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Security and resilience — Authenticity, integrity and trust for products and documents — Validation procedures for the application of artefact metrics

Sécurité et résilience — Authenticité, intégrité et confiance pour les produits et les documents — Procédures de validation pour l'application des métriques d'artéfact

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation 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 Technical Committee ISO/TC 292, *Security and resilience*.

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.

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Introduction

0.1 Artefact metrics

All manufactured objects (artefacts) have variation when studied in detail. Even where artefacts are manufactured using the same material under the same manufacturing conditions during the same period, artefacts generally have some distinguishing characteristic. For example, paper sheets from the same lot made at the same time with the same material and by the same manufacturing process seem to be the same by the human eye. However, when comparing magnified areas (on the same or different sheets), the paper fibres are quite different from each other and no two areas are identical. This is similar to human fingerprints or other biometric attributes.

In some cases, manufacturing techniques and processes can be designed or engineered to impart or cause to emerge distinguishing characteristics artificially to each object.

Using such distinguishing characteristics, individual components can be recognized by procedures similar to those used for biometrics.

A database is often used to support the use of artefact metrics. For artefacts that are to be recognized in this way, unique measurements of distinguishing characteristics for each artefact are acquired and enrolled in a database. When object recognition is performed, the unique measurements of distinguishing characteristics of the target artefact are acquired and compared with entries in the database. Details of this process and its application are explained further in this document.

While many artefact metric systems make use of a database, this is not always necessary and for some applications the measurements of artefacts can be encoded and attached to or associated with the artefact. There are some important differences in this case and a description of such a system is given in Annex B.

This document describes two types of recognition: artefact metric identification and artefact metric verification.

For artefact metric identification, measurements of the single artefact to be identified are compared with measurements of artefacts previously enrolled in a database (one to many) and a candidate list usually comprising one or more identifiers of the closest matching artefact(s) is returned. In this way, artefact metric identification allows a part or a product to be identified. Where information such as manufacturing conditions is associated with the reference, this data can be used to recall this and other artefacts manufactured under the same conditions. Identification also facilitates other functions such as track and trace and authentication.

For artefact metric verification, measurements of artefacts are enrolled and associated with an identifier. This identifier, e.g. a unique number in the form of a barcode, is directly associated with the artefact. The artefact is then subsequently measured, and these measurements are compared with the database entry associated with the identifier in order to verify the artefact's identity (one to one). By performing artefact metric verification, the target artefact is recognized as being the same as that recorded in the database or as an imposter.

NOTE In cases where no database is used, there is no enrolment process and the measurements are encoded directly on the artefact. See Annex B for details.

0.2 Traceability throughout supply chains

With the increase in safety awareness, many manufacturers are required to ensure product quality in their supply chain. In cases where a defect is found in a part included in a product, the manufacturer must locate and recall all parts with the same defect. In order to do so, it is necessary for manufacturers to locate the factory, in which batch, by whom and under what manufacturing conditions defective parts were made.

Manufacturers are required to record sufficient information at the time of manufacturing for all materials, parts, and products and to ensure that processes are in place that will allow the product to be

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located subsequent to its manufacture to enable their recall. Similar product management is required throughout the supply chain to ensure product integrity.

Damage caused by counterfeit products is an increasingly serious concern for many interested parties in supply chains. There have been many cases where counterfeit products have been mixed into the commercial flow of genuine products, and in some cases, the retailer can unknowingly receive and re-sell these counterfeit products to customers. In order to protect their reputation and to keep customer confidence, retailers have a strong motivation to eliminate these counterfeit products.

Quality assurance and anti-counterfeiting are therefore of major concern in supply chains and some form of object recognition technology for products or parts is required to address these concerns. Artefact metrics provide this object recognition capability in a way that is very difficult (impossible in most case) to clone.

Examples of the use of artefact metric systems are provided and explained in Annex A.

0.3 The use of artefact metrics for authentication

This document does not specify all requirements needed to provide an authentication solution but does provide some important measures of an artefact metric system's performance in the recognition of artefacts. When used in conjunction with other measures, artefact metrics can be used as the basis for effective authentication solutions.

Where authentication is needed, this document is intended to be used in conjunction with ISO 22383[2]. The relationship between these two standards is shown in Figure 1.

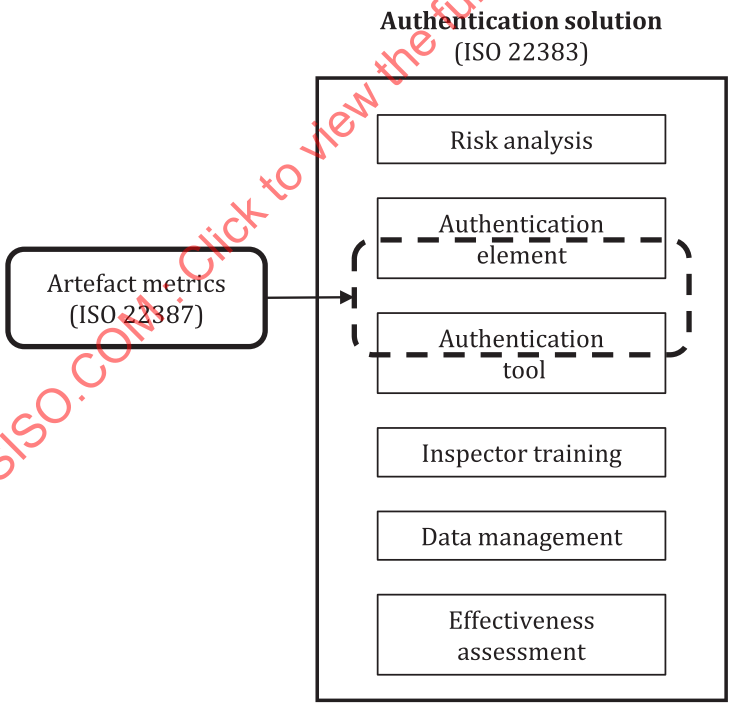

Figure 1 — Use of artefact metrics as part of an authentication solution

As Figure 1 shows, since artefact metrics can use measurements of distinguishing characteristics that are unique to each object, they can provide a very effective basis for authentication. The performance measures described in this document provide a way to measure the effectiveness of the artefact metric system based on the technology evaluated.

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0.4 Overview of this document

This document is primarily designed to help manufacturing organizations prepare for the introduction of artefact metric systems.

— Clause 5 provides an overview of typical artefact metric systems and describes their main functions.

— Clause 6 provides requirements and guidance on how to conduct a set of tests so that they can provide reliable performance metrics.

— Clause 7 describes the set of tests and reporting requirements.

— Clause 8 describes the set of steps required for the introduction of artefact metric systems to an organization.

0.5 Additional considerations

As with the deployment and use of any system, a risk assessment should be carried out before deployment and risks should continue to be assessed throughout the system's life cycle. In addition to general risks that apply to the operation of any system, risks related to the system integrity need to be considered.

Similarly, throughout its life, the system's performance and reliability should be reviewed and when possible improved.

When artefact metrics are used as a basis for authentication, the artefact metric system's performance provided in this document along with other aspects shown in Figure 1 should be considered. ISO 22383 provides guidelines for these aspects and these should be applied for the deployment and use of artefact metric systems.

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Security and resilience — Authenticity, integrity and trust for products and documents — Validation procedures for the application of artefact metrics

1 Scope

This document specifies a process to qualify the suitability, reliability and effectiveness of artefact metrics as well as artefact metric recognition principles for identification and verification.

The artefact metric recognition described in this document can be used to identify or verify artefacts using one or more measurements of their characteristics, each of which is unique to an individual artefact and is supposedly impossible to reproduce.

This document is applicable to artefact metrics throughout the life cycle processes of products.

Measurement of the resilience of the system where the distinguishing characteristic is degraded is out of the scope of this document.

This document is applicable to performance testing of artefact metric systems and algorithms through analysis of the comparison scores and decisions output by the system, without requiring detailed knowledge of the system's algorithms or of the underlying distribution of characteristics in the objects of interest.

This document excludes performance testing where deliberate attacks undermine the artefact metric system.

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 22300, *Security and resilience — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 22300 and the following apply.

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

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

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

3.1
artefact
object made directly or indirectly by a person

Note 1 to entry: An object can be a product, a document or a component part thereof suitable for measurement of their characteristics.

Note 2 to entry: In some cases, artefacts can be naturally occurring objects.

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3.2
artefact metric
measurement of a characteristic of an *artefact* (3.1)

Note 1 to entry: The measurement can be based either on a natural (intrinsic) characteristic of the object itself or on a characteristic expressed during manufacturing.

Note 2 to entry: The use of the term "artefact metrics" is proposed as being conceptually similar to "biometrics", for which uniqueness in biological entities is utilized. Unlike biometrics, artefact metrics utilizes uniqueness in physical objects/things, physical processes or their combinations. In some cases, this document uses the term "artefact metrics" in this way but the meaning is generally clear from the context[5].

3.3
distinguishing characteristic
characteristic shared by a set of *artefacts* (3.1) from which measurements can be made that are unique for each artefact

3.4
artefact metric signal
data that represents the measured characteristic and which are functionally related to the *artefact* (3.1)

Note 1 to entry: A signal can include an image, electrical signal, measurement of physical characteristic, structural geometry, etc.

Note 2 to entry: Unique measurements are extracted from this signal and used as *probes* (3.7) or *references* (3.8).

3.5
artefact metric recognition
automated recognition of single *artefacts* (3.1) based on their *distinguishing characteristics* (3.3)

Note 1 to entry: Artefact metric recognition describes both *artefact metric verification* (3.16) and *artefact metric identification* (3.19).

[SOURCE: ISO/IEC 2382-37:2022, 37.01.03, modified — "artefact metric" replaced "biometric" in the term. "single artefacts" replaced "individuals" and "distinguishing" replaced "biological and behavioural" in the definition. Notes to entry replaced by a new Note 1 to entry.]

3.6
artefact metric system
system for *artefact metric recognition* (3.5) of objects based on *distinguishing characteristics* (3.3)

[SOURCE: ISO/IEC 2382-37:2022, 37.02.03, modified — "artefact metric" replaced "biometric" in the term. "artefact metric recognition" replaced "the purpose of the biometric recognition", "objects" replaced "individuals", and "distinguishing" replaced "biological and behavioural" in the definition. Note 1 to entry deleted.]

3.7
probe
artefact metric data set input to an algorithm for comparison to *reference(s)* (3.8)

Note 1 to entry: Measurement (pre-processed sensor data) of a *distinguishing characteristic* (3.3) of a single artefact is the artefact metric data used as a probe in this document.

[SOURCE: ISO/IEC 2382-37:2022, 37.03.14, modified — "biometric" deleted from the term. "artefact metric data" replaced "biometric sample or biometric feature", "a biometric" deleted. Notes to entry replaced by a new Note 1 to entry.]

3.8
reference
enrolled artefact metric data used as the object of comparison

Note 1 to entry: Measurement (pre-processed sensor data) of a *distinguishing characteristic* (3.3) of a single artefact is the artefact metric data used as a reference in this document.

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[SOURCE: ISO/IEC 2382-37:2022, 37.03.16, modified — “biometric” deleted from the term. “enrolled artefact metric data” replaced “one or more stored biometric samples, biometric templates or biometric models attributed to a biometric data subject and”, “biometric” deleted. Example deleted. Notes to entry replaced by a new Note 1 to entry.]

3.9
comparison decision
determination of whether the *probe(s)* (3.7) and *reference(s)* (3.8) are from the same *artefact* (3.1), based on a comparison score(s), decision policy(ies) including a threshold, and possibly other inputs

[SOURCE: ISO/IEC 2382-37:2022, 37.03.26, modified — “biometric” deleted before “probe(s)” and “reference(s)”, “are from the same artefact” replaced “have the same biometric source”. Note 1 to entry deleted.]

3.10
false match
comparison decision (3.9) of match for a *probe* (3.7) and a *reference* (3.8) that are from different individual *artefacts* (3.1)

[SOURCE: ISO/IEC 2382-37:2022, 73.09.08, modified — “biometric” deleted before “probe” and “reference”, “individual artefacts” replaced “biometric capture subjects”. Note 1 to entry deleted.]

3.11
non-mated comparison trial
comparison of a *probe* (3.7) and a *reference* (3.8) from different *artefacts* (3.1) as part of a performance test

Note 1 to entry: A set of non-mated comparison trials need not contain all possible comparisons of probes and references from different artefacts.

[SOURCE: ISO/IEC 2382-37:2022, 37.09.02, modified — “biometric” deleted from the term. “biometric” deleted before “probe” and “reference”, and “artefacts” replaced “biometric data subjects”. Note 1 to entry deleted. Note 2 to entry renumbered as Note 1 to entry and modified: “biometric” deleted before “non-mated”, “probes” and “references”, and “artefacts” replaced “biometric data subjects”.]

3.12
false match rate
FMR
proportion of the completed *non-mated comparison trials* (3.11) that result in a *false match* (3.10)

Note 1 to entry: “Completed” refers to the computational processes required to make a comparison decision, i.e. failures to decide are excluded.

[SOURCE: ISO/IEC 2382-37:2022, 37.09.09, modified — “biometric” deleted before “non-mated”. Notes 1 and 2 to entry deleted. Note 3 to entry renumbered as Note 1 to entry.]

3.13
false non-match
comparison decision (3.9) of non-match for a *probe* (3.7) and a *reference* (3.8) that are from the same *artefact* (3.1) and of the same artefact metric characteristic

[SOURCE: ISO/IEC 2382-37:2022, 37.09.10, modified — “biometric” deleted before “probe” and “reference”, “artefact” replaced “biometric capture subject”, “artefact metric” replaced “biometric”. Note 1 to entry deleted.]

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3.14
mated comparison trial
comparison of a *probe* (3.7) and a *reference* (3.8) from the same *artefact* (3.1) and the same artefact metric characteristic as part of a performance test

[SOURCE: ISO/IEC 2382-37:2022, 37.09.01, modified — "biometric" deleted in the term. "biometric" deleted before "probe" and "reference", "artefact" replaced "biometric capture subject", "artefact metric" replaced "biometric". Note 1 to entry deleted.]

3.15
false non-match rate
FNMR
proportion of the completed *mated comparison trials* (3.14) that result in a *false non-match* (3.13)

[SOURCE: ISO/IEC 2382-37:2022, 37.09.11, modified — "biometric" deleted before "mated". Notes 1 and 2 to entry deleted.]

3.16
artefact metric verification
process of confirming that a *probe* (3.7) is from the same *artefact* (3.1) as a specified *reference* (3.8)

Note 1 to entry: This method is known as one-to-one comparison.

3.17
false reject rate
FRR
proportion of artefact metric transactions with true artefact metric claims erroneously rejected

[SOURCE: ISO/IEC 19795-1:2021, 3.20, modified — "artefact metric" replaced "biometric".]

3.18
false accept rate
FAR
proportion of transactions with false artefact metric claims erroneously accepted

[SOURCE: ISO/IEC 19795-1:2021, 3.21, modified — "artefact metric" replaced "biometric".]

3.19
artefact metric identification
process of comparing a *probe* (3.7) with a set of *references* (3.8) to find the identity of an *artefact* (3.1)

Note 1 to entry: A set of identifiers of the closest matching artefacts can be returned.

Note 2 to entry: The return can indicate that the probed individual artefact is not enrolled in the database.

Note 3 to entry: This method is known as one-to-many comparison.

3.20
false-negative identification rate
FNIR
proportion of the completed identification trials that the result returned through the trials does not include the individual *artefact* (3.1) same as the *probe* (3.7)

Note 1 to entry: In some cases, true-positive identification rate is used. True-positive identification rate = 1 - false-negative identification rate.

3.21
false-positive identification rate
FPIR
proportion of the completed identification trials that the result of matched *reference(s)* (3.8) is returned through the trials when there are no references in the database which is the same individual *artefact* (3.1) as the *probe* (3.7)

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3.22
closed-set identification
artefact metric identification (3.19) in which all *artefacts* (3.1) are enrolled in the system

3.23
open-set identification
artefact metric identification (3.19) in which some *artefacts* (3.1) are not enrolled in the system

Note 1 to entry: Some artefacts cannot be enrolled, e.g. where counterfeit artefacts are produced or where artefacts were created before the *artefact metric system* (3.6) was introduced.

Note 2 to entry: Where open-set identification is used, "not enrolled" shall be considered a valid database response.

3.24
failure to acquire rate
FTAR
proportion of a specified set of artefact metric acquisition processes that resulted in failure to accept for subsequent comparison an *artefact metric signal* (3.4)

Note 1 to entry: Other possible causes of failure to acquire include poor artefact metrics signal quality, algorithmic deficiencies and measurement of characteristic of outside the range of the system.

[SOURCE: ISO/IEC 2382-37:2022, 37.09.03 and 37.09.04, combined and modified — "artefact metric" replaced "biometric". "resulted in failure to accept for subsequent comparison an artefact metric signal" replaced "failures to acquire". Notes to entry deleted. Note 1 to entry added.]

3.25
failure to enrol rate
FTER
proportion of a specified set of artefact metric enrolment transactions that resulted in a failure to create and store an artefact metric enrolment data record for an eligible artefact, in accordance with an artefact metric enrolment policy

[SOURCE: ISO/IEC 2382-37:2022, 37.09.06 and 37.09.07, combined and modified — "artefact metric" replaced "biometric", "an artefact metric" replaced "a biometric", "artefact" replaced "biometric capture subject", "an artefact" replaced "a biometric". Notes to entry deleted.]

3.26
deployment team
set of people vested with the responsibility to determine the suitability of an *artefact metric system* (3.6) for its intended use

Note 1 to entry: Typically, this includes one or more representatives from the organizations providing and operating the artefact metric system.

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4 Conformity

In order to implement an artefacts metric system in conformity with this document, an artefact metric performance test shall be planned and described in a test specification. The performance test shall be executed and reported in accordance with Clauses 6 and 7.

5 Overview of elements of artefact metric systems

5.1 Conceptual overview of an artefact metric system

Given the variety of applications and technologies, it can seem difficult to draw any generalization about artefact metric systems. All such systems, however, have many elements in common and these are described in this clause.

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The process flow for a typical system using artefact metrics is shown in Figure 2. Some artefact metric systems do not require a database and so differ in some respects from this description. Details of such systems are provided in Annex B.

Measurements of one or more distinguishing characteristics of a single target artefact are produced by the acquisition process. The capture device output corresponds to a characteristic of the artefact from which a distinctive measurement can be obtained. These records are stored in a database as references and associated with an identifier in the enrolment phase.

In the verification and identification phases, these (or similar) data records are used as probes that are compared to the enrolled reference or references. A decision regarding the artefact metric claim is made based upon a comparison between the probe and the enrolled reference or references.

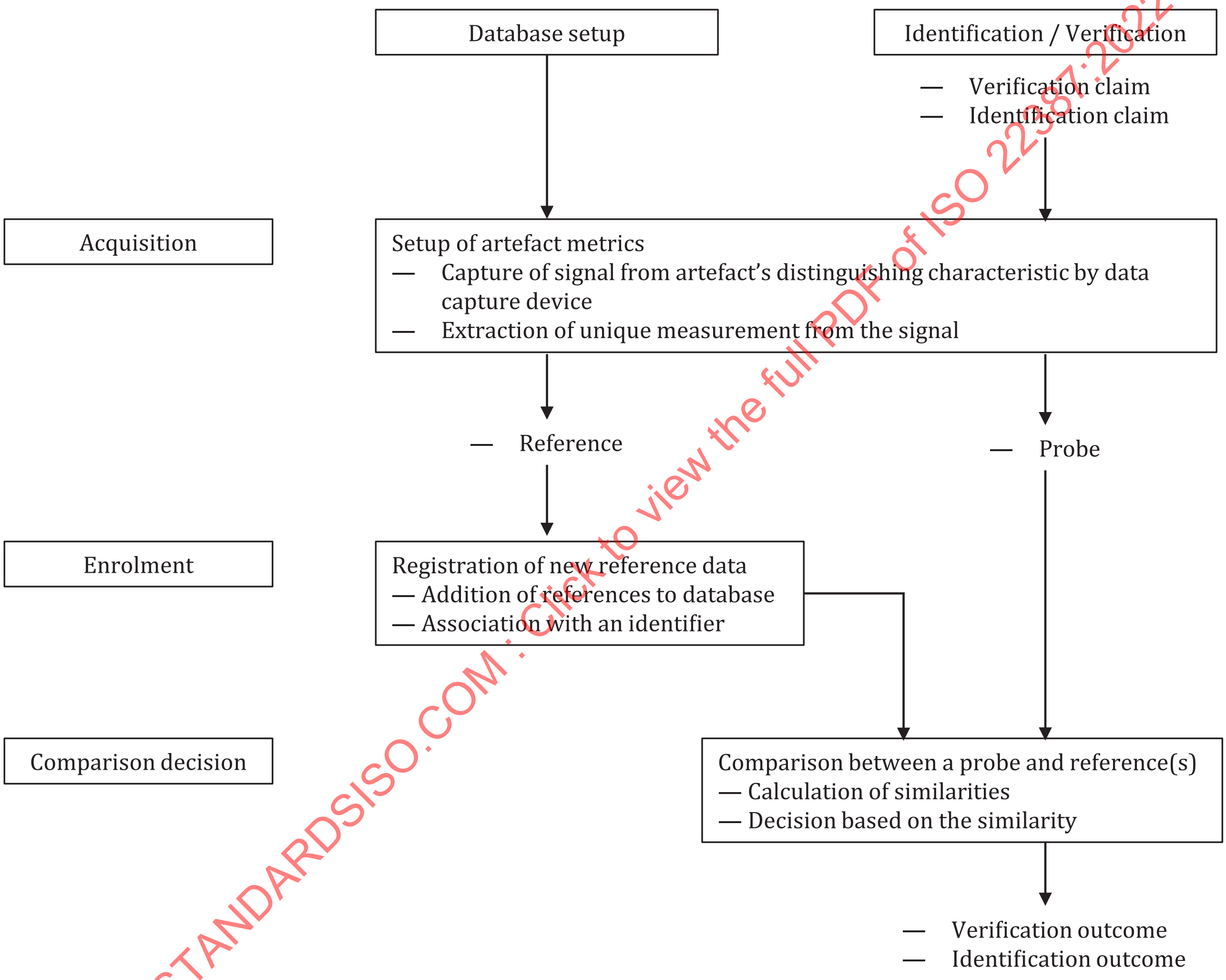

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Figure 2 — Artefact metric system process flow

Figure 2 illustrates the information flow within a general artefact metric system consisting of data acquisition, database setup and comparison decision functions which support the operations of enrolment, verification and identification. The following subclauses describe each of these functions in more detail.

NOTE In any implemented system, some of these conceptual components are absent, e.g. some systems only support verification. In some cases, conceptual components do not have a direct correspondence with a separate physical entity or software module.

Examples of the use of artefact metric systems are explained in Annex A.

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5.2 Acquisition

A data capture device outputs a signal corresponding to one or more characteristics of a target artefact. A wide variety of signals can be used for artefact metrics such as those derived from an optical, electrical, magnetic or vibration property or any distinguishing characteristic. A common example of a signal is an image obtained by capturing a specific surface region of an artefact.

Distinctive measurements are extracted from the signals output by the data capture device. Processing can include:

— enhancement, i.e. improving the quality and clarity of the captured artefact metric signal;

— segmentation, i.e. locating the subject's characteristics within the captured artefact metric signal;

— artefact metric extraction, i.e. deriving the subject's repeatable and distinctive measures from the captured artefact metric signal;

— adjustment, i.e. assessing the suitability of signals, features, references, etc. and possibly affecting other processes, such as returning control to the data capture to collect further signals (recapture), or modifying parameters for segmentation, feature extraction or comparison.

In the case of enrolment and labelling (see Annex B), the acquisition function creates a reference. In the case of verification and identification, the acquisition function creates a probe. The content of the probe is generally similar to the distinctive unique measurement data used to create the reference.

In some cases, the unprocessed signal from the data capture device is used as the reference. Examples of references include a surface image of an artefact, a vibration pattern or distribution of electrical charge.

In some cases, capture conditions and environment can affect the signals and need to be carefully controlled. In some cases, data capture systems automatically adjust to capture the best signal possible in a given environment.

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5.3 Enrolment

In enrolment, an artefact metric reference from the acquisition system is added to a database and associated with a unique digital identifier and other metadata to create an enrolment reference for that individual artefact.

The metadata associated with the artefact at the time of enrolment can include date and place of manufacture, part number, authentication, ownership rights and restrictions of use. The content of this metadata varies substantially from system to system and such details are not covered by this document.

The unique identifier can be attached to the artefact in some way (e.g. as a barcode) in order to facilitate subsequent verification of the artefact.

The references can also be stored using an alternative system rather than a conventional database. For example, the distinctive measurement to be used as a reference can be encoded (possibly using cryptographic techniques) and attached to the artefact itself. Distributed ledger technology can also be used to associate the reference with the artefact's identity. A description of such systems is given in Annex B.

5.4 Comparison decision function

Central to any artefact metric system is a comparison decision process where probes are compared against one or more enrolled references and a comparison score or set of scores indicating the similarities or dissimilarities between the probes and references is calculated. The comparison score or scores are used to determine the comparison decision outcome: a match or a non-match.

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For verification, a single specific claim of artefact enrolment leads to a single comparison score. For identification, the probe is compared with reference data leading to comparison scores indicating the most likely matches.

The comparison decision process uses the comparison scores generated from one or more artefact metric comparisons to provide the decision outcome for a verification or identification transaction.

5.5 Artefact metric verification

For artefact metric verification, each artefact has an identifier. A verification claim is made to confirm that a target artefact is from the same artefact as indicated by the associated identifier. Once the claim is received, the system obtains the enrolled reference associated with the identifier. The decision as to whether the verification claim is acceptable is made based on the comparison score determined from the similarity between the reference and the probe.

NOTE In some cases, the identifier is unique for each artefact., In other cases, multiple artefacts can be assigned the same identifier, e.g. for batch verification.

Typically, a threshold determining the closeness of match required for this comparison is configured as part of the system. In this case, if the comparison score exceeds the threshold, the system returns "match" and if the calculated similarity does not exceed the threshold, the system indicates that no match is found ("non-match").

In some cases, multiple probes (e.g. using a set of surface images or other measurements of characteristics of the artefact) may be used for a single verification transaction and the decision outcome of whether the claim is accepted is made based on the set of comparison scores: a match or a non-match.

When the comparison score exceeds a specified threshold, an artefact metric claim can be verified on the basis of the decision policy, which may allow or require multiple attempts.

When all genuine artefacts are enrolled, verification can be used for anti-counterfeiting.

5.6 Artefact metric identification

Artefact metric identification differs from artefact metric verification in that it assumes no prior information about the artefact, e.g. there is no identifier attached to, integrated with or physically associated with the artefact.

In artefact metric identification, a request is made to identify a target artefact. A probe describing the target artefact is compared with enrolled references and a comparison decision made. The comparison decision outcome is usually a list of one or more artefact identifiers that are best matches to the probe. One possibility is that there are no enrolled references for the target artefact. In such a case, the comparison decision outcome can indicate that the target artefact is not enrolled. The final decision is sent in accordance with the decision policy, which may allow or require multiple attempts.

Artefact metric identification includes two sub-classes: closed-set identification in which all artefacts to be identified are enrolled in the system, and open-set identification in which some artefacts to be identified are not enrolled in the system.

Where open set identification is used, "not enrolled" shall be considered a valid database response.

Identification can be implemented in different ways, e.g. as follows:

— The system compares the probe with each reference in turn and orders these results according to their similarity and the system returns a number of matched references up to a predetermined maximum (the rank).

— The system makes a comparison between the probe and each reference in turn and, based on the comparison similarity threshold, a list of identifiers for all references whose similarity exceeds the threshold is returned.

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— The system makes a comparison between the probe and each reference in turn until an enrolled reference is found where the comparison score exceeds the comparison similarity threshold. This reference is returned, and no subsequent enrolled references are compared.

6 Requirements for planning an evaluation

6.1 General

This clause describes aspects that shall be considered when planning an evaluation of an artefact metric system to determine the suitability of the artefact metric and system performance for its intended use, taking into consideration test results. The evaluation is conducted by a tester based on a test specification that should be provided before any testing begins. A deployment team representing the manufacturer of the artefact metric system and the intended user have overall responsibility for the testing and to ensure that the system is suitable for its intended use. Following best practice, the details of the tests conducted, and the result of testing should be recorded for future reference.

Tests are conducted during each phase of introduction and where the results of testing are poorer than required, the test specification is updated and testing repeated. Multiple tests can be required for each phase (see Clause 8) of the introduction of the system.

6.2 Appointment and responsibilities of the deployment team

Before artefact metric systems are tested, a deployment team shall be appointed. This team should include a representative from the artefact metric system provider and from the organizations planning to deploy the system.

The test specification shall be produced for each test in consultation with the deployment team and agreed by all deployment team members.

One or more testers responsible for conducting the testing shall be appointed by the deployment team and a schedule for testing should be agreed.

6.3 Test specification

A test specification is used as the basis for the tests and this clause provides requirements and guidance for its creation. It shall be produced and agreed by the deployment team before the start of testing. In case additional tests appear to be necessary, the modifications shall be agreed, and the specification shall be updated.

NOTE The specification can be created by different individuals or groups from the deployment team depending on the intended testing phase (Clause 8 describes the test phases).

The set of tests to be conducted shall be specified. Refer to Annex B when selecting the set of tests to be conducted in the case where no database is used. During phased introduction of artefact metrics, the content of the test specification including the set of artefacts used and the tests performed will generally be different for each phase (see Clause 8).

The test conditions to be used for each test should reflect the intended deployment environment where that is known and shall be included in the test specification.

Table 1 indicates the set of tests to be considered and the relevant sections of this document where the tests are specified and specific test details are described. The test specification shall indicate whether each test is required and where the test is required, a detailed specification of the test method shall be included.

Details of any other functionality required shall be specified and added to the test specification along with details of testing to be conducted.

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Table 1 — Tests to be considered for the test specification

Test	Relevant sections	
	Specification	Related details
Artefact metric acquisition and enrolment testing	7.2	5.2, 5.3
Artefact metric comparison performance	7.3	5.4
Artefact metric verification	7.4	5.5, 6.4
Open-set identification	7.5	5.6, 6.4
Closed-set identification	7.5	5.6, 6.4
Throughput performance testing	7.6	6.4

Table 2 provides details of the set of test options to be considered and indicates the section of this document where the options are described. The test specification shall indicate options for the required tests.

Details of any other test options required shall be added to the test specification.

Table 2 — Test options to be included in the test specification

Test option	Relevant sections
Definition of the artefact or range of artefacts that are supported	6.5
Number and selection method of artefacts to be used for assessment	6.5
Characteristic or range of characteristics to be measured	5.2
Method to be used for acquisition of an artefact metric from these characteristics	5.2
The range of data capture environments to be supported	6.6, Annex C
System configuration options to be used for assessment[a]	Clause 5

[a] For example, the maximum number of identifiers to be returned in the identification candidate list (its rank, R) as described in 5.6.

Additional aspects or concerns raised by the deployment team should be recorded.

Some artefact metric systems support a range of artefacts, e.g. manufactured products that differ in size, shape or colour, products manufactured in different locations or using different materials. Where such variation is supported, the range of artefacts shall be clearly specified.

This specification may be created by the system manufacturer, the organization wishing to deploy the system, by the tester conducting the tests or in some other way.

The test specification shall be referenced by the test report.

6.4 Definition of required functionality

The deployment team shall determine the expected level of throughput performance of the artefact metric system and testing shall be conducted with this in mind.

Artefact metrics can be used for identification and verification of artefacts. These two forms of artefact metric recognition require different assessment methods and so it is important to decide which will be required. In some cases, both identification and verification are required.

It is important to decide whether closed-set identification (all artefacts are enrolled) or open-set identification will be used. This will depend on the intended application.

The deployment team shall determine which artefact identification and artefact verification will be used, and where identification is required, whether closed-set identification or open-set identification will be used. This information and the reasons for the choices shall be recorded in the test specification prior to the start of testing.

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The throughput performance of an artefact metric system can be an important factor, and in such cases throughput performance shall be tested. In any event, throughput performance shall be tested before deployment (see 8.2.6).

6.5 Selection of appropriate test artefacts

The deployment team shall select a set of artefacts that is representative of the artefacts to be supported by the system. This should include any artefact variants, artefacts from different manufacturing operations, and where counterfeit goods have been identified, examples of these should be included in the testing.

In some cases, the artefacts to be supported by the system are not available, e.g. when setting up a new production line. In such cases (e.g. during technology testing), it can be appropriate to conduct some of the tests using artefacts with similar characteristics to those that will be supported by the system when deployed.

The number of artefacts selected depends on the type of performance evaluation being conducted. Acquisition testing can be performed with a small number of artefacts, e.g. with a set of prototypes. However, operational evaluation requires a much larger set of artefacts representing the range expected to be encountered in practice. As a general rule, the larger the number of artefacts tested, the more reliable are the results obtained. In the early stages of testing, it is not always possible to obtain many artefacts. In all cases, the number of artefact measurements shall be recorded along with the test results. The number of artefacts used when evaluating performance has a significant impact on the confidence of prediction of future behaviour. Details as to how to determine the number of artefacts required to achieve the desired confidence level are provided in ISO 2859-1[1].

At least one distinguishing characteristic for the test artefact shall be selected, e.g. region(s) where image capture can be performed. When conducting the assessment, a method that allows repeated measurement of the distinguishing characteristic of an artefact, such as marking the part of the surface measured, can be needed.

NOTE When testing artefact metric algorithms for suitability, it can be appropriate to use multiple areas from one test artefact in order to reduce the cost of testing. Where this is done, it is important to ensure that the differences between different areas of the same individual artefact are comparable with the differences between the same area of different individual artefacts.

If the application of artefact metrics is traceability for quality assurance using a database (see Annex A), all artefacts will be enrolled beforehand, and only enrolled artefacts need to be recognized. When testing for this case, all artefacts to be tested should be enrolled and only enrolled artefacts are used to obtain probes for testing (closed-set identification).

If the application of artefact metrics is anti-counterfeiting using a database (see Annex A), genuine artefacts are enrolled as references but artefacts that have not been enrolled (counterfeit artefacts) can also be encountered. When testing for this case, not all artefacts to be tested should be enrolled but all artefacts are used to obtain probes for testing (open-set identification). Where counterfeit artefacts are discovered, they should be included in the set to be tested.

6.6 Definition of acquisition conditions

Measurements of distinguishing characteristics are used to identify or verify artefacts. The condition of each artefact, various acquisition parameters and the data capture environment affect the system performance.

The deployment team shall identify the operational environment and record important aspects. In cases where variations in operating conditions are likely and where deployment will include more than one operational environment, any differences between them shall be clearly indicated.

The environment for enrolment can be different from the environment for identification and verification. In such cases, the operating conditions for each environment shall be indicated.

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The operating environments for artefact metrics differ widely and factors to be considered will therefore be different for each situation. For example, in the case of traceability for quality assurance in a manufacturing operation, the requirements for the supplier of a part can be different from those of the customer for the part which in turn can be different from that of final shipment or subsequent sales.

In the case of part production, it can be necessary to consider the stage in the process where the artefact is measured, and by whom, to keep the production line efficient.

Factors such as the correct use of the data capture device and how the respective measurements are made and enrolled should be determined and documented.

The likely range of artefact conditions (damage, stain on the surface, etc.) and influences of external factors that can affect the data capture condition (factors present at the time of capture, the status of an electrical device, etc.) should be determined and documented.

Where the artefact metric is derived from a limited surface or volume, the method of data capture should consider using a part of the artefact surface or volume where future change is unlikely and is easy to capture images in the operational environment.

There are many environmental factors that can influence the performance of artefact metric recognition. All factors that can affect performance should be determined and documented in one of two categories: factors that can be controlled in the operational environment, and factors that cannot be controlled in the operational environment.

The factors that cannot be controlled should be tested by varying them in a controlled way in a laboratory test to ensure high performance of artefact metric recognition across the likely range of variation.

A suitable configuration for factors that can be controlled in the operational environment should be determined and documented, and variation should be minimized.

Examples of variation in data capture conditions and artefact conditions likely to affect acquisition performance are given in Annex C.

6.7 Appointment of testers

The deployment team shall appoint one or several testers to oversee the testing.

NOTE 1 Different testers can be suitable for different aspects of the testing. For example, it can be appropriate for a representative of the system provider to conduct artefact metric acquisition feasibility testing as it is beneficial to have some knowledge of the acquisition system and signal analysis method.

NOTE 2 Testing can be conducted by a specialized entity (third party).

7 Requirements for testing, data collection, analysis and reporting

7.1 General

The tests specified in this clause are described in a way that allows them to be conducted by a tester with no access to or knowledge of the internal mechanisms of the artefact metric system.

In some cases, the tester has detailed knowledge of the system, e.g. if the tester is the system manufacturer. This knowledge can be used to reduce the time of the testing but the tests shall be conducted in a way that ensures that results are consistent with the testing having been done by a tester with no knowledge of the system.

The report should include test results as described in this clause along with any other characteristics susceptible to influence the results of the evaluation.

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7.2 Acquisition and enrolment testing

This clause specifies a method to test that the artefact metric can be acquired reliably, a reference created and, where a database is used, that a database record can be created for each artefact.

NOTE See Annex B for a description of the artefact metrics system that does not require a database.

Where the system employs an acquisition function that returns an error when the acquired data does not exceed a sufficient quality threshold and so cannot be used as a reference or a probe this is the failure to acquire rate (FTAR) which shall be calculated as shown in Formula (1):

$$R_{\text{FTA}} = \frac{N_{\text{FA}}}{N_{\text{AA}}} \tag{1}$$

where

R_{FTA} is the failure to acquire rate (FTAR);

N_{FA} is the number of failed acquisitions of either a reference or probe;

N_{AA} is the number of acquisition attempts.

According to the test specification, an artefact metric reference should be acquired for each artefact and enrolled in the system. In some cases, this process can fail, e.g. where a unique record cannot be obtained. This is the failure to enrol rate (FTER), which shall be calculated as shown in Formula (2):

$$R_{\text{FTE}} = \frac{N_{\text{FE}}}{N_{\text{EA}}} \tag{2}$$

where

R_{FTE} is the failure to enrol rate;

N_{FE} is the number of failed enrolments;

N_{EA} is the total number of enrolment attempts.

When reporting acquisition and enrolment testing, the following shall be reported:

— FTAR and the number of acquisition attempts;

— FTER and the number of enrolment attempts.

EXAMPLE Reporting acquisition and enrolment performance:

— FTAR: 1,0 % for 500 acquisition attempts;

— FTER: 0,8 % for 500 enrolment attempts.

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7.3 Comparison decision performance testing

7.3.1 General

This clause specifies a method to test the reliability of the comparison decision algorithm for the artefacts and the characteristics used (one-to-one comparison). It is not always possible to access the comparison decision function directly without help from the system manufacturer, and in such cases, this test is not possible.

According to the test specification, acquire an artefact metric to create a reference. The reference for each artefact in the test set shall be recorded separately for the purpose of testing, e.g. by attaching a

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temporary label to the artefact to be used only by the tester (and not the system) for the purpose of knowing its true identity.

7.3.2 False non-match rate

A probe is obtained for each artefact which is compared with the reference from the same artefact (mated comparison) and the result of each comparison recorded along with the total number of comparisons.

In artefact metric comparison, it is an error if the comparison result is deemed to be a non-match for the comparison between a probe and a reference for the same artefact (a false non-match). The false non-match rate (FNMR) is the evaluation index of this error and shall be calculated as shown in Formula (3):

$$R_{\text{FNM}} = \frac{N_{\text{NM}}}{N_{\text{MC}}} \tag{3}$$

where

R_{FNM} is the false non-match rate;

N_{NM} is the number of non-match results;

N_{MC} is the number of mated comparison trials.

7.3.3 False match rate

A probe is obtained for each artefact which is compared with the reference from all artefacts in the test set except the artefact from which the probe was measured (non-mated comparisons) and the result of each comparison recorded along with the total number of comparisons.

In artefact metric comparison, it is an error if the comparison result is deemed to be a match for the comparison between a probe and a reference from different artefacts (a false match). The false match rate (FMR) is the evaluation index of this error and shall be calculated as shown in Formula (4):

$$R_{\text{FM}} = \frac{N_{\text{M}}}{N_{\text{NMC}}} \tag{4}$$

where

R_{FM} is the false match rate;

N_{M} is the number of matched results;

N_{NMC} is the number of non-mated comparisons.

7.3.4 Comparison decision recording and reporting

A lower *FMR*, a higher N_{NMC} and a larger test set indicates a more reliable artefact metric comparison method. When it is important to reduce the risk of misjudging different artefacts as match, a lower FMR is required.

When reporting comparison decision performance, the following shall be reported:

— FNMR and the number of mated comparisons;

— FMR, the number of test artefacts and the number of non-mated comparison trials.

EXAMPLE Reporting comparison decision performance:

— FNMR = 0,015 for 10 000 mated comparison trials;

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— FMR = 0,031 against a test set of 1 000 artefact and 999 000 non-mated comparison trials.

7.4 Verification testing

7.4.1 General

Verification testing is conducted in a similar way to comparison performance decision testing and is assessed using two measures: the false reject rate (FRR), and the false accept rate (FAR).

According to the test specification, acquire an artefact metric to create a reference. The reference for each artefact in the test set shall be recorded separately for the purpose of testing, e.g. by attaching a temporary label to the artefact.

7.4.2 False reject rate

A probe is obtained for each artefact which is presented to the system for verification using its identifier. The result of each comparison is recorded along with the total number of verification transactions.

In artefact metrics, it is an error if the result of a verification transaction is deemed to be a non-match for the comparison between a probe and a reference for the same artefact (a false rejection). The FRR is the evaluation index of this error, which shall be calculated as shown in Formula (5):

$$R_{FR} = \frac{N_{NM}}{N_{MT}} \tag{5}$$

where

R_{FR} is the false reject rate;

N_{NM} is the number of non-match results;

N_{MT} is the number of mated verification transactions.

7.4.3 False accept rate

A probe is obtained for each artefact which is presented for verification with the enrolled reference from all enrolled artefacts except the artefact from which the probe was measured. The result of each verification transaction is recorded along with the total number of transactions.

In artefact metric verification, it is an error if the verification transaction result is deemed to be a match for the verification of a probe and a reference from different artefacts (a false acceptance). The false Accept Rate (FAR) is the evaluation index of this error, which shall be calculated as shown in Formula (6):

$$R_{FA} = \frac{N_{M}}{N_{NMT}} \tag{6}$$

where

R_{FA} is the false accept rate;

N_{M} is the number of matched results;

N_{NMT} is the number of non-mated verification transactions.

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7.4.4 Verification recording and reporting

When comparing two systems, a lower *FAR*, a higher N_{NMT} and a larger database indicates a more reliable artefact metric verification performance. When it is important to reduce the risk of misjudging a probe and reference from the same artefact as a non-match, a low *FRR* is required.

The following shall be reported as the result of verification testing:

— FRR and the number of mated verification transactions;

— FAR, the number of artefacts in the test set and the number of non-mated verification transactions.

EXAMPLE Reporting comparison decision performance:

— FRR = 0,015 for 10 000 mated comparison trials;

— FAR = 0,031 against a test set of 1 000 artefacts and 999 000 non-mated comparison trials.

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NOTE In the case of verification for systems that permit only a single attempt for each verification transaction, the FAR is the same as the FMR, and the FRR is the same as the FNMR as measured for the comparison decision performance.

7.5 Identification testing

7.5.1 General

This clause specifies a method to test the artefact metric system identification performance.

In accordance with the test specification, each artefact in the test set is enrolled and its associated reference is found. The reference for each artefact shall be recorded separately for the purpose of testing, e.g. by attaching a temporary label to the artefact.

In artefact metrics, an identification transaction produces a candidate list containing zero, one or more identifiers, and the system's performance is measured by comparing this list with the (known) identity of each artefact being tested. The length of this list is its rank *R* and this is an important system parameter for artefact metric identification. For some artefact metric systems, this parameter can be changed by a system administrator. Where such functionality is supported, identification transactions may be collected against portions of the enrolment database of various sizes to record how identification performance varies with database size.

In addition to enrolled test subjects, identification testing may include test subjects not enrolled in the system to ensure meaningful estimation of the false-positive identification rate (FPIR). These non-enrolled test subjects shall not be test subjects who failed enrolment. Identification transactions of enrolled subjects and of non-enrolled subjects should be made under the same conditions.

NOTE The reason that artefacts that failed enrolment are excluded from this test is that, if such artefacts are used, the system can appear to identify artefacts that have not been enrolled more successfully than can be achieved in practice.

There are two types of artefact metric identification: closed-set identification where all artefacts are enrolled in the system, and open-set identification where some artefacts are not enrolled in the system.

For closed-set identification, the result is considered to be erroneous if the reference for the test artefact is not a member of the resulting candidate list (false-negative identification). The appropriate evaluation index for closed-set identification is false-negative identification rate (FNIR), which is the ratio of the number of false-negative identifications to the total number of identification transactions.

For open-set identification, the result is considered to be erroneous if either:

— the artefact is enrolled but the correct reference is not returned (false-negative identification); or

— the artefact is not enrolled but a reference is returned (false-positive identification).

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The performance evaluation indices for open-set identification are the FNIR (see 7.5.2) and the FPIR (see 7.5.3).

7.5.2 False-negative identification rate

FNIR is the ratio of the number of identification trials where the candidate list returned does not include the identifier of the test artefact to the total number of trials.

Each artefact is presented to the system for identification and the returned candidate list is examined to check whether the test artefact identifier is included. The number of times the returned candidate list does not include the identifier of the test artefact shall be recorded along with the total number of trials.

FNIR shall be calculated as shown in Formula (7):

$$R_{FNI} = \frac{N_c}{N_{IT}} \tag{7}$$

where

R_{FNI} is the false-negative identification rate;

N_c is the number of transactions where the candidate list does not include the identifier of the artefact being tested;

N_{IT} is the total number of identification trials conducted.

7.5.3 False-positive identification rate

FPIR is the ratio of the number of identification trials where an identifier is included in the candidate list where the test artefact has not been enrolled to the total number of identification trials. This test applies only to open-set identification.

FPIR shall be calculated as shown in Formula (8):

$$R_{FPI} = \frac{N_d}{N_{IT}} \tag{8}$$

where

R_{FPI} is the false-positive identification rate;

N_d is the number of transactions where an identifier is included in the candidate list where the test artefact has not been enrolled;

N_{IT} is the total number of identification trials conducted.

7.5.4 Identification recording and reporting

A lower value for FNIR against a larger number of identification trials and a shorter candidate list indicates a more reliable artefact metric identification method. Therefore, the number of identification trials conducted, the number of enrolled artefacts, and the rank *R* of the candidate list shall be recorded and reported.

The following shall be reported as the result of identification testing:

— FNIR;

— FPIR;

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— the number of enrolled artefacts, the number of identification trials and the rank of the candidate list.

EXAMPLE Reporting identification performance:

— FNIR = 0,015 and FPIR = 0,03 for a database of 100 000 enrolled artefacts and 10 000 identification trials with a candidate list of rank 3.

7.6 Throughput rate testing

The throughput rate of an artefact metric system is often important when selecting a given artefact metric system for a particular application. The throughput rate is the number of artefacts that can be processed per unit time based both on computational speed and human machine interaction. Different performance is likely between the enrolment, verification and identification phases, and therefore all three should be measured.

In the enrolment phase, the time period measured is from the time the artefact is presented to the system until the system indicates that the artefact has been enrolled.

In the verification and identification phases, the time period to be measured is from the time the artefact is presented to the system until the outcome is returned by the system.

The throughput rate for enrolment, identification and verification transactions shall be reported as the number of transactions per unit time, e.g. transactions per minute.

When reporting the throughput rate, details of how the specific start point and end points were determined shall be reported.

EXAMPLE Reporting throughput performance:

— System throughput per minute: 10 enrolment transactions, 100 verification transactions and 15 identification transactions.

— Database size: 10 000 enrolled artefacts.

— Start point: presentation to the sensor.

— End point: successful enrolment indicated.

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8 Recommendations for phased deployment of artefact metrics

8.1 Types of performance evaluation

8.1.1 General

In artefact metrics, where measurements of distinguishing characteristics of artefacts are used for its recognition, it is necessary to ensure suitability and reliability of the artefact metric and of the artefact metric comparison method to be used before it is introduced to a supply chain.

This document recommends a set of validation procedures to ensure the suitability and reliability of artefact metrics before introducing it to a supply chain. Four phases are defined as follows:

— Phase 1: The presence of one or more capturable distinguishing characteristics of the artefact is tested.

— Phase 2: Comparison decision performance is tested to ensure that it is sufficiently accurate.

— Phase 3: Influences of acquisition conditions are considered and tested.

— Phase 4: Reliability of the system in the environment where deployment is intended is tested.

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For each phase, work is carried out in the order: preparing target artefacts, testing, recording and reporting results.

Artefact metric technical performance testing can be of three types: acquisition feasibility and comparison decision (phase 1 and 2), laboratory (phase 3) or operational (phase 4).

Phases 1 and 2 are closely related to each other and are generally conducted together. However, phase 2 testing is only useful where the result of phase 1 testing is satisfactory.

In some cases, all four phases are not necessary. However, phase 4 testing in the intended environment should be conducted before any deployment.

8.1.2 Acquisition feasibility and comparison decision evaluation

In an acquisition feasibility and comparison decision evaluation, testing is performed to check that a method used to measure a characteristic of an artefact produces a result that is unique across a range of artefacts. There are two steps: an acquisition quality test and a comparison decision test. Together these measure the effectiveness of the artefact metrics system when using the selected distinguishing characteristic and associated processing.

Since the range of artefacts is very broad, this is one area which differs from biometrics where all subjects have (more or less) the same set of characteristics. It is therefore important to establish at the outset that the set of artefacts to be measured have at least one distinguishing characteristic that can be measured and which is different for each artefact.

8.1.3 Laboratory evaluation

In a laboratory evaluation, testing is conducted on a complete system in an environment that models the intended deployed environment. The primary aim is to ensure that the acquisition and use of artefact metrics is not affected by small changes in environmental variables.

This evaluation step can provide a basis for comparison between systems. Where multiple systems are being compared, care will be required that data collection across all tested systems is in the same environment with the same population. These test results will be repeatable only to the extent that the modelled scenario can be carefully controlled.

8.1.4 Operational evaluation

In an operational evaluation, testing is performed in the environment where it will be deployed. This testing is essential as it is likely that acquisition is to some extent dependent on the environment where it is deployed.

Repeatability of operational test results can be limited due to unknown and undocumented differences between operational environments. The true identities of the artefacts and the method of acquisition of the signals from test subjects can be difficult to ascertain, particularly under unsupervised conditions without a test administrator, test observer or operational personnel present. For these reasons, successful operation in one environment should not be assumed to guarantee successful operation in another and separate testing of each operating environment is recommended.

8.2 Guidelines for phased introduction

8.2.1 General

In order to introduce artefact metrics into a supply chain, the reliability of a suitable artefact metric and artefact metric comparison method should be verified following these four phases:

— Phase 1: The presence of capturable distinguishing characteristics of the object is verified.

— Phase 2: Comparison decision performance is verified.

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— Phase 3: Influences of acquisition conditions are considered and the operating range is verified.

— Phase 4: Reliability of the operation in the working environment is verified.

This phased introduction ensures the reliable deployment of artefact metric recognition to identify or verify artefacts using one or more measurements of their characteristics that are unique to the individual artefact.

8.2.2 Creating the test specification

A test specification is used as the basis of the testing (see 6.3). The specification is created in different ways and by different individuals depending on the intended testing phase, but in any event is produced and agreed before the start of each phase testing.

During phased introduction of artefact metrics, the content of the test specification including the set of artefacts used and the tests performed will generally be different for each phase.

The test specification specifies the configuration of the artefact metric system to be used for testing.

8.2.3 Phase 1: Validation of presence of capturable characteristics

In order to recognize single objects using artefact metrics, each artefact must have one or more capturable characteristics. This phase of testing is designed to verify that for the range of artefacts, the selected characteristic can be acquired successfully. When this test is successful, phase 2 testing can be started.

This is verified as follows:

— As many instances of the test artefact as is practicable should be prepared for testing. It is often desirable to perform this testing at an early stage of adoption and this is often performed on a small number of artefacts with a view to verifying that the artefacts to be measured include a shared characteristic from which distinguishing and repeatable measurements can be made.

— Testing is performed to determine whether the selected characteristic can be captured for the required set of artefacts.

— During the early stages of the introduction of artefact metrics, this testing can fail as the characteristic cannot be captured. In such cases, the data capture condition or the capture method is changed and the validation test is performed again. The test specification should be updated to include the new test conditions and should also include details of any failures in the testing.

— The result of testing as to whether the measurement of the target artefact characteristic can be made for each artefact should be reported as follows:

  — If no repeatable artefact metric measurement can be made, it should be reported that the test was unable to verify whether the artefact is suitable.

  — If repeatable artefact metric measurements can be made, this is reported together with the FTAR and FTER and the test specification that defined the test.

— The decision as to whether to proceed phase 2 should be made by the deployment team based on this report.

8.2.4 Phase 2: Assessment of comparison decision performance

The purpose of this phase is to ensure that the comparison decision algorithm is able to distinguish the acquired characteristic for each artefact effectively.

Test artefacts should be prepared based on the number and selection method agreed in 6.5.

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Performance assessment should be done based on the data obtained by capturing the prepared artefacts as specified in the test specification. Comparison decision performance should be conducted (see 7.3).

The results of assessments are reported (see 7.3) along with a copy of the test specification. The decision as to whether to proceed phase 3 should be made by the deployment team based on this report.

8.2.5 Phase 3: Consideration of influences of data acquisition conditions

The purpose of this phase is to perform testing in a controlled environment such as in a laboratory where variations in the acquisition conditions can be tested and controlled. Since artefact metric comparison decisions are based on data captured from test artefacts, changing various capture parameters can affect their performance.

Where possible, data capture conditions based on the intended operational environment are established and variations considered.

Test artefacts that are as representative as possible of all artefacts likely to be measured in the operational environment should be selected. For example, artefacts from different production lines and artefacts made on different days should be selected where possible.

Performance assessment should be done based on the types and ranges of acquisition conditions and subject artefact conditions agreed with the deployment team and as specified in the test specification.

Where acquisition and enrolment testing (see 7.1) and comparison decision performance testing (see 7.2) are required, these should be included in the list of required tests in the test specification.

Where verification functionality is required, verification testing (see 7.3) should be performed and where identification functionality is required, identification testing (see 7.4) should be performed. Both should be included in the list of required tests in the test specification.

The results of assessments should be reported as described in Clause 7, along with a copy of the test specification. The decision as to whether to proceed to phase 4 should be made by the deployment team based on this report.

8.2.6 Phase 4: Ensuring reliability in intended operation environment

In this phase, system performance in the operational environment is measured and should consider both reliability and efficiency.

Performance assessment should be done based on a range of test artefacts that are representative of the set of artefacts likely to be encountered during the use of the system. This should include any anticipated variation, and where counterfeiting is an issue, examples of counterfeit products should be included in the testing.

Where acquisition and enrolment testing (see 7.1) is required, this should be included in the list of required tests in the test specification.

Where verification functionality is required, verification testing (see 7.3) should be performed, and where identification functionality is required, identification testing (see 7.4) should be performed. Both should be included in the list of required tests in the test specification.

Throughput rate testing (see 7.6) is included in the list of requirements in the test specification (see 6.4).

NOTE It is often useful that documentation of all tests performed and the results for each test be retained throughout the life of the artefact metric system. Since the performance of the artefact metric system can vary with different numbers of enrolled artefacts, some testing during its deployment can be necessary and any necessary adjustments made.

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Annex A
(informative)

Artefact metric application

A.1 Merits of artefact metrics

A.1.1 Broad applicability

Since these inherent characteristics are used for artefact metric identification, it is possible to track and trace artefacts where it is not possible to attach an identifier due to their material, size or shape limitations. It can be used with or without additional means, which are used for track and trace.

The use of artefact metrics applies to many kinds of artefacts with a relatively low cost for introduction.

A.1.2 Duplication difficulty

Since the variation in these characteristics are unique to individual artefacts, it is extremely difficult to produce a replica that meets the criteria for a match. This applies even when attempting to duplicate the same artefact using the same material and the same apparatus in the same manufacturing environment.

Artefact metrics are therefore potentially very effective in terms of robustness against mass duplication.

In common with all other techniques, testing very large populations can pose specific challenges. Where a component of a product is used for identification (e.g. packaging), the integrity of other associated components (e.g. content of the packaging) cannot be ensured.

A.2 Examples of the use of artefact metrics

A.2.1 Traceability for quality assurance

Artefact metrics enables artefact metric identification of individual artefacts without the need for the addition of a serial number or a code image. Therefore, it is possible to identify hundreds of parts, even small parts such as screws to be used in a final product, not as a lot but individually. From procurements of parts to the production of final products in a supply chain, artefact metric identification can be utilized as a mean of tracking and tracing, linking individual parts to their final product.

Figure A.1 shows an example of traceability achieved by introducing artefact metrics technology into a manufacturing process. In this configuration, in the upstream process (e.g. parts production), artefact metrics for characteristics of individual target parts are acquired and these parts are enrolled in the database together with related information (e.g. manufacturing conditions). In the downstream process (e.g. product assembly), artefact metrics for characteristics of individual target parts are acquired and compared with the characteristics of parts previously enrolled in the database. In this way, parts can be specified as one of the enrolled parts or as a counterfeit part. Information related to this process (e.g. product ID incorporating the part) is linked to the part. With these measures, individual parts in the manufacturing process are associated with manufacturing conditions such as when, where and under what processing conditions it was finally incorporated into which product. This kind of information enables a part-level traceability that includes the complete manufacturing history of each part included in the product.

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