, is established and maintained that describes the fundamental elements that must be incorporated into a defined process;

b) the required inputs and the expected outputs for the *standard* process are determined;

c) sequence and interaction of the *standard* process with other processes is determined;

d) roles, competences, responsibilities and authorities for performing the *standard* process are determined;

e) resources for performing the *standard* process are determined;

f) knowledge necessary for the operation of the *standard* process is determined and maintained.

NOTE Knowledge can be based on internal sources (e.g. intellectual property, knowledge gained from experience, lessons learned, and the results of improvements in the process) and external sources (e.g. standards, academia, conferences, customers and external providers).

When addressing changing needs and trends, the need to acquire or access any necessary additional knowledge and required updates should be considered.

5.2.5.3 PA 3.2 Process deployment process attribute

The process deployment process attribute is a measure of the extent to which a standard process is deployed as a defined process. As a result of full achievement of this process attribute:

a) a defined process is deployed based upon an appropriately tailored standard process;

b) required roles, responsibilities and authorities necessary for performing the defined process are assigned and communicated;

c) required person(s) necessary for performing the defined process are competent on the basis of defined education, training and experience;

d) required resources necessary for performing the defined process are made available, monitored and measured;

e) documented information is available to ensure that the defined process achieves its intended results.

NOTE 1 Responsibilities and authorities are normally assigned to roles or actors in the processes.

NOTE 2 Appropriate tailoring includes deploying the standard process as is.

5.2.5.4 PA 3.3 Process assurance process attribute

The process assurance process attribute is a measure of the extent to which the defined process is assured and continually improved. As a result of full achievement of this process attribute:

a) appropriate data and information are collected and analysed from monitoring and measurement of the process to evaluate the effectiveness and risks of the process, and to identify needs and opportunities for improvement;

b) criteria and methods needed to ensure effective operation and control, and continuing suitability, adequacy, effectiveness and risks of the process are determined and evaluated;

c) conformity of the defined process (and associated activities, outputs and documented information) is objectively assured;

d) action is taken on any nonconformity, based on its nature and effect, and tracked to closure;

e) the standard process is continually improved based on identified needs and opportunities.

Documented information should be retained of any nonconformities describing actions taken, concessions obtained and authority deciding action in respect on the nonconformity. Documented information reviews include management reviews

NOTE Action in dealing with nonconformity can include any of the following a) correction b) segregation, containment or suspension of products or services c) informing the customer d) obtaining authorization for acceptance under concession e) evaluating the need for and eliminating causes in order to prevent re- occurrence. Any action taken to adjust the performance of the process will be managed in the scope of the Performance Management process attribute (PA2.1).

5.2.6 Process capability Level 4: Predictable process

5.2.6.1 General

The previously described *Established process* is now performed predictively. Quantitative management needs are identified, measurement data are collected and analysed to identify assignable causes of variation. Corrective action is taken to address assignable causes of variation.

The following process attributes, together with the previously defined process attributes, demonstrate the achievement of this level.

5.2.6.2 PA 4.1 Quantitative analysis process attribute

The quantitative analysis process attribute is a measure of the extent to which information needs are defined, relationships between process elements are identified and data are collected. As a result of full achievement of this process attribute:

a) process information needs in support of relevant defined quantitative business goals are established;

b) process measurement objectives are derived from process information needs;

c) measurable relationships between process elements that contribute to the process performance are identified;

d) quantitative objectives for process performance are established to support relevant business goals;

e) appropriate measures and frequency of measurement are identified and defined in line with process measurement objectives and quantitative objectives for process performance;

f) techniques for analysing the collected data are selected;

g) results of measurement are collected, validated and reported in order to monitor the extent to which the quantitative objectives for process performance are met.

NOTE 1 Information needs typically reflect management, technical, project, process or product needs.

NOTE 2 Measures can be either process measures or product measures or both.

NOTE 3 Techniques for quantitative data analysis can include statistical and mathematical methods — data tabulation, descriptive data, data aggregation/disaggregation and other advanced analytical methods such as correlation, analysis of variance and regression.

5.2.6.3 PA 4.2 Quantitative control process attribute

The quantitative control process attribute is a measure of the extent to which objective data are used to manage and control process performance that is predictable. As a result of full achievement of this process attribute:

a) assignable causes of process variation are determined through analysis of the collected data;

b) distributions that characterize the performance of the process are established;

c) corrective actions are taken to address assignable causes of variation;

d) separate distributions are established (as necessary) for analysing the process under the influence of assignable causes of variation;

e) process performance data are used to develop predictors of process outcomes.

5.2.7 Process capability Level 5: Innovating process

5.2.7.1 General

The previously described *Predictable process* is now continually improved to respond to changes through identified innovative approaches for process innovation.

NOTE Innovation can involve the adoption of wholly new processes and methods, new technologies that require different processes, or others.

The following process attribute, together with the previously defined process attributes, demonstrates the achievement of this level.

5.2.7.2 PA 5.1 Process innovation process attribute

The process innovation process attribute is a measure of the extent to which changes to the definition, management and performance of the process are identified and effectively implemented from identified innovative approaches for process innovation using internal resources and/or using external ideas according to defined process innovation objectives.

As a result of full achievement of this process attribute:

a) process innovation objectives for the process are defined that support the relevant business goals;

b) appropriate data are analysed to identify opportunities for best practice and innovation;

c) innovation opportunities derived from new technologies and process concepts are identified;

d) an implementation strategy is established to achieve the process innovation objectives;

e) impact of all proposed changes is assessed against the objectives of the defined process and standard process;

f) implementation of all agreed changes is managed to ensure that any disruption to the process performance is understood and acted upon;

g) effectiveness of process change on the basis of actual performance is evaluated against the defined product requirements and process and innovation objectives.

5.3 Process attribute rating scale

Within this process measurement framework, a process attribute is a measurable property of process capability. A process attribute rating is a judgement of the degree of achievement of the process attribute for the assessed process.

A process attribute is measured using an ordinal scale as defined below.

N Not achieved:

There is little or no evidence of achievement of the defined process attribute in the assessed process.

P Partially achieved:

There is some evidence of an approach to, and some achievement of, the defined process attribute in the assessed process. Some aspects of achievement of the process attribute may be unpredictable.

L Largely achieved:

There is evidence of a systematic approach to, and significant achievement of, the defined process attribute in the assessed process. Some weaknesses related to this process attribute may exist in the assessed process.

F Fully achieved:

There is evidence of a complete and systematic approach to, and full achievement of, the defined process attribute in the assessed process. No significant weaknesses related to this process attribute exist in the assessed process.

The ordinal scale defined above shall be understood in terms of percentage achievement of a process attribute.

The corresponding percentages shall be:

N	Not achieved	0 % to ≤15 % achievement
P	Partially achieved	>15 % to ≤50 % achievement
L	Largely achieved	>50 % to ≤85 % achievement
F	Fully achieved	>85 % to ≤100 % achievement

The ordinal scale may be further refined for the measures P and L as defined below.

P+ Partially achieved:

There is some evidence of an approach to, and some achievement of, the defined process attribute in the assessed process. Some aspects of achievement of the process attribute may be unpredictable.

P– Partially achieved:

There is some evidence of an approach to, and some achievement of, the defined process attribute in the assessed process. Many aspects of achievement of the process attribute may be unpredictable.

L+ Largely achieved:

There is evidence of a systematic approach to, and significant achievement of, the defined process attribute in the assessed process. Some weaknesses related to this process attribute may exist in the assessed process.

L– Largely achieved:

There is evidence of a systematic approach to, and significant achievement of, the defined process attribute in the assessed process. Many weaknesses related to this process attribute may exist in the assessed process.

The corresponding percentages shall be:

P–	Partially achieved–	>15 % to ≤32.5 % achievement
P+	Partially achieved+	>32.5 % to ≤50 % achievement
L–	Largely achieved–	>50 % to ≤67.5 % achievement
L+	Largely achieved+	>67.5 % to ≤85 % achievement

5.4 Process attribute rating method

5.4.1 General

A process outcome is the observable result of successful achievement of the process purpose.

A process attribute outcome is the observable result of achievement of a specified process attribute.

Process outcomes and process attribute outcomes may be characterised as an intermediate step to providing a process attribute rating.

When performing rating, the rating method employed shall be specified relevant to the class of assessment. The following rating methods are defined.

The use of rating method may vary according to the class, scope and context of an assessment. The lead assessor shall decide which (if any) rating method to use. The selected rating method(s) shall be specified in the assessment input and referenced in the assessment report.

5.4.2 Rating method R1

The approach to process attribute rating shall satisfy the following conditions:

a) each process outcome of each process within the scope of the assessment shall be characterized for each process instance, based on validated data;

b) each process attribute outcome of each process attribute for each process within the scope of the assessment shall be characterised for each process instance, based on validated data;

c) process outcome characterisations for all assessed process instances shall be aggregated to provide a process performance attribute achievement rating;

d) process attribute outcome characterisations for all assessed process instances shall be aggregated to provide a process attribute achievement rating.

5.4.3 Rating method R2

The approach to process attribute rating shall satisfy the following conditions:

a) each process attribute for each process within the scope of the assessment shall be characterized for each process instance, based on validated data;

b) process attribute characterisations for all assessed process instances shall be aggregated to provide a process attribute achievement rating.

5.4.4 Rating method R3

Process attribute rating across assessed process instances shall be made without aggregation.

5.5 Aggregation method

5.5.1 General

When performing an assessment, ratings may be summarised across one or two dimensions.

For example, when rating a

— process attribute for a given process, one may aggregate ratings of the associated process (attribute) outcomes — such an aggregation will be performed as a vertical aggregation (one dimension).

— process (attribute) outcome for a given process attribute across multiple process instances, one may aggregate the ratings of the associated process instances for the given process (attribute) outcome — such an aggregation will be performed as a horizontal aggregation (one dimension).

— process attribute for a given process, one may aggregate the ratings of all the process (attribute) outcomes for all the processes instances — such an aggregation will be performed as a matrix aggregation across the full scope of ratings (two dimensions).

The use of aggregation of ratings may vary according to the class, scope and context of an assessment. The lead assessor shall decide which (if any) aggregation method to use. The selected aggregation method(s) shall be specified in the assessment input and referenced in the assessment report.

As described in 5.3, process attributes are rated using an ordinal scale. The assessor may choose to apply expert judgement to summarize the ratings without employing a formal mathematical approach, alternatively an aggregation method may be used. An aggregation approach requires that the ordinal ratings be converted to interval values in order to perform aggregation. The validity of this conversion from ordinal ratings to interval values is dependent on two conditions[1]:

a) The ordinal scale must be sufficiently constrained that the ordinal values are reasonably evenly spread. The rating scale defined in this document meets the requirement of being evenly spread.

b) There must be evidence of adequate sample size to assure adequate accuracy of the ordinal values. This condition is met for class 1 and class 2 assessments, both of which are sufficiently rigorous to require an adequate sample size.

Since these conditions are met, then the ordinal ratings can be converted to interval values as follows:

N -> 0; P -> 1; L -> 2; F -> 3 or

N -> 0; P- -> 1; P+ -> 2; L- -> 3; L+ -> 4; F -> 5

5.5.2 One dimensional aggregation methods

5.5.2.1 General

Having converted the ordinal ratings to interval values, one of the following one dimensional aggregation methods may be used to obtain a summary rating.

5.5.2.2 One dimensional aggregation using arithmetic mean

Aggregation may be performed by computing the arithmetic mean (average) of the ratings of the interval values, rounding the result to the nearest integer (by rounding up or down), and converting the result back to the corresponding ordinal rating. When rounding is necessary the interval value will be rounded down to the nearest integer when the average value is less than the midpoint between consecutive integers; it will be rounded up if the average value is at or above the midpoint between consecutive integers.

5.5.2.3 One dimensional aggregation using median

Aggregation may be performed by computing the median (middle value) of the ratings of the interval values, the given data is arranged in order from lowest to highest. If there is an odd number of data then the median is the middle value. If there is an even number of data then the two middle values are selected and the arithmetic mean (average) taken. If there is an even number of ratings and the process of taking an average of the two middle values results in real number, then the number is rounded to an integer value using the rules above.

NOTE The operation of taking the mean is mathematically valid since we are dealing with interval data.

5.5.3 Two dimensional aggregation methods

5.5.3.1 General

In an assessment when there are multiple process instances being assessed, then it may be necessary to summarize the ratings across two dimensions.

For example, for a given process, the process outcomes of several process instances assessed may be aggregated to form an overall process attribute rating.

As noted in 5.5.2, this may be accomplished using the expert judgement of the assessor(s) or it may be accomplished using an aggregation method. Use of expert judgement should not be ruled out since there may be situations where a small number of process instances may be outliers (for example, projects initiated before a process improvement project, or when a small number of projects do not support the rigour of a formal process). Having converted the ordinal ratings to interval values, one of the following two dimensional aggregation methods may be used to obtain a summary rating.

5.5.3.2 Two dimensional aggregation using arithmetic mean

Aggregation may be performed by computing the arithmetic mean across the matrix of the full scope of ratings (expressed as numeric interval values) and converting the result back to the corresponding ordinal rating.

It is not permitted, when performing aggregation, to take an average of averages since such an approach is not statistically valid.

5.5.3.3 Two dimensional aggregation using heuristics

Aggregation may be performed using a defined set of rules to summarise the ratings. For example, see Table 1.

5.6 Process capability level model

The process capability level achieved by a process shall be derived from the process attribute ratings for that process according to the process capability level model defined in Table 1.

Table 1 — Process capability level ratings

Scale	Process attributes	Rating
Level 1	Process performance	Largely or fully
Level 2	Process performance	Fully
	Performance management	Largely or fully
	Documented information management	Largely or fully
Level 3	Process performance	Fully
	Performance management	Fully
	Documented information management	Fully
	Process definition	Largely or fully
	Process deployment	Largely or fully
	Process assurance	Largely or fully
Level 4	Process performance	Fully
	Performance management	Fully
	Documented information management	Fully
	Process definition	Fully
	Process deployment	Fully
	Process assurance	Fully
	Quantitative analysis	Largely or fully
	Quantitative control	Largely or fully
Level 5	Process performance	Fully
	Performance management	Fully
	Documented information management	Fully
	Process definition	Fully
	Process deployment	Fully
	Process assurance	Fully
	Quantitative analysis	Fully
	Quantitative control	Fully
	Process innovation	Largely or fully

Annex A
(informative)

Conformity of the process measurement framework

A.1 Conformance requirements

A.1.1 General

The following requirements (indicated by 'shall' statements) for a process measurement framework are drawn from ISO/IEC 33003 which provides normative requirements for process measurement frameworks.

A.1.2 Conceptualization

A process capability level is characterised by one or more process attributes, which are formative measures of the process capability. Process attributes are required in order to construct the process capability. Process attributes are demonstrated by achievement of the process attribute outcomes, which are reflective measures. See Figure A.1.

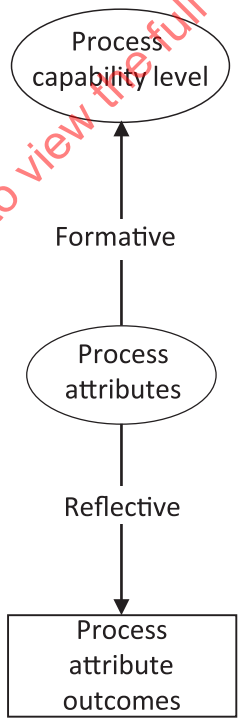

Figure A.1 — Formative and reflective measures of process capability

The concept of process capability does not provide a measure of anything other than process capability formed by process attributes. For example, process capability does not infer anything about organizational performance.

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

   The measurement framework is defined for the single process quality characteristic of software quality.

b) A process quality characteristic in a process measurement framework shall be defined on the basis of a multidimensional construct which consists of a set of unidimensional constructs.

   The process measurement framework is a construct comprised of nine process attributes.

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

   The process measurement framework is a construct comprised of nine process attributes.

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

   The property defined by each process attribute is described in Clause 5.

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

   Each process attribute in this measurement framework is a construct and defined in Clause 5.

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

   The process attributes of this measurement framework are formative.

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

   The policies and assumptions underlying the use and application of this process measurement framework are set out in Clauses 1, 4, and 5.

A.1.3 Construct definition

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

   The meaning of the process quality characteristic and its process attributes are given in Clause 5.

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

   The specifications of the process quality characteristic and its process attributes are given in Clause 5.

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

   Operationalization of the process quality characteristic and its process attributes is given in Clause 5.

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.

   The scales of composite measures in this measurement framework are given in Clause 5.

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.

The process performance attribute (PA 1.1) comprises the achievement of the defined process purpose through achievement of the process outcomes for that process.

A.1.4 Operationalization

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

The process attributes are defined in 5.2; the descriptions follow a common approach, described in 5.1.

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

In the process performance attribute, the achievement of process outcomes is demonstrable based on objective evidence. In all other process attributes, the achievement of the attribute is demonstrable on the basis of objective evidence, employing the process attribute outcomes as base measures.

A.1.5 Construct specification examination

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

Each Process Attribute is operationalized through a set of base or derived measures depending on the class of assessment. See 5.4.1.

A.1.6 Rating process attributes

a) The process attributes shall be rated.

The unit of measurement is specified in 5.3.

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

The measurement scale for base measures are ordinal, defined in 5.3.

c) A measurement method shall be identified that objectively assigns value to each measure.

The method for assigning a value to the measure of process capability is described in 5.3.

A.1.7 Aggregation

a) All aggregations required within the measurement framework shall be identified.

Aggregation methods are defined in 5.5.

b) Aggregation methods shall be specified.

Aggregation methods are defined in 5.5.

c) Aggregation methods shall be statistically valid.

Rationales for the validity of aggregation methods in this document are given in 5.5.

d) Aggregation methods shall utilize consistent measurement scales.

The aggregation methods use consistent scales, described in 5.5.

e) Aggregation methods shall be consistent with the measurement framework policies and assumptions.

f) Aggregation methods shall be consistent with construct specifications.

Consistency with policies and assumptions, and with the construct specifications is described in 5.5.

A.1.8 Sensitivity analysis

a) Sensitivity analysis shall be performed for measurement scales of base and derived measures.

Sensitivity of the process capability scale was tested during the SPICE Trials[5][6]. The investigations included inter-rater agreement and internal consistency, both of which were found to be acceptable. The possibility of increasing internal consistency was investigated by varying the four category scale to a three or two category scale by combining either the middle two ratings (N, (P, L), F) or the outer two ratings ((N, P), (L, F)). The current four category scale cannot be improved by reduction to a three or two category scale.

Sensitivity of process capability level ratings was investigated during the SPICE Trials and reported in the Interim Report[7]. Overall the investigation concluded that distortion downward of the capability level rating had greater effect than distortion upwards, but that guidance should be provided to assessors concerning the potential effects of distortion.

b) Sensitivity analysis shall be performed for aggregation methods.

Some sensitivity analysis data related to aggregation is available in the SPICE Trials reports[6][7], however its relevance to the current approach is limited. The issue of aggregation was examined in detail during the development of this document.

c) Sensitivity analysis shall be performed for weights, if applicable.

Weights are not used in this measurement framework so are not applicable.

A.2 Requirements for the reliability and validation of process measurement frameworks

a) Plans for reliability and validity of process measurement frameworks shall be established at the beginning of standardization. These plans shall include post-standardization activities.

b) Claims on reliability and validity of process measurement frameworks shall be consistent with construct specification.

c) Consistency (also refers to equivalence) as a reliability measure shall be examined for process attributes, if reflective.

d) Validities shall be examined for the process quality characteristic and its process attributes in a process measurement framework.

e) Construct specification shall be empirically examined for the process quality characteristic and its measures in a process measurement framework.

f) External measures (e.g., goals, criteria, and/or achievements) of a process measurement framework under development shall be documented for validity investigation.

Validation was performed during the SPICE trials conducted during standard development.

The measurement method and capability scale were tested during the SPICE trials. There has been no change to the concepts of the measurement scale that would invalidate the process capability scale or the findings of the trial.

A.3 Conformance

A process measurement framework shall be in conformity with the requirements of this document.

When data are available during trials and/or after the publication of a framework, rigorous statistical analyses will be required for all the applicable requirements.

The results of such analyses are referred to when meeting the requirements in A.1 and A.2 and are documented in the following references:

— H.-W. Jung, et al., "Findings from Phase 2 of the SPICE trials," Software Process: Improvement and Practice, vol. 6, pp. 205-242, 2001[5].

— SPICE Trials (1999), SPICE Phase 2 Trials Final Report, ISO/IEC/JTC 1/SC 7/WG 10[6].

— SPICE Trials (1998), SPICE Phase 2 Trials Interim Report, ISO/IEC/JTC1/SC7/WG10[7].

Annex B
(informative)

Indicators of process capability

B.1 Process capability levels and process attributes

Process capability is defined on a six-point ordinal scale that enables capability to be assessed from the bottom of the scale, **Incomplete**, through to the top end of the scale, **Innovating**. The scale represents increasing capability of the implemented process, from failing to achieve the process purpose through to continual improvement to respond to organizational change.

NOTE 1 In the next paragraphs, ISO/IEC 33020 process attribute definitions and process attribute outcomes are identified with italic font.

B.2 Process capability Level 0: Incomplete process

The process is not implemented or fails to achieve its process purpose.

At this level there is little or no evidence of any systematic achievement of the process purpose.

B.3 Process capability Level 1: Performed process

Process capability Level 1: Performed process

The implemented process achieves its process purpose.

[5.2.3]

The following process attribute demonstrates the achievement of this level.

PA 1.1 Process performance process attribute

The process performance attribute is a measure of the extent to which the process purpose is achieved. As a result of full achievement of this process attribute:

a) The process achieves its expected process outcomes.

[5.2.3.2]

Generic practice for PA.1.1

PA.1.1.GP1 Achieve the process outcomes

Achieve the intent of the base practices.

Relevant information items to evidence achievement of the process outcomes are identified.

B.4 Process capability Level 2: Managed process

Process capability Level 2: Managed process

The previously described Performed process is now implemented in a managed fashion (planned, monitored and adjusted) and its documented information are appropriately established, controlled and maintained.

[5.2.4]

The following process attributes, together with the previously defined process attribute, demonstrate the achievement of this level:

PA 2.1 Performance management process attribute

The performance management process attribute is a measure of the extent to which the performance of the process is managed with necessary resources and competences. As a result of full achievement of this process attribute:

a) *results to be achieved are determined and communicated;*

b) *risks that can affect performance of the process are determined and addressed;*

c) *performance of the process is planned, monitored, measured, evaluated and adjusted (as needed);*

d) *responsibilities and authorities for performing the process are determined, assigned and communicated;*

e) *resources necessary for performing the process are determined, provided and maintained (as needed);*

f) *person(s) performing the process are competent on the basis of appropriate education, training, or experience;*

g) *interfaces between the involved parties are managed to ensure both effective communication and the level of control expected.*

[5.2.4.2]

Generic practices for PA.2.1

PA.2.1.GP1 Determine results to be achieved for the performance of the process.

Results to be achieved are determined.

Process performance goals are defined.

Assumptions and constraints are considered when identifying the performance goals.

Results to be achieved are communicated to involved parties.

NOTE Process performance goals for resources, effort, schedule and output are normally stated.

PA.2.1.GP2 Determine and address risks relevant to the performance of the process.

Risks that can affect performance of the process are identified and evaluated for effect and severity.

Actions to mitigate the risks are planned and performed.

Monitor the risks and record the mitigation activities throughout the performance of the process.

PA.2.1.GP3 Plan the performance of the process to achieve the determined results.

Plan(s) for the performance of the process are developed.

Process activities and tasks are defined.

Schedule and milestones are defined and aligned with the approach to performing the process.

Documented information reviews are planned.

PA.2.1.GP4 Control the performance of the process.

Process performance measures are established.

Process performance is monitored and the results are controlled.

Appropriate actions are taken when planned results are not achieved.

The plan(s) are adjusted and rescheduling is performed, as necessary.

PA.2.1.GP5 Assign competent people with the relevant responsibilities and authorities for performing the process. Responsibilities and authorities to perform the process are determined, assigned and communicated. Required competencies are identified based on the responsibilities. Competencies for management and execution of the process are ensured by training or work-based learning. Person(s) performing the process are considered competent on the basis of appropriate education, training, or experience. Necessary competencies are acquired externally when needed.
PA.2.1.GP6 Allocate and maintain resources to perform the process according to plan. The human and infrastructure resources needed for performing the process are determined, provided and maintained. The information necessary to perform the process is identified and made available. The use of the resources is measured and monitored to identify possible deviations.
PA.2.1.GP7 Manage the interfaces between the involved parties. The individuals and groups involved in the process performance are identified. Responsibilities of the involved parties are assigned. Communication is assured between the involved parties. Communication between the involved parties is effective.

PA 2.2 Documented information management process attribute

The documented information management process attribute is a measure of the extent to which the documented information produced internally, or acquired from an external source when performing the process is appropriately managed. As a result of full achievement of this process attribute:

a) *requirements for the documented information of the process are determined;*

b) *requirements for control of the documented information are determined;*

c) *documented information is appropriately identified, and controlled according to requirements;*

d) *documented information is reviewed and approved for suitability and adequacy in accordance with planned arrangements and adjusted as necessary to meet requirements;*

e) *documented information is determined, maintained and retained to the extent necessary to have confidence that the process has been performed as planned and to demonstrate the conformity of products and/or services to their requirements.*

[5.2.4.3]

Generic practices for PA.2.2

PA.2.2.GP1 Define the requirements for the documented information. The requirements for the documented information to be produced are defined. Requirements may include defining contents and structure. Quality criteria of the documented information are identified. Appropriate review and approval criteria for the documented information are defined.

PA.2.2.GP2 Define the requirements for documentation and control of the documented information. Requirements for the documentation and control of the documented information are defined. Such requirements may include requirements for (1) distribution, (2) identification of documented information and their components (3) traceability Dependencies between documented information are identified and understood. Requirements for the approval of documented information to be controlled are defined.
PA.2.2.GP3 Identify and control the documented information in accordance with requirements. The documented information to be controlled are identified. Change control is established for documented information. The documented information is identified and controlled in accordance with requirements. Versions of documented information are assigned to product configurations as applicable. The documented information is made available through appropriate access mechanisms. The revision status of the documented information may readily be ascertained.
PA.2.2.GP4 Review and adjust documented information to meet the defined requirements. Documented information is reviewed against the defined requirements in accordance with planned arrangements. Issues arising from documented information reviews are resolved.
PA.2.2.GP5 Maintain and retain information products to demonstrate that planned results are achieved. Documented information needed to confirm the performance of the process is determined. Documented information is used to demonstrate that the products and/or services satisfy their requirements.

B.5 Process capability Level 3: Established process

Process capability Level 3: Established process *The previously described Managed process is now implemented using a defined process which is assured and continually improved.* *[5.2.5]*

The following process attributes, together with the previously defined process attributes, demonstrate the achievement of this level:

PA 3.1 Process definition process attribute
The process definition process attribute is a measure of the extent to which a standard process is established and maintained. As a result of full achievement of this process attribute:
a) *a standard process, including appropriate tailoring guidelines, is established and maintained that describes the fundamental elements that must be incorporated into a defined process;*
b) *the required inputs and the expected outputs for the standard process are determined;*
c) *sequence and interaction of the standard process with other processes is determined;*
d) *roles, competences, responsibilities and authorities for performing the standard process are determined;*
e) *resources for performing the standard process are determined;*
f) *knowledge necessary for the operation of the standard process is determined and maintained.*
[5.2.5.2]

Generic practices for PA.3.1

PA.3.1.GP1 Establish and maintain a standard process that will support the deployment of the defined process.
A standard process is developed that includes the fundamental process elements.
The standard process identifies the deployment needs and deployment context.
Guidance and/or procedures are provided to support implementation of the process as needed.
Appropriate tailoring guideline(s) are available as needed.
The standard process is maintained to meet the improvement needs and opportunities.
PA.3.1.GP2 Determine the inputs and outputs of the standard process.
Required inputs are identified, including information needed.
Expected outputs are identified.
Start and stop criteria for the standard process are defined as needed.
PA.3.1.GP3 Determine the sequence and interaction of the process as an integrated system of processes.
The process's sequence and interaction with other processes are determined.
Deployment of the standard process as a defined process maintains integrity of processes.
PA.3.1.GP4 Determine the roles, competencies, responsibilities and authorities for performing the standard process.
Roles and related competencies for performing the process are determined.
Authorities necessary for executing responsibilities are determined.
PA.3.1.GP5 Determine the resources for performing the standard process.
Appropriate resources are identified and determined.
Requirements for the quality of the resources are defined.
Process infrastructure components are identified (facilities, tools, networks, methods, etc).
Work environment requirements are defined.

PA.3.1.GP6 Determine and maintain necessary knowledge for the operation of the standard process.

Information and understanding needed to perform the process is determined and maintained.

NOTE Knowledge: facts, information, and skills acquired by a person through experience or education; the theoretical or practical understanding of a subject.

PA 3.2 Process deployment process attribute

The process deployment process attribute is a measure of the extent to which a standard process is deployed as a defined process. As a result of full achievement of this process attribute:

a) *a defined process is deployed based upon an appropriately tailored standard process;*

b) *required roles, responsibilities and authorities necessary for performing the defined process are assigned and communicated;*

c) *required person(s) necessary for performing the defined process are competent on the basis of defined education, training and experience;*

d) *required resources necessary for performing the defined process are made available, monitored and measured;*

a) *documented information is available to ensure that the defined process achieves its intended results.*

[5.2.5.3]

Generic practices for PA.3.2

PA.3.2.GP1 Deploy a defined process that satisfies the context specific requirements of the use of the standard process.

The defined process is appropriately selected and/or tailored from the standard process.

Criteria to verify conformity of the defined process with the standard process are determined.

The defined process is used to achieve the process outcomes.

PA.3.2.GP2 Deploy competent people with defined responsibilities and authorities to support the performance of the defined process.

Competency criteria for the required roles are defined.

The roles for performing the defined process are assigned and communicated.

The responsibilities and authorities for performing the defined process are assigned and communicated.

Competency of the required person(s) is monitored and maintained with appropriate education, training, or experience.

PA.3.2.GP3 Provide resources and information to support the performance of the defined process.

Required human resources are made available, allocated and used.

Required information to perform the process is made available, allocated and used.

Resources are measured and monitored to ensure their effective use.

PA.3.2.GP4 Maintain documented information as evidence of the process achieving expected results.

Documented information is maintained.

Documented information is available for review.

Documented information can be verified by person(s) independent of those performing the process.

PA 3.3 Process assurance process attribute

The process assurance process attribute is a measure of the extent to which the defined process is assured and continually improved. As a result of full achievement of this process attribute:

a) *appropriate data and information are collected and analysed from monitoring and measurement of the process to evaluate the effectiveness and risks of the process, and to identify needs and opportunities for improvement;*

b) *criteria and methods needed to ensure effective operation and control, and continuing suitability, adequacy, effectiveness and risks of the process are determined and evaluated;*

c) *conformity of the defined process (and associated activities, outputs and documented information) is objectively assured;*

d) *action is taken on any nonconformity, based on its nature and effect, and tracked to closure;*

e) *The standard process is continually improved based on identified needs and opportunities.*

[5.2.5.4]

Generic practices for PA.3.3

PA.3.3.GP1 Collect and analyse data about performance of the process to identify needs for improvement.

Data required to understand the behaviour, suitability and effectiveness of the process are identified, collected and analysed.

Results of the analysis are used to identify where continual improvement of the standard and/or defined process can be made.

NOTE Data about process performance may be qualitative or quantitative.

PA.3.3.GP2 Determine suitable methods and measures to monitor and evaluate the process.

Methods and measures for monitoring the suitability, effectiveness and adequacy of the process are determined.

Appropriate criteria and data needed to monitor the process are defined.

The need to conduct internal audit, process compliance audit/reviews and management review is established.

Suitability, adequacy and effectiveness of the process are measured and analysed continually using appropriate methods.

Identified risks are evaluated and managed.

PA.3.3.GP3 Assure conformity of the defined process.

Associated activities, outputs and documented information are evaluated.

Conformity of the defined process with the standard process requirements is verified.

Any nonconformities are identified and documented.

Assurance activities are performed independently of the process instance to ensure objectivity.

PA.3.3.GP4 Act on nonconformities to adjust the performance of the process.

The nature and effect of nonconformities are analysed to plan appropriate actions.

Any changes needed are implemented to ensure that the process achieves its intended results

Actions are managed and tracked to closure.

PA.3.3.GP5 Improve the process based on the monitoring of the process.

Suitability, adequacy and effectiveness of the process are measured and analysed continually using appropriate methods.

Internal audits, process capability audits/reviews and management reviews are performed when needed.

Process changes are implemented to maintain the standard process.

B.6 Process capability Level 4: Predictable process

Process capability Level 4: Predictable process

The previously described Established process now operates predictively to achieve its process outcomes. Quantitative management needs are identified, measurement data are collected and analysed to identify assignable causes of variation. Corrective action is taken to address assignable causes of variation.

[5.2.6]

The following process attributes, together with the previously defined process attributes, demonstrate the achievement of this level:

PA 4.1 Quantitative analysis process attribute

The quantitative analysis process attribute is a measure of the extent to which information needs are defined, relationships between process elements are identified and data are collected. As a result of full achievement of this process attribute:

a) *process information needs in support of relevant defined quantitative business goals are established;*

b) *process measurement objectives are derived from process information needs;*

c) *measurable relationships between process elements that contribute to the process performance are identified;*

d) *quantitative objectives for process performance are established to support relevant business goals;*

e) *appropriate measures and frequency of measurement are identified and defined in line with process measurement objectives and quantitative objectives for process performance;*

f) *techniques for analysing the collected data are selected;*

g) *results of measurement are collected, validated and reported in order to monitor the extent to which the quantitative objectives for process performance are met.*

[5.2.6.2]

Generic practices for PA.4.1

PA.4.1.GP1 Establish process information needs, in support of quantitative business goals.

Quantitative business goals relevant to the process are identified.

Stakeholders of the identified business goals and the quantitatively measured process, and their information needs are identified, defined and agreed.

PA.4.1.GP2 Derive process measurement objectives from process information needs.

Process measurement objectives to satisfy defined process information needs are derived.

PA.4.1.GP3 Identify measurable relationships between process elements.

Relationships between process elements are determined which contribute to the derived measurement objectives.

PA.4.1.GP4 Establish quantitative objectives for the performance of the defined process, according to the alignment of the process with the business goals. Process performance objectives are defined to explicitly reflect the quantitative business goals. Process performance objectives are validated with process stakeholders to be realistic and useful.
PA.4.1.GP5 Identify product and process measures that support the achievement of the quantitative objectives for process performance. Detailed measures are defined to support monitoring, analysis and verification needs of the quantitative objectives. Frequency of data collection is defined. Algorithms and methods to create derived measurement results from base measures are defined, as appropriate. Verification mechanism for base and derived measures is defined. NOTE Typically, the standard process definition is extended to include the collection of data for process measurement.
PA.4.1.GP6 Select analysis techniques, appropriate to collected data. Process control analysis methods and techniques are defined. Selected techniques are validated against process control objectives.
PA.4.1.GP7 Collect product and process measurement results through performing the defined process. Data collection mechanism is created for all identified measures. Required data is collected in an effective and reliable manner. Measurement results are created from the collected data and analysed within defined frequency. Measurement results are reported to those responsible for monitoring the extent to which quantitative objectives are met. NOTE A product measure can contribute to a process measure.

PA 4.2 Quantitative control process attribute *The quantitative control process attribute is a measure of the extent to which objective data are used to manage and control process performance that is predictable. As a result of full achievement of this process attribute:* a) *assignable causes of process variation are determined through analysis of the collected data;* b) *distributions that characterize the performance of the process are established;* c) *corrective actions are taken to address assignable causes of variation;* d) *separate distributions are established (as necessary) for analysing the process under the influence of assignable causes of variation;* e) *process performance data are used to develop predictors of process outcomes.* *[5.2.6.3]*

Generic practices for PA.4.2

PA.4.2.GP1 Determine assignable causes of process variation by analysing the collected data. Variation in process performance is attributed to a specific, unpredictable cause. Assignable cause indicates a possible problem in the defined process.

PA.4.2.GP2 Establish distributions that characterize the process performance. Variation in measurement results is used to analyse process performance. Deviations are analysed to identify potential cause(s) of variation. Trends of process performance are identified.
PA.4.2.GP3 Identify and implement corrective actions to address assignable causes. Results are provided to those responsible for taking action. Corrective actions are determined to address each assignable cause. Corrective actions are implemented to address assignable causes of variation. Corrective action results are monitored. Corrective actions are evaluated to determine their effectiveness.
PA.4.2.GP4 Establish separate distributions for analysing the process. Consequences of process variation are analysed. Distributions are used to quantitatively understand process performance under the influence of assignable causes of variation.
PA.4.2.GP5 Develop predictors for process outcomes. Process performance data are used. Predictors are independent variables to forecast process outcomes.

B.7 Process capability Level 5: Innovating process

Process capability Level 5: Innovating process *The previously described Predictable process is now continually improved to respond to changes through identified innovative approaches for process innovation.* *[Clause 5.2.7]*

The following process attribute, together with the previously defined process attributes, demonstrates the achievement of this level:

PA 5.1 Process innovation process attribute *The process innovation process attribute is a measure of the extent to which changes to the definition, management and performance of the process are identified and effectively implemented from identified innovative approaches for process innovation using internal resources and/or using external ideas according to defined process innovation objectives.*

As a result of full achievement of this process attribute: a) *process innovation objectives for the process are defined that support the relevant business goals;* b) *appropriate data are analysed to identify opportunities for best practice and innovation;* c) *innovation opportunities derived from new technologies and process concepts are identified;* d) *an implementation strategy is established to achieve the process innovation objectives;* e) *impact of all proposed changes is assessed against the objectives of the defined process and standard process;* f) *implementation of all agreed changes is managed to ensure that any disruption to the process performance is understood and acted upon;* g) *effectiveness of process change on the basis of actual performance is evaluated against the defined product requirements and process and innovation objectives.* *[5.2.7.2]*

Generic practices for PA.5.1

PA.5.1.GP1 Define the process innovation objectives for the process that support the relevant business goals. New business visions and goals are analysed to give guidance for new process objectives and potential areas of process innovation. Quantitative and qualitative process innovation objectives are defined and documented.
PA.5.1.GP2 Analyse data of the process to identify opportunities for best practice and innovation. Feedback on opportunities for innovation is actively sought, including analysis of the results from the process measurements. Innovation opportunities are identified. Best practices are identified and evaluated.
PA.5.1.GP3 Identify innovation opportunities of the process from new technologies and process concepts. Possibilities of new process concepts on the innovation of process performance are identified and evaluated. Impact of new technologies on process performance is identified and evaluated. Emergent risks are considered in evaluating innovation opportunities
PA.5.1.GP4 Define an implementation strategy based on long-term innovation vision and objectives. Commitment to innovation is demonstrated by organizational management including the process owner(s), and other relevant stakeholders. Measures that validate the results of process changes are defined to determine the expected effectiveness of the process change and the expected impact on defined business objectives. The proposed process changes are planned and prioritized based on their impact on defined innovation objectives.
PA.5.1.GP5 Assess the impact of each proposed change against the objectives of the defined and standard process. Objective priorities for process innovation are established. Specified changes are assessed against product quality and process performance requirements and goals. Impact of changes to other defined and standard processes is considered.

PA.5.1.GP6 Manage the implementation of agreed changes. A mechanism is established for incorporating accepted changes into the defined and standard process(es) effectively and completely. The factors that impact the effectiveness and full deployment of the process change are identified and managed, such as: — economic factors (productivity, profit, growth, efficiency, quality, competition, resources, and capacity); — human factors (job satisfaction, motivation, morale, conflict/cohesion, goal consensus, participation, training, span of control); — management factors (skills, commitment, leadership, knowledge, ability, organisational culture and risks); — technology factors (sophistication of system, technical expertise, development methodology, need of new technologies). Training is provided to users of the process. Process changes are effectively communicated to all affected parties. Records of the change implementation are maintained.
PA.5.1.GP7 Evaluate the effectiveness of process change. Performance and capability of the changed process are measured and compared with historical data. A mechanism is available for documenting and reporting analysis results to management and owners of standard and defined process. Measures are analysed to evaluate the effectiveness of process changes. Other feedback is recorded, such as opportunities for further innovation of the standard process.

B.8 Mapping of indicators to process attribute outcomes

Mapping between the Generic Practices and the Process Attribute Outcomes are listed in Table B.1.

Table B.1 — Mapping of generic practices to process attribute outcomes

GP	Practice name	Maps to
PA.1.1: Process performance process attribute		
PA.1.1.GP1	Achieve the process outcomes.	PA.1.1
PA.2.1: Performance management process attribute		
PA.2.1.GP1	Determine results to be achieved for the performance of the process.	PA.2.1 a
PA.2.1.GP2	Determine and address risks relevant to the performance of the process.	PA.2.1 b
PA.2.1.GP3	Plan the performance of the process to achieve the determined results.	PA.2.1 c
PA.2.1.GP4	Control the performance of the process.	PA.2.1 c
PA.2.1.GP5	Assign competent people with the relevant responsibilities and authorities for performing the process.	PA.2.1 d, f
PA.2.1.GP6	Allocate and maintain resources to perform the process according to plan.	PA.2.1 e
PA.2.1.GP7	Manage the interfaces between the involved parties.	PA.2.1 g
PA.2.2: Documented information management process attribute		
PA.2.2.GP1	Define the requirements for the documented information.	PA.2.2 a
PA.2.2.GP2	Define the requirements for documentation and control of the documented information.	PA.2.2 b
PA.2.2.GP3	Identify, document and control the documented information.	PA.2.2 c

Table B.1 *(continued)*

GP	Practice name	Maps to
PA.2.2.GP4	Review and adjust documented information to meet the defined requirements.	PA.2.2 d
PA.2.2.GP5	Maintain and retain information products to demonstrate that planned results are achieved.	PA.2.2 e
PA.3.1: Process definition process attribute		
PA.3.1.GP1	Establish and maintain a standard process that will support the deployment of the defined process.	PA.3.1 a
PA.3.1.GP2	Determine the inputs and outputs of the standard process.	PA.3.1 b
PA.3.1.GP3	Determine the sequence and interaction of the process as an integrated system of processes.	PA.3.1 c
PA.3.1.GP4	Determine the roles, competencies, responsibilities and authorities for performing the standard process.	PA.3.1 d
PA.3.1.GP5	Determine the resources for performing the standard process.	PA.3.1 e
PA.3.1.GP6	Determine and maintain necessary knowledge for the operation of the standard process.	PA.3.1 f
PA.3.2: Process deployment process attribute		
PA.3.2.GP1	Deploy a defined process that satisfies the context specific requirements of the use of the standard process.	PA.3.2 a
PA.3.2.GP2	Deploy competent people with defined responsibilities and authorities to support the performance of the defined process.	PA.3.2 b, c
PA.3.2.GP3	Provide resources and information to support the performance of the process.	PA.3.2 d
PA.3.2.GP4	Maintain documented information as evidence of the process achieving expected results.	PA.3.2 e
PA.3.3: Process assurance process attribute		
PA.3.3.GP1	Collect and analyse data about performance of the process to identify needs for improvement.	PA.3.3 a
PA.3.3.GP2	Determine suitable methods and measures to monitor and evaluate the process.	PA.3.3 b
PA.3.3.GP3	Assure conformity of the defined process.	PA.3.3 c
PA.3.3.GP4	Act on nonconformities to adjust the performance of the process.	PA.3.3 d
PA.3.3.GP5	Improve the process based on the monitoring of the process.	PA.3.3 e
PA.4.1 Quantitative analysis process attribute		
PA.4.1.GP1	Establish process information needs, in support of quantitative business goals.	PA.4.1 a
PA.4.1.GP2	Derive process measurement objectives from process information needs.	PA.4.1 b
PA.4.1.GP3	Identify measurable relationships between process elements.	PA.4.1 c
PA.4.1.GP4	Establish quantitative objectives for the performance of the defined process, according to the alignment of the process with the business goals.	PA.4.1 d
PA.4.1.GP5	Identify product and process measures that support the achievement of the quantitative objectives for process performance.	PA.4.1 e
PA.4.1.GP6	Select analysis techniques, appropriate to collected data.	PA.4.1 f
PA.4.1.GP7	Collect product and process measurement results through performing the defined process.	PA.4.1 g
PA.4.2 Quantitative control process attribute		
PA.4.2.GP1	Determine assignable causes of process variation by analysing the collected data.	PA.4.2 a
PA.4.2.GP2	Establish distributions that characterize the process performance.	PA.4.2 b
PA.4.2.GP3	Identify and implement corrective actions to address assignable causes.	PA.4.2 c
PA.4.2.GP4	Establish separate distributions for analysing the process.	PA.4.2 d
PA.4.2.GP5	Develop predictors for process outcomes.	PA.4.2 e

Table B.1 *(continued)*

GP	Practice name	Maps to
PA.5.1 Process innovation process attribute		
PA.5.1.GP1	Define the process innovation objectives for the process that support the relevant business goals.	PA.5.1 a
PA.5.1.GP2	Analyse data of the process to identify opportunities for best practice and innovation.	PA.5.1 b
PA.5.1.GP3	Identify innovation opportunities of the process from new technologies and process concepts.	PA.5.1 c
PA.5.1.GP4	Define an implementation strategy based on long-term innovation vision and objectives.	PA.5.1 d
PA.5.1.GP5	Assess the impact of each proposed change against the objectives of the defined and standard process.	PA.5.1 e
PA.5.1.GP6	Manage the implementation of agreed changes.	PA.5.1 f
PA.5.1.GP7	Evaluate the effectiveness of process change.	PA.5.1 g

Annex C
(informative)

Guidance on the process measurement framework

C.1 Process measurement framework for process capability

The process measurement framework is based on the concept of processes having common process attributes, related to the extent of achievement of the quality characteristic of process capability. These process attributes have been defined and allocated to process capability levels, to form an ordinal measurement scale for process capability.

The following clauses provide guidance on the meaning of the process capability levels, along with guidance on the achievement of the nine process attributes allocated to process capability levels 1 through 5.

C.2 Process capability Level 0: Incomplete process

The *Incomplete* process is one that is either not performed at all, or for which there is little or no evidence of systematic achievement of the process purpose. Systematic achievement is characterized by the routine performance of base practices and the presence of appropriate input and output information items which, collectively, ensure that the process purpose is achieved.

Capability level 0 is the only process capability level with no process attributes; in effect, level 0 can be considered as the state of not being at capability level 1 or above. Accordingly, determination of a process as being capability level 0 will be largely based on the lack of adequate objective evidence to consider it to be operating at capability level 1.

C.3 Process capability Level 1: Performed process

C.3.1 General

The *Performed* process achieves its process purpose through the performance of base practices and the presence of appropriate input and output information items which, collectively, ensure that the process purpose is achieved.

While the process attribute at capability level 1 is stated in such a way as to be common to all processes (as are all process attributes) in reality the process attribute is related to process performance and the achievement of process outcomes which differ from process to process. In other words the assessment indicators of process performance that would demonstrate the evidence of achieving the process attribute at capability level 1 are not common to all processes but are specific for the process being assessed.

Capability level 1 focuses exclusively on the extent to which the outcomes defined for the process are achieved.

C.3.2 PA 1.1 Process performance process attribute

A process outcome describes one or more of the following:

— production of an artefact;

— a significant change of state;

— meeting of specified constraints, e.g. requirements, goals, etc.

Accordingly, assessors will need to focus their attention on information items and practices which relate to one or more of the above process outcomes, depending on the nature of the particular process outcome being considered.

Assessors will verify that the persons performing the process understand the purpose of the process and perform the base practices. The information items resulting from performing the activities, together with input information items, are further evidence of process performance. However, the simple existence of these information items is not sufficient by itself; it should be evident that they contribute to achieving the process purpose.

C.4 Process capability Level 2: Managed process

C.4.1 General

The *Managed* process is planned, monitored and adjusted to meet identified results to be achieved and to produce documented information that are appropriately established, controlled and maintained.

The primary distinction from the performed capability level is that the performance of the process is now planned, monitored and adjusted to deliver documented information that fulfil expressed requirements. Thus, the essential elements of the managed process are the management of its performance and the explicit focus on documented information management. The critical role that proactive management of these two aspects of the process fulfils is to increase assurance that what is produced is what is needed and that the process operates in a more predictable manner.

The proactive management of the process will result in information items and/or activities which are verifiable (e.g. planning and/or plans, monitoring mechanisms and/or adjustments to the process based upon the results of comparison of the planned versus actual performance of the process).

C.4.2 PA 2.1 Performance management process attribute

The performance management process attribute is concerned with the application of basic management techniques to provide reasonable assurance that results to be achieved are determined and met.

The determination and communication of the desired results is a critical requirement for achievement of this process attribute. Typically, the desired results would include things such as (1) quality of artefacts produced, (2) process cycle time and (3) resource usage. Another key issue is the identification and mitigation of risks that could affect the performance.

At this level of process capability, process performance may be monitored in either qualitative terms (e.g. peer reviews will be easy to understand and to conduct) or quantitative terms (e.g. peer reviews will, on average, detect at least 80 % of the defects in the product).

Some processes (e.g. supporting, organizational and management processes) may not require planning for each instance but may perform continuously understanding arrangements.

Without clearly defined responsibilities and understood lines of authority, any group undertaking is at risk from the start. Hence, an important facet of the managed process is the explicit assignment of responsibility and authority for performing the process. The essential aspects to be addressed are the identification, assignment and communication of responsibilities and authorities for performing the process. Note that all stakeholders in the process (e.g. process owner, process implementers, etc) should be informed of these activities.

Person(s) performing the process will be deemed competent on the basis of appropriate education, training, or experience. The resources and information needed to implement the process in accordance with the identified process performance objectives are identified, made available, allocated and used. It is especially important to be prepared to make appropriate adjustments to the resources and information made available as the performance of the process is now being managed and potentially being adjusted as necessary to respond to deviations from the planned performance.

Associated with the management of resources needed to perform the process is the management of interfaces between the involved parties to ensure effective communication and clear assignment of responsibility. There are typically several types of stakeholders to consider — the process owner(s), the process implementer(s), those who provide the necessary resources and information, those involved upstream of the process and those downstream of the process and potentially others. Since even seemingly minor changes in the process performance may have a significant impact on one or more of the stakeholders, it is vital that the interfaces between these parties be planned, monitored and adjusted as appropriate and that these be communicated in a clear and timely manner.

C.4.3 PA 2.2 Documented information management process attribute

The documented information management process attribute is concerned with the application of basic management techniques to provide assurance that documented information produced are appropriately identified and controlled. The documented information referred to in this clause is that which results from the achievement of the process purpose through the process outcomes (e.g. documented information resulting from the process attaining capability level 1).

Documented information are artefacts associated with the execution of a process; accordingly, the nature of the documented information will vary depending on the purpose of the process. Some documented information may be a part of the deliverable product while other documented information may not (e.g. quality records such as personnel records, or meeting minutes).

Requirements for the documented information of the process are identified to provide a basis for their production (as well as verification). Note that requirements for the documented information will likely have a significant influence on the performance requirements for the process itself; thus, the two process attributes at capability level 2 are interdependent.

Requirements for the documented information of the process may be functional requirements which pertain to characteristics of the documented information (performance, size, etc.) or may be non-functional requirements which pertain to agreements or constraints which are not directly related to documented information characteristics (delivery dates, packaging, etc.) or may be a combination of both.

Requirements for the control of the documented information of the process are also defined; these are considered as distinct from the requirements for the documented information. Various degrees of change control or configuration management may be appropriate depending on specific aspects of the documented information and/or the project.

The requirements for the identification and control of the documented information of the process are then applied as the basis for appropriate identification, and control of the documented information.

Documented information of the process resulting from implementation of the process are reviewed in accordance with planned arrangements and adjusted as necessary to meet requirements. The extent and nature of review will depend upon many factors, all of which should be considered as part of the planning for documented information management.

Documented information needs to be retained so that it can be independently verified.

C.5 Process capability Level 3: Established process

C.5.1 General

The *Established* process is based upon a standard process which is effectively deployed as a defined process to achieve its process outcomes. The process is performed using a defined process tailored from an established and maintained standard process. The standard process identifies resources — both human and infrastructure — needed for performance of the process, and these are incorporated into the defined process. Appropriate data are collected to identify opportunities for understanding and improving both the standard process and the defined process.