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ISO TC 211/WG

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

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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).

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).

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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 211 Geographic information/Geomatics incollaboration 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.

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Introduction

This document defines, at a high, implementation-independent level, operations on coverages—_i.e.l₂ digital representations of space-time varying geographic phenomena—_i 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 thethis 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—

 Output

 Description

 List used for code in the sense of the coverage processing language.

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FINAL DRAFT INTERNATIONAL STANDARD

ISO/FDIS 19123-3:2023(E)

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 versionseditions 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
- ___IEC Electropedia: available at https://www.electropedia.org/

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3.1.1

probing function

<coverage> function extracting information from the coverage

4 Conformance

4.1 Notation

 $Table \ 1\ lists the other \ \underline{international\ standards}\ International\ Standards\ and\ packages\ in\ which\ UML\ classes\ used\ in\ this\ document\ have\ been\ defined.$

Table 1 — Sources of externally defined UML classes

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

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$\textbf{4.2} \underline{\textbf{Interoperability and }} \underline{\textbf{Conformance Testing}} \underline{\textbf{conformance testing}}$

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 isshall 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

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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.

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5.2 Coverage model

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 coverage coordinate in the domain ("direct position"):
 "what is the value here?"?":
- a range type: "what do those values mean?"?".

Interface
Coverage::Coverage

+ evaluate(DirectPosition): ValueSet
+ domain(): Domain
+ rangeType(): RecordType
+ interpolation(CoordinateSystemAxis): InterpolationMethod

Interface
MultiPointCoverage::MultiPointCoverage

Interface
MultiPointCoverage::MultiPointCoverage

Interface
GridCoverage::GridCoverage

+ evaluateGrid(DirectPosition): ValueSet

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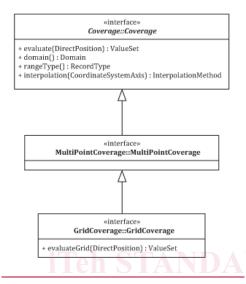


Figure 1 — Coverage and GridCoverage (ISO 19123-1)

NOTE 1 Coverage in <u>ISO</u> 19123-1 defines an interface which describes such an object's <u>behavior behaviour</u>, 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 somea 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

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 mustto 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)

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5.4Domain

5.4.1 Direct Position

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 df interpolation a coverage allows.

For some direct position $p = (p_1,...,p_d)$ from a domain whose d-dimensional CRS contains axes $(a_1,...,a_d)$ 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

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 lessfewer neighbours are available. Figure 2 — shows some regular and irregular grid examples.

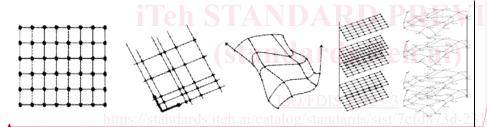


Figure 2 — —Sample regular and irregular grid structures (ISO 19123-1)

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:

- A2 Cartesian ("index") axis, which just requires lower and upper bound (which are of type integer)-1:
- Aa regular axis, which can be described by lower and upper bounds together with a constant distance, the resolution;
- Anan 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 georeferencing. DefinitionThe definition and interpretation of CRSs is based onin accordance with ISO 19111:2019.

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

crs(C)

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

NOTE As perln 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 <u>somea</u> nonempty, totally ordered set of values which can be numeric or, in the general case, strings (such as "2020-08-05T").

For some 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 $\frac{boundbounds}{bounds}$, 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 \bot .

```
pred(D, a, p) = x where if p[a] = D[a].lo domain(C,a).lo then x = \bot 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])
```

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```
succ(D, a, p) = x where if p[a] = D[a].hi domain(C,a).hi then x = \bot 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, 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;

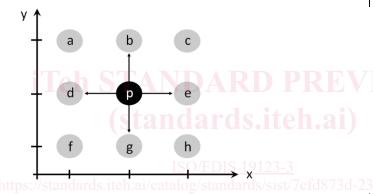


Figure 3 — Sample grid neighbourhood

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 maycan 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 <u>ISO 19123-1:—1</u>, 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

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

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