

DIN EN ISO 19123-1



ICS 35.240.70

Entwurf

Einsprüche bis 2022-04-11
Vorgesehen als Ersatz für
DIN EN ISO 19123:2007-06

**Geoinformation –
Coverage Geometrie- und Funktionsschema –
Teil 1: Grundlagen (ISO/DIS 19123-1:2022);
Englische Fassung prEN ISO 19123-1:2022**

Geographic information –
Schema for coverage geometry and functions –
Part 1: Fundamentals (ISO/DIS 19123-1:2022);
English version prEN ISO 19123-1:2022

Information géographique –
Schéma de la géométrie et des fonctions de couverture –
Partie 1: Principes de base (ISO/DIS 19123-1:2022);
Version anglaise prEN ISO 19123-1:2022

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2022-02-11 wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses Entwurfs besonders zu vereinbaren.

Stellungnahmen werden erbeten

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Gesamtumfang 161 Seiten

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Nationales Vorwort

Dieses Dokument (prEN ISO 19123-1:2022) wurde vom Technischen Komitee ISO/TC 211 „Geographic information/Geomatics“ in Zusammenarbeit mit dem Technischen Komitee CEN/TC 287 „Geoinformation“ (Sekretariat BSI, Belgien) erarbeitet.

Für Deutschland hat hieran der Arbeitsausschuss NA 005-03-03 AA „Geoinformation (SpA zu CEN/TC 287+ISO/TC 211)“ im DIN-Normenausschuss Bauwesen (NABau) mitgearbeitet.

Dieses Dokument enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die Englische Fassung von [prEN ISO 19123-1:2022].

Der Bedarf für eine Deutsche Fassung wird derzeit beraten.

Für die in diesem Dokument zitierten Dokumente wird im Folgenden auf die entsprechenden deutschen Dokumente hingewiesen:

ISO 19107:2019	siehe	DIN EN ISO 19107:2020-09
ISO 19108:2002	siehe	DIN EN ISO 19108:2005-05
ISO 19109:2015	siehe	DIN EN ISO 19109:2016-05
ISO 19111:2019	siehe	DIN EN ISO 19111:2020-09
ISO 19115-1:2014	siehe	DIN EN ISO 19115-1:2014-07

Aktuelle Informationen zu diesem Dokument können über die Internetseiten von DIN (www.din.de) durch eine Suche nach der Dokumentennummer aufgerufen werden.

Änderungen

Gegenüber DIN EN ISO 19123:2007-06 wurden folgende Änderungen vorgenommen:

- a) Aufteilung der ISO 19123 in drei Teile;
- b) generelle Überarbeitung;
- c) redaktionelle Überarbeitung.

Nationaler Anhang NA (informativ)

Begriffe und Abkürzungen

Reihenfolge und Inhalt der folgenden Begriffe sind identisch mit denen im Abschnitt Begriffe der Englischen Fassung.

3 Begriffe

3.1 Begriffe

Für die Anwendung dieses Dokuments gelten die folgenden Begriffe.

ISO und IEC stellen terminologische Datenbanken für die Verwendung in der Normung unter den folgenden Adressen bereit:

- ISO Online Browsing Platform: verfügbar unter <https://www.iso.org/obp>
- IEC Electropedia: verfügbar unter <https://www.electropedia.org/>

3.1.1

analytische Coverage

en analytical coverage

Art der kontinuierlichen Erfassung, die eine räumlich begrenzte, aber unendliche Menge direkter Positionen ist, und eine mathematische Funktion, die die direkte Position mit dem Wert eines Feature-Attributs verknüpft

3.1.2

Achse

en axis

<analytische Geometrie> lineares Merkmal, aus dem ein eindimensionales Koordinatensystem erstellt wird

Anmerkung 1 zum Begriff: Diese Definition wird in Übereinstimmung mit ISO 19111:2019, Abschnitt 10.4 festgelegt.

3.1.3

kontinuierliche Coverage

en continuous coverage

Coverage, die unterschiedliche Werte für dasselbe Feature-Attribut an verschiedenen direkten Positionen innerhalb eines einzigen räumlichen, zeitlichen oder räumlich-zeitlichen Objekts in ihrem Bereich liefert

Anmerkung 1 zum Begriff: Obwohl der Bereich einer dauerhaften Coverage üblicherweise in Bezug auf ihre räumliche und/oder zeitliche Ausdehnung begrenzt ist, kann sie in eine unendliche Anzahl von direkten Positionen unterteilt werden.

3.1.4

Koordinate

en coordinate

eine der Sequenzen von Nummern, die die Position eines Punkts bezeichnen

Anmerkung 1 zum Begriff: Eine direkte Position wird durch eine geordnete Folge von Koordinaten beschrieben. Die Anzahl der Elemente in einer direkten Position wird durch die Anzahl der Achsen der Coverage bestimmt.

[QUELLE: ISO 19111:2019, 3.1.5, modifiziert — Die ursprüngliche Anmerkung 1 zum Begriff wurde durch eine neue Anmerkung zum Begriff ersetzt.]

3.1.5

Koordinatendimension

en coordinate dimension

<analytische Geometrie> Anzahl der Einzelentscheidungen, die zur Beschreibung einer Position in einem Koordinatensystem erforderlich sind

Anmerkung 1 zum Begriff: Die Anzahl der Einzelentscheidungen entspricht der Anzahl der Achsen.

[QUELLE: ISO 19107:2019, 3.17, modifiziert — Ursprüngliche Anmerkung 1 zum Begriff wurde durch eine neue Anmerkung zum Begriff ersetzt.]

3.1.6

Koordinatensystem

en coordinate system

Menge mathematischer Regeln zur Festlegung, wie Koordinaten Punkten zugewiesen werden sollen

[QUELLE: ISO 19111:2019, 3.1.11]

3.1.7

Koordinatenreferenzsystem

en coordinate reference system

Koordinatensystem, das über ein Datum mit einem Objekt verbunden ist

Anmerkung 1 zum Begriff: Geodätische und vertikale Daten werden als Referenzrahmen bezeichnet.

Anmerkung 2 zum Begriff: Das Objekt für geodätische und vertikale Referenzrahmen ist die Erde. In planetarischen Anwendungen können geodätische und vertikale Referenzrahmen auf andere Himmelskörper angewendet werden.

[QUELLE: ISO 19111:2019, 3.1.9]

3.1.8

Coverage

en coverage

Feature, das als Funktion zur Rückgabe von Werten aus seinem Wertebereich für jede direkte Position innerhalb seines Bereichs dient

3.1.9

Coverage-CRS

en coverage CRS

allgemeines CRS, in dem alle Koordinaten einer Coverage angegeben werden

Anmerkung 1 zum Begriff: Manchmal wird das CRS einer Coverage auch als natives CRS der Coverage bezeichnet.

3.1.10

Coverage-Dimension

Koordinatendimension

en coverage dimension, coordinate dimension

<analytische Geometrie> Anzahl der Einzelentscheidungen, die zur Beschreibung einer Position in einem Koordinatensystem erforderlich sind

Anmerkung 1 zum Begriff: Dies entspricht der Anzahl der Achsen im Koordinatenreferenzsystem der Coverage.

[QUELLE: ISO 19107:2019, 3.17, modifiziert — Ursprüngliche Anmerkung 1 zum Begriff wurde durch eine neue Anmerkung zum Begriff ersetzt.]

3.1.11

Coverage-Geometrie

en coverage geometry

Konfiguration des Bereichs einer Coverage, die in anhand von Koordinaten beschrieben wird

3.1.12

Delaunay-Triangulation

en Delaunay triangulation

Netz von Dreiecken, das so beschaffen ist, dass der Kreis, der durch die Scheitelpunkte eines beliebigen Dreiecks verläuft, in seinem Inneren keinen Scheitelpunkt eines anderen Dreiecks enthält

3.1.13

direkte Position

en direct position

<geographische Information> Position, die durch einen einzelnen Koordinatensatz in einem Koordinatenreferenzsystem beschrieben wird

Anmerkung 1 zum Begriff: Die Zellen in einer Gitter-Coverage werden durch ihre direkte Position in der Bereichsmenge dieser Coverage gekennzeichnet.

[QUELLE: ISO 19136-1:2020, 3.1.20, modifiziert — Anmerkung 1 zum Begriff wurde hinzugefügt.]

3.1.14

Zelle

en cell

<Coverage> Nachbarschaft um eine direkte Position in einem Coverage-Gitter

Anmerkung 1 zum Begriff: Coverage-Zellen werden auch als Gitterzellen bezeichnet.

3.1.15

diskrete Coverage

en discrete coverage

Coverage, die für jede direkte Position innerhalb jedes einzelnen Objekts in ihrem Bereich dieselben Werte des Feature-Attributs liefert

Anmerkung 1 zum Begriff: Der Bereich einer diskreten Coverage besteht aus einer endlichen Menge räumlicher, zeitlicher oder raum-zeitlicher Objekte.

Anmerkung 2 zum Begriff: Diskrete Coverages haben nur dort Werte, wo sie definiert sind, während kontinuierliche Coverages interpoliert werden können und damit Zwischenwerte liefern.

3.1.16

Bereich

en domain

wohldefiniertes (Fach-)Gebiet oder bestimmter Wertebereich

Anmerkung 1 zum Begriff: Alle Elemente eines Bereichs sind von einem vorgegebenen Typ.

[QUELLE: ISO 19109:2015, 4.8, modifiziert — Ursprüngliche Anmerkung 1 zum Begriff wurde durch eine neue Anmerkung zum Begriff ersetzt.]

3.1.17

externes Koordinatenreferenzsystem

en external coordinate reference system

Koordinatenreferenzsystem, dessen Bezugspunkt unabhängig von dem Objekt ist, das durch es lokalisiert wird

[QUELLE: ISO 19130-1:2018, 3.25]

3.1.18

Evaluierung

en evaluation

<Coverage> Bestimmung der Werte einer Coverage an einer direkten Position innerhalb des Bereichs der Coverage

3.1.19

Feature

en feature

Abstraktion eines Phänomens der realen Welt

[QUELLE: ISO 19101-1:2014, 4.1.11, modifiziert — Anmerkung 1 zum Begriff wurde entfernt.]

3.1.20

Feature-Attribut

en feature attribute

Merkmal eines Features

Anmerkung 1 zum Begriff: Wird auch als „Feature-Eigenschaft“ bezeichnet und kann ein potenzielles Attribut, eine Qualität oder ein Merkmal eines Features unterstützen.

[QUELLE: ISO 19101-1:2014, 4.1.12, modifiziert — Die ursprünglichen Anmerkungen zum Begriff wurden gelöscht und es wurde eine neue Anmerkung 1 zum Begriff hinzugefügt.]

3.1.21

Funktion

en function

<Mathematik, Programmierung> Regel, die jedes Element eines Bereiches („Quellenbereich“ oder „Bereich“ der Funktion) mit einem einzigartigen Element eines anderen Bereiches („Zielbereich“, „Co-Bereich“ oder „Wertebereich“ einer Funktion) verbindet

[QUELLE: ISO 19107:2019, 3.41]

3.1.22

geometrische Dimension

en geometric dimension

<Geometrie, Topologie> größte Zahl n , sodass jeder Punkt in einer Menge von Punkten mit einer Teilmenge assoziiert werden kann, die den Punkt in ihrem Inneren enthält und die topologisch isomorph zu $\mathbb{E}^n$, euklidischer n -Raum, ist

[QUELLE: ISO 19107:2019, 3.48 modifiziert — Ursprüngliche Anmerkungen zum Begriff wurden gelöscht.]

3.1.23

Geometrieobjekt

en geometric object

<Geometrie> raumbezogenes Objekt, das eine geometrische Menge darstellt

Anmerkung 1 zum Begriff: Ein Geometrieobjekt besteht aus einem geometrischen Primitiv, einer Sammlung geometrischer Primitive oder einem geometrischen Komplex, der als Einzelobjekt behandelt wird. Ein Geometrieobjekt kann die räumliche Repräsentation eines Feature-Objekts sein.

[QUELLE: ISO 19107:2019, 3.49]

3.1.24

geometrische Menge

en geometric set

<geometry> Menge direkter Positionen

[QUELLE: ISO 19136-1:2020, 3.1.32, modifiziert — Ursprüngliche Anmerkung zum Begriff wurde gelöscht.]

3.1.25

Georektifiziert

en georectified

korrigiert im Hinblick auf die Positionsverschiebung in Bezug auf die Erdoberfläche

[QUELLE: ISO 19115-2:2019, 3.11]

3.1.26

Georeferenzierbar

en georeferenceable

mit einer Geopositionierungsinformation im Zusammenhang stehend, die verwendet werden kann, um die Werte der Gitterkoordinaten in die Werte von Koordinaten umzuwandeln, die auf ein externes Koordinatenreferenzsystem in Bezug auf die Erdoberfläche verweisen

[QUELLE: ISO 19163-1:2016]

3.1.27

Georeferenzierung

en georeferencing

Geopositionierung eines Objekts unter Verwendung eines Korrespondenzmodells, das aus einer Reihe von Punkten abgeleitet ist, für die sowohl Boden- als auch Bildkoordinaten bekannt sind

[QUELLE: ISO 19130-1:2018, 3.37]

3.1.28

Gitter

en grid

<Coverage> nicht leere, geordnete Menge von Achsen mit einer Menge von Positionen entlang jeder Achse, die als Bezugspunkte für zusammenhängende kompakte glatte Hyperflächen dienen

Anmerkung 1 zum Begriff: Nach 19123:2005 besteht ein Gitter aus einem Netzwerk aus zwei oder mehr Mengen von Kurven, in dem die Teile jeder Menge die Teile anderen Mengen kreuzen. Diese Definition soll auch auf den Fall 1-D anwendbar sein.

Anmerkung 2 zum Begriff: Die Definition aus 19123:2005 entspricht der überarbeiteten Definition in diesem Dokuments.

3.1.29

Gitterkoordinatenreferenzsystem

en grid coordinate reference system

Koordinatenreferenzsystem für die Positionen in einem Gitter, das ein festgelegtes Koordinatensystem verwendet, das mit dem durch das „GridEnvelope“ (Gitterwerk) und die „axisLabels“ (Achsenbezeichnungen) von gml:GridType beschriebenen Koordinatensystem kongruent ist

Anmerkung 1 zum Begriff: Das Gitter-CRS ist identisch mit dem CRS der Coverage, die durch dieses Gitter definiert wird.

[QUELLE: ISO 19136-2:2015, 4.2.1, modifiziert — Die ursprüngliche Anmerkung 1 zum Begriff wurde gelöscht und es wurde eine neue Anmerkung 1 zum Begriff hinzugefügt.]

3.1.30

Rasterkoordinatensystem

en grid coordinate system

Koordinatensystem, in dem eine Position in Bezug auf den Schnittpunkt von Kurven angegeben ist

[QUELLE: ISO 19115-2:2019, 3.14]

3.1.31

Rasterkoordinaten

en grid coordinates

Folge von zwei oder mehr Zahlen, die eine Position in Bezug auf deren Lage in einem Raster angeben

[QUELLE: ISO 19115-2:2019, 3.15]

3.1.32

Rasterpunkt

en grid point

Punkt am Schnittpunkt von zwei oder mehr Kurven in einem Raster

3.1.33

Rasterdaten

en gridded data

Daten, bei denen die Werte ihrer Attribute mit Positionen in einem Rasterkoordinatensystem assoziiert sind

Anmerkung 1 zum Begriff: Rasterdaten sind ein Untertyp von Coverage-Daten, die Attributwerte von geografischen Merkmalen in Bezug auf ein räumliches Raster darstellen

[QUELLE: ISO 19115-2:2019, 3.16, modifiziert — Anmerkung 1 zum Begriff wurde hinzugefügt.]

3.1.34

Bildkoordinatensystem

Bild-CS

en image coordinate system, Image CS

zweidimensionales, nicht georeferenziertes kartesisches Gitterkoordinatensystem

Anmerkung 1 zum Begriff: Ein Bildkoordinatensystem ist ein zweidimensionales Index-Koordinatensystem, folglich ein Sonderfall eines Index-Koordinatensystems.

3.1.35

Bildkoordinatenreferenzsystem

Bild-CRS

en image coordinate reference system, Image CRS

Auf ein Bild anwendbares kartesisches Koordinatenreferenzsystem

Anmerkung 1 zum Begriff: Das CRS eines Rasterbildes (ohne Georeferenzierung) ist ein zweidimensionales Gitter, dessen Achsen kartesische Achsen sind (d. h. auf einem Index-CRS basieren); dies wird gemeinhin als Bild-CRS bezeichnet.

3.1.36

Bildkoordinaten

en image coordinates

Koordinaten in Bezug auf ein kartesisches Koordinatensystem eines Bildes

Anmerkung 1 zum Begriff: Rasterdaten sind ein Untertyp von Coverage-Daten, die Attributwerte von geografischen Merkmalen in Bezug auf ein räumliches Raster darstellen.

Anmerkung 2 zum Begriff: Die Bildkoordinaten können in Pixeln oder in einem Längenmaß (lineares Maß) angegeben werden.

[QUELLE: ISO 19130-2:2014, 4.33, modifiziert — Es wurde eine neue Anmerkung 2 zum Begriff wurde hinzugefügt.]

3.1.37

Bild-Bezugspunkt

en image datum

Bezugspunkt, der die Beziehung zwischen einem Bildkoordinatensystem und dem Ursprung eines kartesischen Koordinatensystems beschreibt

3.1.38

Index-Koordinatensystem

Index-CS

en index coordinate system

mehrdimensionales, nicht georeferenziertes kartesisches Gitterkoordinatensystem

3.1.39

Index-Koordinatenreferenzsystem

Index-CRS

en index coordinate reference system

mehrdimensionales, nicht georeferenziertes kartesisches Gitterkoordinatenreferenzsystem

3.1.40

Index-Bezugspunkt

en index datum

Bezugspunkt, der die Beziehung zwischen einem Index-Koordinatensystem und dem Ursprung eines kartesischen Koordinatensystems beschreibt

3.1.41

Schnittstelle

en interface

<UML> Klassifikator, der eine Deklaration einer Menge von kohärenten öffentlichen UML-Merkmalen und Verpflichtungen darstellt

Anmerkung 1 zum Begriff: Eine Schnittstelle spezifiziert einen Vertrag; jeder Klassifikator, der die Schnittstelle umsetzt, muss diesen Vertrag erfüllen. Die Verpflichtungen, die mit einer Schnittstelle verknüpft sein können, liegen in Form von verschiedenen Arten von Einschränkungen (wie Vor- und Nachbedingungen) oder Protokollspezifikationen vor, die den Interaktionen über die Schnittstelle Ordnungsbeschränkungen auferlegen können.

[QUELLE: ISO 19103:2015, 4.21]

3.1.42

Masche

en mesh

Geometrie mit zugehöriger Topologie einer Dimension größer als Null

Anmerkung 1 zum Begriff: Geometrie und Topologie sind in ISO 19107 definiert. Beispiele für Maschen sind Kurven, TIN und Körper. Punkte (und Punktmengen) ähneln Geometrien mit der Dimension Null.

3.1.43

Pixel

en pixel

kleinstes Element eines digitalen Bilds, dem Attribute zugewiesen sind

Anmerkung 1 zum Begriff: Ein Pixel ist die kleinsteanzeigeeinheit für ein sichtbares Bild.

Anmerkung 2 zum Begriff: Dieser Begriff entstand als Kurzform von „Bildelement“.

[QUELLE: ISO 19101-2:2018, 3.28, modifiziert — Anmerkung 1 zum Begriff wurde zu Anmerkung 2 zum Begriff geändert und eine neue Anmerkung 1 zum Begriff wurde hinzugefügt.]

3.1.44

Punktmenge

en point cloud

Ansammlung von Datenpunkten in einem 3D-Raum

Anmerkung 1 zum Begriff: Der Abstand zwischen den Punkten ist im Allgemeinen ungleichmäßig, so dass alle drei Koordinaten (kartesisch oder sphärisch) für jeden Punkt spezifisch kodiert werden müssen.

[QUELLE: ISO 19130-2:2014, 4.51]

3.1.45

Punkt-Coverage

en point coverage

Coverage, die einen aus Punkten bestehenden Bereich hat

3.1.46

Polygon-Coverage

en polygon coverage

Coverage, die einen aus Polygonen bestehenden Bereich hat

3.1.47

Wertebereich

en range

<Coverage> Menge von Werten von Feature-Attributen, die durch eine Funktion, der Coverage, mit den Elementen des Bereichs einer Coverage verbunden ist

Anmerkung 1 zum Begriff: Dies stimmt mit der allgemeineren Definition des Wertebereichs in ISO 19107:2019 überein.

3.1.48

Raster

en raster

rechtwinklige Struktur von parallelen Abtastlinien, die ein Gitter bilden

Anmerkung 1 zum Begriff: Der Begriff wird auch als ungenauer Oberbegriff für alle Bild- und Raster-Coverage-Daten verwendet.

Anmerkung 2 zum Begriff: Historisch gesehen leitet sich der Begriff von dem Anzeigemuster einer Kathodenstrahlröhre ab.

3.1.48

gerichtetes Gitter

en rectified grid

Gitter, für welches eine Affintransformation zwischen den Gitterkoordinaten und den Koordinaten eines externen Koordinatenreferenzsystems vorliegt

Anmerkung 1 zum Begriff: Wenn das Koordinatenreferenzsystem durch einen Bezugspunkt auf die Erdoberfläche bezogen ist, handelt es sich um ein georektifiziertes Gitter.

3.1.50

referenzierfähiges Gitter

en referenceable grid

mit einer Umwandlung im Zusammenhang stehendes Gitter, das verwendet werden kann, um die Werte der Gitterkoordinaten in die Werte von Koordinaten umzuwandeln, die auf ein externes Koordinatenreferenzsystem verweisen

Anmerkung 1 zum Begriff: Wenn das Koordinatenreferenzsystem anhand von Ortsdaten mit der Erde in Beziehung gebracht werden kann, so handelt es sich bei dem Gitter um ein georeferenzierbares Gitter.

3.1.51

Körper

en solid

dreidimensionales geometrisches Primitiv, das das kontinuierliche Bild einer Region des euklidischen 3D-Raums darstellt

Anmerkung 1 zum Begriff: Ein Körper ist lokal als eine dreiparametrische Menge direkter Positionen realisierbar. Die Begrenzung eines Körpers ist die Menge der ausgerichteten, geschlossenen Flächen, die die Grenzen des Körpers bilden.

[QUELLE: ISO 19107:2019]

3.1.52

raumbezogenes Objekt

en spatial object

<Topologie, Geometrie> Objekt, das zur Darstellung der raumbezogenen Merkmale eines a Features verwendet wird

[QUELLE: ISO 19107:2019, 3.87]

3.1.53

räumliches Bezugssystem

en spatial reference system

System zur Identifizierung der Position in der realen Welt

[QUELLE: ISO 19155:2012, 4.20]

3.1.54

räumlich-zeitlicher Bereich

en spatio-temporal domain

<Coverage> Bereich, der aus räumlich-zeitlichen Objekten besteht

Anmerkung 1 zum Begriff: Der räumlich-zeitliche Bereich einer kontinuierlichen Coverage besteht aus einer Menge direkter Positionen, die in Bezug auf eine Sammlung von räumlich-zeitlichen Objekten definiert sind.

3.1.55

räumlich-zeitliches Objekt

en spatio-temporal object

Objekt, das eine Menge von direkten Positionen in Raum und Zeit darstellt

3.1.56

Tesselierung

en tessellation

Aufteilung eines Raumes in eine Menge von zusammenhängenden Teilräumen mit der gleichen Dimension wie der aufgeteilte Raum

3.1.57

Thiessen-Polygon

en Thiessen polygon

Polygon, das einen Punkt aus einer Menge von Punkten auf einer Ebene so umschließt, dass alle direkten Positionen, die näher an diesem Punkt liegen als an jedem anderen Punkt der Menge, eingeschlossen sind

3.1.58

unregelmäßiges Dreiecksnetz

TIN

en triangulated irregular network

Tesselierung aus Dreiecken

3.1.59

Vektor

en vector

Größe mit einer Richtung sowie einem Betrag

Anmerkung 1 zum Begriff: Eine gerichtete Linie bildet einen Vektor, wenn Länge und Richtung der Linie gleich dem Betrag und der Richtung des Vektors sind. Der Begriff Vektordaten bezieht sich auf Daten, die eine räumliche Anordnung von Features als Menge gerichteter Linien darstellen.

3.2 Abkürzungen

1D	eindimensional
2D	zweidimensional
3D	dreidimensional
4D	vierdimensional
CRS	Koordinatenreferenzsystem (en: Coordinate Reference System)
DGGS	Diskretes globales Gittersystem (en: Discrete Global Grid System)
GIS	geographisches Informationssystem (en: Geographic Information System)
TIN	unregelmäßiges Dreiecksnetz (en: Triangulated Irregular Network)
UML	Unified Modelling Language

3.3 Schreibweise

In diesem Dokument werden konzeptionelle Schemata in der Unified Modeling Language (UML) dargestellt. ISO 19103 „Conceptual schema language“ stellt das spezifische Profil der UML dar, das in diesem Dokument verwendet wird.

Mehrere Modellelemente, die in diesem Schema verwendet werden, sind in anderen vom ISO/TC 211 entwickelten internationalen Normen festgelegt. Die in diesem Dokument definierten UML-Klassen haben das aus zwei Buchstaben bestehende Präfix CV. Tabelle 1 enthält eine Liste der anderen Normen und Pakete, in denen die in diesem Dokument verwendeten UML-Klassen definiert sind.

Tabelle 1— Quellen für extern definierte UML-Klassen

Präfix	Internationale Norm	Paket
EX	ISO 19115-1	Extent
GF	ISO 19109	General Feature Model
GM	ISO 19107	Geometry
SC	ISO 19111	Spatial Coordinates
TM	ISO 19108	Temporal Schema

Nationaler Anhang NB (informativ)

Literaturhinweise

DIN EN ISO 19107:2020-09, *Geoinformation — Raumbezugsschema (ISO 19107:2019); Englische Fassung EN ISO 19107:2019*

DIN EN ISO 19108:2005-05, *Geoinformation — Zeitliches Schema (ISO 19108:2002); Englische Fassung EN ISO 19108:2005*

DIN EN ISO 19109:2016-05, *Geoinformation — Regeln zur Erstellung von Anwendungsschemata (ISO 19109:2015); Englische Fassung EN ISO 19109:2015*

DIN EN ISO 19111:2020-09, *Geoinformation — Koordinatenreferenzsysteme (ISO 19111:2019); Englische Fassung EN ISO 19111:2020*

DIN EN ISO 19115-1:2014-07, *Geoinformation — Metadaten — Teil 1: Grundsätze (ISO 19115-1:2014); Englische Fassung EN ISO 19115-1:2014*

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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).

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*.

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.

Introduction

This standard defines, at a high, implementation-independent level, the notion of coverages as digital representations of space-time varying geographic phenomena, corresponding to a field in physics: a physical quantity that has a value for each point in space-time. 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 19107:2019 provides a schema for describing features in terms of geometric and topological primitives.

“**Raster data**”¹, on the other hand, deals with real-world phenomena that vary over space and time. It contains a set of values, each associated with one of the elements in an array of points or cells. It is usually associated with a method for interpolating values at spatial positions between the points or within the cells. Since this data structure is not the only one that can be used to represent phenomena that vary continuously over space, this document uses the term “coverage,” adopted from the Abstract Specification of the Open Geospatial Consortium (OGC) [11], to refer to any data representation that assigns values directly to spatio-temporal position. A coverage is a function from a spatial, temporal or spatio-temporal domain to an attribute range. A coverage associates a position within its domain to a record of values of defined data types.

A coverage function has as its domain, an area or space defined by any combination of the three physical spatial dimensions plus the physical dimension time. Mathematics also uses the word dimension to represent an axis in a numeric space. The mathematical meanings of dimension and space are broader than those used in the physical world. The three physical spatial dimensions plus the physical dimension time may be mapped to mathematical dimensions. The range of a coverage function is a set of attribute values for each of the attribute types. These range values may also be represented as mathematical dimensions. That is, we have two complementary ways of viewing a coverage function, as a domain and range or as a mathematical space based on axes.

In this document, coverage is modelled as a subtype of feature as defined in ISO 19101. A coverage is a feature that has multiple values for each attribute type, where each direct position within the geometric representation of the feature has a single value for each attribute type.

A coverage consists of spatio-temporally extended objects where information content depends on (and varies with) the particular coordinate where it is probed. Standardization in this area is a cornerstone for other geographic information design, specification and standardization.

Such space-time varying objects are described as sets of geographic objects (“features”), called coverages. The feature objects collected in a coverage define the positions where values are available (called Direct Positions), and the individual values associated with each feature.

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, triangulated irregular networks, point sets and polygon coverages. Coverages are multi-dimensional, including examples like 1D sensor timeseries, 2D satellite images, 3D x/y/t image

¹ “Raster” is a widely used but imprecise colloquial term that encompasses imagery, gridded and other types of coverage data.

timeseries and x/y/z geophysical voxel data, and 4D x/y/z/t climate and ocean data. Axes of such coverages can have spatial, temporal, or any other dimension, and they can be combined freely.

EXAMPLE The electromagnetic spectrum is an example for an axis with neither spatial nor temporal semantics. As such a spectral axis can be defined following the rules of ISO 19111, so it qualifies as a coverage axis.

A coverage which provides values only at the Direct Positions is called “a discrete coverage” (discrete in its domain); if interpolation information is added so that values can be obtained also beyond 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 features or coverages are not mutually exclusive. The same phenomenon may be represented as either a discrete feature or a coverage. A city may be viewed as a discrete feature that returns a single value for each attribute, such as its name, area and total population. The city feature may also be represented as a coverage that returns values such as population density, land value or air quality index for each position in the city.

A coverage, moreover, can be derived from a collection of discrete features with common attributes, 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; each discrete feature being composed of a set of positions associated with specified attribute values.

The previous version of this standard ISO 19123:2005 addressed coverage modelling on both conceptual and (to some extent) implementation level. For this edition of the document, coverage modelling has been split into two separate, but connected documents: ISO 19123-1 (this document) establishes an abstract, high-level coverage model while ISO 19123-2 establishes an implementation-level model ensuring interoperability, based on the concepts of ISO 19123-1.

– *Entwurf* –

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 type within the domain. A coverage domain consists of a collection of direct positions in a coordinate space that may be defined in terms of spatial and/or temporal dimensions. Examples of coverages include meshes/grids, triangulated irregular networks, point coverages and polygon coverages. Coverages are the prevailing data structures in a number of application areas, such as remote sensing, meteorology and mapping of bathymetry, elevation, soil and vegetation. This document defines the relationship between the domain of a coverage and an associated attribute range. The characteristics of the domain are defined whereas the characteristics of the attribute range are not part of this standard.

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/TS 19101-2:2018, *Geographic information — Reference model — Part 2: Imagery*

ISO 19103:2015, *Geographic information — Conceptual schema language*

ISO 19107:2019, *Geographic information — Spatial schema*

ISO 19108:2002, *Geographic information — Temporal schema*

ISO 19109:2015, *Geographic information — Rules for application schema*

ISO 19111:2019, *Geographic information — Referencing by coordinates*

ISO 19115-1:2014, *Geographic information — Metadata — Part 1: Fundamentals*

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

type of continuous coverage which is a spatially bounded, but transfinite set of direct positions, and a mathematical function that relates direct position to feature attribute value

3.1.2

axis

<coordinate geometry> linear feature from which a one-dimensional coordinate system is constructed

Note 1 to entry: This definition is established in accordance with ISO 19111:2019, Clause 10.4.

3.1.3

continuous coverage

coverage that returns different values for the same feature attribute at different direct positions within a single spatial object, temporal object or spatio-temporal object in its domain

Note 1 to entry: Although the domain of a continuous coverage is ordinarily bounded in terms of its spatial and/or temporal extent, it can be subdivided into an infinite number of direct positions.

3.1.4

coordinate

one of a sequence of numbers designating the position of a point

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.

[SOURCE: ISO 19111:2019, 3.1.5, modified — Original Note 1 to entry has been replaced with a new note to entry.]

3.1.5

coordinate dimension

<coordinate geometry> number of measurements separate decisions needed to describe a position in a coordinate system

Note 1 to entry: The number of separate decisions corresponds to the number of axes.

[SOURCE: ISO 19107:2019, 3.17, modified — Original Note 1 to entry has been replaced with a new note to entry.]

3.1.6

coordinate system

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

[SOURCE: ISO 19111:2019, 3.1.11]

3.1.7

coordinate reference system

coordinate system that is related to an object by a datum

Note 1 to entry: Geodetic and vertical datums are referred to as reference frames.

Note 2 to entry: For geodetic and vertical reference frames, the object will be the Earth. In planetary applications, geodetic and vertical reference frames may be applied to other celestial bodies.

[SOURCE: ISO 19111:2019, 3.1.9]

3.1.8

coverage

feature that acts as a function to return values from its range for any direct position within its domain

3.1.9

coverage CRS

the common CRS in which all coordinates of a coverage are expressed

Note 1 to entry: Sometimes a coverage's CRS is also referred to as the coverage's Native CRS.

3.1.10

coverage dimension

coordinate dimension

<coordinate geometry> number of separate decisions needed to describe a position in a coordinate system

Note 1 to entry: This is equivalent to “the number of axes in the coordinate reference system of the coverage domain set

[SOURCE: ISO 19107:2019, 3.17, modified — Original Note 1 to entry has been replaced with a new note to entry.]

3.1.11

coverage geometry

configuration of the domain of a coverage described in terms of coordinates

3.1.12

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

3.1.13

direct position

<geographic information> position described by a single set of coordinates within a coordinate reference system

Note 1 to entry: Cells in a grid coverage are identified by their direct position in the domain set of this coverage.

[SOURCE: ISO 19136-1:2020, 3.1.20, modified — Note 1 to entry has been added.]

3.1.14

cell

<coverage> neighbourhood around a direct position in a coverage grid

Note 1 to entry: Coverage cells are also known as grid cells.

3.1.15

discrete coverage

coverage that returns the same feature attribute values for every direct position within any object in its domain

Note 1 to entry: The domain of a discrete coverage consists of a finite set of spatial, temporal, or spatio-temporal objects.

Note 2 to entry: Discrete coverages have values only where they are defined, whereas continuous coverages can be interpolated thereby providing intermediate values.

3.1.16

domain

well-defined set

Note 1 to entry: All elements within a domain (set) are of a given type

[SOURCE: ISO 19109:2015, 4.8, modified — Original Note 1 to entry has been replaced with a new note to entry.]

3.1.17

external coordinate reference system

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

[SOURCE: ISO 19130-1:2018, 3.25]

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: 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 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

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

3.1.25

georectified

corrected for positional displacement with respect to the surface of the earth.

[SOURCE: ISO 19115-2:2019, 3.11]

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.

[SOURCE: ISO 19163-1:2016]

3.1.27**georeferencing**

geopositioning an object using a Correspondence Model derived from a set of points for which both ground and image coordinates are known.

[SOURCE: ISO 19130-1:2018, 3.37]

3.1.28**grid**

<coverage> nonempty, ordered set of axes with a set of positions along each axis acting as reference points for connected compact smooth hypersurfaces

Note 1 to entry: In 19123:2005 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. This definition is intended to be applicable also to the 1-D case.

Note 2 to entry: The 19123:2005 definition is equivalent to the revised definition of this document.

3.1.29**grid coordinate reference system**

coordinate reference system for the positions in a grid that uses a defined coordinate system congruent with the coordinate system described by the GridEnvelope and axisLabels of gml:GridType

Note 1 to entry: The grid's CRS is identical to the CRS of the coverage defined by that grid.

[SOURCE: ISO 19136-2:2015, 4.2.1, modified — Original Note 1 to entry has been deleted and a new Note 1 to entry added.]

3.1.30**grid coordinate system**

coordinate system in which a position is specified relative to the intersection of curves

[SOURCE: ISO 19115-2:2019, 3.14]

3.1.31**grid coordinates**

sequence of two or more numbers specifying a position with respect to its location on a grid

[SOURCE: ISO 19115-2:2019, 3.15]

3.1.32**grid point**

point located at the intersection of two or more curves in a grid

3.1.33**gridded data**

data whose attribute values are associated with positions on a grid coordinate system.

Note 1 to entry: Gridded data are a subtype of coverage data, which represent attribute values of geographic features in terms of a spatial grid

[SOURCE: ISO 19115-2:2019, 3.16, modified — Note 1 to entry has been added.]

3.1.34**image coordinate system****Image CS**

two-dimensional non-georeferenced Cartesian grid coordinate system

Note 1 to entry: An Image CS is a two-dimensional Index CS, hence a special case of an Index CS.

3.1.35

image coordinate reference system

Image CRS

Cartesian coordinate reference system applicable to an image

Note 1 to entry: The CRS of a raster image (without georeferencing) is a two-dimensional grid where the axes are Cartesian axes (i.e., based on an Index CRS); this is commonly referred to as Image CRS.

3.1.36

image coordinates

coordinates with respect to a Cartesian coordinate system of an image

Note 1 to entry: Gridded data are a subtype of coverage data, which represent attribute values of geographic features in terms of a spatial grid.

Note 2 to entry: The image coordinates can be in pixels or in a measure of length (linear measure)

[SOURCE: ISO 19130-2:2014, 4.33, modified — A new Note 2 to entry has been added.]

3.1.37

image datum

datum describing the relationship of an image coordinate system to the origin of a Cartesian coordinate system

3.1.38

index coordinate system

Index CS

multi-dimensional non-georeferenced Cartesian grid coordinate system

3.1.39

index coordinate reference system

Index CRS

multi-dimensional non-georeferenced Cartesian grid coordinates reference system

3.1.40

index datum

datum which describes the relationship of an index coordinate system to the origin of a Cartesian coordinate system

3.1.41

interface

<UML> classifier that represents a declaration of a set of coherent public UML features and obligations

Note 1 to entry: An interface specifies a contract; any classifier that realizes the interface must fulfil that contract. The obligations that can be associated with an interface are in the form of various kinds of constraints (such as pre- and post-conditions) or protocol specifications, which can impose ordering restrictions on interactions through the interface.

[SOURCE: ISO 19103:2015, 4.21]

3.1.42

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.

3.1.43

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.]

3.1.44

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 19130-2:2014, 4.51]

3.1.45

point coverage

coverage that has a domain composed of points

3.1.46

polygon coverage

coverage that has a domain composed of polygons

3.1.47

range

<coverage> set of feature attribute values associated by a function, the coverage, with the elements of the domain of a coverage

Note 1 to entry: This is consistent with the more generic definition of range in ISO 19107:2019.

3.1.48

raster

rectangular pattern of parallel scanning lines forming a grid

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

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

3.1.48

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.

3.1.50

referenceable grid

grid associated with a transformation that can be used to convert grid coordinate values to values of coordinates referenced to 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 georeferenceable grid.

3.1.51

solid

three-dimensional geometric primitive, representing the continuous image of a region of Euclidean 3-space

Note 1 to entry: A solid is realizable locally as a three-parameter set of direct positions. The boundary of a solid is the set of oriented, closed surfaces that comprise the limits of the solid.

[SOURCE: ISO 19107:2019]

3.1.52

spatial object

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

[SOURCE: ISO 19107:2019, 3.87]

3.1.53

spatial reference system

system for identifying position in the real world

[SOURCE: ISO 19155:2012, 4.20]

3.1.54

spatio-temporal domain

<coverage> domain composed of spatio-temporal objects

Note 1 to entry: The spatio-temporal domain of a continuous coverage consists of a set of direct positions defined in relation to a collection of spatio-temporal objects.

3.1.55

spatio-temporal object

object representing a set of direct positions in space and time

3.1.56

tessellation

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

3.1.57

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

3.1.58

triangulated irregular network

TIN

tessellation composed of triangles

3.1.59

vector

quantity having direction as well as magnitude

Note 1 to entry: A directed line segment represents a vector if the length and direction of the line segment are equal to the magnitude and direction of the vector. The term vector data refers to data that represents the spatial configuration of features as a set of directed line segments.

3.2 Abbreviated terms

1D	one-dimensional
2D	two-dimensional
3D	three-dimensional
4D	four-dimensional
CRS	Coordinate Reference System
DGGS	Discrete Global Grid System
GIS	Geographic Information System
TIN	Triangulated Irregular Network
UML	Unified Modelling Language

3.3 Notation

In this document, conceptual schemas are presented in the Unified Modeling Language (UML). ISO 19103 Conceptual schema language presents the specific profile of UML used in this document.

Several model elements used in this schema are defined in other International Standards developed by ISO/TC 211. UML classes defined in this document have the two-letter prefix of CV. Table 1 lists the other 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
EX	ISO 19115-1	Extent
GF	ISO 19109	General Feature Model
GM	ISO 19107	Geometry
SC	ISO 19111	Spatial Coordinates
TM	ISO 19108	Temporal Schema

4 Conformance

4.1 Interoperability and Conformance Testing

This document being an abstract standard allows for multiple different implementations and does not define a standardized interoperable implementation. The abstract concepts described herein can be implemented in a variety of ways which may not be directly interoperable, that is: the same abstract coverage represented through two different implementation models will not necessarily be identical in their structure, and services following two different implementation models will not necessarily deliver equivalent results on equivalent queries or other operations. The purpose of the abstract description standardized in this document is to provide an underlying consistency at the data model level that makes it possible to establish concretizing, interoperable standards.

Conformance testing is accomplished by manually validating a candidate concretization against all requirements by exercising the tests set out in Annex A.

In an implementation standard based on this abstract specification the semantics defined in this document will normally be cast into a concrete data model (describing data structures to be stored, transferred, ingested, or extracted) and a concrete service model (describing the functionality of a service operating on coverages); such derived models should be designed in an interoperable manner, i.e.: allow concise conformance testing.

This document has a companion standard, ISO 19123-2 Coverage Implementation Schema (CIS). Based on this ISO 19123-1 standard, ISO 19123-2 defines a concrete coverage model in the sense that interoperability can be guaranteed and interoperability tests (such as the OGC compliance tests on coverages [8]) can be established.

In addition to the main body, Annex D defines a Generic Coverage Data Structure. This structure represents one possible data structure that is compatible with the interface defined in this standard. This is the structure that was defined in the previous version of ISO 19123. The purpose of Annex D is to retain backward compatibility because there exist other standards both in ISO and in external organizations that make direct reference to the generic data classes that were defined in the previous version of ISO 19123 and which now may reference the same classes as defined in this Annex. The interface approach is more flexible, but the classes defined in Annex D are one valid structure that may be supported through the interface.

4.2 Organization

The coverage schema is organized into the packages shown in Figure 1, Figure 2 and Table 2. Each package establishes one requirements class. Grouping into these requirements classes has been done with a practical perspective in mind: Realizations of this document may be focused on particular structures, such as grid coverages or point clouds, while ignoring all the other options.

Table 2 — Conformance classes

Conformance class	Clause	URI
Coverage (Core)	5	https://standards.isotc211.org/19123/-1/1/conf/core
Multi-Point Coverage	6	https://standards.isotc211.org/19123/-1/1/conf/multi-point
Grid Coverage	7	https://standards.isotc211.org/19123/-1/1/conf/grid
Multi-Curve Coverage	8	https://standards.isotc211.org/19123/-1/1/conf/multi-curve
Multi-Surface Coverage	9	https://standards.isotc211.org/19123/-1/1/conf/multi-surface
Multi-Solid Coverage	10	https://standards.isotc211.org/19123/-1/1/conf/multi-solid

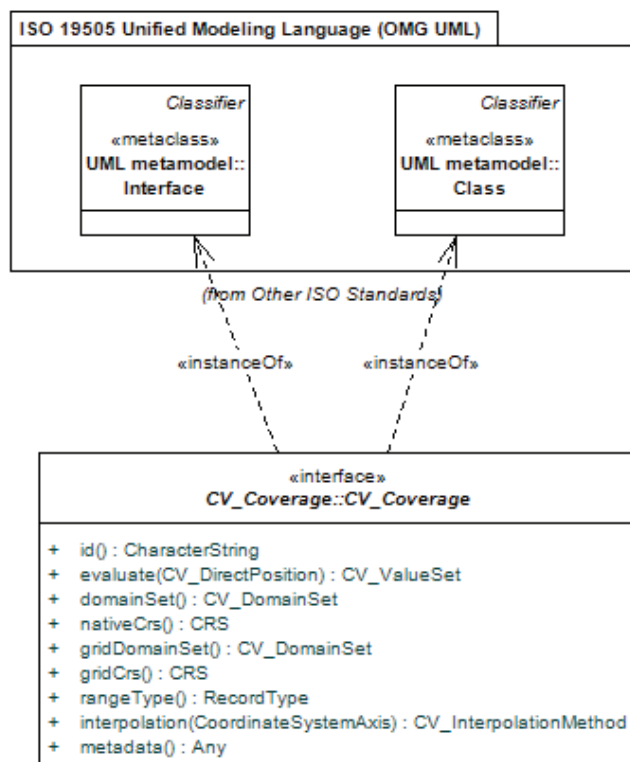


Figure 1 — Coverage Modelling Package Hierarchy

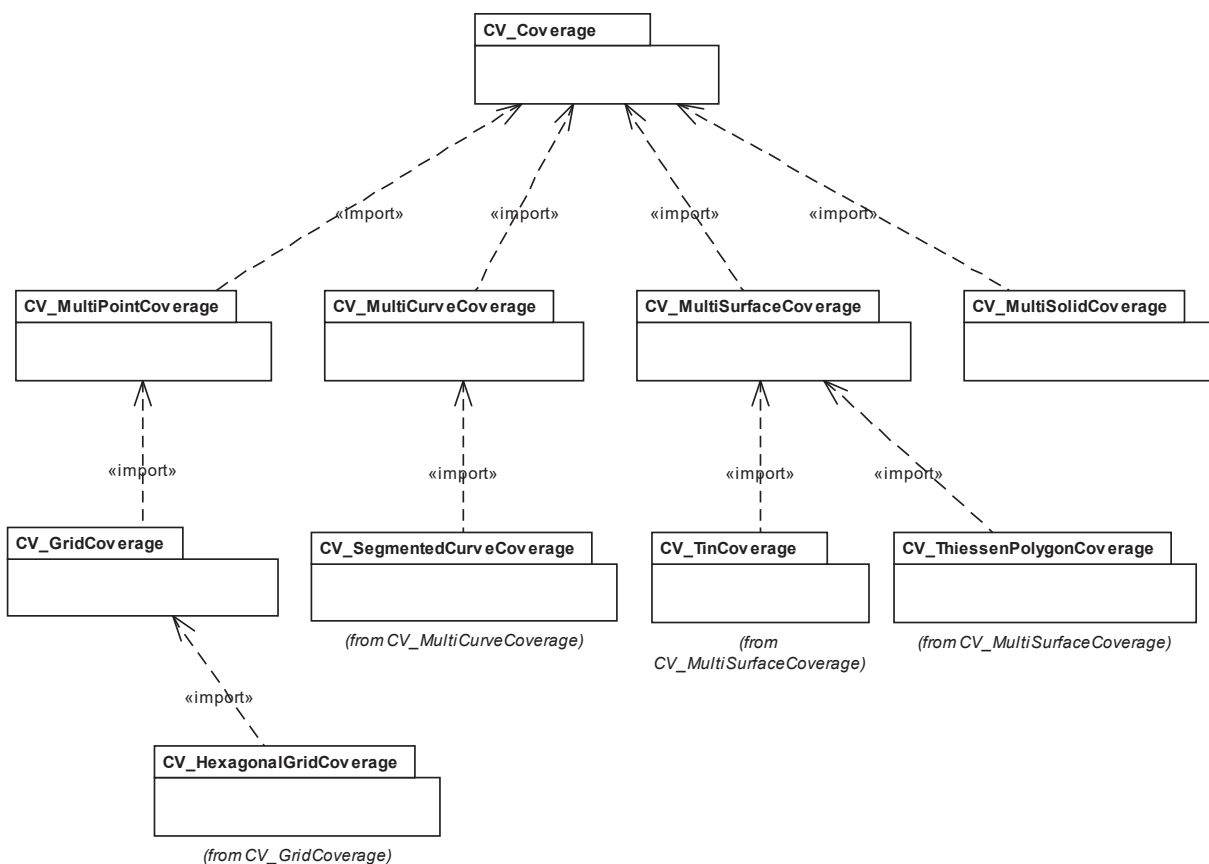


Figure 2 — Packages of the coverage schema

5 Coverages

5.1 Overview

This clause defines conformance class Core of package CV_Coverage.

This Document uses the term *coverage*, adopted from the Abstract Specification of the Open GIS Consortium ^[11], to refer to any data representation that assigns values directly to spatial and/or temporal positions. As such, a coverage conceptually can be viewed as a function which, for every value of its domain set, provides a particular value taken from its range set; actually, a coverage may provide a set of values for a particular position.

EXAMPLE Point clouds can be modelled as Multi-Point Coverages. Several observation values can be acquired for a particular location, and reading such a location will result in the set of all values observed.

Coverages are multi-dimensional by nature – such as 1-D sensor timeseries, 2-D x/y images, 3-D x/y/t image timeseries and x/y/z geophysical information, and 4-D x/y/z/t atmospheric and oceanographic information. The dimension axes spanning the coverage can be of spatial, temporal, or “abstract” nature (where abstract is understood in the sense of being neither spatial nor temporal), or any combination of these. As such, a coverage forms a digital representation of some space/time varying phenomenon.

EXAMPLE A satellite image timeseries has two spatial and one temporal axis. A geo-statistical datacube may have a temporal axis, spatial extents, and population density.

The set of locations (in a wide, spatio-temporal sense) where a coverage has objects sitting and, hence, has values to offer is called the coverage’s *Domain Set*, said locations are called *Direct Positions*. The set of all these values is the coverage’s *Range Set*, described by the *Range Type*.

Coordinates in a coverage are all expressed in one and the same Coordinate Reference System (CRS). Such a CRS may either be defined directly (such as in the EPSG collection of CRSs [17]) or it may be composed from CRS and axis definitions through the mechanisms defined in ISO 19111.

EXAMPLE The CRS of a satellite image timeseries consists of two spatial and one temporal axis, in some given order. Coordinates along each axis are expressed accordingly – horizontal spatial coordinates may be expressed in degrees Lat and Long, laid down in the EPSG:4326 CRS, while time is expressed in seconds since epoch or some calendar, like Gregorian-Proleptic.

In terms of common data structures, coverages encompass regular and irregular grids (requirements class *Grid Coverage*), point clouds (requirements class *Multi-Point Coverage*), and general meshes (requirements classes *Multi-Curve Coverage*, *Multi-Surface Coverage*, and *Multi-Solid Coverage*).

Different views on this coverage concept exist. Therefore, several practically relevant views are explicitly supported:

- In a mathematical view a coverage is defined as a function $C: D \rightarrow R$ with Domain Set D and Range Set R which delivers some value for each element from D . This view is realized as one variant of coverage modelling in subclass CV_CoverageByDomainAndRange (see 5.8.3).
- In standardization terms, a coverage can be described as a set of features (as per ISO 19101-2). As each such feature has a location and attributes, the set of all these pairs defines the coverage’s mapping from location to values. “Geometry” here is understood in the widest possible sense, including all spatial and temporal dimensions. All features in such a collection forming a coverage must have locations expressed in the same CRS (the coverage’s CRS), and all attribute values must share the same data type (the coverage’s Range Type). See 5.8 for details.

5.2 Coverage Schema

This clause describes package CV_Coverage in terms of interfaces (as per ISO 19103) of its central class, CV_Coverage. It defines a set of requirements for compliance with this interface description, based on the concepts of UML modelling from ISO 19103:2015, Coordinates and Collections from ISO 19107, time from ISO 19108, and Coordinate Systems from ISO 19111.

Requirement 1: <https://standards.iso/2011.org/19123-1/1/req/core/packages>

An instantiation of package CV_Coverage shall have all instances and properties specified for this package, its contents, and its dependencies for CV_Coverage as per Figure 2 and Figure 3.

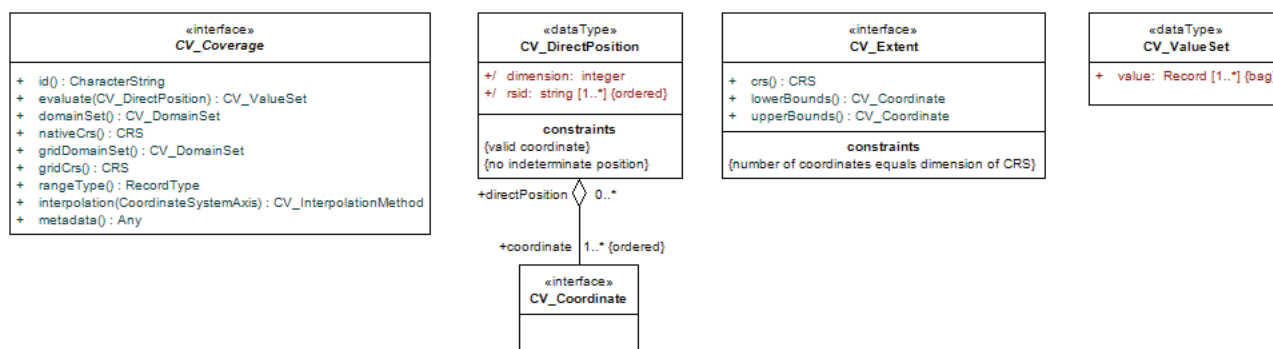


Figure 3 — CV_Coverage central classes

The UML interface modelling approach allows multiple different compatible data structures to be implemented which exhibit the same behaviour through the interface. Standardization targets are specifications concretizing the abstract concepts into implementation standards; one such example is ISO 19123-2 which in turn as standardization target has concrete implementations.

Standardization targets are specifications concretizing the abstract concepts into implementation standards; one such example is ISO 19123-2 which in turn as standardization target has concrete implementations.

Requirement 2: <https://standards.iso/2011.org/19123-1/1/req/core/coordinates>

An instantiation of package CV_Coverage shall make use of ISO 19107 package Coordinates.

5.3 Probing Coverages: *evaluate()* Function

One way to define the semantics of a coverage is via a probing function which, for some Direct Position coordinate expressed in the coverage's CRS, returns the set of values associated with it. This function can be defined, for a coverage C with Domain Set D and value set V of that coverage, as

$$evaluate_C: D \rightarrow V, evaluate_C(p) = \bigcup_{f \in C} f.contains(p)$$

based on the *contains()* probing predicate of ISO 19107.

NOTE This probing function serves for definition purposes only, it is not required to be implemented. In practice, other retrieval functionality is desirable, such as bounding box subsetting in the OGC Web Coverage Service (WCS) Core [10].

While in general more than one value can be returned for a particular Direct Position, sometimes exactly one value will be delivered. This can occur in two cases:

- In case of a Grid Coverage, no two Direct Positions share the same coordinates by definition, and so there is always one value available via *evaluate()*.
- If a Common Point Rule (see 5.7) is defined then this constitutes a selection mechanism ensuring that exactly one member of the set of values available for a given Direct Position is returned by *evaluate()*.

EXAMPLE More than one value per Direct Position can occur in several cases, such as in point clouds with two points incidentally sharing the same coordinates, but bearing different values, or in MultiSolid Coverages that overlap.

5.4 Domain of a coverage

5.4.1 Concept

The coverage domain set describes for which positions in the coverage's multi-dimensional space values are available. Within this multi-dimensional space defined by the Domain's Coordinate Reference System (CRS) the coverage Domain contains a set of geometric objects which determines the Direct Positions, i.e.: the locations in this space where the coverage offers a value. This description can be given through direct enumeration of the Direct Positions (example: point clouds) or through containment descriptions (example: areas and volumes), or some other mechanism (example: Ground Control Points in sensor models). The coverage's Extent gives a bounding box – i.e.: lower and upper bounds along every coordinate axis – within which all its Direct Positions are located.

EXAMPLE 1 The space spanned in coverages representing 1-D temperature measurement timeseries, 2-D x/y images of the Earth surface, 3-D x/y/t image timeseries and x/y/z subsurface voxel data, and 4-D x/y/z/t atmospheric and ocean data, all are described through some appropriate CRS with the respective dimension.

The geometric objects in a coverage domain are not strictly confined through 3-dimensional physical space. They can be m-dimensional objects where $m \leq n$ for an n-dimensional coverage. Coverage subtypes are defined in terms of their domain types in Clause 6 onwards.

EXAMPLE 2 A 3-dimensional x/y/t image timeseries datacube may be composed of 0-dimensional points, its pixels. A domain of coordinate dimension 3 may be composed of points, curves, surfaces, or solids, while a domain of coordinate dimension 2 may be composed only of points, curves or surfaces.

5.4.2 Coordinates

ISO 19111-2 defines CRSs which contain ordered lists of axes used for addressing points in space. For an n-dimensional coverage, $n > 0$, the corresponding CRS contains an ordered set of n axes whose syntax and semantics (such as unit of measure, discrete or continuous) is part of the CRS definition. Points in the coverage domain's n-dimensional space are addressed through n-tuples of coordinates based on the n-dimensional coverage's CRS.

ISO 19107 defines geometric objects (subtypes of class `GM_Object`), ISO 19108 defines temporal objects (class `TM_GeometricPrimitives`) that may be used to define domains of coverages.

The Domain Set of a coverage, as described by its Coordinate Reference System (CRS) consists of a number of axes which together define some n-dimensional space, with $n > 0$.

Often the unit of measure of an axis is numeric, such as degrees or meters or seconds. However, there may be several representations of coordinate measurements, such as degree/minute/seconds or Gregorian Proleptic time/date strings. Finally, axes without any spatial nor temporal semantics, might be added (such as geo statistics measures) which, for the purpose of this standard, are subsumed informally as "abstract". Therefore, `CV_DirectPosition` defining coordinates for `CV_Coverage` takes a broader approach to coordinate values than ISO 19107 class `DirectPosition`, generalizing spatial, temporal, and other coordinate types into one class. Further, as the type now is *Any* instead of numeric any syntax becomes possible for expressing coordinates. In Figure 4, the Spatial Reference System as per ISO 19107 as well as Temporal Reference System as per ISO 19108 are listed; with a proper CRS identifier (see also 5.4.3) these can be referenced by the `rsid` attribute of `CVDirectPosition`. However, further CRSs are possible as well, such as elevation, bathymetry, spectral bands, Planetary Science CRSs, to name but a few. Among others, these CRSs will define the proper syntax for the corresponding coordinate value in the `CV_Coordinate` value in the coordinate tuple (such as number, date string, etc.).

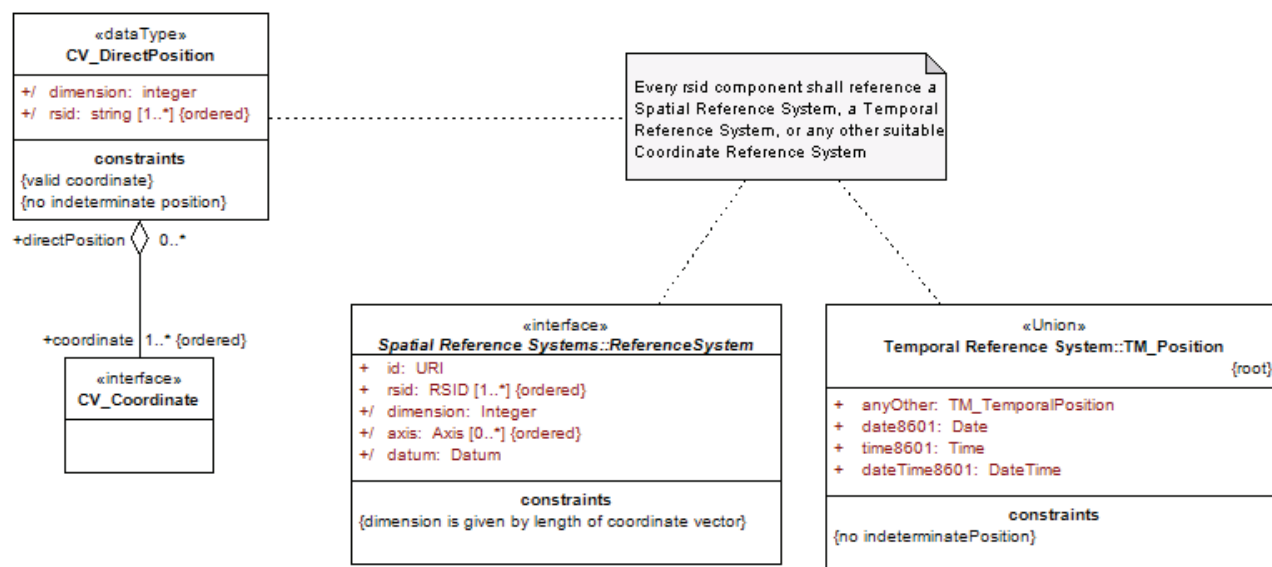


Figure 4 — CV_DirectPosition

EXAMPLE The following is a non-exhaustive list of possible axes in coverage Domain Sets:

- A CRS consisting of a single time axis can model a timeseries of measurements. Time coordinates can be expressed, among others, in seconds since epoch (often: January 1, 1970) or as time/date strings of the Gregorian Proleptic Calendar defined in ISO 8601, such as “2021-05-12”.
- Pressure altitudes, measured in hekto-Pascal (hPa), as well as Flight Levels, expressed in 100 ft steps like “FL150” for 15000 ft above some reference point, represent “proxies” for altitude used in aviation.
- Integer coordinates can be used to define a coverage axis of spectral frequencies.

5.4.3 Coordinate Reference Systems for Coverage Domains

The coverage’s CRS defines the theoretically available space for Direct Positions, bounded additionally by the coverage extent in that space. Generally, though, not for every position in this space a Direct Position may be defined. The type of feature bundled in a coverage determines where Direct Positions, expressed in coordinates based on the coverage’s CRS, are available. As feature types commonly are sorted along their topological dimensions – thereby defining points, lines, surfaces, and solids in natural space – this is an appropriate criterion for classifying coverage types. Additionally, there may hold further constraints, such as with grid coverages which are based points having topological dimension 0, but additionally require the Direct Positions to sit on some grid. In the following clauses, coverage types sorted along their topological dimension as defined in ISO 19107.

ISO 19111-2 describes ways to compose CRSs for building higher-dimensional CRSs from lower-dimensional ones.

Requirement 3: <https://standards.iso211.org/19123/-1/1/req/core/crs>

The coverage CRS shall be described in accordance with ISO 19111 which describes the semantics of CRSs and their axes, as well as their composition into higher-dimensional CRSs.

Requirement 4: <https://standards.iso211.org/19123/-1/1/req/core/rsid>

A coverage CRS shall be identified by an ISO 19107 DirectPosition::RSID.

Requirement 5: <https://standards.iso211.org/19123/-1/1/req/core/associated>

In a coverage CRS, coordinates with spatial semantics shall be represented by an ISO 19107 DirectPosition.

Requirement 6: <https://standards.iso211.org/19123/-1/1/req/core/temporal>

In a coverage CRS, coordinates with temporal semantics shall be represented by an ISO 19108 TM_Position.

The concept of an Image Coordinate Reference System (Image CRS, Figure 5) has been introduced with the purpose of unifying the handling of non-georeferenced imagery and referenced objects. With this Image CRS there is always a CRS for coverages, even if they are not related to any position in space/time. Technically, an Image CRS can be defined as subclass of ISO 19111 Coordinate Reference System consisting of an Image CS and an Image Datum. It is characterized by being 2D and having Cartesian integer coordinates on both axes. As such, an Image CRS is identical to the OGC Index2D CRS.

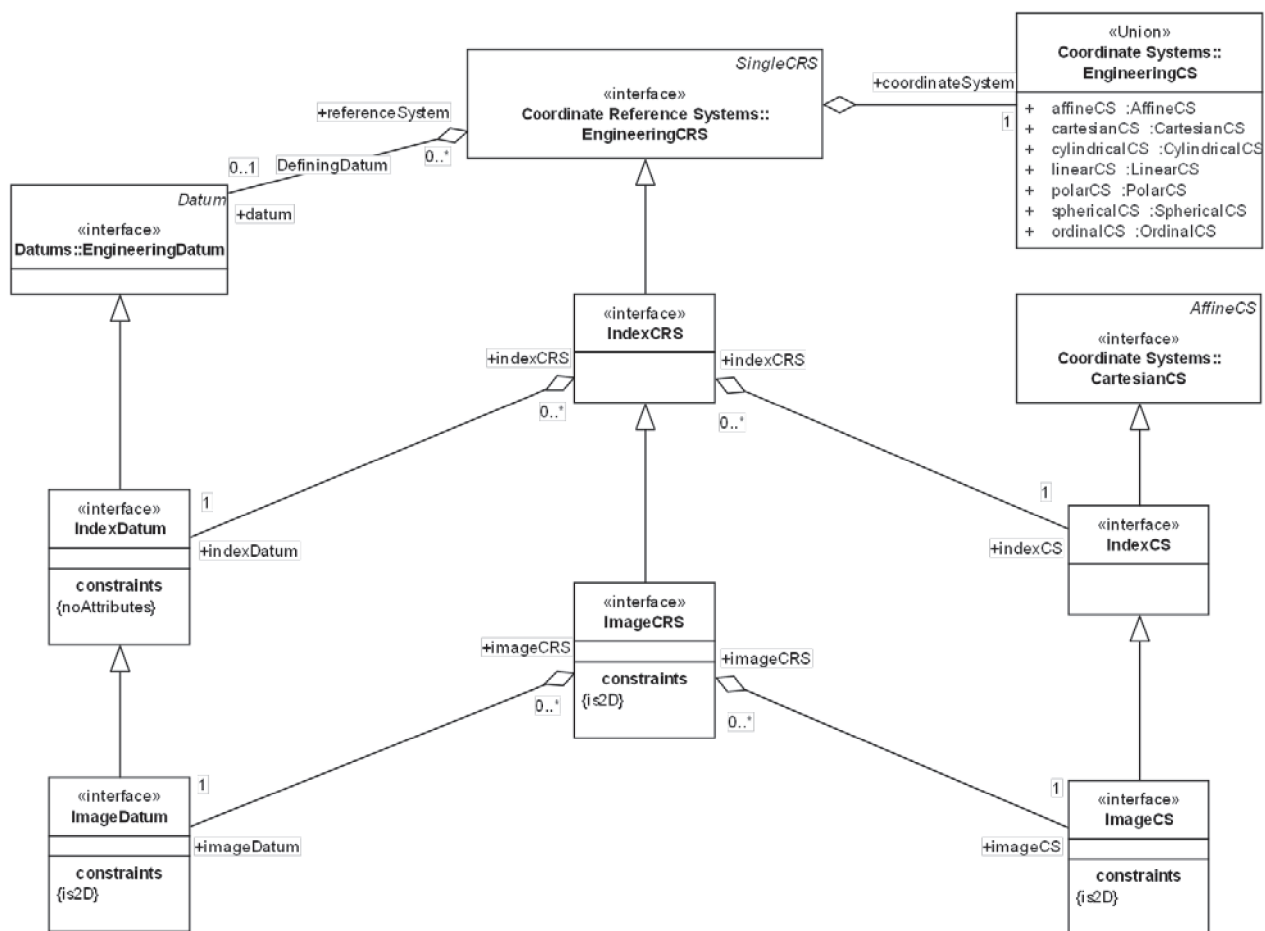


Figure 5 — IndexCRS and ImageCRS

EXAMPLE 2 The Direct Positions in a coverage's Domain Set can be enumerated (example: point sets in a Multi-Point Coverage), they can be given implicitly (example: corner points indicating the set of all raster positions in a Rectified Grid Coverage).

The range of CRSs to be used is open-ended; CRSs not described nor mentioned in this standard might be used in a coverage. Recommendation, though, is to use CRSs from some standard repository, such as the OGC spatial and temporal CRS repository³, or following some standardized syntax, such as OGC WKT⁴, or

⁴ <https://www.ogc.org/standards/wkt-crs>

some geo referenced grid system like DGGS ^[12] which uses a compound tessellation by fitting a polyhedron such as a 20-sided icosahedron or 6-sided cube to a sphere or ellipsoid and then tessellating each facet.

5.4.4 Multi-Dimensional Coverages

A single axis, being a component of a one- or higher-dimensional CRS, can be established in various ways. When composing axes, as per ISO 19111, both CRSs and single axes can be combined into some higher-dimensional CRS. Mechanisms to do so are out of scope of this document, they are defined in ISO 19111.

The Domain Set of a coverage, as described by its Coordinate Reference System (CRS) consists of a number of axes which together define some n -dimensional space, with $n > 0$. While this document does not define Domain Set semantics (this is done in ISO 19111) it can be stated that physical dimensions consist of two horizontal axes (such as x and y), a vertical axis, and a temporal axis. By combining one or more of these axes spatio-temporal objects can be built. Further, axes can represent alternate representations of coordinate measurements. Finally, other possible axes, without any spatial nor temporal semantics, might be called “abstract”.

EXAMPLE The following is a non-exhaustive list of possible axes in coverage Domain Sets:

- A CRS consisting of a single time axis represents a timeseries of values.
- Pressure altitudes, measured in hekto-Pascal (hPa), as well as Flight Levels, expressed in 100 ft steps like “FL150” for 15000 ft above Mean Sea Level, represent “proxies” for altitude used in aviation.
- Spectral frequencies can define a coverage axis.

The CRS defines the theoretically available space for Direct Positions. Generally, though, not for every position in this space a Direct Position may be defined. The type of feature bundled in a coverage determines where Direct Positions, expressed in coordinates based on the coverage’s CRS, are available. As feature types commonly are sorted along their topological dimensions – thereby defining points, lines, surfaces, and solids in natural space – this is an appropriate criterion for classifying coverage types. Additionally, there may hold further constraints, such as with grid coverages which are based points having topological dimension 0, but additionally require the Direct Positions to sit on some grid. In the following clauses, coverage types sorted along their topological dimension as defined in ISO 19107.

5.4.5 Mathematical versus Physical Coordinates

The Domain Set of a coverage, as described by its Coordinate Reference System (CRS) consists of a number of axes which together define some n -dimensional space, with $n > 0$. Geographic data typically have a subset of two horizontal axes, one height axis (expressing elevation or bathymetry), and time. Climate modelling adds a second time axis for differentiating model run time from time modelled. By combining one or more of these axes multi-dimensional spatio-temporal objects can be built. Further, axes can represent alternate representations of coordinate measurements. Additionally, “abstract” (in the sense of non-spatio-temporal) axes may occur as well, like in Online Analytical Processing (OLAP) where, e.g., time / product / subsidiary axes are common.

EXAMPLE Non-spatio-temporal axes occur in practice as well. For example, bands in hyperspectral imagery make sense as a numbered sequence once there are hundreds of such bands, such as the Hyperion instrument on board of EO-1 with its 220 bands⁵. With natural numbers addressing becomes less wieldy.

NOTE Originally spatial dimensions might become non-spatial at some level of generalization. For example, cities in Europe might be expressed through coordinates originally, but at some higher level get abstracted to be in Bavaria, in the Alps region, etc. which is at a symbolic level. This may lead to dimension hierarchies like in OLAP.

⁵ <https://archive.usgs.gov/archive/sites/eo1.usgs.gov/hyperion.html>

5.5 Range of a coverage

At every direct position a coverage holds a single value or a nonempty set of values. All these values of a coverage together make up the coverage's range set.

EXAMPLE 1 A coverage might assign to each direct position in a county the temperature, pressure, humidity, and wind velocity and direction vector, at a specific time, at that point. The coverage maps every direct position in the county to a record of these fields. In this case, the common type of the coverage range values is a record of components, each of its individual type.

The *Range Type* component describes the type of the set of values available for the Range Set. Structures such described can be atomic or a record of named components.

Requirement 7: <https://standards.iso211.org/19123-1/1/req/core/record>

The Range Type component shall be of type *Record Type* as defined in ISO 19103.

Requirement 8: <https://standards.iso211.org/19123-1/1/req/core/mininfo>

The Range Type of a coverage at minimum shall provide the information necessary to decode the Range Set values and process them in a computer system, consisting of (i) data type information in some available typing system, (ii) null values, and (iii) unit of measure.

EXAMPLE 2 RGB images, when modelled as a coverage, have as their range type a record consisting of three components *red*, *green*, and *blue* (in that order), each of them of type unsigned 8-bit integer.

Recommendation 1: <https://standards.iso211.org/19123-1/1/req/core/measurement>

Range Type definitions should rely on some commonly agreed system of measurement.

NOTE One way of providing this information is via a HTTP-URI pointing to a location that provides this information in a standardized manner. Another way is to provide this information directly as part of the coverage.

5.6 Interpolation

5.6.1 Concept

Through interpolation, range values can be obtained for coordinates within the domain set of a coverage which are not Direct Positions. Basically, a coverage provides values only at its Direct Positions. Interpolation means applying some algorithm to obtain a range value for locations inside a coverage's domain set which are not Direct Positions, usually by combining the values of several Direct Positions in the neighbourhood of the coordinate location under inspection.

Interpolation requires domain set coordinates to be in a CRS which allows for expressing "in between" values.

EXAMPLE 1 Index coordinates, representing integer numbers, do not allow expressing any in between value as it would not be an integer any more. Latitude, Longitude, height, and time, conversely allow expressing values between any two given coordinates as they conceptually map to real numbers.

Depending on the interpolation method, i.e.: the algorithm applied, the range type may require providing "in between" values, too. In general, for interpolation it may be necessary that the range type allows for arbitrary such values to be generated, requiring a continuous range type. Therefore, applicability of a particular interpolation method in general also depends on the range type.

EXAMPLE 2 "Nearest neighbour" interpolation does not require new values to be computed as the resulting value is chosen from the available ones taken from the surrounding Direct Positions. "Linear interpolation", on the other hand, usually will generate values different from the surrounding ones, based on the arithmetic means computation.

Interpolation can be applied along a single axis or along several axes simultaneously. Therefore, interpolation methods on high, conceptual level are defined on axis level. A concretization of this standard may bundle interpolation methods to allow only one and the same interpolation method across all (or a subset of) axes.

EXAMPLE 3 In horizontal geographic CRSs interpolation will normally be coupled so that, say, Latitude and Longitude always share the same interpolation. Time and height, on the other hand, will normally be interpolated individually.

5.6.2 Discrete and Continuous Coverages

The domain set characteristics decide in the first place whether interpolation is applicable. The CRS, which defines the set of possible coordinate values, may or may not allow addressing of coordinate values beyond the Direct Positions. Hence, coverages are possible which allow interpolation along one axis, but not along another.

EXAMPLE 1 A grid coverage with Lat, Long, and an index axis can be interpolated in Lat and Long, but not along the index axis.

An axis is called *discrete* if every possible interval with finite bounds describes a finite set of values, otherwise such an axis is called *continuous*.

A coverage is called *discrete* if its axis list contains only discrete axes. A coverage is called *continuous* if its axis list contains at least one continuous axis.

Coverages can be discrete (or continuous) in their range, in their domain, or in both.

EXAMPLE 2 A map of postal code zones is a coverage which is discrete in its range. The postal code zones cover an entire country and at every location in the country one can evaluate the coverage function and get a value that represents the postal code for that location. Within a postal code zone the value is constant. One cannot interpolate such a discrete coverage.

EXAMPLE 3 A coverage that maps a set of polygons to the soil type found within each polygon is a coverage which is discrete in its range. More examples of this type of coverage are given in ISO 19144-2 Classification Systems – Part 2 – Land Cover Meta Language (LCML).

EXAMPLE 4 A point set representing a set of measurements that are only valid at the position of each point, and which cannot be interpolated, is a discrete coverage (discrete in domain).

EXAMPLE 5 An image, sampled by a sensor, may be represented as a grid coverage consisting of a set of pixels corresponding to grid cells in the domain of the coverage. A value is associated with each grid cell. However, since the coverage is continuous an interpolation function – such as linear, quadratic, or cubic – may be applied so that a continuously variable value may be determined at any location within the domain extent of the image.

EXAMPLE 6 In a coverage that maps direct positions in San Diego County to their temperature at noon on a specific day, both domain and range may take an infinite number of different values. This continuous coverage would be associated with a discrete coverage that holds the temperature values observed at a set of weather stations (discrete in domain). That is, the measured values correspond to a point set coverage. This point set coverage is discrete because each point can only have one value. The associated continuous coverage uses the point values as driving values for the coverage function and allows interpolation between the points.

EXAMPLE 7 A set of bathymetric soundings is a discrete point set coverage with a single measured water depth value at each point location (discrete in domain). An associated continuous coverage allows one to interpolate between the measured depth soundings to determine the bottom surface of a body of water.

EXAMPLE 8 Evaluation of a triangulated irregular network involves interpolation of values within a triangle composed of three neighbouring point value pairs.

5.6.3 Interpolation Set

The Interpolation Set component contains a – possibly empty – set of interpolation methods which are applicable to the coverage on hand, thereby establishing ways to derive values for locations beyond the coverage's direct position. If interpolation is allowed on a coverage then proper range values can be obtained between direct positions by applying one of the coverage's interpolation methods.

An empty interpolation set indicates that no interpolation can be applied meaningfully. See Annex B for descriptions of specific interpolation methods. This list is open ended – additional interpolation methods, including interpolation methods for higher-dimensional coverages, may be defined in an Application Schema that makes use of this standard.

NOTE 1 As coverages are passive data structures this cannot be enforced. However, it is a valuable hint to any application as to what interpolation technique(s) can be applied meaningfully to the data set on hand.

ISO 19107 defines a set of interpolation methods, individually for the particular geometry types, upon which this Document relies.

Requirement 9: <https://standards.iso/20123-1/1/req/core/iso19107-interpolation>

Interpolation types allowed for the geometries contained in a coverage shall be given by the interpolation methods specified in ISO 19107 for the respective geometry type.

Recommendation 2: <https://standards.iso/20123-1/1/req/core/interpolation-method>

An application may apply one interpolation method collectively along all axes of the coverage, or it may allow indicating individual interpolation methods applied to different axes of the coverage.

EXAMPLE In an image timeseries having Latitude, Longitude, and time axes several ways of interpolation are relevant:

- Linear interpolation along latitude and longitude (“bilinear interpolation”), with temporal resolution unchanged (in plain words: all existing timeslices get extracted) and, hence, no interpolation occurring along time.
- Interpolate each pixel’s history (i.e., along time) using linear interpolation, without any spatial interpolation.
- Linear interpolation along latitude, longitude, and time simultaneously (“trilinear interpolation”).

NOTE 2 As this standard is a data model and not a processing nor service model use of a particular interpolation method on a given coverage cannot be enforced. Rather, a coverage may provide information on the set of interpolation methods that should be applied whenever, in the course of performing some general processing, interpolation needs to be performed (such as in rescaling a coverage along one or more axes).

NOTE 3 Interpolation methods may require additional control parameters; these are not considered in this document.

5.7 Common Point Rule

The optional CV_Coverage attribute commonPointRule of type CV_CommonPointRule, carried over from ISO 19123:2005 as legacy, identifies the procedure to be used for evaluating the CV_Coverage at a position for which more than one range values exist. Its behaviour is defined in Annex D.

5.8 Realization Variants

5.8.1 Overview

In a coverage, the domain and range sets may be organised in different ways, driven by practical considerations. Possible organisations include:

- Separate representation of domain and range sets in some serialization; if both use the same serialization scheme then corresponding location/value pairs can be identified through their position in the sequence. This is useful, for example, in image processing when the domain is not needed for the image operation on hand.
- Having an implicit description (rather than an explicit representation) of the domain. This reduces a coverage’s size and, again, allows convenient range set processing while avoiding the sometimes unwanted overhead of addressing each value one by one through its direct position.
- A set of position/value pairs. This is a natural representation, for example, for point clouds.
- Partitioning a coverage into smaller units. This is commonly known as tiling. In fact, this concept can be extended to recursively nested coverages.

- A functional, analytic description where domain and range are defined through mathematical expressions.
- Combinations of the above, where feasible.

NOTE One interoperable concretization supporting various such organizations is given by ISO 19123-2[5] which is identical to OGC CIS ^[9].

In the subclauses below some of the above coverage structures are detailed further. They are summarized in Figure 6.

5.8.2 Geometry/Value Pair View

The collection of feature objects constituting a coverage can be seen as establishing a mapping from the features' space to the set of values associated with the features. In case these features and their values get enumerated this naturally leads to a set representation where each set element is a (geometry, value) pair. This is the view supported by the ISO 19107 Collection paradigm, captured in CV_CoverageByPartitioning containing a Partition Set consisting of geometry/value pairs (Figure 6). The constraints relevant for this coverage variant are established in 5.8.3.

However, other logical organisations of a coverage, with identical information content, can be constructed. Two of them are established below. Figure 6 gives a synoptic view of all variants discussed.

Requirement 10: <https://standards.iso/211.org/19123/-1/1/req/core/gv-pair>

A CV_CoverageByGeometryValuePair shall be structured as described in Figure 6 — .

5.8.3 Domain/Range View

Another way of viewing a coverage is as a mapping from a set of direct positions (given by the geometry objects) to a set of values (given by the feature's associated value payload). In this view, a coverage is defined as a function $C: D \rightarrow R$ with Domain Set D and Range Set R which delivers some value for each element from D . This variant is realized in subclass CV_CoverageByDomainAndRange (Figure 6).

Requirement 11: <https://standards.iso/211.org/19123/-1/1/req/core/domain-range>

A CV_CoverageByDomainAndRange shall be structured as described in Figure 6 — .

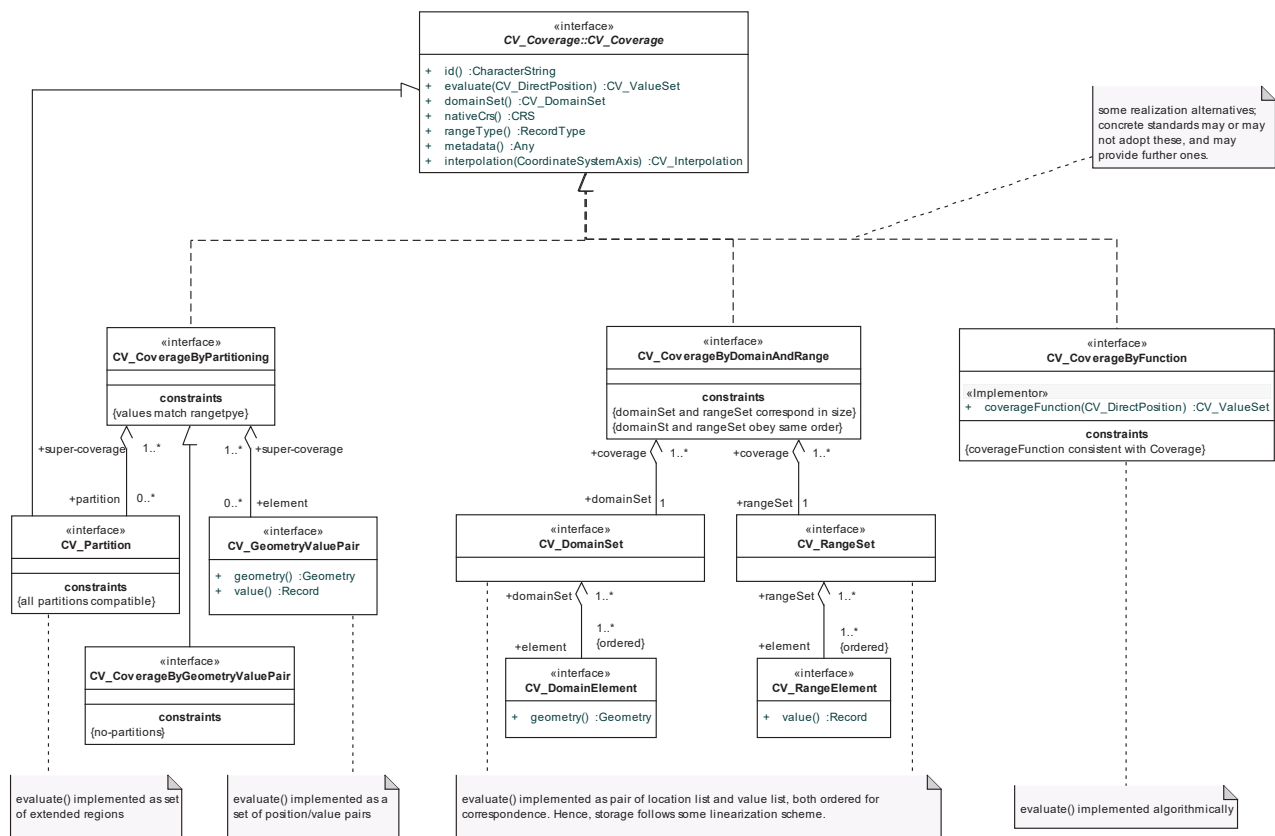


Figure 6 — Class CV_Coverage with multiple variants

NOTE Conceptually, the Domain Set of a coverage consists of all Direct Positions defined for this coverage. This set can be enumerated (Example: point sets in a MultiPointCoverage), they can be given implicitly (Example: corner points indicating the set of all raster positions in a RectifiedGridCoverage as per ISO 19123:2005). Hence, the domain/range view on a coverage is particularly relevant for grid coverages.

5.8.4 Partitioned View

The previously introduced modelling variants resemble two extreme ends of a modelling continuum: In the geometry/value pair representation, the finest possible granularity is adopted by having each single feature object with its value represented together. In the domain/range variant, conversely, the coarsest possible granularity is adopted by having one set of positions which get mapped to one set of values. In the partitioning approach, organizations in between these extremes are gathered. To this end, a coverage gets split into sub-coverages forming partitions of the original coverage. In the coverage model, this is captured by a PartitionSet containing Partitions.

For a coverage set to be aggregated into a larger coverage, some homogeneity constraints must hold:

Requirement 12: <https://standards.isotc211.org/19123/-1/1/req/core/partitioning>

A CV_CoverageByPartitioning shall be structured as described in Figure 6 — .

Requirement 13: <https://standards.isotc211.org/19123/-1/1/req/core/sub-coverages>

All sub-coverages in a partition shall share the same CRS and range type; their Domain Sets shall fulfil all constraints imposed on the particular coverage type of the super-coverage.

Requirement 14: <https://standards.isotc211.org/19123/-1/1/req/core/cyclefree-hierarchies>

A coverage shall not recursively contain itself in a partitioning hierarchy.

NOTE 1 Having only one partition realizes the domain/range variant. Having partitions which contain only one feature object each represents the geometry/value pair variant.

NOTE 2 Partitioned storage organization can massively increase performance of access and processing. In technology such partitioning is also known as tiling and chunking.

5.8.5 Functional View

A coverage can be given by some mathematical descriptions. These descriptions must support the *evaluate()* function. This standard does not explicitly describe any particular mechanism for expressing such functions.

Requirement 15: <https://standards.iso211.org/19123/-1/1/req/core/by-function>

A CV_CoverageByFunction shall be structured as described in Figure 6 — .

EXAMPLE In Constructive Solid Geometry (CSG) objects are built by recursive composition of analytical primitives (such as box, sphere, cylinder, torus, etc.) through (regularized) set operations.

5.9 Envelope

For practical purposes it may be convenient for an application reading a coverage that it can quickly determine where approximately Direct Positions can be expected. Therefore, Coverage contains an optional component envelope of type Envelope of type Extent (as per ISO 19115-1) giving a simplified summary description of the coverage's Domain Set. This envelope consists of an enclosing bounding shape which should be close to the actual coverage extent but does not have to be minimal. Further, the envelope can be expressed in any CRS which can be transformed to and from the coverage's CRS.

EXAMPLE A satellite swath image may contain a bounding box expressed in WGS 84 (Figure 7).

Recommendation 3: <https://standards.iso211.org/19123/-1/1/req/core/envelope>

Coverages should contain an Envelope.

Requirement 16: <https://standards.iso211.org/19123/-1/1/req/core/envelope-axes>

The Envelope of a Coverage shall contain all or a subset of the axes of the corresponding Domain Set.

EXAMPLE In a 3D x/y/t image timeseries datacube the extent may only represent the approximated 2D footprint on the Earth surface, say, in WGS84, thus ignoring the time axis.

Requirement 17: <https://standards.iso211.org/19123/-1/1/req/core/envelope-tight>

The Envelope of a Coverage should approximate its Domain Set as closely as possible, for all axes of the Domain Set present in Extent.

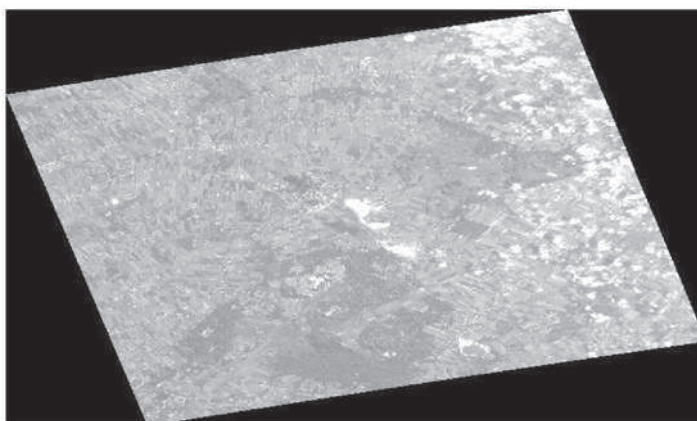


Figure 7 — Satellite image embedded in bounding box

Requirement 18: <https://standards.iso211.org/19123/-1/1/req/core/envelope-domainset>

If a Coverage contains an Envelope then this Envelope shall contain the Domain Set of this Coverage.

Requirement 19: <https://standards.iso211.org/19123/-1/1/req/core/iso19111-crs>

The CRS component of the Coverage shall reference a CRS definition conformant with ISO 19111.

The association Coordinate Reference System shall link the Coverage to the coordinate reference system to which the direct positions in the domain set are referenced. Class SC_CRS is specified in ISO 19111.

6 Multi-Point Coverages

This clause defines conformance class package CV_MultiPointCoverage.

A MultiPointCoverage is a coverage consisting of a collection of points. To maintain a unique value per Direct Position it is mandatory that the point coordinates be disjoint.

Requirement 20: <https://standards.iso/211.org/19123-1/1/req/multi-point/multi-point>

A MultiPointCoverage shall contain only elements of the same type, which is ISO 19107 data type PointData or a subtype thereof, as described by Figure 8.

Requirement 21: <https://standards.iso/211.org/19123-1/1/req/multi-point/multi-point-evaluate>

Function *evaluate()* shall be defined, for some multi-point coverage *c* and position *p*, as

$evaluate(p) = \{ v \mid \exists \text{ point feature } f \in c: f.contains(p) \}$ where *contains()* is defined in ISO 19107.

NOTE An alternative (and different) realization of MultiPointCoverage is given by the ISO 19107 data type PointCloud. MultiPointCoverage is included here for achieving a complete, coherent framework across all topological and geometric dimensions.

7 Grid Coverages

7.1 Overview

This clause defines conformance class package CV_GridCoverage.

A Grid Coverage is a special case of a Multi-Point Coverage in that all direct positions must sit on a grid. The concept of a multi-dimensional grid is defined in 7.2.

Requirement 22: <https://standards.iso/211.org/19123-1/1/req/grid/grid-subtype-of-point>

A Grid Coverage shall be a subtype of Multi-Point Coverage.

NOTE Although abstractly Grid Coverage is a subtype of Multi-Point Coverage, in practice implementation of both types will differ substantially. The regularity of a grid generally allows determining Direct Positions easier than in a point cloud, and often – depending on the degree of regularity of the grid – it is not even required to materialize the coordinates. This entails particularly efficient storage and processing methods.

7.2 Grids

7.2.1 Grid Definition

In a Grid Coverage, a Grid serves to determine the locations of the Direct Positions of the Domain. The Direct Positions carrying range values are aligned to specific points given by the grid definition. The grid's CRS is identical to the CRS of the coverage defined by that grid.

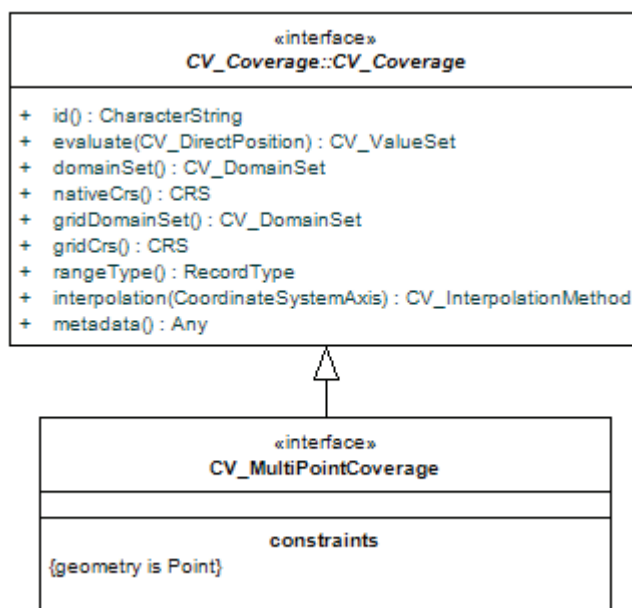


Figure 8 — Class MultiPointCoverage

Grids generally can be constructed based on triangles, rectangles, or hexagons. In the context of coverages, rectangular grids are modelled through Grid Coverages, hexagonal grids can be mapped to Grid Coverages (Clause 7.6), and triangular grids are modelled through meshes, i.e., Multi-Surface (Clause 9) or Multi-Solid Coverages (Clause 10). Therefore, in this standard the term “grid” is always understood as a rectangular grid.

NOTE 1 In 2-D, rectangular grids form tessellations based on quadrilaterals; in the n-D case these become n-gons.

In a rectangular grid, every direct position not sitting on the domain set boundary (“inner position”) has exactly two distinct neighbouring direct positions; those direct positions sitting on the domain set boundary (“boundary position”) have exactly one such neighbouring direct position. Rectangular grids in general do not have equidistant spacing between the Direct Positions. Figure 9 illustrates some cases of regular and irregular grids.

NOTE 2 As opposed to a mesh (in Computational Fluid Dynamics also called unstructured grid) where a vertex (i.e.: cell) can be connected with any number of neighbouring vertices a Grid has a regular structure based on some given number of neighbourhood vertices; therefore such a Grid sometimes is referred to as a structured grid, for clarity.

Mathematically, an n-dimensional Grid is a tessellation of the Grid Coverage’s Domain Set defining a set of Direct Positions through geometric rules as follows. For some $n > 0$ let $A = (a_1, \dots, a_n)$ be a finite ordered set of axes where each axis $a_i = \{v_{i,1}, \dots, v_{i,m_i}\}$ is a totally ordered set of $m_i > 0$ values. This induces a Grid $G = a_1 \times \dots \times a_n$ as the cross product. G can be interpreted as a set of coordinates yielding Direct Positions, $G = \{(x_1, \dots, x_n) \mid x_i \in a_i \text{ for } 1 \leq i \leq n\}$. In a coverage context, A is described by an n-dimensional CRS together with axis boundaries, typically given as lower and upper bounds per axis. The resulting regular and irregular grids are described in 7.2.2.2.

Obviously, when walking from one Direct Position to the next neighbour by incrementing or decrementing just one single axis coordinate x_i to the next allowed value of this axis we obtain another Direct Position, except when starting from the lower or upper bound of the axis. We can therefore replace the actual axis coordinates by counts and establish a bijective mapping between an axis $a_i = \{v_{i,1}, \dots, v_{i,m_i}\}$ and a Cartesian axis $c_i = \{0, \dots, m_i\}$. The CRS corresponding to this Cartesian grid is an Index CRS.

NOTE 3 Often rectangular grids get described through curve bundles, one per axis, whose intersections establish the Direct Positions; within each such bundle the curves pairwise must not touch nor intersect). In case of

CV_IndexAxis, CV_RegularAxis and CV_IrregularAxis a curve bundle will be a set of straight lines. Obviously this construction method can only explain grids in 2-D or higher.

Cartesian grids, also known as square grids, can be represented efficiently as arrays in programming languages, which leads to a preferred storage technique for coverages where the range set is modelled as an array based on some implementation-dependent mapping (such as row-major or column-major arrangement) of the CRS to the array's Cartesian CRS. This allows tools like image processing to ignore the real-world coordinates and operate on the (Cartesian) array.

Implementations will use their own individual correlation between Direct Positions expressed in native and grid CRS, and normally this mapping will not be disclosed to the application. This standard does not make any assumption about this mapping except that there is a one-to-one correlation between Direct Positions expressed in native and grid CRS, respecting the topological neighbourhood of the grid. In other words: going from any Direct Position to a neighbouring Direct Position in any direction on the new position must deliver the same result regardless of whether this step was done in native or grid CRS.

Requirement 23: <https://standards.iso/20123-1/1/req/grid/native-and-grid-CRS-equality>

Start with the lowest Direct Position p in the native CRS, corresponding to Direct Position q in the grid CRS. The equality $evaluate(p) = evaluateGrid(q)$ shall hold. Pick some immediate neighbour position in the grid, having coordinates p' and q' in the native and grid CRS, resp. Repeat the equality test. Inspect all direct positions of the coverage this way.

This grid notion can be generalized so that Direct Positions do not sit at the coordinate positions induced by the grid, but with some offset in arbitrary directions (although not beyond the neighbouring positions). Further, n -D grids can be embedded in some $(n+m)$ -D space for some $m > 0$. These cases are addressed in 7.2.2.3.

In the most general case, coordinates of the Direct Positions are not stored explicitly, but obtained algorithmically from some implementation-dependent parameters. This case is covered by 7.2.2.4.

Requirement 24: <https://standards.iso/20123-1/1/req/grid/rectangular-grid>

In a Grid Coverage, the Direct Positions shall be given by a rectangular Grid.

Requirement 25: <https://standards.iso/20123-1/1/req/grid/single-point-value>

In a Grid Coverage, Direct Position has exactly one value (taken from the coverage's Range Type) associated, i.e.: $|evaluate(p)| = 1$ for all Direct Positions p .

7.2.2 Grid Axis Types

7.2.2.1 General

The axes of a CRS are defined in the CRS, as per ISO 19111. Hence, every axis (set) definition contains a reference to the overall CRS it is embedded in. Additionally, axes describe the subset of coordinate values at which Direct Positions are given. The complete coordinate tuples (as per CRS) can be constructed as the cross product of these admissible axis values due to the lattice isomorphy of the grid (for example, such a grid does not contain "holes"). In Figure 9, type Axis – with its subtypes Index Axis, Regular Axis, and Irregular Axis – establishes how isolated, single axes can be described (see 7.2.2.2). Multiple axes making up a grid (or belonging to it, with further, independent axes existing) Grid axes are defined through Displacement Axis Nest (see 7.2.2.3). In the most general case, axis information is derived algorithmically, represented by Algorithmic Axis (see 7.2.2.4).

7.2.2.2 Index, Regular, and Irregular Axes

An Index Axis is a 1D Cartesian axis: there is no georeference, and admissible coordinates are at discrete, integer positions and unit-less.

Requirement 26: <https://standards.iso/20123-1/1/req/grid/index-axis>

An Index Axis shall be given by an axis identifier, a CRS, lower and upper bounds lo and hi with $lo, hi \in C$ and

$lo \leq hi$. Direct Positions shall be defined for every coordinate tuple where the coordinate value of the Index Axis on hand is from the closed interval $S = \{ x \in \mathbf{Z} \mid lo \leq x \leq hi \}$.

NOTE 1 The unit of measure of an Index Axis is 1, i.e.: coordinate values are unitless.

NOTE 2 As distances are known (always 1) there is no need to store such values as they can be computed when accessing particular Direct Positions.

A Regular Axis has an equi-distant spacing like an Index Axis, but is continuous and not constrained to integer positions and distances. It can be georeferenced, i.e.: it can have a spatial or temporal semantics attached.

Requirement 27: <https://standards.iso/2011.org/19123/-1/1/req/grid/regular-axis>

A Regular Axis shall be given by an axis identifier, a 1D CRS, lower and upper bounds lo and hi with $lo, hi \in C$ and $lo \leq hi$, a resolution $r \in C$. Direct Positions shall be defined for every coordinate tuple where the coordinate value of the Regular Axis on hand is from the set $S = \{ x \in C \mid lo \leq x*r \leq hi \}$.

NOTE 3 Unit of measure, coordinate set, as well as datum are defined in the CRS.

NOTE 4 Storing Direct Positions along irregular axes requires materialization of the initial point (such as the minimum position on the axis) and the (constant) offset; any storage location of a Direct Position can be computed from this.

The next level of generalization is an Irregular Axis. It is continuous, possibly georeferenced, and its distances are irregular. Such an axis can be georeferenced, i.e.: it can have a spatial or temporal semantics attached.

Requirement 28: <https://standards.iso/2011.org/19123/-1/1/req/grid/irregular-axis>

An Irregular Axis shall be given by an axis identifier, a 1D CRS, a set of positions

$P = \{ p_1, \dots, p_n \} \subseteq C$. Direct Positions shall be defined for every coordinate tuple where the coordinate value of the Irregular Axis on hand is from P .

NOTE 5 Storing Direct Positions along irregular axes requires storage of the positions list as they cannot be computed.