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Geographic information — Schema for coverage geometry and functions —

Part 1:
Fundamentals

Information géographique — Schéma de la géométrie et des fonctions de couverture —
Partie 1: Principes de base

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Foreword

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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 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), and in collaboration with the Open Geospatial Consortium (OGC).

This first edition cancels and replaces the first edition (ISO 19123:2005), which has been technically revised.

The main changes are as follows:

— the document has been renamed as “Part 1: Fundamentals”, since a new “Part 2: Coverage Implementation Schema” has been published;

— the text has been simplified for better understanding;

— concepts, while in principle unchanged, have been defined more rigorously and some errors have been corrected;

— the approach to standardization taken in this document has been changed. This edition of the document defines a high-level, generic concept of coverages with an interface definition from which many different (not necessarily interoperable) implementation structures can be derived. The previous edition of this document, ISO 19123, defined a single generic data structure for coverages. This remains valid as one of the many possible data structures that can implement the ISO 19123-1 interface. This data structure, which is defined in Annex D, allows for backward compatibility in the sense that standardization targets that referenced ISO 19123 can continue referencing these same classes, although new realizations are not encouraged to do so. It is noted, however, that the coverage definition terms in Clause 3 which are owned by other documents have been updated to refer to newer editions of the documents (including their definitions) where such newer editions are in place.

— all operations except *evaluate*() have been removed, for simplification purposes. ISO 19123-3:—[1)] is to take over the operations part;

— the Scope has been extended to include Mesh;

— the concept of discrete and continuous coverages has been generalized to achieve an improved conceptual basis and to allow for coverages which are discrete along some domain axes and continuous along other domain axes. This is achieved by using the coordinate reference system axes as the basis for the definitions so that any axis individually can be discrete or continuous. Since this is a generalization of the previous concept it is backward compatible. As a side effect, this reworking has greatly simplified the structure of this document;

— updates in ISO 19103 have been reflected, and corresponding adjustments have been made where necessary; the informative Annex on "UML notation" has been deleted since this is now described in ISO 19103.

— all coordinate-related definitions are based on ISO 19111, and corresponding adjustments have been made in all places necessary;

— the definition of image CRS has been moved from ISO 19111 to this document;

— the definition of interpolation is now based on the interpolation definition of ISO 19107 in order to avoid duplicate and diverging definitions;

— the UML diagrams have been redrawn for clarity, in order to correct errors, and to follow the new conventions established in ISO/TC 211.

— the bibliography has been revised to include additional references and has been reformatted.

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.

1) Under preparation. Stage at the time of publication: ISO/FDIS 19123-3:2023.

Introduction

This document defines, at a high, implementation-independent level, the notion of coverages as digital representations of space-time varying phenomena, corresponding to the notion of a field in physics. Such coverages can be discrete or continuous.

Historically, geographic information has been treated in terms of two fundamental types called "vector data" and "raster data".

Vector data deals with discrete phenomena, each of which is conceived of as a feature. The spatial characteristics of a discrete real-world phenomenon are represented by a set of one or more geometric primitives (points, curves, surfaces or solids). Other characteristics of the phenomenon are recorded as feature attributes. Usually, a single feature is associated with a single set of attribute values. ISO 19107 provides a schema for describing features in terms of geometric and topological primitives.

Raster data, on the other hand, deals with phenomena that vary over space and time, mathematically described by “fields”. It contains a set of values, each associated with one of the elements in an array of points or cells. It is often associated with a method for interpolating values at spatial positions between the points or within the cells.

The coverage concept, originally adopted from the Abstract Specification of the Open Geospatial Consortium (OGC),[15] generalizes these and further data structures, such as point clouds, into a model for representing phenomena that vary continuously over space and time, and possibly over further dimensions such as spectral bands. Formally, a coverage is a function from a spatial (such as horizontal x and y and vertical height or depth), temporal, other (in ISO 19111 nomenclature: parametric) domain or any combination thereof to values of some data type.

A coverage consists of a set of spatio-temporally extended geometric (often geographic) objects, each with associated attribute values. The spatio-temporal locations with which attribute values are associated are called “direct positions”.

Formally, a coverage itself is a subtype of feature as defined in ISO 19101-1. This feature is a set of features all sharing some key properties, such as the same attribute definition and coordinate reference system.

NOTE Direct positions can be of different dimensions. For example, in a raster image modelled as a coverage, the direct positions will be the grid points; in a multi-solid coverage a direct position is given by the interior of a 3D solid.

In practice, coverages encompass regular and irregular grids, point clouds and general meshes. Examples include raster data, point clouds, meshes such as triangulated irregular networks and polygon sets. Coverages are multi-dimensional, including examples like 1D sensor timeseries, 2D satellite images, 3D x/y/t image timeseries and x/y/z geophysical voxel data, and 4D x/y/z/t climate and ocean data. Coordinate axes of such coverages can have spatial, temporal, or any other meaning, and they can be combined freely for *n*-dimensional coverages.

EXAMPLE The electromagnetic spectrum is an example of an axis with neither spatial nor temporal semantics. Such a spectral axis can be defined as a “parametric CRS” as established in ISO 19111.

A coverage which provides values only at the direct positions is called “a discrete coverage”; if interpolation information is added so that values can be obtained also between the coverage’s direct positions, such a coverage is called “a continuous coverage”.

Just as the concepts of discrete and continuous phenomena are not mutually exclusive, their representations as discrete coverages are not mutually exclusive. The same phenomenon can be represented as either a discrete feature or a coverage, depending on the particular context and requirements. A city can be viewed as a discrete coverage that returns a single value for each attribute, such as its name, area and total population, but it can also be represented as a coverage that returns values such as population density, land value or air quality index for each location in the city.

A coverage, moreover, can be derived by bundling a collection of discrete features sharing a common attribute definition, the values of the coverage at each position being the values of the attributes of the feature located at that position. Conversely, a collection of discrete features can be derived from a coverage by extracting all direct positions with their associated attribute values.

The previous edition of this document, ISO 19123:2005, addressed coverage modelling on both a conceptual and (to some extent) an implementation level, effectively mixing both. Coverage modelling has now been split into two separate, but connected documents: ISO 19123-1 (this document), which establishes an abstract, high-level coverage model, and ISO 19123-2, which establishes an implementation-level model ensuring interoperability, based on the concepts of ISO 19123-1. A corresponding high-level processing model for coverages is defined in ISO 19123-3.

Geographic information — Schema for coverage geometry and functions —

Part 1: **Fundamentals**

1 Scope

This document defines a conceptual schema for coverages. A coverage is a mapping from a spatial, temporal or spatio-temporal domain to attribute values sharing the same attribute type. A coverage domain consists of a collection of direct positions in a coordinate space that can be defined in terms of spatial and/or temporal dimensions, as well as non-spatio-temporal (in ISO 19111: “parametric”) dimensions. Examples of coverages include point clouds, grids, meshes, triangulated irregular networks, and polygon sets. Coverages are the prevailing data structures in a number of application areas, such as remote sensing, meteorology and mapping of depth, elevation, soil and vegetation. This document defines the coverage concept including the relationship between the domain of a coverage and its associated attribute range. This document defines the characteristics of the domain; the characteristics of the attribute range are not defined in this document, but left to specific implementation standards. Consequently, the standardization target of this document consists of implementation standards, not concrete implementations themselves.

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 19103, *Geographic information — Conceptual schema language*

ISO 19107, *Geographic information — Spatial schema*

ISO 19111, *Geographic information — Referencing by coordinates*

3 Terms, definitions, abbreviated terms and notation

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions 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/

3.1.1
analytical coverage
<coverage> coverage where the mapping function from domain to range is given by an analytical mathematical function

3.1.2
axis
<coordinate geometry> tuple of axis name, axis abbreviation, axis direction, axis unit and further information, as specified in ISO 19123-1

Note 1 to entry: This definition is established in accordance with ISO 19111:2019, Table 26 and subclause 10.4.

Note 2 to entry: Inside a coordinate reference system (CRS) containing several axes the axis names are required to be pairwise different.

Note 3 to entry: The axis unit (of measure) defines the set of values which can be used as a coordinate along this axis. These can be numbers (such as in Latitude and Longitude) or general strings (such as in timestamps or special identifiers like "FL100" in aviation).

3.1.3
cell
<coverage> neighbourhood around a direct position in a coverage grid, not overlapping with any other direct position neighbourhood in the coverage grid

Note 1 to entry: Coverage cell is synonymous to grid cell.

Note 2 to entry: All cells of a grid coverage together establish a tessellation (i.e. complete, overlap-free cover) of the grid space.

3.1.4
continuous coverage
coverage that returns values for both direct positions and positions between direct positions

3.1.5
coordinate
<coverage> one of a sequence of measures designating the position of a point

Note 1 to entry: In a coordinate reference system, the coordinate numbers are usually qualified by units. Some coordinates may use a unit representation, for example date/time conformant with ISO 8601-1. When coordinates are an index (ordinal coordinates) they are unitless (which possibly can be represented by a unit of 1).

[SOURCE: ISO 19111:2019, 3.1.5, modified — Original note 1 to entry has been amended.]

3.1.6
coordinate reference system
coordinate system that is related to an object by a datum

[SOURCE: ISO 19111:2019, 3.1.9, modified — Notes 1 and 2 to entry have been deleted.]

3.1.7
coordinate system
set of mathematical rules for specifying how coordinates are to be assigned to points

Note 1 to entry: A coordinate system contains an ordered sequence of one or more axes; their names are required to be pairwise different.

[SOURCE: ISO 19111:2019, 3.1.11, modified — Note 1 to entry has been added.]

3.1.8
coordinate tuple
tuple composed of coordinates

Note 1 to entry: The number of coordinates in the coordinate tuple equals the dimension of the coordinate system; the order of coordinates in the coordinate tuple is identical to the order of the axes of the coordinate system.

[SOURCE: ISO 19111:2019, 3.1.13]

3.1.9
coverage
function which returns values from its range type for any direct position within its domain

3.1.10
coverage coordinate reference system
coverage CRS
coordinate reference system (CRS) in which all coordinates in a coverage domain are expressed

Note 1 to entry: Sometimes a coverage's CRS is also referred to as the coverage's native CRS to express that this is the CRS to which all the coverage's location data refer.

3.1.11
coverage dimension
<coordinate geometry> number of separate decisions needed to describe a direct position in a coverage domain

Note 1 to entry: This is equivalent to "the number of axes in the coverage domain CRS".

Note 2 to entry: This definition is based on the term "coordinate dimension" defined in ISO 19107:2019, 3.17.

3.1.12
coverage geometry
domain of a coverage described in terms of geometric objects

3.1.13
Delaunay triangulation
network of triangles such that the circle passing through the vertices of any triangle does not contain, in its interior, the vertex of any other triangle

3.1.14
direct position
<coverage> position inside one of the geometric objects in a coverage described by a coordinate tuple within the coverage coordinate reference system

Note 1 to entry: A direct position is described by an ordered sequence of coordinates. The number of elements in a direct position is established by the number of axes of the coverage CRS.

Note 2 to entry: This is consistent with the definition in ISO 19136-1:2020, 3.1.20.

3.1.15
discrete coverage
coverage that returns value only for the direct positions within its domain

Note 1 to entry: Discrete coverages have values only for their direct positions, whereas continuous coverages can be interpolated, thereby providing values between direct positions in addition.

3.1.16
domain
set of geometric objects

Note 1 to entry: Examples of such geometric objects are points, lines, faces and solids. All elements within a domain (set) are of a single given type.

3.1.17
external coordinate reference system
coordinate reference system whose datum is independent of the object that is located by it

Note 1 to entry: This term is kept only for backwards compatibility and is not used in nor fundamental to the coverage definition of this document.

[SOURCE: ISO 19130-1:2018, 3.25, modified — Note 1 to entry has been added.]

3.1.18
evaluation
<coverage> determination of the values of a coverage at a direct position within the domain of the coverage

3.1.19
feature
abstraction of real world phenomena

[SOURCE: ISO 19101-1:2014, 4.1.11, modified — Note 1 to entry has been removed.]

3.1.20
feature attribute
characteristic of a feature

Note 1 to entry: The value associated with a direct position. Also known as "feature property" and may support potential attribute, quality, or characteristic of a feature.

[SOURCE: ISO 19101-1:2014, 4.1.12, modified — Original notes to entry and examples have been deleted and a new Note 1 to entry added.]

3.1.21
function
<mathematics, programming> rule that associates each element from a domain ("source domain", or "domain" of the function) to a unique element in another domain ("target domain", "co-domain" or "range" of the function)

[SOURCE: ISO 19107:2019, 3.41]

3.1.22
geometric dimension
<geometry, topology> largest number *n* such that each point in a set of points can be associated with a subset that has that point in its interior and is topologically isomorphic to $\mathbb{E}^n$, Euclidean *n*-space

[SOURCE: ISO 19107:2019, 3.48 modified — Original notes to entry have been deleted.]

3.1.23
geometric object
<geometry> spatial object representing a geometric set

Note 1 to entry: A geometric object consists of a geometric primitive, a collection of geometric primitives, or a geometric complex treated as a single entity. A geometric object may be the spatial representation of a feature object.

[SOURCE: ISO 19107:2019, 3.49]

3.1.24
geometric set
<geometry> set of direct positions

Note 1 to entry: A geometric set describes a single geometric object. The domain of a coverage consists of a set of such geometric objects. In the case of point clouds and grid data where each geometric set consists of only one single point, the domain is a set of these direct positions. For higher-dimensional geometric sets, such as curves, surfaces and solids, the set can be described through other means than enumeration, such as Boundary Representation or constructive solid geometry (CSG).

[SOURCE: ISO 19136-1:2020, 3.1.32, modified — Original note to entry has been deleted and a new Note 1 to entry has been added.]

3.1.25
georectified
corrected for positional displacement with respect to the surface of the Earth

Note 1 to entry: This term is kept only for backwards compatibility and is not fundamental to the coverage definition of this document.

[SOURCE: ISO 19115-2:2019, 3.11, modified — Note 1 to entry has been added]

3.1.26
georeferenceable
associated with a geopositioning information that can be used to convert grid coordinate values to values of coordinates referenced to an external coordinate reference system related to the Earth by a datum

Note 1 to entry: This term is kept only for backwards compatibility and is not fundamental to the coverage definition of this document.

[SOURCE: ISO/TS 19163-1:2016, 4.9, modified — Note 1 has been added]

3.1.27
georeferencing
geopositioning an object using a correspondence model mapping coverage domain elements to ground coordinates

[SOURCE: ISO 19130-1:2018, 3.37, modified — Definition has been generalized for coverages to not only consider images]

3.1.28
grid
<coverage> covering of a multi-dimensional region using quadrilateral shapes (in the 2D case) or their *n*-dimensional generation (in the *n*D case) with no overlaps and gaps

Note 1 to entry: The term "grid" originates historically from a 2D view: in ISO 19123 a grid consists of a network composed of one or more sets of curves in which the members of each set intersect the members of the other sets. Meantime, *n*D grids (including 1D) are known and in use. The “covering” of a region is also known as a "tessellation" in mathematics.

Note 2 to entry: The ISO 19123 definition is equivalent to the revised definition of this document.

3.1.29
grid coordinate reference system
grid coverage’s coordinate reference system

Note 1 to entry: This is consistent with the definition in ISO 19136-2:2015, 4.2.1.

3.1.30
grid coordinates
sequence of coordinates specifying a position on a grid

Note 1 to entry: This is consistent with the definition in ISO 19115-2:2019, 3.15

3.1.31
grid coverage
coverage whose domain is described by a grid

3.1.32
grid point
point of a grid

3.1.33
image coordinate reference system
image CRS
engineering grid coverage coordinate reference system (CRS)

Note 1 to entry: The CRS of a raster image (without georeferencing) is a 2D grid with Cartesian axes; this special case of an index CRS is commonly referred to as "image CRS".

3.1.34
index coordinate reference system
index CRS
coverage coordinate reference system (CRS) in which all axes are Cartesian

3.1.35
mesh
geometry with associated topology of dimension greater than zero

Note 1 to entry: Geometry and topology are defined in ISO 19107. Mesh examples include curves, TINs and solids. Points (and point clouds) resemble geometries with dimension zero.

3.1.36
pixel
smallest element of a digital image to which attributes are assigned

Note 1 to entry: A pixel is the smallest unit of display for a visible image.

Note 2 to entry: This term originated as a contraction of "picture element".

[SOURCE: ISO 19101-2:2018, 3.28, modified — Note 1 to entry has been moved to Note 2 to entry and a new Note 1 to entry has been added.]

3.1.37
point cloud
collection of data points in 3D space

Note 1 to entry: The distance between points is generally non-uniform and hence all three coordinates (Cartesian or spherical) for each point must be specifically encoded.

[SOURCE: ISO/TS 19130-2:2014, 4.51]

3.1.38
point coverage
coverage that has a domain composed of points

3.1.39
polygon coverage
coverage that has a domain composed of polygons

3.1.40
range
<**coverage**> set of values associated by a function, the coverage, with the domain of a coverage

Note 1 to entry: This is consistent with the more generic definition of range in ISO 19107.

Note 2 to entry: Coverage range types and values correspond to the notion of feature attribute types and values.

3.1.41
raster
rectilinear grid

Note 1 to entry: The term is also used as an imprecise generic term for imagery and gridded coverage data.

Note 2 to entry: Historically, the term derives from the scanning lines display pattern on a cathode ray tube.

3.1.42
rectified grid
grid for which there is an affine transformation between the grid coordinates and the coordinates of an external coordinate reference system

Note 1 to entry: If the coordinate reference system is related to the Earth by a datum, the grid is a georectified grid.

Note 2 to entry: This term is kept only for backwards compatibility and is not used in nor fundamental to the coverage definition of this document.

3.1.43
referenceable grid
grid with an external coordinate reference system whose type is either geodetic or projected

Note 1 to entry: If the coordinate reference system is related to the Earth by a datum, the grid is a georeferenceable grid.

Note 2 to entry: This term is kept only for backwards compatibility and is not used in nor fundamental to the coverage definition of this document.

3.1.44
solid
geometric set with three spatial dimensions

Note 1 to entry: This is consistent with the definition in ISO 19107.

Note 2 to entry: A solid may have further dimensions, such as time.

3.1.45
spatial object
<topology, geometry> object used for representing a spatial characteristic of a feature

[SOURCE: ISO 19107:2019, 3.87]

3.1.46
spatio-temporal object
object representing a set of direct positions in space and time

3.1.47
temporal coordinate reference system
coordinate reference system based on a temporal datum

[SOURCE: ISO 19111:2019, 3.1.63]

3.1.48
tessellation
partitioning of a space into a set of conterminous subspaces having the same dimension as the space being partitioned

3.1.49
Thiessen polygon
polygon that encloses one of a set of points on a plane so as to include all direct positions that are closer to that point than to any other point in the set

3.1.50
triangulated irregular network
TIN
tessellation composed of triangles