ISO-/FDIS 19123-3:####(X:2023(E)

ISO TC 211/WG 6

Date: 2022-12-012023-02-07

Formatted: Portuguese (Brazil)

Formatted: Portuguese (Brazil)

Formatted: Different first page header

Formatted: Portuguese (Brazil)

Geographic information — Schema for coverage geometry and functions — Part 3: Processing fundamentals

Formatted: Font: 11 pt, Not Bold

FDIS stage

Formatted: Justified

Formatted: Space Before: 18 pt, Line spacing: Exactly 12 pt

Formatted: Font: Bold
Formatted: Font: Bold
Formatted: Normal, Space After: 36 pt, Line spacing: Exactly 12 pt
Formatted: Font: Bold
Formatted: Font: 12 pt, Bold

Contents

Formatted: Space Before: 18 pt, Line spacing: Exactly 12 pt

Formatted: Justified

Formatted: Space Before: 18 pt, Line spacing: Exactly 12 pt

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation 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 211, *Geographic information/Geomatics*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 287, *Geographic Information,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement), ~~under participation of the IEEE GRSS Earth Science Informatics Technical Committee,~~ and ~~derived from~~ in collaboration with the Open Geospatial Consortium (OGC~~) standard WCPS 1.1 with permission.~~).

A list of all parts in the ISO 19123 series can be found on the ISO website.

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.

Formatted: Justified

Formatted: Font: Italic

Formatted: Font: Italic

Formatted: Foreword Text

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: Space Before: 18 pt, Line spacing: Exactly 12 pt

Introduction

This document defines, at a high, implementation-independent level, operations on coverages~~—~~, i.e~~.~~., digital representations of space-time varying geographic phenomena~~—~~, as defined in ISO 19123-1. Specifically, regular and irregular grid coverages are addressed. The operations can be applied through an expression language allowing composition of unlimited complexity and combining an unlimited number of coverages for data fusion.

The language is functionally defined and free of any side effects. Its conceptual foundation relies on only two constructs: A “coverage constructor” builds a coverage, either from scratch or by deriving it from one or more other coverages. A “coverage condenser” derives summary information from a coverage by performing an aggregation like count, sum, minimum, maximum~~,~~ and average.

The coverage processing language is independent from any particular request and response encoding, as no concrete request/response protocol is assumed. Hence, this document does not define a concrete service, but acts as the foundation for defining service standards functionality. One such standardization target is the OGC Web Coverage Service (WCS~~) [3].~~).[4]

Throughout ~~the~~this document, the following formatting conventions apply~~:~~.

— Bold-Face in the text~~—~~, such as **processCoveragesExpr**~~—~~, represents syntax elements, normatively defined in ~~Annex B.~~**Error! Reference source not found.**.
— Text in italics~~—~~, such as *succ*~~()—~~(), represents mathematical functions and variables.
~~—~~Courier font~~—~~, such as **`return`** and `encode`~~()—~~(), is used for code in the sense of the coverage processing language.

Formatted: Font: Bold
Formatted: Font: Bold
Formatted: Normal, Space After: 36 pt, Line spacing: Exactly 12 pt
Formatted: Font: Bold
Formatted: Font: 12 pt, Bold
Formatted: Space Before: 18 pt, Line spacing: Exactly 12 pt

Geographic information — Schema for coverage geometry and functions —

Part 3: Processing fundamentals

1 Scope

This document defines a coverage processing language for server-side extraction, filtering, processing, analytics, and fusion of multi-dimensional geospatial coverages representing, for example, spatio-temporal sensor, image, simulation, or statistics datacubes. Services implementing this language provide access to original or derived sets of coverage information, in forms that are useful for client-side consumption.

This document relies on the abstract coverage model defined in ISO 19123-1. In this ~~version~~ edition, regular and irregular multi-dimensional grids are supported~~,~~ for axes that can carry spatial, temporal~~,~~ or any other semantics. Future ~~versions~~editions will additionally support further axis types as well as further coverage types from ISO 19123-1, in particular~~:~~, point clouds and meshes.

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 19111, *Geographic information — Referencing by coordinates*

ISO 19123-1, *Geographic information — Schema for coverage geometry and functions — Part 1: ~~Coverage~~ Fundamentals*

3 Terms, definitions, abbreviated terms and notation

3.1 Terms and definitions

For the purposes of this document, the terms~~,~~ and definitions ~~and abbreviated terms~~ given in ISO 19123-1 and the following apply.

~~For the purposes of this document, the following terms and definitions apply.~~

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

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

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

3.1.1
probing function
<coverage> function extracting information from the coverage

4 Conformance

4.1 Notation

Table 1 lists the other ~~international standards~~International Standards and packages in which UML classes used in this document have been defined.

Table 1 — Sources of externally defined UML classes

Prefix	International Standard	Package
	ISO 19123-1	Coverage Core, Grid Coverage

4.2 Interoperability and ~~Conformance Testing~~conformance testing

~~This~~As this document ~~being~~is an abstract standard, it allows for multiple different implementations and does not define a standardized interoperable implementation. Rather, standardization targets are specifications of coverage operations and services which may use this language to describe the semantics of their operations.

Conformance testing ~~is~~shall be accomplished by validating a candidate concretization against all requirements by exercising the tests set out in ~~Annex A.~~**Error! Reference source not found.**. As a prerequisite, a candidate shall also pass all conformance tests of ISO 19123-1 Coverage Core and Grid Coverage.

4.3 Organization

Table 1 provides details of the conformance classes described in this document. The name and contact information of the maintenance agency for this document can be found at www.iso.org/maintenance_agencies.

Table 2 — Conformance classes

Conformance class	Clause	Identifying URL
Coverage Processing	6	https://standards.isotc211.org/19123/-3/1/conf/coverage-processing

5 Coverage model

5.1 Overview

This document defines a language whose expressions accept any number of input coverages (together with further common inputs like numbers and strings) to generate any number of output coverages or non-coverage results. Coverages are defined in ISO 19123-1.

Formatted: Normal, Space After: 36 pt, Line spacing: Exactly 12 pt
Formatted: Font: 12 pt, Bold
Formatted: Font: 13 pt
Formatted: Font: 12 pt
Formatted Table
Formatted: Centered
Formatted: Font: 12 pt
Formatted: Font: 12 pt
Formatted: Font: 12 pt
Formatted Table
Formatted: Font: 13 pt
Formatted: Space Before: 0 pt
Formatted: Font: 12 pt
Formatted: Space Before: 18 pt, After: 0 pt, Line spacing: Exactly 12 pt

Formatted: Normal, Right, Space After: 36 pt, Line spacing: Exactly 12 pt

Formatted: Font: 12 pt, Bold

5.2 Coverage model

Formatted: Font: 12 pt

Following the mathematical notion of a function that maps elements of a domain (such as spatio-temporal coordinates) to a range (such as values of a “pixel”, “voxel”, etc.), a coverage consists of (**Error! Reference source not found.**):

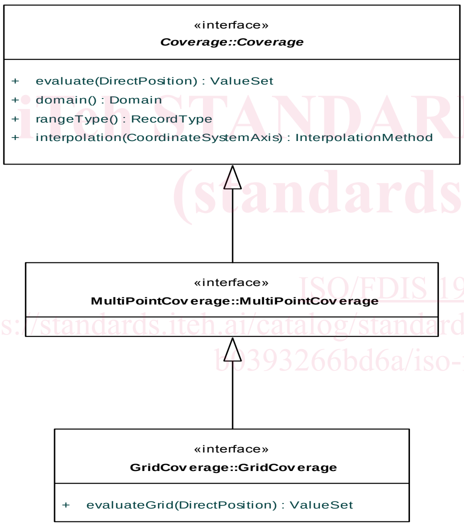
— an *identifier* which uniquely identifies a coverage in some context (here:, the context of an expression));

— a *domain* of coordinate points (expressed in a common Coordinate Reference System, CRS): “*where in the multi-dimensional space can I find values?*”?”;

— a probing function which answers for each coordinate in the domain (“*direct position*”): “*what is the value here?*”?”;

— a *range type*: “*what do those values mean?*”?”.

Formatted: Indent: Left: 0 cm, Hanging: 0.63 cm, Space After: 6 pt



Formatted: Space Before: 18 pt, After: 0 pt, Line spacing: Exactly 12 pt

Formatted: Normal, Space After: 36 pt, Line spacing: Exactly 12 pt

Formatted: Font: 12 pt, Bold

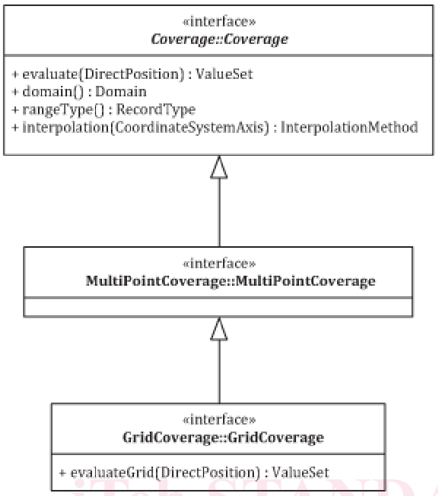


Figure 1 — Coverage and GridCoverage (ISO 19123-1)

NOTE 1 Coverage in ISO 19123-1 defines an interface which describes such an object's ~~behavior~~behaviour, but does not yet assume any particular data structure. One interoperable concretization of it is the implementation standard ISO 19123-2.

Below "probing functions" are introduced which extract components from ~~some~~a given coverage. For every component of a coverage a corresponding probing function exists so that altogether all properties of a coverage can be retrieved. They serve to define the document's language semantics.

NOTE 2 In the processing definition of this document, further probing functions ~~–~~, beyond the ISO 19123-1 probing function *evaluate*~~() –~~(), are used as a concise means to describe all aspects of coverage-valued function results.

5.3 Coverage identifier

Formatted: Font: 12 pt

Coverages in this document have an identifier which is used in a query to address a coverage to derive from. Therefore, it is necessary for this identifier ~~must~~to be unique within some context (here: a query). Beyond this, no particular assumption is made on the realization of this identifier. In particular, when the context of the coverage object changes (such as during delivery to a client) uniqueness is not necessarily guaranteed any longer ~~so that~~, and therefore querying the object in the new context is potentially ~~is not~~no longer possible ~~any longer~~.

NOTE In a concrete service, coverages available would typically ~~would~~ be those which are stored on this server, where access control allows addressing the coverage according to the user sending the request, etc. All these aspects are out of scope of this document.

The corresponding probing function for a coverage *C* is:

id(*C*)

Formatted: Space Before: 18 pt, After: 0 pt, Line spacing: Exactly 12 pt

Formatted: Normal, Right, Space After: 36 pt, Line spacing: Exactly 12 pt

Formatted: Font: 12 pt, Bold

5.4 Domain

Formatted: Font: 12 pt

5.4.1 Direct Position

Formatted: Font: 11 pt

A coverage offers values for particular positions in its domain; these are called "direct positions"; further values can ~~possibly~~ be derived through interpolation, depending on whether and what type of interpolation a coverage allows.

For some direct position $p = (p_1,\ldots,p_d)$ from a domain whose d-dimensional CRS contains axes $(a_1,\ldots,a_d$~~) we write~~), $p[a_i]$ is written for accessing the coordinate tuple component corresponding with axis a_i:

$p[a_i] = p_i$

5.4.2 Grid

Formatted: Font: 11 pt

The domain contains the coordinate tuples describing the coverage's direct positions, which for the purpose of this document all sit on a multi-dimensional grid. Informally speaking this means that every direct position inside the grid has exactly one next neighbour in both directions of every axis, except for the rim, where ~~obviously less~~fewer neighbours are available. Figure 2 — shows some regular and irregular grid examples.

Formatted: English (India)

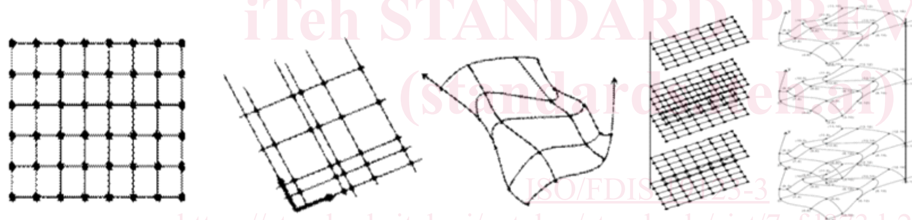


Figure 2 — ~~–~~Sample regular and irregular grid structures (ISO 19123-1)

The grid description depends on the complexity of the grid. As a grid is composed from an ordered sequence of axes, the resulting complexity is determined by the types of axes (such as integer versus Latitude versus time) as well as the rules determining the direct positions along these axes. The following axis types defined in ISO 19123-1 are currently supported by this document:

— ~~A~~a **Cartesian** ("index") axis, which just requires lower and upper bound (which are of type integer~~).~~);

— ~~A~~a **regular** axis, which can be described by lower and upper bounds together with a constant distance, the resolution~~.~~;

— ~~An~~an **irregular** axis, which has individual distances, described by a sequence of coordinates.

As per ISO 19123-1, the coverage domain with its axes has a single CRS which can serve for geo-referencing. ~~Definition~~The definition and interpretation of CRSs is ~~based on~~in accordance with ISO 19111~~:2019~~.

The CRS of a domain is obtained through function $crs(C)$.

$crs(C)$

Formatted: Space Before: 18 pt, After: 0 pt, Line spacing: Exactly 12 pt

Auxiliary probing function *axisList*()extracts the ordered list of axes (a_1,...,a_d) from a *d*-dimensional CRS:

axisList(*crs*)

NOTE As perIn accordance with ISO 19123-1, all axis names in such a list are pairwise disjoint so that the names can act as a unique identifier within their CRS.

Each axis contributes coordinates from somea nonempty, totally ordered set of values which can be numeric or, in the general case, strings (such as “2020-08-05T”).

For somea given coverage *C*, probing function *domain*() delivers the coverage domain in its CRS:

domain(*C*)

The domain information describes the coverage’s grid and its extent for each axis:

— the lower and upper bound of the direct positions;

— additionally the following information:

  — for index axes: nothing further;

  — for regular axes: the resolution, expressed in the unit of measure (uom) of the axis;

  — for irregular axes: the sequence of points.

This information is accessible through extended variants of the abovementioned functions. For some coverage domain *D* with axis *a*, the following expressions return lower and upper boundbounds, respectively:

domain(*C*, *a*).lo
domain(*C*, *a*).hi

For convenience, a function pair identical in effect, but based on the domain is defined:

$D[a].lo = domain(C, a).lo$
$D[a].hi = domain(C, a).hi$

The grid of the coverage domain is represented implicitly through functions “walking” the grid from one direct position to one of its neighbours. This is based on the topological structure of a grid where each direct position has exactly one lower and one higher neighbour along each axis, with an exception of the domain rims where no such neighbour is available; therefore, these functions are partial.

Let *D* be given as the domain of coverage *C*, so that *D* = *domain*(*C*). Let further *a* be some axis from the CRS of *D*. Then, functions *pred*() and *succ*() each return a neighbouring direct position for some given position. Function *pred*() returns the immediate preceding direct position along axis *a*, function *succ*() returns the immediate succeeding direct position along *a*. Where there is no such direct position (because the input position is sitting at the rim of the domain extent) the value is undefined, written as ⊥.

pred(*D*, *a*, *p*) = *x* where
  if $p[a] = D[a].lo$ $domain(C,a).lo$ then $x = \perp$
  else *x* is given by: $x[a_x] = p[a_x]$ for all $a_x \in domain(C) \setminus \{a\}$, and $x[a] = \max(x' \mid x' \in domain(C, a)$ and $x' < p[a])$

succ(*D*, *a*, *p*) = *x* where

if *p*[*a*] = *D*[*a*].*hi domain*(*C*,*a*).*hi* then *x* = ⊥

else *x* is given by: $x[a_x] = p[a_x]$ for all $a_x \in domain(C) \setminus \{a\}$, and $x[a] = \min(x' \mid x' \in domain(C, a)$ and $x' > p[a])$

EXAMPLE In Figure 3 —, neighbours of *p* in coverage domain *D* with axes *x* and *y* can be reached as follows:
a = *succ*(*D*, *y*, *pred*(*D*, *x*, *p*)) = *pred*(*D*, *x*, *succ*(*D*, *y*, *p*))
b = *succ*(*D*, *y*, *p*)
c = *succ*(*D*, *y*, *succ*(*D*, *x*, *p*)) = *succ*(*D*, *x*, *succ*(*D*, *y*, *p*))
d = *pred*(*D*, *x*, *p*)
e = *succ*(*D*, *x*, *p*)
f = *pred*(*D*, *x*, *pred*(*D*, *y*, *p*)) = *pred*(*D*, *y*, *pred*(*D*, *x*, *p*))
g = *pred*(*D*, *y*, *p*)
h = *succ*(*D*, *x*, *succ*(*D*, *y*, *p*)) = *succ*(*D*, *y*, *succ*(*D*, *x*, *p*))

In this document, for the ~~reader's~~user's convenience, basic arithmetic functions are assumed on this grid navigation:

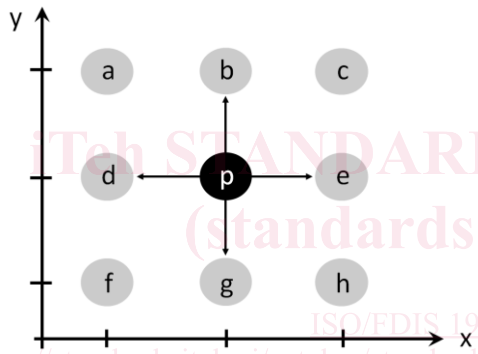


Figure 3 — ~~—~~Sample grid neighbourhood

5.5 Interpolation

In ISO 19123-1 a coverage contains an indication on possible interpolation between direct positions. Such interpolation can be set for all axes in a coverages simultaneously or~~—~~, following a more fine-grain approach~~—~~, individually per axis.

NOTE 1 In ISO 19123-1 every coverage has exactly one interpolation method associated (for all axes or per axis). In practice, coverages ~~may~~can allow users to pick one of several interpolation methods, such as with imagery where linear, quadratic~~,~~ and cubic interpolation are applicable on principle, and users can choose any one of those. Conceptually, however, two coverages differing only in the interpolation methods are distinct as they will deliver identical range values on their direct positions, but differing values inbetween those. On the abstract level of ISO 19123-1 and ISO 19123-3, this ambiguity is not desirable.

For the purpose of this document a special interpolation method `none` is assumed as defined, ~~e.g.,~~for example, in ISO 19123-1:~~—~~[1], Annex B. `None` indicates that no interpolation is possible along the axis under consideration.

NOTE 2 ~~Interpolation~~The interpolation method `none` is different from `nearest-neighbor`: An interpolation of `nearest-neighbor` provides values inbetween direct positions which are derived from the closest direct

[1] Under preparation. Stage at the time of publication: ISO/FDIS 19123-1:2023.

Formatted: Normal, Right, Space After: 36 pt, Line spacing: Exactly 12 pt
Formatted: Font: 12 pt, Bold
Formatted: Font: 9 pt
Formatted: Font: 9 pt
Formatted: Font: 9 pt
Formatted: Font: 9 pt
Formatted: Font: 12 pt
Formatted: Space Before: 18 pt, After: 0 pt, Line spacing: Exactly 12 pt