

INTERNATIONAL
STANDARD

ISO
19107

Second edition
2019-12

Geographic information — Spatial schema

Information géographique — Schéma spatial



Reference number
ISO 19107:2019(E)

© ISO 2019



COPYRIGHT PROTECTED DOCUMENT

© ISO 2019

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

	Page
Foreword	viii
Introduction	ix
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Symbols, notation and abbreviated terms	17
4.1 Presentation and notation.....	17
4.1.1 Unified Modeling Language (UML).....	17
4.1.2 Naming conventions.....	17
4.2 Organization.....	18
4.3 Abbreviated terms and symbols.....	18
5 Conformance	19
5.1 Requirements class conformance targets.....	19
5.1.1 Conformance targets.....	19
5.1.2 Geometry metrics (geodesy).....	22
5.1.3 Topological dimensionality.....	22
5.1.4 Interpolation schemes.....	22
5.1.5 Structural complexity.....	23
5.1.6 Functional complexity.....	24
5.2 Conformance classes.....	24
5.3 Requirements classes.....	25
6 Coordinates and core geometry	26
6.1 Semantics.....	26
6.2 Requirements Class Coordinate.....	27
6.2.1 Codelists to specify capabilities.....	27
6.2.2 Coordinate systems for Geometry — Semantics.....	27
6.2.3 GeometricReferenceSurface.....	31
6.2.4 Interface ReferenceSystem.....	35
6.2.5 Codelist ReferenceSystemTypes.....	36
6.2.6 Interface CompoundReferenceSystem.....	36
6.2.7 Interface HomogeneousCoordinateSystem.....	37
6.2.8 Interface GeometricCoordinateSystem.....	37
6.2.9 Datatype DirectPosition.....	42
6.2.10 Union Datatype RSID.....	44
6.2.11 Codelist Axis.....	45
6.2.12 Role metadata: AxisDescription.....	45
6.2.13 Datatype Axis Description.....	45
6.2.14 Codelist SpatialAxis.....	45
6.2.15 Codelist SphericalAxis.....	45
6.2.16 Codelist TemporalAxis.....	45
6.2.17 Codelist ParametricAxis.....	46
6.2.18 Codelist Datum.....	46
6.2.19 Datatype Parameter.....	47
6.2.20 Datatype Permutation, Projection.....	47
6.2.21 Interface ReferenceDirection.....	48
6.2.22 Datatype Bearing.....	48
6.2.23 Codelist Rotation.....	50
6.2.24 Codelist RelativeDirection.....	50
6.2.25 Codelist FixedDirection.....	50
6.2.26 Codelist CurveRelativeDirection.....	50
6.2.27 Datatype Vector.....	51
6.2.28 Interface Envelope.....	52

6.2.29	Engineering coordinate systems, Tangent spaces and local interpolations	53
6.3	Requirements Class Coordinate Data	53
6.4	Requirements Class Geometry	54
6.4.1	Semantics	54
6.4.2	Interface TransfiniteSetOfDirectPositions	55
6.4.3	CodeList: BoundaryType	55
6.4.4	Interface Geometry	56
6.4.5	Datatype GeometryData	70
6.4.6	CodeList: GeometryType	70
6.4.7	Interface Encoding	70
6.4.8	Interface Query2D	71
6.4.9	Interface Query3D	74
6.4.10	Interface Empty	75
6.4.11	Interface Primitive	76
6.4.12	Datatype PrimitiveData	77
6.4.13	Interface Point	78
6.4.14	Datatype PointData	80
6.4.15	Interface Orientable	80
6.4.16	Datatype OrientableData	81
6.4.17	Datatype Knot	82
6.4.18	Interface Curve	83
6.4.19	Datatype CurveData	93
6.4.20	Interface OffsetCurve	93
6.4.21	Datatype OffsetCurveData	94
6.4.22	Interface ProductCurve	94
6.4.23	ProductCurveData	96
6.4.24	CodeList: CurveInterpolation	96
6.4.25	Interface Surface	97
6.4.26	Datatype SurfaceData	101
6.4.27	CodeList: SurfaceInterpolation	101
6.4.28	Interface Solid	101
6.4.29	Datatype SolidData	104
6.4.30	CodeList: SolidInterpolation	104
6.4.31	Interface Collection	105
6.4.32	Role element: Geometry	106
6.4.33	Datatype CollectionData	107
6.4.34	Interface Complex	107
6.4.35	Role Complex: generator: Primitive	110
6.4.36	Role Complex: superComplex and subComplex	110
6.5	Requirements Class Geometry Data	111
7	Interpolations for Curves	111
7.1	Requirements Class Line Curve	111
7.1.1	Semantics	111
7.1.2	Interface Line	111
7.1.3	Datatype LineData	113
7.2	Requirements Class Line Data	114
7.3	Requirements Class Geodesic Curve	114
7.3.1	Semantics	114
7.3.2	Interface Geodesic	115
7.3.3	Datatype GeodesicData	115
7.4	Requirements Class Geodesic Curve Data	115
7.5	Requirements Class Rhumb	116
7.5.1	Interface Rhumb	116
7.5.2	Datatype RhumbData	116
7.6	Requirements Class Rhumb Curve Data	117
7.7	Requirements Class Polynomial Curves	117
7.7.1	Semantics	117
7.7.2	Interface RealFunction	118

7.7.3	Interface FunctionArc	118
7.7.4	Association Role function	118
7.7.5	Interface FunctionCurve	119
7.7.6	Interface RealPolynomial	119
7.7.7	Interface PolynomialArc	120
7.7.8	Datatype PolynomialArcData	121
7.7.9	Interface PolynomialCurve	121
7.7.10	Datatype PolynomialCurveData	121
7.8	Requirements Class Polynomial Curve Data	121
7.9	Requirements Class Conic Curves	122
7.9.1	Semantics	122
7.9.2	Interface Arc	123
7.9.3	Datatype ArcData	124
7.9.4	Interface Circle	125
7.9.5	Interface Conic	125
7.9.6	Interface EllipticArc, Datatype EllipticArcData	128
7.10	Requirements Class Conic Curve Data	128
7.11	Requirements Class Spiral Curve	128
7.11.1	Semantics, Mathematical background: curves and curvature	128
7.11.2	Interface Spiral Curves	134
7.11.3	Interface Clothoid Curve	136
7.11.4	Datatype SpiralData	136
7.12	Requirements Class Spiral Curve Data	136
7.13	Requirements Class Spline Curve	136
7.13.1	Semantics	136
7.13.2	CodeList: KnotType	137
7.13.3	CodeList: SplineCurveForm	138
7.13.4	Interface SplineCurve	138
7.13.5	Interface PolynomialSpline	141
7.13.6	Interface CubicSpline	142
7.13.7	Interface Bezier	143
7.13.8	Interface BSplineCurve (and NURBS)	144
7.13.9	Datatype BsplineData	145
7.14	Requirements Class Spline Curve Data	145
8	Interpolations for Surfaces	145
8.1	Requirements Class Polygon Surface	145
8.1.1	Semantics	145
8.1.2	Interface Polygon	145
8.1.3	Datatype PolygonData	147
8.1.4	Interface PolyhedralSurface	147
8.1.5	Datatype PolyhedralSurfaceData	147
8.1.6	Interface Triangle	147
8.1.7	Datatype TriangleData	148
8.1.8	Interface TriangulatedSurface	148
8.1.9	Datatype TriangulatedSurfaceData	148
8.2	Requirements Class Polygon Surface Data	148
8.3	Requirements Class Parametric Curve Surface	148
8.3.1	Semantics	148
8.3.2	Interface ParametricCurveSurface	149
8.3.3	Datatype ParametricCurveSurfaceData	152
8.3.4	Interface BilinearGrid	152
8.3.5	Extensions of ParametricCurveSurface	153
8.4	Requirements Class Parametric Curve Surface Data	153
8.5	Requirements Class Conic Surface	154
8.5.1	Semantics	154
8.5.2	Interface Sphere	154
8.5.3	Interface Cone	155
8.5.4	Interface Cylinder	155

8.6	Requirements Class Conic Surface Data	155
8.7	Requirements Class Spline Surface	156
8.7.1	Semantics	156
8.7.2	Interface BSplineSurface (and NURBS)	156
8.7.3	Codelist BSplineSurfaceForm	158
8.8	Requirements Class Spline Surface Data	158
9	Interpolations for Solids	158
9.1	Requirements Class Boundary Representation Solid	158
9.2	Requirements Class Boundary Representation Solid Data	159
9.3	Requirements Class Parametric Curve Solid	159
9.3.1	Interface ParametricCurveSolid	159
9.3.2	Interface BSolidSpline	160
9.3.3	Other interpolations	161
9.4	Requirements Class Parametric Curve Solid Data	161
10	Topology	161
10.1	Requirements Class Topology root	161
10.1.1	Semantics	161
10.1.2	Interface Topology	162
10.1.3	Interface Primitive	166
10.1.4	Interface DirectedTopo	168
10.1.5	Datatype TopologyData	170
10.1.6	DataType PrimitiveData	171
10.1.7	DataType ComplexData	171
10.1.8	Datatype Expression	171
10.1.9	Datatype ExpressionTerm	174
10.2	Requirements Class Topology Root Data	174
10.3	Requirements Class Node	174
10.3.1	Semantics	174
10.3.2	Interface Node	174
10.3.3	Interface DirectedNode	175
10.4	Requirements Class Edge	175
10.4.1	Interface Edge	175
10.4.2	Interface DirectedEdge	176
10.5	Requirements Class Face	177
10.5.1	Semantics	177
10.5.2	Interface Face	177
10.5.3	Interface DirectedFace	178
10.6	Requirements Class Topology Solid	178
10.6.1	Interface Solid	178
10.6.2	Interface DirectedSolid	179
10.7	Requirements Class Topological Complex	179
10.7.1	Semantics	179
10.7.2	Interface Complex	179
10.8	Requirements Class Derived Topological Relations	182
10.8.1	Introduction	182
10.8.2	Canonical form for Geometry	183
10.8.3	Boundary operators for aggregate objects	183
10.8.4	Boolean or set operators	185
10.8.5	Egenhofer operators	186
10.8.6	Full topological operators	187
10.8.7	Combinations	190
11	Special Requirements Classes	190
11.1	Requirements Class Simplicial geometry	190
11.1.1	Semantics	190
11.1.2	Datatype Simplex	191
11.1.3	DataType SimplicialTerm	193
11.1.4	DataType::SimplicialPolynomial	193

11.1.5	DataType::SimplicialComplex.....	193
11.2	Requirements Class Point Clouds.....	193
11.2.1	Semantics.....	193
11.2.2	Interface PointCloud.....	194
Annex A	(normative) Abstract test suite.....	196
Annex B	(informative) Examples for application schemas.....	211
Annex C	(informative) MiniTopo.....	215
Annex D	(informative) Crosswalk 19107:2003 to current version.....	220
Bibliography	223

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing documents 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*.

This second edition cancels and replaces the first edition (ISO 19107:2003), which has been technically revised. The main changes compared to the previous edition are as follows:

- It now forms a logical subset of this second edition. In other words, this document is 100 % backwardly compatible with its previous version, ISO 19107:2003, except in a few areas (in NURBS) where the previous version contained technical errors that are corrected in this revision.

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 document provides conceptual schemas for describing, representing and manipulating the spatial characteristics of geographic entities. Standardization in this area is the cornerstone for other geographic information design, specification and standardization.

"Vector" data consists of geometric primitives used to construct expressions of the spatial characteristics of geographic features. "Raster" data is based on the division of the extent covered into small units according to a tessellation of the space. This document deals only with vector data.

There is a hierarchy of complexity in the "geometry" of the underlying object used in various coordinate systems. These may use reference planes (map geometry – Euclidean), reference spheres (spherical geometry — using spherical trigonometry), reference ellipsoids (ellipsoidal geometry using Gaussian or Riemannian metrics) or more complex surfaces (usually using numeric approximations for calculation). The coordinates of a point locate it on, or in relation to, the reference geometry. With the exception of "map geometry," the usual Euclidean formulae for distance and area do not apply directly in the coordinate system.

Topology expressions provide qualitative descriptions of the spatial relations between geometry objects. Topology deals with the characteristics of geometric figures that remain invariant if the space is deformed elastically. Topological properties do not change when information is transformed from one coordinate system to another, usually including the coordinate function that map from R^2 or R^3 to the reference geometry. Topological properties in the domain of the coordinate system will be identical to those on the geographic surface; but the metric properties may change significantly (e.g. distance, area, direction).

Spatial operators are functions and procedures that use, query, create, modify or delete spatial objects. This document defines the taxonomy of some of the more important operators, their definitions and implementations. The goals are to:

- Define spatial operators unambiguously, so that different implementations will yield comparable results within the limitations of accuracy and resolution.
- Use these definitions to define a set of standard operations that will form the basis of compliant systems and thus act as a test-bed for implementers and a benchmark set for validation of compliance.
- Define an operator algebra that will allow combinations of the base operators to be used predictably in the query and manipulation of geographic feature data.

Standardized conceptual schemas for spatial characteristics will increase the ability to share geographic information between applications. These schemas will be used by geographic information system and software developers and users of geographic information to provide consistently understandable spatial data structures and functions.

This document is technical because geometry is a technical topic. Euclid was speaking of a simpler form of geometry to the most powerful man in his world when he said:

There is no royal road to geometry (μή εἶναι βασιλικήν ἀτραπόν ἐπί γεωμετρίας).

Euclid to Ptolemy I Soter (General with Alexander the Great, Pharaoh of Egypt) —

Attributed by Proclus (412–485 AD) in Commentary on the First Book of Euclid's Elements

Geographic information — Spatial schema

1 Scope

This document specifies conceptual schemas for describing the spatial characteristics of geographic entities, and a set of spatial operations consistent with these schemas. It treats "vector" geometry and topology. It defines standard spatial operations for use in access, query, management, processing and data exchange of geographic information for spatial (geometric and topological) objects. Because of the nature of geographic information, these geometric coordinate spaces will normally have up to three spatial dimensions, one temporal dimension and any number of other spatially dependent parameters as needed by the applications. In general, the topological dimension of the spatial projections of the geometric objects will be at most three.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 19103, *Geographic information — Conceptual schema language*

ISO 19108, *Geographic information — Temporal schema*

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

ISO 19111, *Geographic information — Spatial referencing by coordinates*

ISO/IEC 11404:2007, *Information technology — General-Purpose Datatypes (GPD)*

ISO/IEC 19505-2:2012, *Information technology — Object Management Group Unified Modeling Language (OMG UML) — Part 2: Superstructure*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 11404, ISO 19103, ISO/IEC 19505-2 and the following apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>