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Geographic information — Well-known text representation of coordinate reference systems

Information géographique — Représentation textuelle bien lisible de systèmes de référence par coordonnées

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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* in close collaboration with the Open Geospatial Consortium (OGC).

This second edition cancels and replaces the first edition (ISO 19162:2015), which has been technically revised.

The main changes compared to the previous edition are as follows:

— updates to reflect the changes made in ISO 19111:2019 from its previous edition ISO 19111:2007 to describe dynamic geodetic reference frames, three-dimensional projected coordinate reference systems, datum ensembles and coordinate metadata;

— remodelling of the descriptions of temporal coordinate reference systems, to reflect the changes made in ISO 19111:2019;

— the correction of minor errors.

Further details are given in Annex D.

In accordance with the ISO/IEC Directives, Part 2, 2018, *Rules for the structure and drafting of International Standards*, in International Standards the decimal sign is a comma on the line. However, the General Conference on Weights and Measures *(Conférence Générale des Poids et Mesures)* at its meeting in 2003 passed unanimously the following resolution:

“The decimal marker shall be either a point on the line or a comma on the line.”

In practice, the choice between these alternatives depends on customary use in the language concerned. In the technical areas of geodesy and geographic information it is customary for the decimal point always to be used, for all languages. That practice is used throughout this document.

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

Well-known text (WKT) offers a compact machine- and human-readable representation of geometric objects. WKT may also be used for succinctly describing the critical elements of coordinate reference system (CRS) definitions.

WKT was described in the Open Geospatial Consortium implementation specifications 99-036 through 06-103r4 and ISO 19125-1:2004. The WKT representation of coordinate reference systems was subsequently extended in Open Geospatial Consortium implementation specification 01-009 "Coordinate Transformation Services" and this extension was later adopted in the Open Geospatial Consortium GeoAPI 3.0 implementation standard 09-083r3 and GeoPackage 1.0 implementation standard 12-128r10. The WKT representation of coordinate reference systems as defined in ISO 19125-1:2004 and OGC specification 01-009 is inconsistent with the terminology and technical provisions of ISO 19111:2007 and OGC Abstract Specification topic 2 (08-015r2), "Geographic information — Spatial referencing by coordinates".

The 2015 version of this document provided an updated version of WKT representation of coordinate reference systems that follows the provisions of ISO 19111:2007 and ISO 19111-2:2009. It extended earlier WKT to allow for the description of coordinate operations.

This document updates WKT for the extensions to ISO 19111 made through its 2019 revision:

— the description of dynamic geodetic and vertical coordinate reference systems;

— the change of coordinate values within a coordinate reference system due to point motion caused by tectonic deformation;

— the description of geoid-based vertical coordinate reference systems;

— the description of datum ensembles, groups of realizations of one terrestrial or vertical reference system that for low accuracy purposes may be merged ignoring coordinate transformation;

— a rigorous description of temporal coordinate reference systems;

— the removal (deprecation) of image coordinate reference systems; and

— the remodelling of scope and extent information.

This document defines the structure and content of well-known text strings. It does not prescribe how implementations should read or write these strings.

Geographic information — Well-known text representation of coordinate reference systems

1 Scope

This document defines the structure and content of a text string implementation of the abstract model for coordinate reference systems described in ISO 19111. The string defines frequently needed types of coordinate reference systems and coordinate operations in a self-contained form that is easily readable by machines and by humans. The essence is its simplicity; as a consequence there are some constraints upon the more open content allowed in ISO 19111. To retain simplicity in the well-known text (WKT) description of coordinate reference systems and coordinate operations, the scope of this document excludes parameter grouping and pass-through coordinate operations. The text string provides a means for humans and machines to correctly and unambiguously interpret and utilise a coordinate reference system definition with look-ups or cross references only to define coordinate operation mathematics. A WKT string is not suitable for the storage of definitions of coordinate reference systems or coordinate operations because it omits metadata about the source of the data and may omit metadata about the applicability of the information.

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 8601-1, *Date and time — Representations for information interchange — Part 1: Basic rules*

ISO/IEC 10646, *Information technology — Universal Coded Character Set (UCS)*

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

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

3.1.1
affine coordinate system
coordinate system in Euclidean space with straight axes that are not necessarily mutually perpendicular

[SOURCE: ISO 19111:2019, 3.1.1]

3.1.2
bearing
<geodesy> horizontal angle at a point relative to a specified direction

Note 1 to entry: The direction is usually specified to be north. In some communities the term bearing refers specifically to grid north and directions relative to true north are then termed ‘azimuth’; in other communities a bearing refers specifically to true north. In this document bearing is used for any specified reference direction. The angle may be reckoned positive clockwise or positive counter-clockwise depending upon the application.

3.1.3
Cartesian coordinate system
coordinate system in Euclidean space which gives the position of points relative to n mutually perpendicular straight axes all having the same unit of measure

Note 1 to entry: n is 2 or 3 for the purposes of this document.

Note 2 to entry: A Cartesian coordinate system is a specialisation of an affine coordinate system.

[SOURCE: ISO 19111:2019, 3.1.2]

3.1.4
compound coordinate reference system
coordinate reference system using at least two independent coordinate reference systems

Note 1 to entry: Coordinate reference systems are independent of each other if coordinate values in one cannot be converted or transformed into coordinate values in the other.

[SOURCE: ISO 19111:2019, 3.1.3]

3.1.5
coordinate conversion
coordinate operation that changes coordinates in a source coordinate reference system to coordinates in a target coordinate reference system in which both coordinate reference systems are based on the same datum

Note 1 to entry: A coordinate conversion uses parameters which have specified values.

EXAMPLE 1 A mapping of ellipsoidal coordinates to Cartesian coordinates using a map projection.

EXAMPLE 2 Change of units such as from radians to degrees or from feet to metres.

[SOURCE: ISO 19111:2019, 3.1.6]

3.1.6
coordinate epoch
epoch to which coordinates in a dynamic coordinate reference system are referenced

[SOURCE: ISO 19111:2019, 3.1.7]

3.1.7
coordinate operation
process using a mathematical model, based on a one-to-one relationship, that changes coordinates in a source coordinate reference system to coordinates in a target coordinate reference system, or that changes coordinates at a source coordinate epoch to coordinates at a target coordinate epoch within the same coordinate reference system

[SOURCE: ISO 19111:2019, 3.1.8]

3.1.8
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]

3.1.9
coordinate system
set of mathematical rules for specifying how coordinates are to be assigned to points

[SOURCE: ISO 19111:2019, 3.1.11]

3.1.10
coordinate transformation
coordinate operation that changes coordinates in a source coordinate reference system to coordinates in a target coordinate reference system in which the source and target coordinate reference systems are based on different datums

Note 1 to entry: A coordinate transformation uses parameters which are derived empirically. Any error in those coordinates will be embedded in the coordinate transformation and when the coordinate transformation is applied the embedded errors are transmitted to output coordinates.

Note 2 to entry: A coordinate transformation is colloquially sometimes referred to as a 'datum transformation'. This is erroneous. A coordinate transformation changes coordinate values. It does not change the definition of the datum. In this document coordinates are referenced to a coordinate reference system. A coordinate transformation operates between two coordinate reference systems, not between two datums.

[SOURCE: ISO 19111:2019, 3.1.12]

3.1.11
cylindrical coordinate system
three-dimensional coordinate system in Euclidean space in which position is specified by two linear coordinates and one angular coordinate

[SOURCE: ISO 19111:2019, 3.1.14]

3.1.12
datum
reference frame
parameter or set of parameters that realize the position of the origin, the scale, and the orientation of a coordinate system

[SOURCE: ISO 19111:2019, 3.1.15]

3.1.13
datum ensemble
group of multiple realizations of the same terrestrial or vertical reference system that, for approximate spatial referencing purposes, are not significantly different

Note 1 to entry: Datasets referenced to the different realizations within a datum ensemble may be merged without coordinate transformation.

Note 2 to entry: 'Approximate' is for users to define but typically is in the order of under 1 decimetre but may be up to 2 metres.

EXAMPLE "WGS 84" as an undifferentiated group of realizations including WGS 84 (TRANSIT), WGS 84 (G730), WGS 84 (G873), WGS 84 (G1150), WGS 84 (G1674) and WGS 84 (G1762). At the surface of the Earth these have changed on average by 0.7 m between the TRANSIT and G730 realizations, a further 0.2 m between G730 and G873, 0.06 m between G873 and G1150, 0.2 m between G1150 and G1674 and 0.02 m between G1674 and G1762.

[SOURCE: ISO 19111:2019, 3.1.16]

3.1.14
derived coordinate reference system
coordinate reference system that is defined through the application of a specified coordinate conversion to the coordinates within a previously established coordinate reference system

Note 1 to entry: The previously established coordinate reference system is referred to as the base coordinate reference system.

Note 2 to entry: A derived coordinate reference system inherits its datum or reference frame from its base coordinate reference system.

Note 3 to entry: The coordinate conversion between the base and derived coordinate reference system is implemented using the parameters and formula(s) specified in the definition of the coordinate conversion.

[SOURCE: ISO 19111:2019, 3.1.8]

3.1.15
dynamic coordinate reference system
coordinate reference system that has a dynamic reference frame

Note 1 to entry: Coordinates of points on or near the crust of the Earth that are referenced to a dynamic coordinate reference system may change with time, usually due to crustal deformations such as tectonic motion and glacial isostatic adjustment.

Note 2 to entry: Metadata for a dataset referenced to a dynamic coordinate reference system should include coordinate epoch information.

[SOURCE: ISO 19111:2019, 3.1.9]

3.1.16
dynamic reference frame
dynamic datumreference frame in which the defining parameters include time evolution

Note 1 to entry: The defining parameters that have time evolution are usually a coordinate set.

[SOURCE: ISO 19111:2019, 3.1.20]

3.1.17
ellipsoid
reference ellipsoid
<geodesy> geometric reference surface embedded in 3D Euclidean space formed by an ellipse that is rotated about a main axis

Note 1 to entry: For the Earth the ellipsoid is bi-axial with rotation about the polar axis. This results in an oblate ellipsoid with the midpoint of the foci located at the nominal centre of the Earth.

[SOURCE: ISO 19111:2019, 3.1.22]

3.1.18
ellipsoidal coordinate system
geodetic coordinate system
coordinate system in which position is specified by geodetic latitude, geodetic longitude and (in the three-dimensional case) ellipsoidal height

[SOURCE: ISO 19111:2019, 3.1.23]

3.1.19
ellipsoidal height
geodetic height
h
distance of a point from the reference ellipsoid along the perpendicular from the reference ellipsoid to this point, positive if upwards or outside of the reference ellipsoid

Note 1 to entry: Only used as part of a three-dimensional ellipsoidal coordinate system or as part of a three-dimensional Cartesian coordinate system in a three-dimensional projected coordinate reference system, but never on its own.

[SOURCE: ISO 19111:2019, 3.1.24]

3.1.20
engineering coordinate reference system
coordinate reference system based on an engineering datum

EXAMPLE 1 System for identifying relative positions within a few kilometres of the reference point, such as a building or construction site.

EXAMPLE 2 Coordinate reference system local to a moving object such as a ship or an orbiting spacecraft.

EXAMPLE 3 Internal coordinate reference system for an image. This has continuous axes. It may be the foundation for a grid.

[SOURCE: ISO 19111:2019, 3.1.25]

3.1.21
engineering datum
local datum
datum describing the relationship of a coordinate system to a local reference

Note 1 to entry: Engineering datum excludes both geodetic and vertical reference frames.

[SOURCE: ISO 19111:2019, 3.1.26]

3.1.22
epoch
<geodesy> point in time

Note 1 to entry: In this document an epoch is expressed in the Gregorian calendar as a decimal year.

EXAMPLE 2017-03-25 in the Gregorian calendar is epoch 2017,23.

[SOURCE: ISO 19111:2019, 3.1.27]

3.1.23
flattening
f
ratio of the difference between the semi-major axis (a) and semi-minor axis (b) of an ellipsoid to the semi-major axis: $f = (a - b)/a$

Note 1 to entry: Sometimes inverse flattening $1/f = a/(a - b)$ is given instead; $1/f$ is also known as reciprocal flattening.

[SOURCE: ISO 19111:2019, 3.1.28]

3.1.24
frame reference epoch
epoch of coordinates that define a dynamic reference frame

[SOURCE: ISO 19111:2019, 3.1.29]

3.1.25
geodetic coordinate reference system
three-dimensional coordinate reference system based on a geodetic reference frame and having either a three-dimensional Cartesian or a spherical coordinate system

Note 1 to entry: In this document a coordinate reference system based on a geodetic reference frame and having an ellipsoidal coordinate system is geographic.

[SOURCE: ISO 19111:2019, 3.1.31]

3.1.26
geodetic latitude
ellipsoidal latitude
φ
angle from the equatorial plane to the perpendicular to the ellipsoid through a given point, northwards treated as positive

[SOURCE: ISO 19111:2019, 3.1.32]

3.1.27
geodetic longitude
ellipsoidal longitude
λ
angle from the prime meridian plane to the meridian plane of a given point, eastward treated as positive

[SOURCE: ISO 19111:2019, 3.1.33]

3.1.28
geodetic reference frame
reference frame or datum describing the relationship of a two- or three-dimensional coordinate system to the Earth

Note 1 to entry: In the data model described in this document, the UML class GeodeticReferenceFrame includes both modern terrestrial reference frames and classical geodetic datums.

[SOURCE: ISO 19111:2019, 3.1.34]

3.1.29
geographic coordinate reference system
coordinate reference system that has a geodetic reference frame and an ellipsoidal coordinate system

[SOURCE: ISO 19111:2019, 3.1.35]

3.1.30
linear coordinate system
one-dimensional coordinate system in which a linear feature forms the axis

EXAMPLE 1 Distances along a pipeline.

EXAMPLE 2 Depths down a deviated oil well bore.

[SOURCE: ISO 19111:2019, 3.1.39]

3.1.31
map projection
coordinate conversion from an ellipsoidal coordinate system to a plane

[SOURCE: ISO 19111:2019, 3.1.40]

3.1.32
parametric coordinate reference system
coordinate reference system based on a parametric datum

[SOURCE: ISO 19111:2019, 3.1.45]

3.1.33
parametric coordinate system
one-dimensional coordinate system where the axis units are parameter values which are not inherently spatial

[SOURCE: ISO 19111:2019, 3.1.46]

3.1.34
parametric datum
datum describing the relationship of a parametric coordinate system to an object

Note 1 to entry: The object is normally the Earth.

[SOURCE: ISO 19111:2019, 3.1.47]

3.1.35
point motion operation
coordinate operation that changes coordinates within one coordinate reference system due to the motion of the point

Note 1 to entry: The change of coordinates is from those at an initial epoch to those at another epoch.

Note 2 to entry: In this document the point motion is due to tectonic motion or crustal deformation.

[SOURCE: ISO 19111:2019, 3.1.48]

3.1.36
polar coordinate system
two-dimensional coordinate system in Euclidean space in which position is specified by one distance coordinate and one angular coordinate

Note 1 to entry: For the three-dimensional case, see spherical coordinate system.

[SOURCE: ISO 19111:2019, 3.1.49]

3.1.37
prime meridian
meridian from which the longitudes of other meridians are quantified

[SOURCE: ISO 19111:2019, 3.1.50]

3.1.38
projected coordinate reference system
coordinate reference system derived from a geographic coordinate reference system by applying a map projection

Note 1 to entry: May be two- or three-dimensional, the dimension being equal to that of the geographic coordinate reference system from which it is derived.

Note 2 to entry: In the three-dimensional case the horizontal coordinates (geodetic latitude and geodetic longitude coordinates) are projected to northing and easting and the ellipsoidal height is unchanged.

[SOURCE: ISO 19111:2019, 3.1.51]