

Open Geospatial Consortium

Submission Date: 2018-06-05

Approval Date: 2019-06-03

Publication Date: 2019-08-13

External identifier of this OGC® document: <http://www.opengis.net/doc/is/crs-wkt/2.0.6>

Internal reference number of this OGC® document: 18-010r7

Version: 2.0.6

Category: OGC® Implementation Standard

Editor: Roger Lott

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

Copyright notice

Copyright © 2019 Open Geospatial Consortium
To obtain additional rights of use, visit <http://www.opengeospatial.org/legal/>.

Warning

This document is an OGC Member approved international standard. This document is available on a royalty free, non-discriminatory basis. Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Document type: OGC® Approved Standard
Document subtype: Encoding
Document stage: Approved for Public Release
Document language: English

License Agreement

Permission is hereby granted by the Open Geospatial Consortium, ("Licensor"), free of charge and subject to the terms set forth below, to any person obtaining a copy of this Intellectual Property and any associated documentation, to deal in the Intellectual Property without restriction (except as set forth below), including without limitation the rights to implement, use, copy, modify, merge, publish, distribute, and/or sublicense copies of the Intellectual Property, and to permit persons to whom the Intellectual Property is furnished to do so, provided that all copyright notices on the intellectual property are retained intact and that each person to whom the Intellectual Property is furnished agrees to the terms of this Agreement.

If you modify the Intellectual Property, all copies of the modified Intellectual Property must include, in addition to the above copyright notice, a notice that the Intellectual Property includes modifications that have not been approved or adopted by LICENSOR.

THIS LICENSE IS A COPYRIGHT LICENSE ONLY, AND DOES NOT CONVEY ANY RIGHTS UNDER ANY PATENTS THAT MAY BE IN FORCE ANYWHERE IN THE WORLD.

THE INTELLECTUAL PROPERTY IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NONINFRINGEMENT OF THIRD PARTY RIGHTS. THE COPYRIGHT HOLDER OR HOLDERS INCLUDED IN THIS NOTICE DO NOT WARRANT THAT THE FUNCTIONS CONTAINED IN THE INTELLECTUAL PROPERTY WILL MEET YOUR REQUIREMENTS OR THAT THE OPERATION OF THE INTELLECTUAL PROPERTY WILL BE UNINTERRUPTED OR ERROR FREE. ANY USE OF THE INTELLECTUAL PROPERTY SHALL BE MADE ENTIRELY AT THE USER'S OWN RISK. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR ANY CONTRIBUTOR OF INTELLECTUAL PROPERTY RIGHTS TO THE INTELLECTUAL PROPERTY BE LIABLE FOR ANY CLAIM, OR ANY DIRECT, SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES, OR ANY DAMAGES WHATSOEVER RESULTING FROM ANY ALLEGED INFRINGEMENT OR ANY LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR UNDER ANY OTHER LEGAL THEORY, ARISING OUT OF OR IN CONNECTION WITH THE IMPLEMENTATION, USE, COMMERCIALIZATION OR PERFORMANCE OF THIS INTELLECTUAL PROPERTY.

This license is effective until terminated. You may terminate it at any time by destroying the Intellectual Property together with all copies in any form. The license will also terminate if you fail to comply with any term or condition of this Agreement. Except as provided in the following sentence, no such termination of this license shall require the termination of any third party end-user sublicense to the Intellectual Property which is in force as of the date of notice of such termination. In addition, should the Intellectual Property, or the operation of the Intellectual Property, infringe, or in LICENSOR's sole opinion be likely to infringe, any patent, copyright, trademark or other right of a third party, you agree that LICENSOR, in its sole discretion, may terminate this license without any compensation or liability to you, your licensees or any other party. You agree upon termination of any kind to destroy or cause to be destroyed the Intellectual Property together with all copies in any form, whether held by you or by any third party.

Except as contained in this notice, the name of LICENSOR or of any other holder of a copyright in all or part of the Intellectual Property shall not be used in advertising or otherwise to promote the sale, use or other dealings in this Intellectual Property without prior written authorization of LICENSOR or such copyright holder. LICENSOR is and shall at all times be the sole entity that may authorize you or any third party to use certification marks, trademarks or other special designations to indicate compliance with any LICENSOR standards or specifications. This Agreement is governed by the laws of the Commonwealth of Massachusetts. The application to this Agreement of the United Nations Convention on Contracts for the International Sale of Goods is hereby expressly excluded. In the event any provision of this Agreement shall be deemed unenforceable, void or invalid, such provision shall be modified so as to make it valid and enforceable, and as so modified the entire Agreement shall remain in full force and effect. No decision, action or inaction by LICENSOR shall be construed to be a waiver of any rights or remedies available to it.

i. Abstract

This Standard defines the structure and content of well-known text strings describing coordinate reference systems (CRSs) and coordinate operations between coordinate reference systems. It does not prescribe how implementations should read or write these strings.

This Standard provides an updated version of WKT representation of coordinate reference systems that follows the provisions of ISO 19111:2019. It extends the WKT in OGC document 12-063r5 (ISO 19162) which was based on ISO 19111:2007 and ISO 19111-2:2009. That version consolidated several disparate versions of earlier WKT (so-called WKT1) and added the description of coordinate operations.

This jointly developed draft has been submitted by ISO TC211 for circulation as a Draft International Standard (DIS). This version incorporates comments made during the ISO TC211 New Work Item Proposal acceptance ballot.

ii. Keywords

The following are keywords to be used by search engines and document catalogues.

Ogcdoc, OGC document, iso, 19162, coordinate reference systems, crs, well-known text, wkt,

iii. Submitting organizations

The following organizations submitted this Document to the Open Geospatial Consortium (OGC):

Name	Affiliation
Roger Lott (editor)	IOGP
Keith Ryden	ESRI
Martin Desruisseaux	Geomatys
Mark Hedley	UK Met Office
Charles Heazel	WiSC Enterprises

All questions regarding this submission should be directed to the editor or the submitters.

iv. Revision history

Date	Release	Author	Paragraph modified	Description
2018-06-06	2.0.0	Roger Lott		As submitted to ISO.
2018-08-23	2.0.1	Roger Lott	Minor revisions throughout to address comments made in ISO NWIP ballot.	As drafted for submission to ISO for publication as DIS.
2018-09-18	2.0.2	Roger Lott	Editorial corrections in examples in 10.4, 15.2, 16.6, and C.6 table 2.	As submitted to ISO for publication as DIS.
2019-01-23	2.0.3	Roger Lott	Editorial corrections in response to RFC. Concatenated operation examples added.	These corrections will be submitted to ISO DIS ballot
2019-02-27	2.0.4	Roger Lott	6.2, 7.3	Inclusion of two editorial changes from ISO DIS ballot.

2019-03-24	2.0.5	Roger Lott	9, 14, 17-20	In BNF for Derived CRSs, added missing identifier to base CRS; in coordinate operations, added missing operation version attribute.
2019-6-24	2.0.6	Roger Lott	Document	Minor edits to track ISO CS editorial changes of a non-technical nature.

v. Changes to the OGC[®] Abstract Specification

The OGC[®] Abstract Specification does not require changes to accommodate this OGC[®] standard.

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

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

Copyright notice

This ISO document is a Draft International Standard and is copyright-protected by ISO. Except as permitted under the applicable laws of the user's country, neither this ISO draft nor any extract from it may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, photocopying, recording or otherwise, without prior written permission being secured.

Requests for permission to reproduce should be addressed to either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Reproduction may be subject to royalty payments or a licensing agreement.

Violators may be prosecuted.

Contents

Page

1	Scope	1
2	Normative references	1
3	Terms, definitions and abbreviated terms	1
3.1	Terms and definitions	1
3.2	Abbreviated terms	9
4	Conformance requirements	10
5	Backus-Naur Form notation and syntax	11
6	WKT string form	12
6.1	Overview	12
6.2	Encoding	12
6.3	Characters used in WKT	12
6.3.1	Basic characters	12
6.3.2	Numbers	14
6.3.3	Date and time	14
6.3.4	CRS WKT characters	15
6.3.5	Double quote	16
6.4	Delimiter	16
6.5	Case sensitivity	16
6.6	Reserved keywords	17
6.7	Backward compatibility	18
7	WKT representation of common attributes	19
7.1	General	19
7.2	Name	19
7.3	Scope, extent, identifier and remark	19
7.3.1	General	19
7.3.2	Usage (scope and extent)	19
7.3.3	Identifier	23
7.3.4	Remark	24
7.4	Unit and unit conversion factor	25
7.4.1	Unit description	25
7.4.2	Conversion factor — Spatial and parametric units	26
7.4.3	Conversion factor — Temporal quantities	26
7.4.4	Default unit	27
7.5	Coordinate system	27
7.5.1	Syntax	27
7.5.2	Coordinate system type, dimension and coordinate data type	30
7.5.3	Axis name and abbreviation	31
7.5.4	Axis direction	32
7.5.5	Axis order	33
7.5.6	Axis unit and coordinate system unit	33
7.5.7	Examples of WKT describing coordinate systems	34
7.6	Datum ensemble	36
7.7	Dynamic coordinate reference systems	38
8	WKT representation of geodetic and geographic coordinate reference systems	40
8.1	Overview	40
8.2	Geodetic reference frame (geodetic datum)	41
8.2.1	Ellipsoid	41
8.2.2	Prime meridian	42
8.2.3	Geodetic reference frame (datum)	43
8.3	Coordinate systems for geodetic and geographic CRSs	44
8.4	Examples of WKT describing a geodetic or geographic CRS	44
9	WKT representation of projected CRSs	46
9.1	Overview	46

9.2	Base CRS	46
9.2.1	General	46
9.2.2	Ellipsoidal CS unit	47
9.3	Map projection	48
9.3.1	Introduction	48
9.3.2	Map projection name and identifier	49
9.3.3	Map projection method	49
9.3.4	Map projection parameter	50
9.4	Coordinate systems for projected CRSs	50
9.5	Examples of WKT describing a projected CRS	51
10	WKT representation of vertical CRSs	53
10.1	Overview	53
10.2	Vertical reference frame (vertical datum)	53
10.3	Vertical coordinate system	54
10.4	Example of WKT describing a vertical CRS	54
11	WKT representation of engineering CRSs	55
11.1	Overview	55
11.2	Engineering datum	55
11.3	Coordinate systems for engineering CRSs	55
11.4	Examples of WKT describing an engineering CRS	55
12	WKT representation of parametric CRSs	57
12.1	Overview	57
12.2	Parametric datum	57
12.3	Parametric coordinate system	57
12.4	Example of WKT describing a parametric CRS	57
13	WKT representation of temporal CRSs	58
13.1	Temporal CRS	58
13.2	Temporal datum	58
13.3	Temporal coordinate system	59
13.3.1	General	59
13.3.2	Axis unit for temporalDateTime coordinate systems	59
13.3.3	Axis unit for temporalCount and temporalMeasure coordinate systems	59
13.4	Examples of WKT describing a temporal CRS	60
14	WKT representation of derived CRSs	61
14.1	Overview	61
14.2	Deriving conversion	61
14.2.1	General	61
14.2.2	Derived CRS conversion method	62
14.2.3	Derived CRS conversion parameter	62
14.2.4	Derived CRS conversion parameter file	63
14.2.5	Derived CRS conversion example	63
14.3	Derived geodetic CRS and derived geographic CRS	64
14.3.1	Representation	64
14.3.2	Example of WKT describing a derived geographic CRS	65
14.4	Derived projected CRS	66
14.4.1	Representation	66
14.4.2	Example of WKT describing a derived projected CRS	67
14.5	Derived vertical CRS	68
14.6	Derived engineering CRS	68
14.6.1	Representation	68
14.7	Derived parametric CRS	69
14.8	Derived temporal CRS	69
15	WKT representation of compound coordinate reference systems	71
15.1	Overview	71
15.2	Examples of WKT describing a compound CRS	71
16	WKT representation of coordinate epoch and coordinate metadata	73

16.1	Coordinate epoch	73
16.2	Coordinate metadata	73
17	WKT representation of coordinate transformations and coordinate conversions excluding map projections	75
17.1	Coordinate operations	75
17.2	Transformation and conversion components	75
17.2.1	Operation name and version	75
17.2.2	Source and target CRS	75
17.2.3	Transformation and conversion name and identifier	76
17.2.4	Coordinate operation method	76
17.2.5	Coordinate operation parameter	76
17.2.6	Coordinate operation parameter file	77
17.2.7	Interpolation CRS	77
17.2.8	Coordinate operation accuracy	77
17.2.9	Other coordinate operation attributes	78
17.3	Examples of WKT describing a coordinate transformation	78
18	WKT representation of point motion operations	80
19	WKT representation of concatenated coordinate operations	81
19.1	General	81
19.2	Examples of WKT describing a concatenated coordinate operation	82
20	WKT representation of CRS and coordinate operation couplets	84
20.1	Bound CRS	84
20.2	Bound CRS components	84
20.2.1	Abridged coordinate transformation	84
20.2.2	Coordinate operation method in abridged coordinate transformations	85
20.2.3	Abridged coordinate transformation parameter	85
20.2.4	Coordinate operation parameter file	85
20.3	Examples of WKT describing a bound CRS	86
Annex A	(normative) Abstract test suite	87
A.1	Conformance of a WKT string describing a geodetic or geographic CRS	87
A.2	Conformance of a WKT string describing a projected CRS	87
A.3	Conformance of a WKT string describing a vertical CRS	88
A.4	Conformance of a WKT string describing an engineering CRS	88
A.5	Conformance of a WKT string describing a parametric CRS	89
A.6	Conformance of a WKT string describing a temporal CRS	89
A.7	Conformance of a WKT string describing a derived geodetic or derived geographic CRS	90
A.8	Conformance of a WKT string describing a derived projected CRS	90
A.9	Conformance of a WKT string describing a derived vertical CRS	91
A.10	Conformance of a WKT string describing a derived engineering CRS	91
A.11	Conformance of a WKT string describing a derived parametric CRS	92
A.12	Conformance of a WKT string describing a derived temporal CRS	92
A.13	Conformance of a WKT string describing a compound CRS	93
A.14	Conformance of a WKT string describing coordinate metadata	93
A.15	Conformance of a WKT string describing a coordinate transformation	94
A.16	Conformance of a WKT string describing a point motion operation	94
A.17	Conformance of a WKT string describing a concatenated coordinate operation	95
A.18	Conformance of a WKT string describing a bound CRS	95
Annex B	(informative) Recommended practice for implementation	96
B.1	General	96
B.2	Keywords	96
B.2.1	Keyword case sensitivity	96
B.2.2	Alternative keywords	96
B.2.3	Handling of unrecognised keywords	96
B.3	Characters	96
B.3.1	Handling of unrecognised characters	96
B.3.2	String length	96
B.4	White space	97

B.4.1	Insertion of white space.....	97
B.4.2	Parsing of white space outside of quoted text.....	97
B.4.3	Parsing of white space within quoted text.....	97
B.5	Identifiers	97
B.5.1	Use of identifiers	97
B.5.2	Using names to interpret identity	97
B.6	Numbers	97
B.6.1	Precision	97
B.6.2	Defining parameters for a sphere	98
B.6.3	Implied units	98
B.7	Attribute order	98
B.8	Version of CRS WKT	98
Annex C	(informative) Mapping of concepts from previous versions of CRS WKT	99
C.1	BNF	99
C.2	Backward compatibility of CRS common attributes	99
C.2.1	Name.....	99
C.2.2	ID (Authority).....	99
C.3	Backward compatibility of coordinate reference system components.....	100
C.3.1	Ellipsoid.....	100
C.3.2	Prime meridian.....	100
C.3.3	Datum	100
C.3.4	Map projection	101
C.3.5	Coordinate system	102
C.4	Backward compatibility of coordinate reference systems	103
C.4.1	Geodetic CRS.....	103
C.4.2	Projected CRS.....	103
C.4.3	Vertical CRS and engineering (local) CRS	104
C.4.4	Compound CRS	105
C.4.5	Fitted CS.....	105
C.5	Backward compatibility of coordinate operations	105
C.6	Mapping of tokens and keywords from previous versions of CRS WKT to this document.....	106
Annex D	(informative) Backward compatibility with ISO 19162:2015	111
Annex E	(normative) Triaxial ellipsoid.....	114
Annex F	(informative) Identifiers for coordinate operation methods and parameters.....	115
F.1	General	115
F.2	Map projection methods	116
F.3	Map projection parameters.....	116
F.4	Coordinate transformation methods	118
F.5	Coordinate transformation parameters.....	118

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 on 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 WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information www.iso.org/iso/foreword.html](http://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 changes in this edition compared to the previous edition are:

- 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.

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 19111:2019. 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 are referenced to a dynamic coordinate reference system

[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, 3.1.18]

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, 3.1.19]

3.1.16

dynamic reference frame

dynamic datum

reference 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 datum 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 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]

3.1.39**reference frame**

datum

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, 3.1.52]

3.1.40

semi-major axis

a

semi-diameter of the longest axis of an ellipsoid

[SOURCE: ISO 19111:2019, 3.1.53]

3.1.41

semi-minor axis

b

semi-diameter of the shortest axis of an ellipsoid

[SOURCE: ISO 19111:2019, 3.1.54]

3.1.42

spatio-parametric coordinate reference system

compound coordinate reference system in which one constituent coordinate reference system is a spatial coordinate reference system and one is a parametric coordinate reference system

Note 1 to entry: Normally the spatial component is “horizontal” and the parametric component is “vertical”.

[SOURCE: ISO 19111:2019, 3.1.57]

3.1.43

spatio-parametric-temporal coordinate reference system

compound coordinate reference system comprised of spatial, parametric and temporal coordinate reference systems

[SOURCE: ISO 19111:2019, 3.1.58]

3.1.44

spatio-temporal coordinate reference system

compound coordinate reference system in which one constituent coordinate reference system is a spatial coordinate reference system and one is a temporal coordinate reference system

[SOURCE: ISO 19111:2019, 3.1.59]

3.1.45

spherical coordinate system

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

Note 1 to entry: Not to be confused with an ellipsoidal coordinate system based on an ellipsoid ‘degenerated’ into a sphere.

[SOURCE: ISO 19111:2019, 3.1.60]

3.1.46

spheroid

closed surface that differs only slightly from that of a sphere

3.1.47

static coordinate reference system

coordinate reference system that has a static reference frame

Note 1 to entry: Coordinates of points on or near the crust of the Earth that are referenced to a static coordinate reference system do not change with time.

Note 2 to entry: Metadata for a dataset referenced to a static coordinate reference system does not require coordinate epoch information.

[SOURCE: ISO 19111:2019, 3.1.61]

3.1.48**static reference frame**

static datum

reference frame in which the defining parameters exclude time evolution

[SOURCE: ISO 19111:2019, 3.1.62]

3.1.49**temporal coordinate reference system**

coordinate reference system based on a temporal datum

[SOURCE: ISO 19111:2019, 3.1.63]

3.1.50**temporal coordinate system**

<geodesy> one-dimensional coordinate system where the axis is time

[SOURCE: ISO 19111:2019, 3.1.64]

3.1.51**temporal datum**

datum describing the relationship of a temporal coordinate system to an object

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

[SOURCE: ISO 19111:2019, 3.1.65]

3.1.52**vertical coordinate reference system**

one-dimensional coordinate reference system based on a vertical reference frame

[SOURCE: ISO 19111:2019, 3.1.70]

3.1.53**vertical coordinate system**

one-dimensional coordinate system used for gravity-related height or depth measurements

[SOURCE: ISO 19111:2019, 3.1.71]

3.1.54**vertical reference frame**

vertical datum

reference frame describing the relation of gravity-related heights or depths to the Earth

Note 1 to entry: In most cases, the vertical reference frame will be related to mean sea level. Vertical datums include sounding datums (used for hydrographic purposes), in which case the heights may be negative heights or depths.

Note 2 to entry: Ellipsoidal heights are related to a three-dimensional ellipsoidal coordinate system referenced to a geodetic reference frame.

[SOURCE: ISO 19111:2019, 3.1.72]

3.1.55**white space**

sequence of one or more characters that have no glyphs

[SOURCE: ISO/IEC 9075-2:2016, 3.1.6.77]

3.2 Abbreviated terms

BNF Backus-Naur form

CRS coordinate reference system

CS	coordinate system
EPSG	European Petroleum Survey Group (geodetic parameter dataset now maintained at www.epsg-registry.org by the International Association of Oil and Gas Producers)
IRM	international reference meridian
OGC	Open Geospatial Consortium, www.opengeospatial.org
TRF	Terrestrial Reference Frame
UTC	Coordinated Universal Time
VRF	Vertical Reference Frame
WKT	Well-known text

4 Conformance requirements

This document defines eighteen classes of conformance (see Annex A):

- a) Any WKT string claiming conformance of a coordinate reference system definition shall satisfy the requirements in Annex A as shown in Table 1.

Table 1 — Conformance requirements for coordinate reference systems

Coordinate reference system type	Conformance requirements given in
geodetic	A.1
geographic	
projected	A.2
vertical	A.3
engineering	A.4
parametric	A.5
temporal	A.6
derived geodetic	A.7
derived geographic	
derived projected	A.8
derived vertical	A.9
derived engineering	A.10
derived parametric	A.11
derived temporal	A.12
compound	A.13

- b) Any WKT string claiming conformance of coordinate metadata shall satisfy the requirements given in A.14.

- c) Any WKT string claiming conformance of a coordinate operation definition shall satisfy the requirements in Annex A as shown in Table 2.

Table 2 — Conformance requirements for coordinate operations

Coordinate operation type	Conformance requirements given in
coordinate transformation coordinate conversion other than a deriving conversion	A.15
deriving conversion	Within derived CRS in A.2 and A.7 to A.12
point motion operation	A.16
concatenated coordinate operation	A.17

- d) Any WKT string claiming conformance of coordinate transformation bound to a coordinate reference system definition shall satisfy the requirements given in A.18.

Conformance is applicable to the WKT string. Recommended practices for implementations writing or reading coordinate reference system WKT strings are given in Annex B.

5 Backus-Naur Form notation and syntax

The WKT representation of coordinate reference systems and coordinate operations is defined in this document using the extended version of Backus-Naur form (BNF) notation that is defined in ISO/IEC 9075-1:2016, 6.2. The BNF provides the mechanism for generating a WKT string. The production rules in ISO/IEC 9075-1:2016, 6.2 apply.

In this extended version of BNF the characters have the meaning:

- A character string enclosed in angle brackets "< >" is a syntactic element.
- A vertical bar "|" indicates alternatives.
- Braces "{" }" define a group of elements.
- Square brackets "["]" denote optional elements. This use of square brackets within BNF notation should not be confused with the use of square brackets as delimiters in WKT strings.
- Ellipsis after an element "< >..." allows the use of one or multiple instances of that element.
- Ellipsis after braces "{ }..." allows the use of one or multiple instances of the group of elements.
- Ellipsis after square brackets "[]..." means that the content inside the square brackets may occur zero to many times.
- Double exclamation marks "!!" introduce normal English text. This is used when the definition of a syntactic element is supplemented by constraints not in the BNF definition but given later in the text.

In the BNF notation spaces are used to separate syntactic elements. Multiple spaces and line breaks are treated as a single space. These spaces do not form part of the resulting WKT string. All other characters in the BNF stand for themselves. The order of syntactic elements in the BNF is significant; it defines the format of the WKT string.

6 WKT string form

6.1 Overview

The WKT string is a representation of the definition of a CRS or coordinate operation. A string describes one CRS or coordinate operation object. Each object is represented by a token comprised of a keyword followed by a set of attributes of the object, the set enclosed by delimiters. Some objects are composed of other objects so the result may be a nested structure. Nesting may continue to any depth.

EXAMPLE KEYWORD1[attribute1,KEYWORD2[attribute2,attribute3]]

Keywords are case-insensitive. Where human readability of the string is important, as in this document, keywords are normally in upper case.

The delimiters are normally <left bracket> and <right bracket>. Implementations are free to substitute parentheses for brackets.

Attributes may be from an enumeration, may be numbers or may be text. Text is enclosed in double quotes. Two forms of text are defined, one restricted to the Latin1 character set and the other permitting any Unicode character set. Attributes are separated by a comma.

A WKT string contains no white space outside of double quotes. However padding with white space to improve human readability is permitted; the examples of WKT that are included in this document have spaces and line feeds inserted to improve clarity. Any padding is stripped out or ignored by parsers, refer to Annex B.

6.2 Encoding

All WKT strings are realized as a sequence of characters, or a character string. It is not the goal of this document to specify any encoding used in a given implementation. The only restriction is that the same encoding shall be used throughout the entire WKT definition.

Requirements:

- A WKT string shall use one encoding throughout the entire string. UTF-8 shall be used if no encoding is specified in the carrier.
- The characters used in a WKT string shall be wholly contained within the domain of a specific character set. This character set shall exist as a subset of the repertoire of the Universal Character Set specified by ISO/IEC 10646.

6.3 Characters used in WKT

6.3.1 Basic characters

The basic characters in a CRS WKT string are taken directly from ISO/IEC 9075-2:2016, 5.1 and 5.3.

```
<simple Latin upper case letter> ::= A|B|C|D|E|F|G|H|I|J|K|L|M|
                                   N|O|P|Q|R|S|T|U|V|W|X|Y|Z
                                   !! ISO/IEC 10646:2012 character identifiers U+0041
                                   through U+005A

<simple Latin lower case letter> ::= a|b|c|d|e|f|g|h|i|j|k|l|m|
                                   n|o|p|q|r|s|t|u|v|w|x|y|z
                                   !! ISO/IEC 10646:2012 character identifiers U+0061
                                   through U+007A

<digit>                          ::= 0|1|2|3|4|5|6|7|8|9
                                   !! ISO/IEC 10646:2012 character identifiers U+0030
                                   through U+0039
```


<space>	::=	SP	!! ISO/IEC 10646:2012 character identifier U+0020
<double quote>	::=	"	!! ISO/IEC 10646:2012 character identifier U+0022
<number sign>	::=	#	!! ISO/IEC 10646:2012 character identifier U+0023
<percent>	::=	%	!! ISO/IEC 10646:2012 character identifier U+0025
<ampersand>	::=	&	!! ISO/IEC 10646:2012 character identifier U+0026
<quote>	::=	'	!! ISO/IEC 10646:2012 character identifier U+0027
<left paren>	::=	(!! ISO/IEC 10646:2012 character identifier U+0028
<right paren>	::=)	!! ISO/IEC 10646:2012 character identifier U+0029
<asterisk>	::=	*	!! ISO/IEC 10646:2012 character identifier U+002A
<plus sign>	::=	+	!! ISO/IEC 10646:2012 character identifier U+002B
<comma>	::=	,	!! ISO/IEC 10646:2012 character identifier U+002C
<minus sign> ::- <hyphen>	::=	-	!! ISO/IEC 10646:2012 character identifier U+002D
<period>	::=	.	!! ISO/IEC 10646:2012 character identifier U+002E
<solidus>	::=	/	!! ISO/IEC 10646:2012 character identifier U+002F
<colon>	::=	:	!! ISO/IEC 10646:2012 character identifier U+003A
<semicolon>	::=	;	!! ISO/IEC 10646:2012 character identifier U+003B
<less than operator>	::=	<	!! ISO/IEC 10646:2012 character identifier U+003C
<equals operator>	::=	=	!! ISO/IEC 10646:2012 character identifier U+003D
<greater than operator>	::=	>	!! ISO/IEC 10646:2012 character identifier U+003E
<question mark>	::=	?	!! ISO/IEC 10646:2012 character identifier U+003F
<left bracket>	::=	[!! ISO/IEC 10646:2012 character identifier U+005B
<reverse solidus>	::=	\	!! ISO/IEC 10646:2012 character identifier U+005C
<right bracket>	::=]	!! ISO/IEC 10646:2012 character identifier U+005D
<circumflex>	::=	^	!! ISO/IEC 10646:2012 character identifier U+005E
<underscore>	::=	_	!! ISO/IEC 10646:2012 character identifier U+005F
<left brace>	::=	{	!! ISO/IEC 10646:2012 character identifier U+007B
<vertical bar>	::=		!! ISO/IEC 10646:2012 character identifier U+007C
<right brace>	::=	}	!! ISO/IEC 10646:2012 character identifier U+007D
<degree symbol>	::=	°	!! ISO/IEC 10646:2012 character identifier U+00B0

6.3.2 Numbers

<number>	::=	<signed numeric literal> <unsigned numeric literal>
<signed numeric literal>	::=	[<sign>] <unsigned numeric literal>
<unsigned numeric literal>	::=	<exact numeric literal> <approximate numeric literal>
<approximate numeric literal>	::=	<mantissa> E <exponent>
<mantissa>	::=	<exact numeric literal>
<exponent>	::=	<signed integer>
<signed integer>	::=	[<sign>] <unsigned integer>
<exact numeric literal>	::=	<unsigned integer> [<period> [<unsigned integer>]] <period> <unsigned integer>
<unsigned integer>	::=	<digit>...
<sign>	::=	<plus sign> <minus sign>

The integer and fractional parts of a number are separated by a <period>; a comma is not permitted. No other separator (e.g. for thousands or multiples thereof) is allowed.

6.3.3 Date and time

In this document calendar dates and times are restricted to the Gregorian calendar and the 24-hour clock as defined in ISO 8601-1. Only the ISO 8601-1 extended format (separators between date units and between sexagesimal time units) is permitted. Any precision is allowed. When time is included a UTC or local time zone designator is required. Other date formats such as geological eras or calendars other than Gregorian may be stated through a free format quoted text string.

<datetime>	::=	<Gregorian calendar datetime> <Gregorian ordinal datetime>
<Gregorian calendar datetime>	::=	<Gregorian calendar date> [<24 hour clock>]
<Gregorian calendar date>	::=	<year> [<hyphen> <month> [<hyphen> <day>]]
<year>	::=	<unsigned integer> <i>!! four digits</i>
<month>	::=	<unsigned integer> <i>!! two digits including leading zero if less than 10</i>
<day>	::=	<unsigned integer> <i>!! two digits including leading zero if less than 10</i>
<Gregorian ordinal datetime>	::=	<Gregorian ordinal date> [<24 hour clock>]
<Gregorian ordinal date>	::=	<year> [<hyphen> <ordinal day>]
<ordinal day>	::=	<unsigned integer> <i>!! three digits including leading zeroes if less than 100</i>
<24 hour clock>	::=	<time designator> <hour> [<colon> <minute> [<colon> <second>]] <time zone designator>
<time designator>	::=	T

<hour>	::=	<unsigned integer> <i>!! two digits including leading zero if less than 10</i>
<minute>	::=	<unsigned integer> <i>!! two digits including leading zero if less than 10</i>
<second>	::=	<seconds integer> [<period> [<seconds fraction>]] <i>!! In this document the separator between the integer and fractional parts of a second value shall be a period. The ISO 8601 preference for comma is not permitted.</i>
<seconds integer>	::=	<unsigned integer> <i>!! two digits including leading zero if less than 10</i>
<seconds fraction>	::=	<unsigned integer>
<time zone designator>	::=	<utc designator> <local time zone designator>
<utc designator>	::=	Z
<local time zone designator>	::=	{ <plus sign> <minus sign> } <hour> [<colon> <minute>]

In ISO 8601-1 time zone designator may be omitted, in which case local time is assumed but unspecified. In this document a time zone designator is mandatory.

EXAMPLE 1	2014	(Precision = year)
EXAMPLE 2	2014-01	(Calendar date, precision = month)
EXAMPLE 3	2014-03-01	(Calendar date, precision = day)
EXAMPLE 4	2014-060	(Ordinal date, precision = day)
EXAMPLE 5	2014-05-06T23Z	(Calendar date, precision = hour, UTC)
EXAMPLE 6	2014-157T23Z	(Ordinal date, precision = hour, UTC)
EXAMPLE 7	2014-07-12T16:00Z	(Precision = minute, UTC)
EXAMPLE 8	2014-07-12T17:00+01	(Precision = minute, local time one hour ahead of UTC)
EXAMPLE 9	2014-09-18T08:17:56-08	(Precision = second, local time eight hours behind UTC)
EXAMPLE 10	2014-11-23T00:34:56.789Z	(Precision = 1/1000 second, UTC)

6.3.4 CRS WKT characters

The characters permitted in elements of a CRS WKT string formed from those in 6.3.1, 6.3.2 and 6.3.3 are:

<left delimiter>	::=	<left bracket> <left paren> <i>!! In this document the preferred left delimiter is <left bracket>. <left paren> is permitted for backward compatibility. Implementations shall be able to read both forms.</i>
<right delimiter>	::=	<right bracket> <right paren> <i>!! See 6.4</i>
<wkt separator>	::=	<comma>
<quoted Latin text>	::=	<double quote> <wkt Latin text character>... <double quote>

<wkt Latin text character>	::=	<simple Latin upper case letter> <simple Latin lower case letter> <digit> <underscore> <left bracket> <right bracket> <left paren> <right paren> <left brace> <right brace> <less than operator> <equals operator> <greater than operator> <period> <comma> <colon> <semicolon> <plus sign> <minus sign> <space> <number sign> <percent> <ampersand> <quote> <asterisk> <circumflex> <solidus> <reverse solidus> <question mark> <vertical bar> <degree symbol> <doublequote symbol>
<quoted Unicode text>	::=	<double quote> { <wkt Unicode text character> }... <double quote>
<wkt Unicode text character>	::=	<nondoublequote character> <doublequote symbol>
<nondoublequote character>	::=	!! A <nondoublequote character> is any character of the source language character set other than a <double quote>.
<doublequote symbol>	::=	"" !! two consecutive <double quote> characters

6.3.5 Double quote

Requirement: If a double quote is required within a <quoted Latin text> or <quoted Unicode text> string, a <doublequote symbol> shall be used.

EXAMPLE "Datum origin is 30°25'20""N, 130°25'20""E."

6.4 Delimiter

In WKT strings the attributes for an item are included within a pair of left and right delimiters. The delimiters should normally be <left bracket> and <right bracket>. Implementations are free to substitute parentheses for brackets. If <left bracket> is used as a <left delimiter> then <right bracket> is required to be used as the corresponding <right delimiter>; if <left paren> is used as a <left delimiter> then <right paren> is required to be used as the corresponding <right delimiter>. A nested token is required to use the same type of delimiter as the token in which it is nested.

Requirement: A CRS WKT string shall include only one of the two forms of delimiter, brackets or parentheses, allowed in 6.3.4.

6.5 Case sensitivity

WKT keywords are case insensitive: KEYWORD, keyword, KeyWord and KEYwORd are all equivalent. Where human readability is important (as in the examples in this document) keywords should be written in only the <simple Latin upper case letter> set. KEYWORD is not equivalent to KEY_WORD; the underscore character is significant.

WKT enumerations are case insensitive. CARTESIAN is equivalent to cartesian is equivalent to Cartesian; NORTH is equivalent to north is equivalent to North.

Within quoted text, case is significant. "H" is not equivalent to "h".

Requirement: Outside of quoted text, characters in a WKT string shall not be case sensitive.

6.6 Reserved keywords

The keywords defined in Clauses 7 to 20 and Annex E of this document for coordinate reference systems, coordinate operations, their component elements and their attributes are summarised here. Those formed from multiple words or abbreviations are given in camel case to aid understanding; see 6.5 for implementation in a WKT string.

<u>Keyword</u>	<u>BNF element</u>	<u>Clause in which defined</u>
abridgedTransformation	<abridged transformation keyword>	20
anchor	<datum anchor keyword>	8, 10, 11 and 12
angleUnit	<angle unit keyword>	7
area	<area description keyword>	7
axis	<axis keyword>	7
baseEngCRS	<base engineering crs keyword>	14
baseGeodCRS	<base geodetic crs keyword>	9 and 14
baseGeogCRS	<base geographic crs keyword>	9 and 14
baseParamCRS	<base parametric crs keyword>	14
baseProjCRS	<base projected crs keyword>	14
baseTimeCRS	<base temporal crs keyword>	14
baseVertCRS	<base vertical crs keyword>	14
bBox	<geographic bounding box keyword>	7
bearing	<bearing keyword>	7
boundCRS	<bound crs keyword>	20
calendar	<calendar keyword>	13
citation	<citation keyword>	7
compoundCRS	<compound crs keyword>	15
concatenatedOperation	<concatenated operation keyword>	19
conversion	<map projection keyword>	9
coordEpoch	Alternative keyword for coordinate epoch	16
coordinateMetadata	<coordinate metadata keyword>	16
coordinateOperation	<operation keyword>	17
cs	<cs keyword> (coordinate system)	7
datum	<geodetic reference frame keyword>	8
derivedProjCRS	<derived projected crs keyword>	14
derivingConversion	<deriving conversion keyword>	14
dynamic	<dynamic crs keyword>	7
eDatum	<engineering datum keyword>	11
ellipsoid	<ellipsoid keyword>	8
engCRS	<engineering crs keyword>	11 and 14
engineeringCRS	Alternative keyword for engineering crs	11 and 14
engineeringDatum	Alternative keyword for engineering datum	11
ensemble	<datum ensemble keyword>	7
ensembleAccuracy	<datum ensemble accuracy keyword>	7
epoch	<coordinate epoch keyword>	16
frameEpoch	<frame reference epoch keyword>	7
geodCRS	<geodetic crs keyword>	8 and 14
geodeticCRS	Alternative keyword for geodetic crs	8 and 14
geodeticDatum	Alternative keyword for geodetic reference frame	8
geogCRS	<geographic crs keyword>	8 and 14
geographicCRS	Alternative keyword for geographic crs	8 and 14
geoidModel	<geoid model ID keyword>	10
id	<identifier keyword>	7
interpolationCRS	<interpolation crs keyword>	17
lengthUnit	<length unit keyword>	7
member	<datum ensemble member keyword>	7
meridian	<meridian keyword>	7
method	(i) <map projection method keyword> (ii) <operation method keyword>	9 14, 17 and 18
model	<deformation model ID keyword>	7

<u>Keyword</u>	<u>BNF element</u>	<u>Clause in which defined</u>
operationAccuracy	<operation accuracy keyword>	17 and 18
order	<axis order keyword>	7
parameter	<parameter keyword>	9, 14, 17 and 18
parameterFile	<parameter file keyword>	14, 17 and 18
parametricCRS	<parametric crs keyword>	12 and 14
parametricDatum	Alternative keyword for parametric datum	12
parametricUnit	<parametric unit keyword>	7
pDatum	<parametric datum keyword>	12
pointMotionOperation	<point motion operation keyword>	18
primeM	<prime meridian keyword>	8
primeMeridian	Alternative keyword for prime meridian	8
projCRS	<projected crs keyword>	9
projectedCRS	Alternative keyword for projected crs	9
projection	Alternative keyword for map projection method	9
remark	<remark keyword>	7
scaleUnit	<scale unit keyword>	7
scope	<scope keyword>	7
sourceCRS	<source crs keyword>	17 and 18
spheroid	Alternative keyword for ellipsoid	8
step	concatenated operation <step keyword>	19
targetCRS	<target crs keyword>	17
tDatum	<temporal datum keyword>	13
TRF	Alternative keyword for geodetic reference frame	8
temporalQuantity	Alternative keyword for time unit	7
timeCRS	<temporal crs keyword>	13 and 14
timeDatum	Alternative keyword for temporal datum	13
timeExtent	<temporal extent keyword>	7
timeOrigin	<temporal origin keyword>	13
timeUnit	<temporal unit keyword>	7
triaxial	<triaxial ellipsoid keyword>	Annex E
unit	Alternative keyword for all units	7
uri	<uri keyword>	7
usage	<usage keyword>	7
vDatum	<vertical reference frame keyword>	10
velocityGrid	Alternative keyword for deformation model ID	7
version	<operation version keyword>	17-20
vertCRS	<vertical crs keyword>	10 and 14
verticalCRS	Alternative keyword for vertical crs	10 and 14
verticalDatum	Alternative keyword for vertical reference frame	10
verticalExtent	<vertical extent keyword>	7
VRF	Alternative keyword for vertical reference frame	10

6.7 Backward compatibility

This document makes several references to backward compatibility. Backward compatibility means that an implementation of the text strings in this document would be able to read CRS WKT strings conforming to the old (ISO 19125-1:2004) syntax. It does not mean that a parser of a string compliant to ISO 19125-1:2004 could read WKT strings written in conformance with this document. It also does not require an implementation of the text strings in this document to be able to output an object according to the old syntax. B.8 gives guidance on determining the version of a CRS WKT string. A mapping of older syntaxes to this document is given in Annex C. Revisions to ISO 19162:2015 made in this document are described in Annex D

7 WKT representation of common attributes

7.1 General

The WKT representation of attributes that are common to coordinate reference systems and coordinate operations — name, scope, extent, identifier and remarks — is described in 7.2 to 7.4. Coordinate system (a component of coordinate reference systems) is described in 7.5. Elements for a datum ensemble and a dynamic coordinate reference system are described in 7.6 and 7.7 respectively. Attributes specific to coordinate reference systems and to coordinate operations are described in Clauses 8 to 19.

7.2 Name

From a computational perspective name is redundant information provided for human readability. For example an ellipsoid is defined by the values of the semi-major axis and inverse flattening, and the ellipsoid name is redundant information. However the name may be used to verify the defining values against those from an authoritative source. Comment on the comparison of text strings is given in Annex B.

NOTE Name is a required attribute for the CRS object as well as for some component objects. Depending upon the convention adopted for CRS naming, this can result in duplication of name within the CRS WKT string.

7.3 Scope, extent, identifier and remark

7.3.1 General

The BNF element `<scope extent identifier remark>` is a collection of four optional attributes which may be applied to a coordinate reference system, a coordinate operation or a bound CRS. The `<scope extent identifier remark>` collection is to simplify the BNF through grouping. Usage (`<scope>` and `<extent>`) is described in 7.3.2, `<identifier>` in 7.3.3 and `<remark>` in 7.3.4.

Requirement: The WKT representation of a `<scope extent identifier remark>` element shall be:

```
<scope extent identifier remark> ::= [ { <wkt separator> <usage> } ] ...
                                   [ { <wkt separator> <identifier> } ] ...
                                   [ { <wkt separator> <remark> } ]
```

7.3.2 Usage (scope and extent)

7.3.2.1 Usage

Usage is an optional attribute which if included in a WKT string shall include both `<scope>` and `<extent>`. Multiple pairs of scope/extent may be used to describe the usage for different purposes over different extents. In this document the `<scope>` and `<extent>` elements may not be given alone but only as a pairing. Within each pairing, extent may consist of one or more of area textual description, area bounding box, vertical extent and/or temporal extent, see 7.3.2.3.

Requirement: The WKT representation of a `<usage>` element shall be:

```
<usage> ::= <usage keyword> <left delimiter>
           <scope> <wkt separator> <extent>
           <right delimiter>

<usage keyword> ::= USAGE
```

EXAMPLE 1 Structure of one scope-extent pairing

```
USAGE [<scope>, <extent>]
```

EXAMPLE 2 Structure of two scope-extent pairings

USAGE[scope1, extent1], USAGE[scope2, extent2]

The individual <scope> and <extent> elements are described in the following subclauses. See 7.3.2.4 for further examples of scope and extent pairings.

7.3.2.2 Scope

Scope describes the purpose or purposes for which a CRS, datum, datum ensemble, coordinate operation or bound CRS is applied.

Requirement: The WKT representation of a <scope> shall be:

```
<scope> ::= <scope keyword> <left delimiter>
           <scope text description> <right delimiter>

<scope keyword> ::= SCOPE

<scope text description> ::= <quoted Latin text>
```

EXAMPLE SCOPE["Large scale topographic mapping and cadastre."]

7.3.2.3 Extent

7.3.2.3.1 General

Extent describes the spatial and/or temporal applicability of a CRS, datum, datum ensemble, coordinate operation or bound CRS. Extent in this document uses the concepts described in ISO 19115-1. However this document permits horizontal extent to be described by description and/or by geographic bounding box, but not by polygon because of string length considerations. It also allows for vertical and temporal extent. These extent attributes are all optional, although at least one shall be included in any Usage. Multiple extent attributes may be provided, but there is a constraint that within any one scope-extent pairing these shall be of different types.

Requirement: The WKT representation of an <extent> shall be:

```
<extent> ::= <area description> | <geographic bounding box> | <vertical extent> | <temporal extent>
           | { <area description> <wkt separator> <geographic bounding box> }
           | { <area description> <wkt separator> <vertical extent> }
           | { <area description> <wkt separator> <temporal extent> }
           | { <geographic bounding box> <wkt separator> <vertical extent> }
           | { <geographic bounding box> <wkt separator> <temporal extent> }
           | { <vertical extent> <wkt separator> <temporal extent> }
           | { <area description> <wkt separator> <geographic bounding box> <wkt separator>
               <vertical extent> }
           | { <area description> <wkt separator> <geographic bounding box> <wkt separator>
               <temporal extent> }
           | { <area description> <wkt separator> <vertical extent> <wkt separator>
               <temporal extent> }
           | { <geographic bounding box> <wkt separator> <vertical extent> <wkt separator>
               <temporal extent> }
           | { <area description> <wkt separator> <geographic bounding box> <wkt separator>
               <vertical extent> <wkt separator> <temporal extent> }
```


7.3.2.3.2 Area description

Area description is an optional attribute which describes a geographic area over which a CRS or coordinate operation is applicable.

Requirement: The WKT representation of an <area description> shall be:

<area description> ::= <area description keyword> <left delimiter>
<area text description> <right delimiter>

<area description keyword> ::= AREA

<area text description> ::= <quoted Latin text>

EXAMPLE AREA["Netherlands offshore."]

7.3.2.3.3 Geographic bounding box

The geographic bounding box is an optional attribute which describes a "north up" area. Upper right latitude will be greater than the lower left latitude. Generally the upper right longitude will be greater than the lower left longitude. However when the area crosses the 180° meridian, the value of the lower left longitude will be greater than the value of the upper right longitude.

The geographic bounding box is an approximate description of location. For most purposes a coordinate precision of two decimal places of a degree is sufficient. At this resolution the identification of the geodetic CRS to which the bounding box coordinates are referenced is not required.

Requirement: The WKT representation of a <geographic bounding box> shall be:

<geographic bounding box> ::= <geographic bounding box keyword> <left delimiter>
<lower left latitude> <wkt separator> <lower left longitude>
<wkt separator> <upper right latitude> <wkt separator>
<upper right longitude> <right delimiter>

<geographic bounding box keyword> ::= BBOX

<lower left latitude> ::= <number> *!! See text*

<lower left longitude> ::= <number> *!! See text*

<upper right latitude> ::= <number> *!! See text*

<upper right longitude> ::= <number> *!! See text*

Requirement: bounding box latitude coordinates shall be given in decimal degrees in the range -90 to +90, longitude coordinates shall be given in decimal degrees in the range -180 to +180 relative to the international reference meridian.

EXAMPLE 1 Geographic bounding box enveloping offshore Netherlands:

BBOX[51.43, 2.54, 55.77, 6.40]

EXAMPLE 2 Geographic bounding box enveloping offshore New Zealand and crossing the 180° meridian:

BBOX[-55.95, 160.60, -25.88, -171.20]

7.3.2.3.4 Vertical extent

Vertical extent is an optional attribute which describes a height range over which a CRS or coordinate operation is applicable. Depths have negative height values. Vertical extent is an approximate description of location; heights are relative to an unspecified mean sea level.

Requirement: The WKT representation of a <vertical extent> shall be:

```

<vertical extent> ::= <vertical extent keyword> <left delimiter>
                    <vertical extent minimum height> <wkt separator>
                    <vertical extent maximum height>
                    [ <wkt separator> <length unit> ] <right delimiter>

```

<vertical extent keyword> ::= VERTICALEXTENT

<vertical extent minimum height> ::= <number>

$$\langle \text{vertical extent maximum height} \rangle ::= \langle \text{number} \rangle$$

Requirement: If vertical extent units are not stated they shall be assumed to be metres.

EXAMPLE 1 `VERTICALEXTENT[-1000,0,LENGTHUNIT["metre",1.0]]`

EXAMPLE 2 `VERTICALEXTENT[-1000,0]` (where the heights are implicitly in metres).

7.3.2.3.5 Temporal extent

Temporal extent is an optional attribute which describes a date or time range over which a CRS or coordinate operation is applicable. The format for date and time values is defined in ISO/IEC 9075-2. Start time is earlier than end time.

Requirement: The WKT representation of a <temporal extent> shall be:

```

<temporal extent> ::= <temporal extent keyword> <left delimiter>
                     <temporal extent start> <wkt separator>
                     <temporal extent end> <right delimiter>

```

`<temporal extent keyword>` ::= TIMEEXTENT

<temporal extent start> ::= <datetime> | <quoted Latin text>

```
<temporal extent end> ::= <datetime> | <quoted Latin text>
!! <temporal extent end> should have the same
data type (dateTime or quoted Latin text) as
<temporal extent start>.
```

EXAMPLE 1 TIMEEXTENT[2013-01-01,2013-12-31]

EXAMPLE 2 `TIMEEXTENT["Jurassic","Quaternary"]`

7.3.2.4 Examples of WKT describing usage

EXAMPLE 1 One scope-extent pairing (the <extent> including two extent attributes, area description and temporal extent):

```
USAGE[SCOPE["Spatial referencing."],
AREA["Netherlands offshore."],TIMEEXTENT[1976-01,2001-04]]
```

EXAMPLE 2 Two scope-extent pairings, the second of which has multiple extent attributes:

```
USAGE[SCOPE["Small scale topographic mapping."],
AREA["Finland - onshore and offshore."],
USAGE[SCOPE["Cadastre."],
AREA["Finland - onshore between 26°30'E and 27°30'E."],
BBOX[60.36,26.5,70.05,27.5]]
```

7.3.3 Identifier

Identifier is an optional attribute which references an external description of the object and which may be applied to a coordinate reference system, a coordinate operation or a bound CRS. It may also be utilised for components of these objects although this is recommended only for the following circumstances:

- coordinate operation methods and parameters;
- source and target CRSs when embedded within a coordinate transformation or a concatenated coordinate operation;
- source CRS when embedded within a point motion operation;
- individual coordinate operations embedded within a concatenated coordinate operation;
- base CRS when embedded within a derived CRS (including projected CRS);
- source CRS, target CRS and abridged transformation when embedded within a bound CRS;
- individual members of a datum ensemble.

Multiple identifiers may be given for any object.

When an identifier is given for a coordinate reference system, coordinate operation or bound CRS, it applies to the whole object including all of its components.

Should any attributes or values given in the cited identifier be in conflict with attributes or values given explicitly in the WKT description, the WKT values shall prevail.

Requirement: The WKT representation of an <identifier> shall be:

<identifier>	::=	<identifier keyword> <left delimiter> <authority name> <wkt separator> <authority unique identifier> [<wkt separator> <version>] [<wkt separator> <authority citation>] [<wkt separator> <id uri>] <right delimiter>
<identifier keyword>	::=	ID
<authority name>	::=	<quoted Latin text>
<authority unique identifier>	::=	<number> <quoted Latin text>
<version>	::=	<number> <quoted Latin text>

<authority citation>	::=	<citation keyword> <left delimiter> <citation> <right delimiter>
<citation keyword>	::=	CITATION
<citation>	::=	<quoted Latin text>
<id uri>	::=	<uri keyword> <left delimiter> <uri> <right delimiter> }
<uri keyword>	::=	URI
<uri>	::=	<quoted Latin text>

Version is an optional attribute indicating the version of the repository or object that is cited. Citation is an optional attribute that may be used to give further details of the authority. URI is an optional attribute that may be used to give reference to an online resource.

NOTE In previous specifications the authority object was defined more narrowly than is the identifier object in this document. See Annex C.

EXAMPLE 1 ID["Authority name", "Abcd_Ef", 7.1]

EXAMPLE 2 ID["EPSG", 4326]

EXAMPLE 3 ID["EPSG", 4326, URI["urn:ogc:def:crs:EPSG::4326"]]

EXAMPLE 4 ID["EuroGeographics", "ES_ED50 (BAL99) to ETRS89", "2001-04-20"]

Further examples are included in Clauses 8 to 17.

7.3.4 Remark

<remark> is an optional attribute. Any information contained in a <remark> is informative. It does not modify the defining parameters of an object.

A <remark> may be applied to a coordinate reference system, coordinate operation or bound CRS as a whole. A <remark> should not be included in the WKT for components of a coordinate reference system or coordinate operation, but a remark in the coordinate reference system or coordinate operation object may include information about these components.

NOTE A <remark> can be included within the descriptions of source and target CRS embedded within a coordinate transformation as well as within the coordinate transformation itself.

Any character other than a <wkt Latin text character> that is to be contained in a CRS WKT string may be included only as part of <quoted Unicode text> within a <remark>.

Requirement: The WKT representation of a <remark> shall be:

<remark>	::=	<remark keyword> <left delimiter> <quoted Unicode text> <right delimiter>
<remark keyword>	::=	REMARK

EXAMPLE 1 REMARK["A remark in ASCII"]

EXAMPLE 2 REMARK["Замечание на русском языке"]

EXAMPLE 3 GEOGCRS["S-95",
DATUM["Pulkovo 1995",

```

        ELLIPSOID["Krassowsky 1940",6378245,298.3,
            LENGTHUNIT["metre",1.0]]
    ],
    CS[ellipsoidal,2],
        AXIS["latitude",north,ORDER[1]],
        AXIS["longitude",east,ORDER[2]],
        ANGLEUNIT["degree",0.0174532925199433],
    REMARK["Система Геодезических Координат года 1995 (СК-95)"]
]

```

Further examples including remarks are given in Clauses 8 to 19.

7.4 Unit and unit conversion factor

7.4.1 Unit description

Some attributes of coordinate system axes and coordinate operation parameters are numbers which require the unit to be specified. General aspects are described here. For additional aspects that are specific to ordinal and temporal coordinate system axes see 7.5.6.

Requirement: The WKT representation of a <unit> description shall be:

<unit>	::=	<spatial unit> <time unit>
<spatial unit>	::=	<angle unit> <length unit> <parametric unit> <scale unit>
<angle unit>	::=	<angle unit keyword> <left delimiter> <unit name> <wkt separator> <conversion factor> [{ <wkt separator> <identifier> }]... <right delimiter>
<length unit>	::=	<length unit keyword> <left delimiter> <unit name> <wkt separator> <conversion factor> [{ <wkt separator> <identifier> }]... <right delimiter>
<parametric unit>	::=	<parametric unit keyword> <left delimiter> <unit name> <wkt separator> <conversion factor> [{ <wkt separator> <identifier> }]... <right delimiter>
<scale unit>	::=	<scale unit keyword> <left delimiter> <unit name> <wkt separator> <conversion factor> [{ <wkt separator> <identifier> }]... <right delimiter>
<time unit>	::=	<time unit keyword> <left delimiter> <unit name> [<wkt separator> <conversion factor>] [{ <wkt separator> <identifier> }]... <right delimiter> <i>!! In this document when the <time unit> is applied to a temporal coordinate system axis the <conversion factor> is conditional: see 7.4.3.</i>
<angle unit keyword>	::=	ANGLEUNIT UNIT <i>!! In this document the preferred keyword is ANGLEUNIT. UNIT is permitted for backward compatibility. Implementations shall be able to read both forms.</i>

<length unit keyword>	::=	LENGTHUNIT UNIT <i>!! In this document the preferred keyword is LENGTHUNIT. UNIT is permitted for backward compatibility. Implementations shall be able to read both forms.</i>
<parametric unit keyword>	::=	PARAMETRICUNIT
<scale unit keyword>	::=	SCALEUNIT UNIT <i>!! In this document the preferred keyword is SCALEUNIT. UNIT is permitted for backward compatibility. Implementations shall be able to read both forms.</i>
<time unit keyword>	::=	TIMEUNIT TEMPORALQUANTITY <i>!! In this document the preferred keyword is TIMEUNIT. TEMPORALQUANTITY is permitted. Implementations shall be able to read both forms.</i>
<unit name>	::=	<quoted Latin text>
<conversion factor>	::=	<unsigned numeric literal> <i>!! <conversion factor> is the number of SI standard units per unit. See 7.4.2 and 7.4.3.</i>

<identifier> is described in 7.3.4.

7.4.2 Conversion factor — Spatial and parametric units

Requirements: If the unit is linear its conversion factor shall be to metres and is the number of metres per unit. If the unit is angular its conversion factor shall be to radians and is the number of radians per unit. For parametric units the appropriate SI standard unit shall be used. For scale, unity shall be used.

EXAMPLE 1 LENGTHUNIT["metre",1]
 EXAMPLE 2 LENGTHUNIT["German legal metre",1.0000135965]
 EXAMPLE 3 ANGLEUNIT["degree",0.0174532925199433]
 EXAMPLE 4 SCALEUNIT["parts per million",1E-06]
 EXAMPLE 5 PARAMETRICUNIT["hectopascal",100]

Further examples are included in 7.5 and Clauses 8 to 17.

7.4.3 Conversion factor — Temporal quantities

Unit uses the datatype of UnitOfMeasure. This is defined in ISO 19103. The class includes a note "conversion ToISOstandardUnit is not null only if the conversion is a simple scale". For many temporal cases, the unit is not a simple scale: the size of a month, a day or an hour vary at different locations in the calendar due to correction factors and alterations such as leap seconds, leap years, and seasonal time zone changes. Conversion of a temporal quantity (time unit) to the SI base unit for time, the second, therefore may or may not be ambiguous when compared to a calendar definition of that quantity. Examples are given in ISO 19111:2019, D.4. In these cases, UnitOfMeasure instances for temporalCount and temporalMeasure are described with no relation to the second.

NOTE In ISO 8601-1 the terms 'calendar day', 'calendar month' and 'calendar year' are used, with the note: often referred to as 'day', 'month' and 'year' respectively.

POSIX time is commonly used in software. It is dimensioned in seconds, but leap seconds are ignored (not applied)^[6]. A unit of measure "second" may be used to represent this, but it shall be defined

independent of the SI second, not as a specific number of SI seconds. It may be thought of as a "calendar second".

Requirement: For temporal quantities, in this document called time units, the unit conversion factor shall be to seconds and is the number of seconds per unit, but the conversion factor is not to be given when it is not a simple scaling.

EXAMPLE 1 Simple scaling, so conversion factor is required.

```
TIMEUNIT["millisecond", 0.001]
```

EXAMPLE 2 Scaling not simple (number of seconds in a month varies), so conversion factor not required.

```
TIMEUNIT["calendar month"]
```

EXAMPLE 3 Using the POSIX formula ^[6] which ignores leap seconds, so conversion factor not required.

```
TIMEUNIT["calendar second"]
```

Note: the example given in ISO 19162:2015:

```
TIMEUNIT["day", 86400.0]
```

is deprecated. The number of seconds in a calendar day is not a simple scaling (because some days contain leap seconds) so conversion factor is not to be given.

7.4.4 Default unit

Recommended practice is for units to be explicitly described. However, for backward compatibility reasons, this document in places permits unit description to be implied. This may result in incomplete specification.

EXAMPLE: Angular units cannot be inferred from a coordinate system with linear units, as in the angle unit for longitude of a prime meridian which cannot be inferred from a geodetic coordinate reference system having a Cartesian coordinate system.

Requirement: Where no implied unit can be inferred then in this document the default implied linear unit shall be metre, the default implied angular unit shall be degree.

7.5 Coordinate system

7.5.1 Syntax

Most coordinate system attributes are common to all subtypes of spatial and temporal coordinate systems. Exceptions are associated with the coordinate system axis unit attribute and its qualifier, the conversion factor to an SI base unit:

- a) When the coordinate system type is 'temporalCount' or 'temporalMeasure', the inclusion of the axis unit conversion factor in WKT is conditional, see 7.4.3.
- b) When the coordinate system type is 'ordinal' or 'temporalDateTime', the axis unit attribute and its conversion factor are not required in WKT, see 7.5.6 and 13.3.

The syntax for all coordinate systems is described here.

Requirement: The WKT representation of a coordinate system shall be:

```
<coordinate system> ::= <spatial cs>
                        | <temporalCountMeasure cs> | <ordinal-dateTime cs>
```

<spatial cs>	::=	<cs keyword> <left delimiter> <spatial cs type> <wkt separator> <dimension> [{ <wkt separator> <identifier> }]... <right delimiter> { <wkt separator> <spatial axis> }... [<wkt separator> <cs unit>] <i>!! Requires axis unit attributes including conversion factor.</i>
<temporalCountMeasure cs>	::=	<cs keyword> <left delimiter> <temporalCountMeasure cs type> <wkt separator> <dimension> [{ <wkt separator> <identifier> }]... <right delimiter> <wkt separator> <temporalCountMeasure axis> <i>!! Requires axis unit attributes, conversion factor is conditional. See 7.5.2.</i>
<ordinal-dateTime cs>	::=	<cs keyword> <left delimiter> <ordinal-dateTime cs type> <wkt separator> <dimension> [{ <wkt separator> <identifier> }]... <right delimiter> { <wkt separator> <ordinal-dateTime axis> }... <i>!! Axis unit is not required.</i>
<cs keyword>	::=	CS
<spatial cs type>	::=	affine Cartesian cylindrical ellipsoidal linear parametric polar spherical vertical <i>!! See 7.5.2 for constraints.</i>
<temporalCountMeasure cs type>	::=	temporalCount temporalMeasure <i>!! See 7.5.2 for constraints.</i>
<ordinal-dateTime cs type>	::=	ordinal temporalDateTime <i>!! See 7.5.2 for constraints.</i>
<dimension>	::=	1 2 3 <i>!! Unsigned integer. See 7.5.2 for constraints.</i>
<spatial axis>	::=	<axis keyword> <left delimiter> <axis nameAbbrev> <wkt separator> <axis direction> [<wkt separator> <axis order>] [<wkt separator> <spatial unit>] [{ <wkt separator> <identifier> }]... <right delimiter> <i>!! Axis unit and conversion factor mandatory. See 7.5.6.2.</i>
<temporalCountMeasure axis>	::=	<axis keyword> <left delimiter> <axis nameAbbrev> <wkt separator> <axis direction> [<wkt separator> <axis order>] [<wkt separator> <time unit>] [{ <wkt separator> <identifier> }]... <right delimiter> <i>!! Axis unit mandatory, conversion factor conditional. See 7.5.6.4</i>

<ordinal-dateTime axis>	::=	<axis keyword> <left delimiter> <axis nameAbbrev> <wkt separator> <axis direction> [<wkt separator> <axis order>] [{ <wkt separator> <identifier> }]... <right delimiter> <i>!! The attribute 'axis unit' is not required for an ordinal coordinate system or for a temporal dateTime coordinate system. See 7.5.6.3.</i>
<axis keyword>	::=	AXIS
<axis nameAbbrev>	::=	<double quote> { <axis name> <axis abbreviation> <axis name and abbrev> } <double quote>
<axis name>	::=	<wkt Latin text character>...
<axis abbreviation>	::=	<left paren> <simple Latin letter>... <right paren>
<axis name and abbrev>	::=	<axis name> <space> <axis abbreviation> <i>!! See 7.5.3 for requirements for axis name and abbreviation.</i>
<axis direction>	::=	north [{ <wkt separator> <meridian> }] northNorthEast northEast eastNorthEast east eastSouthEast southEast southSouthEast south [{ <wkt separator> <meridian> }] southSouthWest southWest westSouthWest west westNorthWest northWest northNorthWest geocentricX geocentricY geocentricZ up down forward aft port starboard clockwise <wkt separator> <bearing> counterClockwise <wkt separator> <bearing> columnPositive columnNegative rowPositive rowNegative displayRight displayLeft displayUp displayDown future past towards awayFrom unspecified <i>!! See 7.5.4 for constraints</i>
<meridian>	::=	<meridian keyword> <left delimiter> <number> <wkt separator> <angle unit> <right delimiter> <i>!! See 7.5.4 for constraints</i>
<meridian keyword>	::=	MERIDIAN
<bearing>	::=	<bearing keyword> <left delimiter> <number> <right delimiter> <i>!! See 7.5.4 for constraints</i>
<bearing keyword>	::=	BEARING
<axis order>	::=	<axis order keyword> <left delimiter> <unsigned integer> <right delimiter> <i>!! See 7.5.5 for constraints</i>
<axis order keyword>	::=	ORDER
<cs unit>	::=	<unit> <i>!! See 7.4 and 7.5.6 for constraints</i>
<spatial unit>		See 7.4 and 7.5.6.

<time unit>

See 7.4 for time unit definition and 13.3 for application to coordinate systems.

An <ellipsoidal 2D coordinate system> is a special case of <coordinate system> required in the construct of the <geographic2D crs> element of a compound CRS (Clause 15):

```
<ellipsoidal 2D coordinate system> ::= <cs keyword> <left delimiter> <ellipsoidal 2D cs type>
<wkt separator> <ellipsoidal 2D dimension>
[ { <wkt separator> <identifier> } ]... <right delimiter>
{ <wkt separator> <spatial axis> }...
[ <wkt separator> <cs unit> ]
```

```
<ellipsoidal 2D cs type> ::= ellipsoidal
```

```
<ellipsoidal 2D dimension> ::= 2
```

7.5.2 Coordinate system type, dimension and coordinate data type

For various types of CRS the type of coordinate system that may be used is constrained, as is the permissible number of axes. Additionally the data type for coordinates in an ordinal coordinate system and in a temporal coordinate system is constrained. These constraints are summarised in Table 2.

Table 2 — Permitted coordinate system type, dimension and coordinate data type by CRS

CRS type	Permitted CS type(s)	Dimension (number of axes)	Coordinate data type
geodetic derived geodetic	Cartesian spherical (ellipsoidal - read only: see 8.3)	3 3 (2 or 3)	
geographic derived geographic	ellipsoidal	2 or 3	
projected	Cartesian	2 or 3	
derived projected	affine Cartesian cylindrical ordinal polar spherical	2 or 3 2 or 3 3 1 or 2 or 3 2 3	(no constraint) (no constraint) (no constraint) integer (no constraint) (no constraint)
vertical derived vertical	vertical	1	
engineering derived engineering	affine Cartesian cylindrical linear ordinal polar spherical	2 or 3 2 or 3 3 1 1 or 2 or 3 2 3	(no constraint) (no constraint) (no constraint) (no constraint) integer (no constraint) (no constraint)
parametric derived parametric	parametric	1	
temporal derived temporal	temporalDateTime temporalCount temporalMeasure	1 1 1	dateTime integer real

See 6.5 for comment on case sensitivity.

The constraints on the data type of coordinates in an ordinal or temporal coordinate system applies to the coordinate data set. The data type is not explicitly described in the CRS definition. However it is implied. If a CRS's coordinate system is ordinal or is temporalCount, it is implied that the coordinates referenced to the CRS shall be integer. If a CRS's coordinate system is temporalMeasure, it is implied that the coordinates referenced to the CRS shall be real; if a CRS's coordinate system is temporalDateTime, it is implied that the coordinates referenced to the CRS shall be dateTime.

7.5.3 Axis name and abbreviation

ISO 19111 requires the name and abbreviation for each axis. In this document, name and/or abbreviation is permitted. They are contained in a single quoted text string. If abbreviation is included in the text string it is given in parentheses.

EXAMPLE 1 "easting"

EXAMPLE 2 "(X)"

EXAMPLE 3 "easting (X)"

Requirement: The following constraints shall apply:

- a) In WKT strings all axis abbreviations shall be from the <wkt Latin text character> set.
- b) For geodetic CRSs having a geocentric Cartesian coordinate system, in WKT strings the axis name should be omitted as it is given through the mandatory axis direction, see 7.5.4 c), but the axis abbreviation, respectively 'X', 'Y' and 'Z', shall be given.
- c) For geographic CRSs having a two-dimensional ellipsoidal coordinate system, the two-dimensional ellipsoidal coordinate system axes are geodetic latitude and geodetic longitude. In WKT strings the values of axis name shall be 'latitude' and 'longitude' respectively.

ISO 19111 specifies the lower case Greek letters ϕ and λ as symbols for geodetic latitude and geodetic longitude. In this document the abbreviations to be used in WKT strings shall be from the Latin character set. P and L are the transliterations of the Greek letters phi and lambda. B for Breite and L for Länge are the standard German abbreviations and used in academic texts worldwide. 'lat' and 'lon' are in common usage.

- d) For geographic CRSs having a three-dimensional ellipsoidal coordinate system, the name and abbreviation of the horizontal axes in a WKT string shall follow the requirements in c). The vertical axis name shall be 'ellipsoidal height'; the vertical axis abbreviation shall be 'h' and shall be included when abbreviations for the horizontal axes are included.
- e) For projected CRSs, the two-dimensional Cartesian coordinate system axes names shall be 'northing' or 'southing' and 'easting' or 'westing' and shall be given when the axis direction and order are not east first, north second. Axis name may be omitted from WKT strings when the axis direction and order are east first, north second with abbreviations 'E' and 'N' respectively. Axis abbreviation shall be given.
- f) For projected CRSs having a three-dimensional Cartesian coordinate system, the name and abbreviation of the horizontal axes in a WKT string shall follow the requirements in e). The vertical axis name shall be 'ellipsoidal height'; the vertical axis abbreviation shall be 'h' and shall be included.
- g) For vertical CRSs, the axis direction is up or down, see 7.5.4. In WKT strings the value of axis name shall be 'gravity-related height' and 'depth' respectively. Axis abbreviation may be omitted but if given for height it shall not be 'h' (which is used for the ellipsoidal height component of an ellipsoidal 3D coordinate system, see 7.5.3 d) above); the abbreviation for gravity-related height should normally be 'H'.

Recommendations:

For engineering CRSs using a polar coordinate system where the lower-case Greek letter θ is conventionally used as the symbol for direction, the letter 'U' from the Latin character set should be used as a one-character abbreviation in WKT strings.

For geodetic and engineering CRSs using a spherical coordinate system where the Greek letters ϕ and θ are conventionally used as the symbols for direction, the letters 'U' and 'V' respectively from the Latin character set should be used as a one-character abbreviations in WKT strings.

7.5.4 Axis direction

Axis direction indicates the positive increment along an axis. The handedness of a 2- or 3-dimensional coordinate system may be derived from the directions.

Requirement: the following constraints shall apply:

For geographic CRSs having an ellipsoidal 2-D coordinate system, the two-dimensional ellipsoidal coordinate system axes are geodetic latitude, positive northwards, and geodetic longitude, positive eastwards. Axis direction shall be 'north' and 'east' respectively.

- a) For geographic CRSs having an ellipsoidal 3-D coordinate system, the three-dimensional ellipsoidal coordinate system axes are geodetic latitude, positive northwards, geodetic longitude, positive eastwards, and ellipsoidal height, positive upwards. Axis direction shall be 'north', 'east' and 'up' respectively.
- b) For geodetic CRSs having a geocentric Cartesian coordinate system, in WKT strings the axis directions shall be 'geocentricX', 'geocentricY' and 'geocentricZ' respectively. The first axis of the earth-centred 3D Cartesian coordinate system lies in the equatorial plane such that a vector pointing in the positive direction passes through the intersection of the equator and the prime meridian. The second axis is in the equatorial plane such that a vector pointing in the positive direction passes through the intersection of the equator and the meridian of 90°E. The third axis is perpendicular to the first two such that it completes a right-handed coordinate system; it is approximately parallel to the earth's rotation axis, positive towards the north pole.
- c) For projected CRSs, except for coordinate systems centred on a pole, the horizontal axis direction shall be 'north' or 'south' and 'east' or 'west'. For the 3D case the vertical axis direction shall be 'up'.

For coordinate systems centred on a pole the direction for both axes will be 'south' (for the north pole case) or 'north' (for the south pole case); the axes direction shall be supplemented with a <meridian> description. This is the value of the meridian that the axis follows from the pole. The prime meridian from which the meridian value is reckoned is given through the <prime meridian> object; if no <prime meridian> object is in the WKT string then the IRM or Greenwich meridian shall be assumed.

- d) For vertical CRSs, the axis direction shall be 'up' or 'down'.
- e) For temporal CRSs, the axis direction shall be 'future' or 'past'.
- f) In engineering CRSs the horizontal directions are only approximate, the set of directions indicating whether the coordinate system is left-handed or right-handed. (In the 2D case, the handedness is when viewed from above the plane of the system). For engineering CRSs with polar coordinate systems the direction of the rotational axis shall be 'clockwise' or 'counterClockwise'. The specified direction from which the rotation is measured shall be given through the supplementary object <bearing>; the bearing value shall be given in the unit defined through <axis unit>.

See 6.5 for comment on case sensitivity.

7.5.5 Axis order

Axis is repeated in a sequence. The number of axes in the sequence is the same as the dimensions of the coordinate system.

<axis order> identifies the order in which the coordinates of a point in a dataset are given and therefore is significant. In this document it is defined in the BNF as an optional attribute to allow backward compatibility with OGC 01-009, however it is recommended that it should be explicitly included in a CRS WKT string.

Requirement: The following constraints shall apply:

- a) For coordinate systems with more than one axis, either every axis description shall include an <axis order> or none of the axes descriptions shall include an <axis order>.
- b) When <axis order> is present in the WKT string the sequence of <axis> descriptions shall start at 1 and increment in steps of 1..
- c) If <axis order> is omitted from the WKT string the sequence of <axis> descriptions shall imply the order of the axes and of coordinates referenced to the CRS.
- d) For compound CRSs, the axes are described through each component CRS description and the order values shall apply to each component system, not to the compound system. The order of the axes in the compound system shall be inferred from firstly the order of the component CRSs then secondly the order of axes within each component CRS.

EXAMPLE A compound CRS consists of a projected CRS with a vertical CRS, the component CRSs described in that order. The axes of the projected CRS are northing first, easting second. The only and therefore first axis of the vertical CRS is gravity-related height. The axis order for the compound CRS is northing first, easting second and gravity-related height third.

7.5.6 Axis unit and coordinate system unit

7.5.6.1 General

This document provides two methods for specifying the coordinate system axis units. <axis unit> is an optional attribute which may be applied to each axis description and if applied shall describe the unit for that axis. <cs unit> is an optional attribute which if applied shall specify the unit for all axes of the coordinate system. <axis unit> and <cs unit> are subsets of <unit> which is described in 7.4.

For coordinate systems in which all axes have the same units, the use of <axis unit> leads to duplication of unit name and conversion factor. Duplication is avoided through the use of <cs unit>.

<axis unit> or <cs unit> may also specify the unit for implied map projection parameter values, as described in 9.3.

7.5.6.2 Axis unit for spatial and parametric coordinate systems

Requirement: The following constraints shall apply:

- a) A CRS WKT string for all types of coordinate system except ordinal, temporalDateTime, temporalCount and temporalMeasure shall include either <spatial axis unit> for each axis or <cs unit> applying to all axes.
- b) <cs unit> shall not be used if the unit does not apply to all axes. In these cases <axis unit> shall be used.

EXAMPLE 1 A polar coordinate system requires one axis to be an angle and the other axis to be a length: <spatial axis unit> shall be used.

EXAMPLE 2 A three-dimensional ellipsoidal coordinate system requires two axes (geodetic latitude and geodetic longitude) to be angles and the third axis (ellipsoidal height) to be a length: <spatial axis unit> shall be used.

7.5.6.3 Axis unit for ordinal coordinate systems

The coordinates in ordinal coordinate systems are integers. The WKT syntax for an ordinal coordinate system is given in 7.5.1; no axis unit shall be given.

Requirement: For an ordinal coordinate system, neither <axis unit> nor <cs unit> shall be given.

EXAMPLE

```
CS[ordinal,2],
  AXIS["inline (I)",southeast,ORDER[1]]
  AXIS["crossline (J)",northeast,ORDER[2]]
```

Note: This requirement also applies to temporalDateTime coordinate systems, see 13.3.2.

Per 7.5.1 and 7.5.3, for an ordinal CS both axis name/abbreviation and axis direction shall be given but axis order may be given or be implied.

7.5.6.4 Axis unit for temporal coordinate systems

Temporal coordinate systems have constraints on their treatment of <axisUnit> and its <conversion factor> which differ from the requirements for other types of coordinate system. Unit for temporalCount and temporalMeasure coordinate system axis is described in 7.4.3. Requirements for temporalDateTime coordinate system axis unit are described in 13.3.

7.5.7 Examples of WKT describing coordinate systems

7.5.7.1 Coordinate systems for geodetic CRSs

EXAMPLE 1 Earth centred earth fixed Cartesian CS. Axis order is implied, <cs unit> is used.

```
CS[Cartesian,3],
  AXIS["(X)",geocentricX],
  AXIS["(Y)",geocentricY],
  AXIS["(Z)",geocentricZ],
  LENGTHUNIT["metre",1.0]
```

EXAMPLE 2 Topocentric Cartesian CS. Axis order is implied, <cs unit> is used.

```
CS[Cartesian,3],
  AXIS["(X)",east],AXIS["(Y)",north],AXIS["(Z)",up],
  LENGTHUNIT["metre",1.0]
```

EXAMPLE 3 Spherical CS. Axis order is explicit, <axis unit> is used, axes have name and abbreviation.

```
CS[spherical,3],
  AXIS["distance
(r)",awayFrom,ORDER[1],LENGTHUNIT["kilometre",1000]],
  AXIS["longitude (U)",counterClockwise,BEARING[0],ORDER[2],
  ANGLEUNIT["degree",0.0174532925199433]],
  AXIS["elevation (V)",up,ORDER[3],
  ANGLEUNIT["degree",0.0174532925199433]]
```

7.5.7.2 Coordinate systems for geographic CRSs

EXAMPLE 1 3D ellipsoidal CS. Axis order is explicit, <axis unit> is used, first two axes have name but no abbreviation.

```
CS[ellipsoidal,3],
  AXIS["latitude",north,ORDER[1],ANGLEUNIT["degree",0.0174532925199433]],
  AXIS["longitude",east,ORDER[2],ANGLEUNIT["degree",0.0174532925199433]],
  AXIS["ellipsoidal height (h)",up,ORDER[3],LENGTHUNIT["metre",1.0]]
```

EXAMPLE 2 2D ellipsoidal CS. Axis order is implied, <cs unit> is used, axes have abbreviation but no name.

```
CS[ellipsoidal,2],
  AXIS["(lat)",north],
  AXIS["(lon)",east],
  ANGLEUNIT["degree",0.0174532925199433]
```

7.5.7.3 Coordinate systems for projected CRSs

EXAMPLE 1 CS[Cartesian,2],
 AXIS["(E)",east,ORDER[1],LENGTHUNIT["metre",1.0]],
 AXIS["(N)",north,ORDER[2],LENGTHUNIT["metre",1.0]] (using <axis unit>)

EXAMPLE 2 CS[Cartesian,2],
 AXIS["(E)",east],
 AXIS["(N)",north],
 LENGTHUNIT["metre",1.0] (using <cs unit>)

EXAMPLE 3 CS[Cartesian,2],
 AXIS["northing (X)",north,ORDER[1]],
 AXIS["easting (Y)",east,ORDER[2]],
 LENGTHUNIT["German legal metre",1.0000135965]

EXAMPLE 4 For an azimuthal projection centred on the north pole:
 CS[Cartesian,2],
 AXIS["easting (X)",south,
 MERIDIAN[90,ANGLEUNIT["degree",0.0174532925199433]],ORDER[1]
],
 AXIS["northing (Y)",south,
 MERIDIAN[180,ANGLEUNIT["degree",0.0174532925199433]],ORDER[2]
],
 LENGTHUNIT["metre",1.0]

EXAMPLE 5 For a projected 3D CRS (using <cs unit>)
 CS[Cartesian,3],
 AXIS["(E)",east],
 AXIS["(N)",north],
 AXIS["ellipsoid height (h)",up],
 LENGTHUNIT["metre",1.0]

7.5.7.4 Coordinate systems for vertical CRSs

EXAMPLE 1 CS[vertical,1],
 AXIS["gravity-related height (H)",up],
 LENGTHUNIT["metre",1.0] (using <cs unit>)

EXAMPLE 2 CS[vertical,1],
 AXIS["depth (D)",down],
 LENGTHUNIT["metre",1.0] (using <axis unit>)

7.5.7.5 Coordinate systems for engineering CRSs

EXAMPLE 1 `CS[Cartesian,2],`
 `AXIS["site north (x)",southeast,ORDER[1]],`
 `AXIS["site east (y)",southwest,ORDER[2]],`
 `LENGTHUNIT["metre",1.0]`

EXAMPLE 2 `CS[polar,2],`
 `AXIS["distance (r)",awayFrom,ORDER[1],LENGTHUNIT["metre",1.0]],`
 `AXIS["bearing (U)",clockwise,BEARING[234],ORDER[2],`
 `ANGLEUNIT["degree",0.0174532925199433]`
 `]`

EXAMPLE 3 `CS[Cartesian,3],`
 `AXIS["ahead (x)",forward,ORDER[1]],`
 `AXIS["right (y)",starboard,ORDER[2]],`
 `AXIS["down (z)",down,ORDER[3]],`
 `LENGTHUNIT["metre",1.0]`

EXAMPLE 4 `CS[ordinal,2],`
 `AXIS["Inline (I)",northEast,ORDER[1]],`
 `AXIS["Crossline (J)",northwest,ORDER[2]]`

7.6 Datum ensemble

Geodetic and vertical CRSs are associated with either a reference frame (datum) or a datum ensemble. The members of a datum ensemble are given as a list of reference frames. The list may contain reference frame name and/or identifier. All members of a datum ensemble are realizations of one shared terrestrial or vertical reference system.

For an ensemble of geodetic reference frames (datums), the WKT string includes the description of the ellipsoid used by the members. This information is available from any and all of the definitions of each member. It is included in the ensemble WKT to facilitate direct access to the information. The WKT string for a datum ensemble may also include the description of the prime meridian applying to all members of the ensemble.

For both geodetic and vertical datum ensembles, the ensemble description includes its 'accuracy', an indication of the difference in coordinate values of a point between different members of the datum ensemble. It may be regarded as a measure of the inaccuracy introduced through the assumption that ensemble members are approximately equivalent.

Use of the datum ensemble concept comes with a health warning. If data is associated with a CRS having a datum ensemble, it will not be possible to identify which of the datum ensemble members the data might more accurately be referenced to. In high accuracy applications, datum ensembles should not be used; individual reference frames should be identified.

Requirement: The WKT representation of a datum ensemble shall be:

<datum ensemble>	::=	<geodetic datum ensemble> <vertical datum ensemble>
<geodetic datum ensemble>	::=	<datum ensemble keyword> <left delimiter> <datum ensemble name> { <wkt separator> <datum ensemble member> }... <wkt separator> <ellipsoid> <wkt separator> <datum ensemble accuracy> [<wkt separator> <datum ensemble identifier>]... <right delimiter> { <wkt separator> <prime meridian> }
<vertical datum ensemble>	::=	<datum ensemble keyword> <left delimiter> <datum ensemble name> { <wkt separator> <datum ensemble member> }... <wkt separator> <datum ensemble accuracy> [{ <wkt separator> <datum ensemble identifier> }]... <right delimiter>
<datum ensemble keyword>	::=	ENSEMBLE
<datum ensemble name>	::=	<quoted Latin text> <i>!! See 7.2</i>
<datum ensemble member>	::=	<datum ensemble member keyword> <left delimiter> <datum ensemble member name> [{ <wkt separator> <datum ensemble member identifier> }]... <right delimiter>
<datum ensemble member keyword>	::=	MEMBER
<datum ensemble member name>	::=	<quoted Latin text> <i>!! See 7.2</i>
<datum ensemble member identifier>	::=	<identifier> <i>!! See 7.3.4</i>
<datum ensemble accuracy>	::=	<datum ensemble accuracy keyword> <left delimiter> <accuracy> <right delimiter>
<datum ensemble accuracy keyword>	::=	ENSEMBLEACCURACY
<accuracy>	::=	<number> <i>!! <accuracy> is in metres</i>
<datum ensemble identifier>	::=	<identifier> <i>!! See 7.3.4</i>

<ellipsoid> is described in 8.2.1.

<prime meridian> is described in 8.2.2.

EXAMPLE 1 Ensemble of geodetic reference frames with ensemble member name only

```
ENSEMBLE["WGS 84 ensemble",
  MEMBER["WGS 84 (TRANSIT)"],
  MEMBER["WGS 84 (G730)"],
  MEMBER["WGS 84 (G834)"],
  MEMBER["WGS 84 (G1150)"],
  MEMBER["WGS 84 (G1674)"],
  MEMBER["WGS 84 (G1762)"],
  ELLIPSOID["WGS 84", 6378137, 298.2572236, LENGTHUNIT["metre", 1.0]],
  ENSEMBLEACCURACY[2]
]
```

EXAMPLE 2 Ensemble of geodetic reference frames with ensemble member name and ID

```
ENSEMBLE["WGS 84 ensemble",
  MEMBER["WGS 84 (TRANSIT)",ID["EPSG",1166]],
  MEMBER["WGS 84 (G730)",ID["EPSG",1152]],
  MEMBER["WGS 84 (G834)",ID["EPSG",1153]],
  MEMBER["WGS 84 (G1150)",ID["EPSG",1154]],
  MEMBER["WGS 84 (G1674)",ID["EPSG",1155]],
  MEMBER["WGS 84 (G1762)",ID["EPSG",1156]],
  ELLIPSOID["WGS 84",6378137,298.2572236,LENGTHUNIT["metre",1.0]],
  ENSEMBLEACCURACY[2]
]
```

EXAMPLE 3 Ensemble of vertical reference frames with ensemble member name only

```
ENSEMBLE["EVRS ensemble",
  MEMBER["EVRF2000"],MEMBER["EVRF2007"],
  ENSEMBLEACCURACY[0.01]
]
```

7.7 Dynamic coordinate reference systems

Some types of coordinate reference system may be dynamic. A CRS is dynamic if its reference frame is dynamic. For a dynamic CRS the WKT for the dynamic attributes as described below is embedded within the CRS definition (clauses 8 and 10).

In a dynamic CRS the coordinate values of a point on or near the surface of the Earth change with time. When a coordinate set is referenced to a dynamic CRS, to be unambiguous the coordinate set needs to additionally be referenced to a coordinate epoch. The WKT for coordinate epoch is described in clause 16.

Requirement: The WKT representation of the dynamic attributes of a dynamic coordinate reference system shall be:

<dynamic crs>	::=	<dynamic crs keyword> <left delimiter> <frame reference epoch> [<wkt separator> <deformation model ID>] <right delimiter>
<dynamic crs keyword>	::=	DYNAMIC
<frame reference epoch>	::=	<frame reference epoch keyword> <left delimiter> <reference epoch> <right delimiter> <i>!! Used when the CRS has a dynamic reference frame.</i>
<frame reference epoch keyword>	::=	FRAMEEPOCH
<reference epoch>	::=	<unsigned integer> [<period> [<unsigned integer>]] <i>!! See 6.3.2</i>
<deformation model ID>	::=	<deformation model ID keyword> <left delimiter> <deformation model name> [{ <wkt separator> <identifier> }]... <right delimiter> <i>!! Used when the CRS is associated with a deformation model or velocity grid. A full description may be given separately - see clause 18. A full description of the deformation model shall not be embedded within the CRS WKT.</i>

<deformation model ID keyword> ::= MODEL | VELOCITYGRID
!! In this document for brevity the preferred keyword is MODEL. VELOCITYGRID is permitted. Implementations should be prepared to read both forms.
Note that MODEL when used for a deformation model should not be confused with the reference to a geoid model for a geoid-based vertical CRS, for which the keyword is GEOIDMODEL: see clause 10.

<deformation model name> ::= <quoted Latin text> *!! See 7.2*

EXAMPLE 1 CRS with dynamic reference frame.
 DYNAMIC[FRAMEEPOCH[2010.0]]

EXAMPLE 2 CRS with dynamic reference frame and deformation model.
 DYNAMIC[FRAMEEPOCH[2010.0],MODEL["NAD83(CSRs)v6 velocity grid"]]

8 WKT representation of geodetic and geographic coordinate reference systems

8.1 Overview

Requirement: The WKT representation of a geodetic or a geographic coordinate reference system shall be:

<geodetic crs>	::=	<static geodetic crs> <dynamic geodetic crs> <geographic crs>
<geographic crs>	::=	<static geographic crs> <dynamic geographic crs>
<static geodetic crs>	::=	<geodetic crs keyword> <left delimiter> <crs name> <wkt separator> { <geodetic reference frame> <geodetic datum ensemble> } <wkt separator> <coordinate system> <scope extent identifier remark> <right delimiter>
<dynamic geodetic crs>	::=	<geodetic crs keyword> <left delimiter> <crs name> <wkt separator> <dynamic crs> <wkt separator> <geodetic reference frame> <wkt separator> <coordinate system> <scope extent identifier remark> <right delimiter>
<static geographic crs>	::=	<geographic crs keyword> <left delimiter> <crs name> <wkt separator> { <geodetic reference frame> <geodetic datum ensemble> } <wkt separator> <coordinate system> <scope extent identifier remark> <right delimiter>
<dynamic geographic crs>	::=	<geographic crs keyword> <left delimiter> <crs name> <wkt separator> <dynamic crs> <wkt separator> <geodetic reference frame> <wkt separator> <coordinate system> <scope extent identifier remark> <right delimiter>
<geodetic crs keyword>	::=	GEODCRS GEODETICCRS <i>!! The <geodetic crs keyword> should be used when the CRS's coordinate system type is either Cartesian or spherical: see 8.3 and 7.5. In this document for brevity the preferred keyword is GEODCRS. GEODETICCRS is permitted. Implementations should be prepared to read both forms.</i>
<geographic crs keyword>	::=	GEOGCRS GEOGRAPHICCRS <i>!! The <geographic crs keyword> should be used when the CRS's coordinate system type is ellipsoidal: see 8.3 and 7.5. In this document for brevity the preferred keyword is GEOGCRS. GEOGRAPHICCRS is permitted. Implementations should be prepared to read both forms.</i>
<crs name>	::=	<quoted Latin text> !! See 7.2

<dynamic crs> is described in 7.7. It is mandatory when the geodetic CRS or geographic CRS is dynamic, and shall not be given when the geodetic CRS or geographic CRS is static.

<geodetic datum ensemble> is described in 7.6, <scope extent identifier remark> is described in 7.3.

8.2 Geodetic reference frame (geodetic datum)

8.2.1 Ellipsoid

The `<ellipsoid>` object is an attribute of `<geodetic reference frame>`. It is not used with other types of datum.

Requirement: The WKT representation of an oblate ellipsoid shall be:

```

<ellipsoid> ::= <ellipsoid keyword> <left delimiter> <ellipsoid name>
               <wkt separator> <semi-major axis>
               <wkt separator> <inverse flattening>
               [ <wkt separator> <length unit> ]
               [ { <wkt separator> <identifier> } ]... <right delimiter>

```

```
<ellipsoid keyword> ::= ELLIPSOID | SPHEROID
    !! In this document the preferred keyword is
    ELLIPSOID. SPHEROID is permitted for backward
    compatibility. Implementations should be prepared to
    read both forms.
```

<ellipsoid name> ::= **<quoted Latin text>** *!! See 7.2*

```
<semi-major axis> ::= <unsigned numeric literal>      !! See below for constraint
```

```
<inverse flattening> ::= <unsigned numeric literal>      !! See below for constraint
```

ISO 19111 allows an oblate ellipsoid to be defined through semi-major axis (a) and either semi-minor axis (b) or inverse flattening (1/f). If semi-minor axis is used as the second defining parameter the value for inverse flattening to be shown in the WKT string should be calculated from $1/f = a / (a - b)$.

ISO 19111 also allows for the earth model to be a sphere, for which $1/f$ is infinite. In this document if the earth model is a sphere <inverse flattening> shall be given an artificial value of zero.

Requirements:

- a) The WKT representation of a sphere shall have an <inverse flattening> value of 0.
- b) <length unit> is an optional attribute, optional for reasons of backward compatibility, but it is recommended that it is explicitly included in WKT strings. Its <conversion factor> shall be to metres and is the number of metres per unit. <length unit> is described in 7.4. If it is omitted then the value for the length of the semi-axis or -axes shall be given in metres. Conversely, if it is omitted then the value for the semi-major axis shall be assumed to be in metres.

Note: In the WKT for a geodetic, geographic or projected CRS, the length unit for the ellipsoid may differ from the length unit for the coordinate system. The units in which coordinates are expressed are given by the CS element.

Examples of WKT describing an ellipsoid:

```
EXAMPLE 1 ELLIPSOID["GRS 1980",6378137,298.257222101,LENGTHUNIT["metre",1.0]]
```

EXAMPLE 2 (unit = metre is implied)
SPHEROID["GRS 1980",6378137.0,298.257222101]

```
EXAMPLE 3    ELLIPSOID["Clark 1866",20925832.164,294.97869821,  
              LENGTHUNIT["US survey foot",0.304800609601219]]
```

EXAMPLE 4 ELLIPSOID["Sphere",6371000,0,LENGTHUNIT["metre",1.0]]

The definition of WKT for a triaxial ellipsoid required for planetary mapping is given in Annex E.

8.2.2 Prime meridian

The prime meridian is the meridian with a value of zero longitude. The prime meridian is usually defined to be the international reference meridian which for the Earth passes near Greenwich, but this may not always be the case. The <prime meridian> object is conditional.

Requirements:

- a) Prime meridian shall not be given for any type of datum and CRS other than geodetic reference frame.

NOTE For projected CRSs the prime meridian is inherited through the base geodetic CRS.

- b) Prime meridian shall be given if the CRS type is geodetic or geographic and the prime meridian is not the international reference meridian. It may be given if the CRS type is geodetic or geographic and the prime meridian is the international reference meridian.
- c) Conversely if the CRS type is geodetic or geographic and prime meridian is not given, the prime meridian shall be assumed to be the international reference meridian.
- d) If the prime meridian's angle unit is omitted, the IRM longitude value shall be in the angular unit of the CRS containing the prime meridian when the CRS has an ellipsoidal CS, else it shall be in decimal degrees.
- e) The WKT representation of a prime meridian shall be:

```
<prime meridian> ::= <prime meridian keyword> <left delimiter>
                    <prime meridian name> <wkt separator> <irm longitude>
                    [ { <wkt separator> <identifier> } ]... <right delimiter>

<prime meridian keyword> ::= PRIMEM | PRIMEMERIDIAN
    !! In this document the preferred keyword is
    PRIMEM for backward compatibility. PRIMEMERIDIAN
    is permitted. Implementations should be prepared
    to read both forms.

<prime meridian name> ::= <quoted Latin text>                !! See 7.2

<irm longitude> ::= <signed numeric literal> [ <wkt separator> <angle unit> ]
    !! If <angle unit> is omitted, the <signed numeric
    literal> value must be in the CRS's CS angular
    unit if available, else in decimal degrees.
```

<irm longitude> is the longitude of the prime meridian measured from the international reference meridian, positive eastward.

<angle unit> is an optional attribute, optional for reasons of backward compatibility, but best practice is that it is included in WKT strings. If it is omitted then the value for <irm longitude> shall be given in the CRS's <cs unit> where this is angular, else in decimal degrees. If the subtype of the geodetic CRS to which the prime meridian is an attribute is geographic, the prime meridian's <irm longitude> value shall be given in the same angular units as those for the horizontal axes of the geographic CRS; if the geodetic CRS subtype is geocentric the prime meridian's <irm longitude> value shall be given in degrees. Its <conversion factor> shall be to radians and is the number of radians per unit. <angle unit> is described in 7.4.

Examples of WKT describing a prime meridian:

EXAMPLE 1 PRIMEM["Paris",2.5969213,ANGLEUNIT["grad",0.015707963267949]]

EXAMPLE 2 PRIMEM["Ferro",-17.6666667]
(unit unspecified so it takes <cs unit> if angular, else decimal degrees)

EXAMPLE 3 PRIMEM["Greenwich",0.0, ANGLEUNIT["degree",0.0174532925199433]]

NOTE: When the prime meridian name is "Greenwich" or the longitude of the international reference meridian in the geodetic CRS is zero, the inclusion of the prime meridian object in a WKT string is optional, so this example string should not normally be present. It is included here for backward compatibility reasons as the prime meridian object was mandatory in earlier CRS WKT specifications.

8.2.3 Geodetic reference frame (datum)

In this document a geodetic reference frame is either a modern *terrestrial reference frame* or a classical *geodetic datum*. For backward compatibility and to assist modular programming of different types of CRS, in this document 'datum' is retained in the WKT.

Geodetic reference frames are either static or dynamic. If the reference frame is dynamic all CRSs based on it are dynamic CRSs. The *frame reference epoch* attribute is then required. However a geodetic or geographic CRS may also be associated with a deformation model. In this document the *frame reference epoch* attribute of a dynamic reference frame is treated with the deformation model at the CRS level as described in 7.7 and 8.1.

Requirement: The WKT representation of a geodetic reference frame (geodetic datum) shall be:

<code><geodetic reference frame></code>	<code>::=</code>	<code><geodetic reference frame keyword></code> <code><left delimiter> <datum name> <wkt separator></code> <code><ellipsoid> [<wkt separator> <datum anchor>]</code> <code>[{ <wkt separator> <identifier> }]... <right delimiter></code> <code>[{ <wkt separator> <prime meridian> }]</code>
<code><geodetic reference frame keyword></code>	<code>::=</code>	DATUM TRF GEODETICDATUM <i>!! In this document for compatibility with previous versions of WKT the preferred keyword is DATUM, TRF is also permitted (see B.2.2 for additional comment). For consistency with the other datum types described in Clauses 10 to 13 either GEODETICDATUM or TRF is permitted. Implementations should be prepared to read all three forms.</i>
<code><datum name></code>	<code>::=</code>	<code><quoted Latin text></code> <i>!! See 7.2</i>
<code><datum anchor></code>	<code>::=</code>	<code><datum anchor keyword> <left delimiter></code> <code><datum anchor description> <right delimiter></code>
<code><datum anchor keyword></code>	<code>::=</code>	ANCHOR
<code><datum anchor description></code>	<code>::=</code>	<code><quoted Latin text></code>

`<geodetic reference frame>` is used when the CRS type is geodetic or geographic. For a projected CRS, the geodetic reference frame (datum) is included in the Base Geodetic CRS, see Clause 9.

`<ellipsoid>` is described in 8.2.1.

`<prime meridian>` is a conditional attribute; see 8.2.2. Following the data model of ISO 19111 it would be nested within the geodetic reference frame object. In this document its nesting follows previous versions of CRS WKT.

EXAMPLE 1 DATUM["North American Datum 1983",
ELLIPSOID["GRS 1980",6378137,298.257222101,LENGTHUNIT["metre",1.0]]
]

EXAMPLE 2 `TRF["World Geodetic System 1984",
 ELLIPSOID["WGS 84",6378388.0,298.257223563,LENGTHUNIT["metre",1.0]]
],
 PRIMEM["Greenwich",0.0]`

NOTE When the prime meridian name is "Greenwich" or the longitude of the IRM meridian in the geodetic CRS is zero, the inclusion of the prime meridian object in a WKT string is optional, so this example string can omit the prime meridian object, as shown in Example 1.

EXAMPLE 3 `GEODETICDATUM["Tananarive 1925",
 ELLIPSOID["International 1924",6378388.0,297.0,LENGTHUNIT["metre",1.0]]
],
 ANCHOR["Tananarive observatory:21.0191667gS, 50.23849537gE of Paris"]
],
 PRIMEM["Paris",2.5969213,ANGLEUNIT["grad",0.015707963267949]]`

8.3 Coordinate systems for geodetic and geographic CRSs

<coordinate system> is described in 7.5. Several constraints and recommendations for coordinate systems used in geodetic and geographic CRSs are described there. These include the requirement for

- a geodetic CRS to contain either a 3D Cartesian or a 3D spherical coordinate system, and
- a geographic CRS to contain an ellipsoidal coordinate system, either 2D or 3D.

The previous version of this document did not distinguish between geodetic CRS and geographic CRS, and a geodetic CRS could have an ellipsoidal coordinate system. Implementations should be prepared to read a WKT string for a geodetic CRS which includes an ellipsoidal coordinate system. Implementations in conformance with this document should not write geodetic CRSs containing an ellipsoidal coordinate system.

8.4 Examples of WKT describing a geodetic or geographic CRS

EXAMPLE 1 Static geodetic CRS with Cartesian coordinate system and including scope, extent, ID and remarks

```
GEODCRS["JGD2000",
  DATUM["Japanese Geodetic Datum 2000",
    ELLIPSOID["GRS 1980",6378137,298.257222101]
  ],
  CS[Cartesian,3],
  AXIS["(X)",geocentricX],
  AXIS["(Y)",geocentricY],
  AXIS["(Z)",geocentricZ],
  LENGTHUNIT["metre",1.0],
  USAGE[SCOPE["Geodesy, topographic mapping and cadastre"],
    AREA["Japan"],
    BBOX[17.09,122.38,46.05,157.64],
    TIMEEXTENT[2002-04-01,2011-10-21]
  ],
  ID["EPSG",4946,URI["urn:ogc:def:crs:EPSG::4946"]],
  REMARK["注：JGD2000 ジオセントリックは現在 JGD2011 に代わりました。"]
]
```

Non-Latin characters may only be included within remarks (see 7.3.4).

EXAMPLE 2 Dynamic geographic CRS with ellipsoidal 3D coordinate system, no optional attributes

```

GEOGCRS["WGS 84 (G1762)",
  DYNAMIC[FRAMEEPOCH[2005.0]],
  TRF["World Geodetic System 1984 (G1762)",
    ELLIPSOID["WGS 84",6378137,298.257223563,LENGTHUNIT["metre",1.0]
  ]
],
  CS[ellipsoidal,3],
  AXIS["(lat)",north,ANGLEUNIT["degree",0.0174532925199433]],
  AXIS["(lon)",east,ANGLEUNIT["degree",0.0174532925199433]],
  AXIS["ellipsoidal height (h)",up,LENGTHUNIT["metre",1.0]]
]

```

EXAMPLE 3 Static geographic CRS with IRM as prime meridian and ellipsoidal 2D coordinate system in degrees

```

GEOGRAPHICCRS["NAD83",
  DATUM["North American Datum 1983",
    ELLIPSOID["GRS 1980",6378137,298.257222101,LENGTHUNIT["metre",1.0]]
  ],
  CS[ellipsoidal,2],
  AXIS["latitude",north],
  AXIS["longitude",east],
  ANGLEUNIT["degree",0.017453292519943],
  ID["EPSG",4269],
  REMARK["1986 realisation"]
]

```

EXAMPLE 4 Static geographic CRS with prime meridian other than IRM and ellipsoidal 2D coordinate system in grads

```

GEOGCRS["NTF (Paris)",
  DATUM["Nouvelle Triangulation Francaise",
    ELLIPSOID["Clarke 1880 (IGN)",6378249.2,293.4660213]
  ],
  PRIMEM["Paris",2.5969213],
  CS[ellipsoidal,2],
  AXIS["latitude",north,ORDER[1]],
  AXIS["longitude",east,ORDER[2]],
  ANGLEUNIT["grad",0.015707963267949],
  REMARK["Nouvelle Triangulation Française"]
]

```

Non-Latin1 characters may only be included within remarks (see 7.3.4).

9 WKT representation of projected CRSs

9.1 Overview

A projected CRS is a special case of a derived CRS. Because of its importance to geographic information and particularly for backward compatibility reasons necessitating a different string structure it is treated separately from the general case described in Clause 14. The structures of WKT strings for principal and derived CRSs are compared in 14.1, to which the reader is referred.

Requirement: The WKT representation of a projected coordinate reference system shall be:

```

<projected crs> ::= <projected crs keyword> <left delimiter> <crs name>
                  <wkt separator> <base geodetic crs>
                  <wkt separator> <map projection>
                  <wkt separator> <coordinate system>
                  <scope extent identifier remark> <right delimiter>

<projected crs keyword> ::= PROJCRS | PROJECTEDCRS
                          !! In this document for brevity the preferred
                          keyword is PROJCRS. PROJECTEDCRS is permitted.
                          Implementations should be prepared to read both
                          forms.

<crs name> ::= <quoted Latin text>                                !! See 7.2

```

9.2 Base CRS

9.2.1 General

The base CRS for a projected CRS may be either a geodetic CRS or (more usually) a geographic CRS. A geographic 2D CRS may act as the base CRS for only another 2D CRS.

Requirement: The dimension of a derived CRS shall be equal to or less than the dimension of its base CRS.

Requirement: The WKT representation of a projected coordinate reference system's base CRS shall be:

```

<base geodetic crs> ::= <base static geodetic crs> | <base dynamic geodetic crs>
                      <base static geographic crs> | <base dynamic geographic
                      crs>
                      !! The projected CRS takes its static/dynamic
                      status from its base CRS.

<base static geodetic crs> ::= <base geodetic crs keyword> <left delimiter>
                              <base crs name> <wkt separator>
                              { <geodetic reference frame> | <geodetic datum ensemble> }
                              [ <wkt separator> <ellipsoidal cs unit> ]
                              [ { <wkt separator> <identifier> } ]... <right delimiter>

<base dynamic geodetic crs> ::= <base geodetic crs keyword> <left delimiter>
                              <base crs name> <wkt separator> <dynamic crs>
                              <wkt separator> <geodetic reference frame>
                              [ <wkt separator> <ellipsoidal cs unit> ]
                              [ { <wkt separator> <identifier> } ]... <right delimiter>

```

<base static geographic crs>	::=	<base geographic crs keyword> <left delimiter> <base crs name> <wkt separator> { <geodetic reference frame> <geodetic datum ensemble> } [{ <wkt separator> <ellipsoidal cs unit> }] [{ <wkt separator> <identifier> }]... <right delimiter>
<base dynamic geographic crs>	::=	<base geographic crs keyword> <left delimiter> <base crs name> <wkt separator> <dynamic crs> <wkt separator> <geodetic reference frame> [{ <wkt separator> <ellipsoidal cs unit> }] [{ <wkt separator> <identifier> }]... <right delimiter>
<base geodetic crs keyword>	::=	BASEGEODCRS
<base geographic crs keyword>	::=	BASEGEOGCRS <i>!! In this document the base CRS keyword should reflect the type of CRS (geodetic or geographic) upon which the projected CRS is referenced. Usually this will be BASEGEOGCRS. The previous version of this document used only BASEGEODCRS. Implementations should be prepared to read both forms.</i>
<base crs name>	::=	<quoted Latin text> !! See 7.2
<ellipsoidal cs unit>	::=	<angle unit>

<dynamic crs> is described in 7.7. It is mandatory when the base CRS is dynamic and should not be given when the base CRS is static. The projected CRS has the same static/dynamic status as its base CRS.

<geodetic reference frame> is described in 8.2. It includes ellipsoid and prime meridian descriptions. <geodetic datum ensemble> is described in 7.6.

NOTE Constructs similar to <base static geodetic crs>, <base dynamic geodetic crs>, <base static geographic crs> and <base dynamic geographic crs> but excluding the <ellipsoidal cs unit> element are also used for derived geodetic and derived geographic CRSs, see 14.3.

9.2.2 Ellipsoidal CS unit

The base geographic CRS <ellipsoidal cs unit> is that in which geodetic latitude and longitude would be quoted in the geographic CRS. It is defined as an optional attribute for backward compatibility reasons (see 9.3).

<angle unit> is described in 7.4.

Requirement: The <ellipsoidal cs unit> of the base geographic CRS shall be included in projected CRS WKT strings when the units of the map projection angular parameters are not explicitly given within those parameters.

Recommendation: The units of the map projection angular parameters should be explicitly included in the projected CRS WKT string and when this is done the <ellipsoidal cs unit> of the base geographic CRS should not be included in the string.

9.3 Map projection

9.3.1 Introduction

Map projection is a deriving conversion (see 14.2). By definition the source CRS is the base geodetic or geographic CRS and the target CRS is projected CRS; these are therefore implied rather than explicitly stated in the WKT string. Additionally, for reasons of backward compatibility, in map projections the parameter units may be implied; map projection is therefore a specialised subset of deriving conversion.

Requirement: The WKT representation of a map projection shall be:

<map projection>	::=	<map projection keyword> <left delimiter> <map projection name> <wkt separator> <map projection method> [{ <wkt separator> <map projection parameter> }]... [{ <wkt separator> <identifier> }]... <right delimiter>
<map projection keyword>	::=	CONVERSION
<map projection name>	::=	<quoted Latin text> <i>!! See 7.2</i>
<map projection method>	::=	<map projection method keyword> <left delimiter> <map projection method name> [{ <wkt separator> <identifier> }]... <right delimiter>
<map projection method keyword>	::=	METHOD PROJECTION <i>!! In this document the preferred keyword is METHOD. PROJECTION is permitted for backward compatibility. Implementations should be prepared to read both forms.</i>
<map projection method name>	::=	<quoted Latin text> <i>!! See 7.2</i>
<map projection parameter>	::=	<parameter keyword> <left delimiter> <parameter name> <wkt separator> <parameter value> [<wkt separator> <map projection parameter unit>] [{ <wkt separator> <identifier> }]... <right delimiter>
<parameter keyword>	::=	PARAMETER
<parameter name>	::=	<quoted Latin text> <i>!! See 7.2</i>
<parameter value>	::=	<signed numeric literal>
<map projection parameter unit>	::=	<length unit> <angle unit> <scale unit> <i>!! See 9.3.4 for constraints</i>

EXAMPLE 1 Identifier given for the method and each parameter.

```

CONVERSION["UTM zone 10N",
  METHOD["Transverse Mercator",ID["EPSG",9807]],
  PARAMETER["Latitude of natural origin",0,
    ANGLEUNIT["degree",0.0174532925199433],
    ID["EPSG",8801]],
  PARAMETER["Longitude of natural origin",-123,
    ANGLEUNIT["degree",0.0174532925199433],ID["EPSG",8802]],
  PARAMETER["Scale factor at natural origin",0.9996,
    SCALEUNIT["unity",1.0],ID["EPSG",8805]],
  PARAMETER["False easting",500000,
    LENGTHUNIT["metre",1.0],ID["EPSG",8806]],
  PARAMETER["False northing",0,LENGTHUNIT["metre",1.0],ID["EPSG",8807]]
]

```

EXAMPLE 2 Identifier given for conversion as a whole.

```

CONVERSION["UTM zone 10N",
  METHOD["Transverse Mercator"],
  PARAMETER["Latitude of natural origin",0,
    ANGLEUNIT["degree",0.0174532925199433]],
  PARAMETER["Longitude of natural origin",-123,
    ANGLEUNIT["degree",0.0174532925199433]],
  PARAMETER["Scale factor at natural origin",0.9996,
    SCALEUNIT["unity",1.0]],
  PARAMETER["False easting",500000,LENGTHUNIT["metre",1.0]],
  PARAMETER["False northing",0,LENGTHUNIT["metre",1.0]],
  ID["EPSG",16010]
]

```

Further examples are included in 9.5.

9.3.2 Map projection name and identifier

Map projection (zone) encompasses the collection of method and parameter values. Its name is for human readability. Depending upon the naming convention in use it may also be included as part of the projected CRS name.

<identifier> is described in 7.3.4. It is an optional attribute. If an identifier is provided as an attribute within the <map projection conversion> object, because it is expected to describe a complete collection of zone name, method, parameters and parameter values, it shall override any identifiers given within the map projection method and map projection parameter objects.

9.3.3 Map projection method

Method name is for human readability. For interoperability it is the method formula that is critical in determining the equivalence of methods; this may be given through a map projection method <identifier>.

<identifier> is described in 7.3.4. It is an optional attribute. However if an identifier is included as an attribute within the <map projection> object (9.3.1), it will take precedence over any identifier within the map projection method object.

If a map projection method <identifier> is not given, the WKT description is potentially ambiguous, relying on interpretation of method name. It is recommended that a map projection identifier or a map projection method identifier is included in WKT strings. Identifiers for commonly encountered map projection methods are given in F.2.

9.3.4 Map projection parameter

Parameter name is for human readability. For interoperability it is the method formula and its parameters that are critical in determining the equivalence of methods. See Annex F. Identifiers for commonly encountered map projection methods are given in F.2; their parameters are listed in F.3.

The map projection parameters required are specific to the map projection method and will be listed sequentially. The order within the sequence is not significant but should be logical.

<map projection parameter unit> is an optional attribute, for reasons of backward compatibility. Best practice is that it is included explicitly in WKT strings.

Requirements: If <map projection parameter unit> is omitted from <map projection parameter> then:

- a) Map parameter values that are lengths shall be given in metres.
- b) Map projection parameter values that are angles shall be given in decimal degrees.
- c) Map projection parameters that are unitless (for example scale factor) shall be given as a number which is close to or is unity (1.0).

Note: The original parameter values can be in units other than metres, degrees and unity. For this reason best practice is that units are not omitted.

The parameter unit type is included in F.3.

<identifier> is described in 7.3.4. It is an optional attribute. If an identifier is included as an attribute within the *map projection conversion* object (9.3.1) or *map projection method* object (9.3.3), it will take precedence over any identifier within the map projection parameter object.

9.4 Coordinate systems for projected CRSs

<coordinate system> is described in 7.5. Several constraints and recommendations for coordinate systems used in projected CRSs are described there. These include the requirement for a projected CRS to contain a Cartesian coordinate system.

9.5 Examples of WKT describing a projected CRS

EXAMPLE 1 PROJCRS["ETRS89 Lambert Azimuthal Equal Area CRS",
 BASEGEOGCRS["ETRS89",
 DATUM["ETRS89",
 ELLIPSOID["GRS 80",6378137,298.257222101,LENGTHUNIT["metre",1.0]]
],ID["EuroGeographics","ETRS89-LatLon"]
],
 CONVERSION["LAEA",
 METHOD["Lambert Azimuthal Equal Area",ID["EPSG",9820]],
 PARAMETER["Latitude of origin",52.0,
 ANGLEUNIT["degree",0.0174532925199433]],
 PARAMETER["Longitude of origin",10.0,
 ANGLEUNIT["degree",0.0174532925199433]],
 PARAMETER["False easting",4321000.0,LENGTHUNIT["metre",1.0]],
 PARAMETER["False northing",3210000.0,LENGTHUNIT["metre",1.0]]
],
 CS[Cartesian,2],
 AXIS["(Y)",north,ORDER[1]],
 AXIS["(X)",east,ORDER[2]],
 LENGTHUNIT["metre",1.0],
 USAGE[SCOPE["Description of a purpose"],AREA["An area description"]],
 ID["EuroGeographics","ETRS-LAEA"]
]

EXAMPLE 2 PROJCRS["NAD27 / Texas South Central",
 BASEGEOGCRS["NAD27",
 DATUM["North American Datum 1927",
 ELLIPSOID["Clarke 1866",20925832.164,294.97869821,
 LENGTHUNIT["US survey foot",0.304800609601219]]
],
],
 CONVERSION["Texas South Central SPCS27",
 METHOD["Lambert Conic Conformal (2SP)",ID["EPSG",9802]],
 PARAMETER["Latitude of false origin",27.83333333333333,
 ANGLEUNIT["degree",0.0174532925199433],ID["EPSG",8821]],
 PARAMETER["Longitude of false origin",-99.0,
 ANGLEUNIT["degree",0.0174532925199433],ID["EPSG",8822]],
 PARAMETER["Latitude of 1st standard parallel",28.38333333333333,
 ANGLEUNIT["degree",0.0174532925199433],ID["EPSG",8823]],
 PARAMETER["Latitude of 2nd standard parallel",30.28333333333333,
 ANGLEUNIT["degree",0.0174532925199433],ID["EPSG",8824]],
 PARAMETER["Easting at false origin",2000000.0,
 LENGTHUNIT["US survey foot",0.304800609601219],ID["EPSG",8826]],
 PARAMETER["Northing at false origin",0.0,
 LENGTHUNIT["US survey foot",0.304800609601219],ID["EPSG",8827]]
],
 CS[Cartesian,2],
 AXIS["(X)",east],
 AXIS["(Y)",north],
 LENGTHUNIT["US survey foot",0.304800609601219],
 REMARK["Fundamental point: Meade's Ranch KS, latitude 39°13'26.686\"N,
 longitude 98°32'30.506\"W."]
]

EXAMPLE 3 This example is included for backwards compatibility to show the implicit description of parameter units. It is recommended that units are explicitly given in the string, as in the previous two examples.

```
PROJCRS["NAD83 UTM 10",
  BASEGEOGCRS["NAD83(86)",
    DATUM["North American Datum 1983",
      ELLIPSOID["GRS 1980",6378137,298.257222101]], (default length unit is metre)
      PRIMEM["Greenwich",0]], (implied angle unit is degree)
    CONVERSION["UTM zone 10N",
      METHOD["Transverse Mercator"],
      PARAMETER["Latitude of natural origin",0.0], (implied angle unit is degree)
      PARAMETER["Longitude of natural origin",-123.0], (implied angle unit is degree)
      PARAMETER["Scale factor",0.9996], (implied scale unit is unity)
      PARAMETER["False easting",500000.0], (implied length unit is degree)
      PARAMETER["False northing",0.0], (implied length unit is degree)
      ID["EPSG",16010]],
    CS[Cartesian,2],
      AXIS["(E)",east,ORDER[1]],
      AXIS["(N)",north,ORDER[2]],
      LENGTHUNIT["metre",1.0],
    REMARK["In this example parameter value units are not given. This is allowed
      for backward compatibility. However it is strongly recommended that units are
      explicitly given in the string, as in the previous two examples."]]
```

EXAMPLE 4 3D Projected CRS

```
PROJCRS["WGS 84 (G1762) / UTM zone 31N 3D",
  BASEGEOGCRS["WGS 84",
    DATUM["World Geodetic System of 1984 (G1762)",
      ELLIPSOID["WGS 84",6378137,298.257223563,LENGTHUNIT["metre",1.0]]
    ]
  ],
  CONVERSION["UTM zone 31N 3D",
    METHOD["Transverse Mercator (3D)"],
    PARAMETER["Latitude of origin",0.0,
      ANGLEUNIT["degree",0.0174532925199433]],
    PARAMETER["Longitude of origin",3.0,
      ANGLEUNIT["degree",0.0174532925199433]],
    PARAMETER["Scale factor",0.9996,SCALEUNIT["unity",1.0]],
    PARAMETER["False easting",500000.0,LENGTHUNIT["metre",1.0]],
    PARAMETER["False northing",0.0,LENGTHUNIT["metre",1.0]]
  ],
  CS[Cartesian,3],
    AXIS["(E)",east,ORDER[1]],
    AXIS["(N)",north,ORDER[2]],
    AXIS["ellipsoidal height (h)",up,ORDER[3]],
    LENGTHUNIT["metre",1.0]
  ]
```


10 WKT representation of vertical CRSs

10.1 Overview

Requirement: The WKT representation of a vertical coordinate reference system shall be:

<vertical crs>	::=	<static vertical crs> <dynamic vertical crs>
<static vertical crs>	::=	<vertical crs keyword> <left delimiter> <crs name> <wkt separator> { <vertical reference frame> <vertical datum ensemble> } <wkt separator> <coordinate system> [<wkt separator> <geoid model ID>] <scope extent identifier remark> <right delimiter>
<dynamic vertical crs>	::=	<vertical crs keyword> <left delimiter> <crs name> <wkt separator> <dynamic crs> <wkt separator> <vertical reference frame> <wkt separator> <coordinate system> [<wkt separator> <geoid model ID>] <scope extent identifier remark> <right delimiter>
<geoid model ID>	::=	<geoid model keyword> <left delimiter> <geoid model name> [<wkt separator> <identifier>] <right delimiter> <i>!! This information identifies the geoid model for a geoid-based vertical CRS. A full description may be given separately - see clause 17. A full description of the geoid model shall not be embedded within the vertical CRS WKT.</i>
<geoid model ID keyword>	::=	GEOIDMODEL
<geoid model name>	::=	<quoted Latin text> <i>!! See 7.2</i>
<vertical crs keyword>	::=	VERTCRS VERTICALCRS <i>!! In this document for brevity the preferred keyword is VERTCRS. VERTICALCRS is permitted. Implementations should be prepared to read both forms.</i>
<crs name>	::=	<quoted Latin text> <i>!! See 7.2</i>

<dynamic crs> is described in 7.7. It is mandatory when the vertical CRS is dynamic, and shall not be given when the vertical CRS is static.

<vertical datum ensemble> is described in 7.6, <scope extent identifier remark> is described in 7.3.

10.2 Vertical reference frame (vertical datum)

Modern geodetic terminology is to use the term *vertical reference frame*. Previous versions of this document used *vertical datum*. For backward compatibility and to assist modular programming of different types of CRS, in this document 'datum' is retained in the WKT.

Vertical reference frames are either static or dynamic. If the reference frame is dynamic all CRSs based on it are dynamic CRSs. In this document the *frame reference epoch* attribute of a dynamic vertical reference frame is treated at the CRS level as described in 7.7 and 10.1.

Requirement: The WKT representation of a vertical reference frame (vertical datum) shall be:

```

<vertical reference frame>          ::= <vertical reference frame keyword> <left delimiter>
                                     <datum name> [ <wkt separator> <datum anchor> ]
                                     [ { <wkt separator> <identifier> } ]... <right delimiter>

<vertical reference frame keyword> ::= VDATUM | VRF | VERTICALDATUM
                                     !! In this document for consistency with other
                                     datum types described in this document the
                                     preferred keyword is VDATUM, but either VRF or
                                     VERTICALDATUM is permitted. Implementations
                                     should be prepared to read all three forms.
                                     See B.2.2 for additional comment.

<datum name>                       ::= <quoted Latin text>                      !! See 7.2

<datum anchor>                     ::= <datum anchor keyword> <left delimiter>
                                     <datum anchor description> <right delimiter>

<datum anchor keyword>              ::= ANCHOR

<datum anchor description>          ::= <quoted Latin text>

```

EXAMPLE 1 VDATUM["Newlyn"]

EXAMPLE 2 VERTICALDATUM["Newlyn",ANCHOR["Mean Sea Level 1915 to 1921."]]

10.3 Vertical coordinate system

<coordinate system> is described in 7.5. Several constraints and recommendations for coordinate systems used in vertical CRSs are described there. These include the requirement for a vertical CRS to contain a vertical coordinate system.

10.4 Example of WKT describing a vertical CRS

EXAMPLE 1 Static vertical CRS

```

VERTCRS["NAVD88",
        VDATUM["North American Vertical Datum 1988"],
        CS[vertical,1],
        AXIS["gravity-related height (H)",up],
        LENGTHUNIT["metre",1.0]
]

```

EXAMPLE 2 Static geoid-based vertical CRS

```

VERTCRS["CGVD2013",
        VRF["Canadian Geodetic Vertical Datum of 2013"],
        CS[vertical,1],
        AXIS["gravity-related height (H)",up],
        LENGTHUNIT["metre",1.0],
        GEOIDMODEL["CGG2013",ID["EPSG",6648]]
]

```

EXAMPLE 3 Dynamic vertical CRS

```

VERTCRS["RH2000",
        DYNAMIC[FRAMEEPOCH[2000.0],MODEL["NKG2016LU"]],
        VDATUM["Rikets Hojdsystem 2000"],
        CS[vertical,1],
        AXIS["gravity-related height (H)",up],
        LENGTHUNIT["metre",1.0]
]

```

11 WKT representation of engineering CRSs

11.1 Overview

Requirement: The WKT representation of an engineering coordinate reference system shall be:

```

<engineering crs> ::= <engineering crs keyword> <left delimiter> <crs name>
                    <wkt separator> <engineering datum>
                    <wkt separator> <coordinate system>
                    <scope extent identifier remark> <right delimiter>

<engineering crs keyword> ::= ENGCRS | ENGINEERINGCRS
    !! In this document for brevity the preferred
    keyword is ENGCRS. ENGINEERINGCRS is permitted.
    Implementations should be prepared to read both
    forms.

<crs name> ::= <quoted Latin text> !! See 7.2

```

<scope extent identifier remark> is described in 7.3.

11.2 Engineering datum

Requirement: The WKT representation of an engineering datum shall be:

```

<engineering datum> ::= <engineering datum keyword> <left delimiter> <datum name>
                        [ <wkt separator> <datum anchor> ]
                        [ { <wkt separator> <identifier> } ]... <right delimiter>

<engineering datum keyword> ::= EDATUM | ENGINEERINGDATUM
    !! In this document for brevity the preferred
    keyword is EDATUM, but ENGINEERINGDATUM is
    permitted. Implementations should be prepared to
    read both forms.

<datum name> ::= <quoted Latin text> !! See 7.2

<datum anchor> ::= <datum anchor keyword> <left delimiter>
                  <datum anchor description> <right delimiter>

<datum anchor keyword> ::= ANCHOR

<datum anchor description> ::= <quoted Latin text>

```

11.3 Coordinate systems for engineering CRSs

<coordinate system> is described in 7.5. Several constraints and recommendations for coordinate systems used in engineering CRSs are described there. These include the requirement for an engineering CRS to contain an affine, Cartesian, cylindrical, linear, ordinal, polar or spherical coordinate system.

11.4 Examples of WKT describing an engineering CRS

EXAMPLE 1 `ENGCRS["A construction site CRS",
EDATUM["P1",ANCHOR["Peg in south corner"]],
CS[Cartesian,2],
 AXIS["site east",southWest,ORDER[1]],
 AXIS["site north",southEast,ORDER[2]],
 LENGTHUNIT["metre",1.0],
 USAGE[SCOPE["Construction"],TIMEEXTENT["date/time t1","date/time t2"]]`

]

EXAMPLE 2 ENGINEERINGCRS["Astra Minas Grid",
 ENGINEERINGDATUM["Astra Minas"],
 CS[Cartesian,2],
 AXIS["northing (x)",north,ORDER[1]],
 AXIS["westing (y)",west,ORDER[2]],
 LENGTHUNIT["metre",1.0],
 ID["EPSG",5800]
]

EXAMPLE 3 ENGCRS["A ship-centred CRS",
 EDATUM["Ship reference point",ANCHOR["Centre of buoyancy"]],
 CS[Cartesian,3],
 AXIS["(x)",forward],
 AXIS["(y)",starboard],
 AXIS["(z)",down],
 LENGTHUNIT["metre",1.0]
]

EXAMPLE 4 A continuous (not discrete) CRS for an image.
 ENGCRS["An analogue image CRS",
 EDATUM["Image reference point",
 ANCHOR["Top left corner of image = 0,0"]],
 CS[Cartesian,2],
 AXIS["Column (x)",columnPositive],
 AXIS["Row (y)",rowPositive],
 LENGTHUNIT["micrometre",1E-6]
]

EXAMPLE 5 A discrete CRS for an image.
 ENGCRS["A digital image CRS",
 EDATUM["Image reference point",
 ANCHOR["Top left corner of image = 0,0"]],
 CS[ordinal,2],
 AXIS["Column pixel (x)",columnPositive,ORDER[1]],
 AXIS["Row pixel (y)",rowPositive,ORDER[2]]
]

12 WKT representation of parametric CRSs

12.1 Overview

Requirement: The WKT representation of a parametric coordinate reference system shall be:

```

<parametric crs>          ::=  <parametric crs keyword> <left delimiter> <crs name>
                               <wkt separator> <parametric datum>
                               <wkt separator> <coordinate system>
                               <scope extent identifier remark> <right delimiter>

<parametric crs keyword>   ::=  PARAMETRICCRS

<crs name>                 ::=  <quoted Latin text>                                !! See 7.2

```

<scope extent identifier remark> is described in 7.3.

12.2 Parametric datum

Requirement: The WKT representation of a parametric datum shall be:

```

<parametric datum>        ::=  <parametric datum keyword> <left delimiter> <datum name>
                               [ <wkt separator> <datum anchor> ]
                               [ { <wkt separator> <identifier> } ]... <right delimiter>

<parametric datum keyword> ::=  PDATUM | PARAMETRICDATUM
                               !! In this document for brevity the preferred
                               keyword is PDATUM, but PARAMETRICDATUM is
                               permitted. Implementations should be prepared to
                               read both forms.

<datum name>               ::=  <quoted Latin text>                                !! See 7.2

<datum anchor>              ::=  <datum anchor keyword> <left delimiter>
                               <datum anchor description> <right delimiter>

<datum anchor keyword>     ::=  ANCHOR

<datum anchor description> ::=  <quoted Latin text>

```

12.3 Parametric coordinate system

<coordinate system> is described in 7.5. Several constraints and recommendations for coordinate systems used in parametric CRSs are described there. These include the requirement for a parametric CRS to contain a parametric coordinate system.

12.4 Example of WKT describing a parametric CRS

```

EXAMPLE  PARAMETRICCRS["WMO standard atmosphere layer 0",
                      PDATUM["Mean Sea Level",ANCHOR["1013.25 hPa at 15°C"]],
                      CS[parametric,1],
                      AXIS["pressure (hPa)",up],PARAMETRICUNIT["HectoPascal",100.0]
                      ]

```

13 WKT representation of temporal CRSs

13.1 Temporal CRS

The document supports three subtypes of temporal CRS: temporalDateTime (date and time using the representation defined in ISO 8601), temporalCount (when the temporal quantities are integers) and temporalMeasure (when the temporal quantities are real numbers). In WKT strings this subtyping is exposed through the coordinate system element.

Requirement: The WKT representation of a temporal coordinate reference system shall be:

```

<temporal crs> ::= <temporal crs keyword> <left delimiter> <crs name>
                  <wkt separator> <temporal datum>
                  <wkt separator> <coordinate system>
                  <scope extent identifier remark> <right delimiter>

<temporal crs keyword> ::= TIMECRS

<crs name> ::= <quoted Latin text>                                !! See 7.2

```

<scope extent identifier remark> is described in 7.3.

13.2 Temporal datum

Requirement: The WKT representation of a temporal datum shall be:

```

<temporal datum> ::= <temporal datum keyword> <left delimiter> <datum name>
                    [ <wkt separator> <calendar> ]
                    [ <wkt separator> <temporal origin> ]
                    [ { <wkt separator> <identifier> } ]... <right delimiter>

<temporal datum keyword> ::= TDATUM | TIMEDATUM
                           !! In this document for brevity the preferred
                           keyword is TDATUM, but TIMEDATUM is permitted.
                           Implementations should be prepared to read both
                           forms.

<datum name> ::= <quoted Latin text>                                !! See 7.2

<temporal origin > ::= <temporal origin keyword> <left delimiter>
                     <temporal origin description> <right delimiter>

<temporal origin keyword> ::= TIMEORIGIN

<temporal origin description> ::= <datetime> | <quoted Latin text>

<calendar> ::= <calendar keyword> <left delimiter>
              <calendar identifier> <right delimiter>

<calendar keyword> ::= CALENDAR

<calendar identifier> ::= <quoted Latin text>

```

In this document the “proleptic Gregorian” calendar as defined in ISO 8601-1 is the only standardised entry for the calendar identifier. If the calendar element is omitted, “proleptic Gregorian” is the assumed value. If the temporal origin element is omitted then “1875-05-20” is the assumed default value.

Note: The default value for TemporalOrigin of 1875-05-20 is the date of signing of the Convention du Mètre, an international treaty that was signed in Paris on 20 May 1875 by representatives of 17 nations (Argentina, Austria-Hungary, Belgium, Brazil, Denmark, France, Germany, Italy, Peru, Portugal, Russia, Spain, Sweden and Norway, Switzerland, Turkey, United States of America, and Venezuela). The treaty created the International Bureau of Weights and Measures (BIPM), an intergovernmental organization under the authority of the General Conference on Weights and Measures (CGPM) and under the supervision of the International Committee for Weights and Measures (CIPM), which coordinates international metrology and the development of the metric system. The Gregorian Calendar was introduced in October 1582. Adoption of this calendar has occurred in various countries over a 400 year period.

EXAMPLE 1 Temporal datum in which Calendar included.

```
TIMEDATUM["Gregorian calendar",CALENDAR["proleptic Gregorian"],
TIMEORIGIN[0000-01-01]]
```

EXAMPLE 2 Temporal datum with Calendar omitted so should be assumed to be “proleptic Gregorian”.

```
TDATUM["Gregorian calendar",TIMEORIGIN["0001 January 1st"]]
```

EXAMPLE 3 Temporal datum with Calendar omitted so should be assumed to be “proleptic Gregorian”, and with TimeOrigin omitted so should be assumed to be 1875-05-20. This will normally be used with a temporalDateTime coordinate system.

```
TDATUM["Gregorian calendar"]
```

13.3 Temporal coordinate system

13.3.1 General

<coordinate system> is described in 7.5. Several general constraints and recommendations for coordinate systems are described there. Those in 7.5.1 to 7.5.5 apply to temporal coordinate systems. Temporal coordinate systems treat <axisUnit> and <conversion factor> differently from other types of coordinate system and their additional constraints are described here.

13.3.2 Axis unit for temporalDateTime coordinate systems

The dateTime syntax is a representation of a compound string including multiple temporal quantities. Its components are defined in ISO 8601-1. The syntax for a dateTime value in WKT is given in 6.3. The syntax for a temporalDateTime coordinate system in WKT is given in 7.5.1; no axis unit is included.

Requirement: For a temporalDateTime coordinate system, neither <axis unit> nor <cs unit> shall be given.

NOTE This requirement also applies to ordinal coordinate systems, see 7.5.6.3.

Per 7.5.1 to 7.5.5, for a temporalDateTime CS axis name/abbreviation and axis direction shall be given, axis order may be given or be implied. Only axis unit is omitted.

13.3.3 Axis unit for temporalCount and temporalMeasure coordinate systems

For temporalCount and temporalMeasure coordinate systems, the requirements for coordinate system and coordinate system axis are the same as those for a spatial coordinate system and spatial coordinate system axis except that the axis unit conversion factor is conditional, to be given only when the temporal quantity (time unit) has a simple scalar conversion ratio to the SI base unit of a second. Requirements and examples are in 7.4.1 and 7.4.3.

13.4 Examples of WKT describing a temporal CRS

EXAMPLE 1 Temporal CRS with a temporalDateTime coordinate system (axis time unit shall not be given). Calendar attribute is omitted and time origin attribute is omitted (defaults inferred in both cases):

```
TIMECRS["DateTime",
  TDATUM["Gregorian Calendar"],
  CS[TemporalDateTime,1], AXIS["Time (T)", future]
]
```

NOTE Example coordinate data suitable for use with this CRS:
(2018-04-25T16:30:00Z, 2018-05-01T09:35:24Z, ...)

EXAMPLE 2 Temporal CRS with a temporalCount CS (coordinates are integers) in which axis unit includes a scalar conversion factor:

```
TIMECRS["GPS milliseconds",
  TDATUM["GPS time origin", TIMEORIGIN[1980-01-01T00:00:00.0Z]],
  CS[TemporalCount,1], AXIS["(T)", future, TIMEUNIT["millisecond
(ms)", 0.001]]
]
```

NOTE Example coordinate data suitable for use with this CRS: (5351236450450, 5351236450950, ...)

EXAMPLE 3 Temporal CRS with a temporalCount CS in which axis quantity is integer count. Axis unit is used but conversion factor is omitted because not scalar.

```
TIMECRS["Calendar hours from 1979-12-29",
  TDATUM["29 December 1979", TIMEORIGIN[1979-12-29T00Z]],
  CS[TemporalCount,1], AXIS["Time", future, TIMEUNIT["hour"]]
]
```

NOTE Example coordinate data suitable for use with this CRS: (429, 453, ...)

EXAMPLE 4 Temporal CRS with a temporalMeasure CS (coordinates are real numbers) in which <axis unit> is used but <conversion factor> is omitted because not scalar:

```
TIMECRS["Decimal Years CE",
  TDATUM["Common Era", TIMEORIGIN[0000]],
  CS[TemporalMeasure,1], AXIS["Decimal years (a)", future, TIMEUNIT["year"]]
]
```

NOTE Example coordinate data suitable for use with this CRS: (2000.4, 2002.8, ...)

EXAMPLE 5 Temporal CRS with a temporalCount CS (coordinates are integers). <axis unit> is used but <conversion factor> is omitted because not scalar:

```
TIMECRS["Unix time",
  TDATUM["Unix epoch", TIMEORIGIN[1970-01-01T00:00:00Z]],
  CS[TemporalCount,1], AXIS["Time", future, TIMEUNIT["second"]]
]
```

NOTE The timeunit second is a calendar second, not an SI second; leap seconds are not applied^[7].
Example coordinate data suitable for use with this CRS: (1528368006, 1528368219, ...)

14 WKT representation of derived CRSs

14.1 Overview

ISO 19111 includes a modelling concept of a derived CRS. A derived CRS is a CRS which cannot exist in its own right but is defined through a coordinate conversion from another coordinate reference system.

A projected CRS is a special case of a derived CRS. Because of its importance to geographic information and particularly for backward compatibility reasons necessitating a different string structure it is treated separately from the general case and is described in Clause 9.

NOTE Georeferenced image coordinates are not referenced to a derived CRS but to an engineering CRS. The georeferencing is accomplished through a coordinate transformation between the image's engineering CRS and the (usually geodetic or projected) CRS to which the image is georeferenced.

This document implements this modelling concept through the inclusion of a 'base CRS' description within the description of the CRS. Table 3 compares the general structure of WKT for the principal CRS types described in Clauses 8 and 10 to 14 with the general structure of WKT for a derived CRS.

Table 4 — Comparison of general structure of WKT for principal and derived CRSs

Structure for principal CRSs	Structure for derived CRSs
a) keyword	a) keyword
b) name	b) name
c) datum or datum ensemble	c) base CRS including its datum or datum ensemble
	d) deriving conversion
d) coordinate system	e) coordinate system
e) optional metadata	f) optional metadata

In derived CRSs the base CRS detail includes the name and datum of the base CRS from which the derived CRS is derived. The base CRS detail does not include optional metadata or the coordinate system information for that base CRS, but the dimension of the base CRS's coordinate system constrains the dimension of the derived CRS.

Requirement: The dimension of a derived CRS shall be equal to or less than the dimension of its base CRS.

14.2 Deriving conversion

14.2.1 General

The deriving conversion in a derived CRS is a specialised case of coordinate conversion described in Clause 17 in which the source and target CRSs are by definition the base CRS and the derived CRS respectively. These are therefore implied rather than explicitly stated in the WKT string. Because by definition coordinate conversions are exact, the attribute operation accuracy is not relevant and excluded from the deriving conversion WKT string. A map projection is a special case of a deriving conversion (see 9.3).

Requirement: The WKT representation of a <deriving conversion> shall be:

<deriving conversion> ::= <deriving conversion keyword> <left delimiter>
 <deriving conversion name>
 <wkt separator> <operation method>
 [{ <wkt separator>
 { <operation parameter> | <operation parameter file> } }]...
 [{ <wkt separator> <identifier> }]... <right delimiter>

<deriving conversion keyword> ::= DERIVINGCONVERSION

<deriving conversion name> ::= <quoted Latin text> *!! See 7.2*

Operation method, operation parameter and operation parameter file are described in 17.2.4 to 17.2.6.

Identifier is described in 7.3.4.

14.2.2 Derived CRS conversion method

Requirement: The WKT representation of a derived CRS conversion method shall be:

<operation method> ::= <operation method keyword> <left delimiter>
 <operation method name>
 [{ <wkt separator> <identifier> }]... <right delimiter>

<operation method keyword> ::= METHOD

<operation method name> ::= <quoted Latin text> *!! See 7.2*

Method name is for human readability. For interoperability it is the method formula that is critical in determining the equivalence of methods; this may be given through an operation method <identifier>.

<identifier> is described in 7.3.4. It is an optional attribute. If an identifier is included as an attribute within the derived CRS conversion object (14.2.1), it shall take precedence over any identifier within the operation method object.

If an <identifier> is omitted for both derived CRS conversion and derived CRS conversion method, the WKT description is potentially ambiguous, relying on interpretation of method name. It is recommended that either a derived CRS conversion identifier or a derived CRS conversion method identifier is included in WKT strings. Identifiers for commonly encountered coordinate transformation methods are given in E.4.

14.2.3 Derived CRS conversion parameter

Requirement: The WKT representation of a derived CRS conversion parameter shall be:

<operation parameter> ::= <parameter keyword> <left delimiter> <parameter name>
 <wkt separator><parameter value> <wkt separator> <parameter unit>
 [{ <wkt separator> <identifier> }]... <right delimiter>

<parameter keyword> ::= PARAMETER

<parameter name> ::= <quoted Latin text> *!! See 7.2*

<parameter value> ::= <signed numeric literal>

<parameter unit> ::= <length unit> | <angle unit> | <scale unit> | <time unit> | <parametric unit>

Units are described in 7.4.

Parameter name is for human readability. For interoperability it is the method formula and its parameters that are critical in determining the equivalence of methods. See Annex F. Identifiers for commonly

encountered coordinate operation methods and their parameters are given in F.4; the parameters are listed in F.5. The coordinate operation parameters required are specific to the coordinate operation method and are listed sequentially. The order within the sequence is not significant but should be logical. Implementations should be prepared to read any order. For those methods included in Annex F the parameter order given in F.4 is recommended.

Requirements:

- a) In derived CRS conversion WKT strings <parameter value> shall be given in the sense base CRS to derived CRS. If the parameter unit is linear its conversion factor shall be to metres and is the number of metres per unit. If the parameter unit is angular its conversion factor shall be to radians and is the number of radians per unit. If the parameter is a scaling unit the conversion factor shall be to unity, for example parts per million (ppm) shall be given as 10^{-6} .

NOTE For commonly-encountered parameters the parameter type is included in F.5.

- b) <identifier> is described in 7.3.4. It is an optional attribute. If an identifier is included as an attribute within the *derived CRS conversion* object (14.2.1) or *coordinate operation method* object (14.2.2), it shall take precedence over any identifier within the derived CRS conversion parameter object.

14.2.4 Derived CRS conversion parameter file

Requirement: The WKT representation of a derived CRS conversion parameter file shall be:

```
<operation parameter file> ::= <parameter file keyword> <left delimiter> <parameter name>
                             <wkt separator> <parameter file name>
                             [ { <wkt separator> <identifier> } ]... <right delimiter>
```

```
<parameter file keyword> ::= PARAMETERFILE
```

```
<parameter name> ::= <quoted Latin text> !! See 7.2
```

```
<parameter file name> ::= <quoted Latin text> !! See 7.2
```

For <parameter name> and <identifier> the requirements given in 17.2.5 shall apply.

14.2.5 Derived CRS conversion example

```
EXAMPLE DERIVINGCONVERSION["conversion name",
    METHOD["method name",ID["authority",123]],
    PARAMETER["parameter 1 name",0,
        ANGLEUNIT["degree",0.0174532925199433],
        ID["authority",456]
    ],
    PARAMETER["parameter 2 name",-123,
        ANGLEUNIT["degree",0.0174532925199433],
        ID["authority",789]
    ]
]
```

14.3 Derived geodetic CRS and derived geographic CRS

14.3.1 Representation

Requirement: The WKT representation of a derived geodetic or a derived geographic coordinate reference system shall be:

<derived geodetic crs>	::=	<derived static geod crs> <derived dynamic geod crs> <derived geographic crs>
<derived geographic crs>	::=	<derived static geog crs> <derived dynamic geog crs>
<derived static geod crs>	::=	<geodetic crs keyword> <left delimiter> <derived crs name> <wkt separator> { <base static geod crs> <base static geog crs> } <wkt separator> <deriving conversion> <wkt separator> <coordinate system> <scope extent identifier remark> <right delimiter>
<derived dynamic geod crs>	::=	<geodetic crs keyword> <left delimiter> <derived crs name> <wkt separator> { <base dynamic geod crs> <base dynamic geog crs> } <wkt separator> <deriving conversion> <wkt separator> <coordinate system> <scope extent identifier remark> <right delimiter>
<derived static geog crs>	::=	<geographic crs keyword > <left delimiter> <derived crs name> <wkt separator> { <base static geod crs> <base static geog crs> } <wkt separator> <deriving conversion> <wkt separator> <coordinate system> <scope extent identifier remark> <right delimiter>
<derived dynamic geog crs>	::=	<geographic crs keyword > <left delimiter> <derived crs name> <wkt separator> { <base dynamic geod crs> <base dynamic geog crs> } <wkt separator> <deriving conversion> <wkt separator> <coordinate system> <scope extent identifier remark> <right delimiter>
<geodetic crs keyword>	::=	GEODCRS GEODETICCRS <i>!! See 8.1</i>
<geographic crs keyword>	::=	GEOGCRS GEOGRAPHICCRS <i>!! See 8.1</i>
<derived crs name>	::=	<quoted Latin text> <i>!! See 7.2</i>
<base static geod crs>	::=	<base geodetic crs keyword> <left delimiter> <base crs name> <wkt separator> { <geodetic reference frame> <geodetic datum ensemble> } [{ <wkt separator> <identifier> }]... <right delimiter>
<base dynamic geod crs>	::=	<base geodetic crs keyword> <left delimiter> <base crs name> <wkt separator> <dynamic crs> <wkt separator> <geodetic reference frame> [{ <wkt separator> <identifier> }]... <right delimiter>

<base static geog crs>	::=	<base geographic crs keyword> <left delimiter> <base crs name> <wkt separator> { <geodetic reference frame> <geodetic datum ensemble> } [{ <wkt separator> <identifier> }]... <right delimiter>
<base dynamic geog crs>	::=	<base geographic crs keyword> <left delimiter> <base crs name> <wkt separator> <dynamic crs> <wkt separator> <geodetic reference frame> [{ <wkt separator> <identifier> }]... <right delimiter>
<base geodetic crs keyword>	::=	BASEGEODCRS
<base geographic crs keyword>	::=	BASEGEOGCRS <i>!! The base CRS keyword should reflect the type of CRS (geodetic or geographic) upon which the derived CRS is referenced. The previous version of this document used only BASEGEODCRS. Implementations should be prepared to read both forms.</i>
<base crs name>	::=	<quoted Latin text> !! See 7.2

<coordinate system> is described in 7.5; the constraints for geodetic CRSs and geographic CRSs apply to derived geodetic CRSs and derived geographic CRSs.

<dynamic crs> is described in 7.7. It is mandatory when the base CRS is dynamic and should not be given when the base CRS is static. The derived CRS has the same static/dynamic status as its base CRS.

<geodetic reference frame> is described in 8.2; it includes ellipsoid and prime meridian descriptions. <geodetic datum ensemble> is described in 7.6.

<deriving conversion> is described in 14.2, <scope extent identifier remark> in 7.3.

NOTE Constructs similar to <base static geod crs>, <base dynamic geod crs>, <base static geog crs> and <base dynamic geog crs>, but with an extra element, are also used for projected CRSs, see 9.2.

14.3.2 Example of WKT describing a derived geographic CRS

EXAMPLE Derived geographic CRS with rotated pole, base CRS is dynamic

```
GEOGCRS["WMO Atlantic Pole",
  BASEGEOGCRS["WGS 84 (G1762)",
    DYNAMIC[FRAMEEPOCH[2005.0]],
    TRF["World Geodetic System 1984 (G1762)",
      ELLIPSOID["WGS 84", 6378137, 298.257223563, LENGTHUNIT["metre", 1.0]]
    ],
  DERIVINGCONVERSION["Atlantic pole",
    METHOD["Pole rotation", ID["Authority", 1234]],
    PARAMETER["Latitude of rotated pole", 52.0,
      ANGLEUNIT["degree", 0.0174532925199433]],
    PARAMETER["Longitude of rotated pole", -30.0,
      ANGLEUNIT["degree", 0.0174532925199433]],
    PARAMETER["Axis rotation", -25.0,
      ANGLEUNIT["degree", 0.0174532925199433]]
  ],
  CS[ellipsoidal, 2],
  AXIS["latitude", north, ORDER[1]],
  AXIS["longitude", east, ORDER[2]],
  ANGLEUNIT["degree", 0.0174532925199433]
```

14.4 Derived projected CRS

14.4.1 Representation

The term 'derived projected CRS' is used for consistency in the ISO 19111 UML modelling. A derived projected CRS is not a projected CRS; 'derived from projected CRS' would be a more accurate description. However, in addition to inheriting its datum or reference frame from its base projected CRS, a derived projected CRS also inherits the projection distortions of its base projected CRS

Requirement: The WKT representation of a derived projected coordinate reference system shall be:

```

<derived projected crs> ::= <derived projected crs keyword> <left delimiter>
                           <derived crs name> <wkt separator> <base projected crs>
                           <wkt separator> <deriving conversion>
                           <wkt separator> <coordinate system>
                           <scope extent identifier remark> <right delimiter>

<derived projected crs keyword> ::= DERIVEDPROJCRS

<derived crs name> ::= <quoted Latin text>                !! See 7.2

<base projected crs> ::= <base projected crs keyword> <left delimiter>
                        <base crs name>
                        <wkt separator> <base geodetic geographic crs>
                        <wkt separator> <map projection>
                        [ { <wkt separator> <identifier> } ]... <right delimiter>

<base projected crs keyword> ::= BASEPROJCRS

<base crs name> ::= <quoted Latin text>                !! See 7.2

<base geodetic geographic crs> ::= <base static geod crs> | <base dynamic geod crs>
                                   | <base static geog crs> | <base dynamic geog crs>
                                   !! These four elements are described in
                                   14.3.1.
                                   The derived projected CRS takes its dynamic
                                   characteristics from its base geodetic or
                                   geographic CRS.

```

<coordinate system> is described in 7.5; the constraint on projected CRS having CS type of Cartesian does not apply to derived projected CRSs.

<deriving conversion> is described in 14.2, <map projection> in 9.3 and <scope extent identifier remark> in 7.3.

14.4.2 Example of WKT describing a derived projected CRS

```

DERIVEDPROJCRS["Gulf of Mexico speculative seismic survey bin grid",
  BASEPROJCRS["NAD27 / Texas South Central",
    BASEGEOGCRS["NAD27",
      DATUM["North American Datum 1927",
        ELLIPSOID["Clarke 1866",20925832.164,294.97869821,
          LENGTHUNIT["US survey foot",0.304800609601219]
        ]
      ]
    ],
    CONVERSION["Texas South Central SPCS27",
      METHOD["Lambert Conic Conformal (2SP)",ID["EPSG",9802]],
      PARAMETER["Latitude of false origin",27.83333333333333,
        ANGLEUNIT["degree",0.0174532925199433],ID["EPSG",8821]],
      PARAMETER["Longitude of false origin",-99.0,
        ANGLEUNIT["degree",0.0174532925199433],ID["EPSG",8822]],
      PARAMETER["Latitude of 1st standard parallel",28.38333333333333,
        ANGLEUNIT["degree",0.0174532925199433],ID["EPSG",8823]],
      PARAMETER["Latitude of 2nd standard parallel",30.28333333333333,
        ANGLEUNIT["degree",0.0174532925199433],ID["EPSG",8824]],
      PARAMETER["Easting at false origin",2000000.0,
        LENGTHUNIT["US survey foot",0.304800609601219],ID["EPSG",8826]],
      PARAMETER["Northing at false origin",0.0,
        LENGTHUNIT["US survey foot",0.304800609601219],ID["EPSG",8827]]
    ]
  ],
  DERIVINGCONVERSION["Gulf of Mexico speculative survey bin grid",
    METHOD["P6 (I = J-90°) seismic bin grid transformation",ID["EPSG",1049]],
    PARAMETER["Bin grid origin I",5000,SCALEUNIT["Bin",1.0],ID["EPSG",8733]],
    PARAMETER["Bin grid origin J",0,SCALEUNIT["Bin",1.0],ID["EPSG",8734]],
    PARAMETER["Bin grid origin Easting",871200,
      LENGTHUNIT["US survey foot",0.304800609601219],ID["EPSG",8735]],
    PARAMETER["Bin grid origin Northing", 10280160,
      LENGTHUNIT["US survey foot",0.304800609601219],ID["EPSG",8736]],
    PARAMETER["Scale factor of bin grid",1.0,
      SCALEUNIT["Unity",1.0],ID["EPSG",8737]],
    PARAMETER["Bin width on I-axis",82.5,
      LENGTHUNIT["US survey foot",0.304800609601219],ID["EPSG",8738]],
    PARAMETER["Bin width on J-axis",41.25,
      LENGTHUNIT["US survey foot",0.304800609601219],ID["EPSG",8739]],
    PARAMETER["Map grid bearing of bin grid J-axis",340,
      ANGLEUNIT["degree",0.0174532925199433],ID["EPSG",8740]],
    PARAMETER["Bin node increment on I-axis",1.0,
      SCALEUNIT["Bin",1.0],ID["EPSG",8741]],
    PARAMETER["Bin node increment on J-axis",1.0,
      SCALEUNIT["Bin",1.0],ID["EPSG",8742]]
  ],
  CS[ordinal,2],
  AXIS["Inline (I)",northNorthWest],
  AXIS["Crossline (J)",westSouthWest]
]

```

NOTE A similar approach can be used to describe any rectangular grid referencing system based on a projected CRS. The grid cell size and placement are defined through the deriving conversion.

14.5 Derived vertical CRS

Requirement: The WKT representation of a derived vertical coordinate reference system shall be:

<derived vertical crs>	::=	<vertical crs keyword> <left delimiter> <derived crs name> <wkt separator> <base vertical crs> <wkt separator> <deriving conversion> <wkt separator> <coordinate system> <scope extent identifier remark> <right delimiter>
<vertical crs keyword>	::=	VERTCRS VERTICALCRS !! See 10.1
<derived crs name>	::=	<quoted Latin text> !! See 7.2
<base vertical crs>	::=	<base static vertical crs> <base dynamic vertical crs> <i>!! The derived CRS takes its dynamic characteristics from its base CRS.</i>
<base static vertical crs>	::=	<base vertical crs keyword> <left delimiter> <base crs name> <wkt separator> { <vertical reference frame> <vertical datum ensemble> } [{ <wkt separator> <identifier> }]... <right delimiter>
<base dynamic vertical crs>	::=	<base vertical crs keyword> <left delimiter> <base crs name> <wkt separator> <dynamic crs> <wkt separator> <vertical reference frame> [{ <wkt separator> <identifier> }]... <right delimiter>
<base vertical crs keyword>	::=	BASEVERTCRS
<base crs name>	::=	<quoted Latin text> !! See 7.2

<coordinate system> is described in 7.5; the constraints for vertical CRSs apply to vertical derived CRSs.

<dynamic crs> is described in 7.7. It is mandatory when the base CRS is dynamic and should not be given when the base CRS is static. The derived CRS has the same static/dynamic status as its base CRS.

<vertical reference frame> is described in 10.2, <vertical datum ensemble> in 7.6, <deriving conversion> in 14.2 and <scope extent identifier remark> in 7.3.

14.6 Derived engineering CRS

14.6.1 Representation

Requirement: The WKT representation of a derived engineering coordinate reference system shall be:

<derived engineering crs>	::=	<engineering crs keyword> <left delimiter> <derived crs name> <wkt separator> <base engineering crs> <wkt separator> <deriving conversion> <wkt separator> <coordinate system> <scope extent identifier remark> <right delimiter>
<engineering crs keyword>	::=	ENGCRS ENGINEERINGCRS !! See 11.1
<derived crs name>	::=	<quoted Latin text> !! See 7.2

<base engineering crs> ::= <base engineering crs keyword> <left delimiter>
 <base crs name> <wkt separator> <engineering datum>
 [{ <wkt separator> <identifier> }]... <right delimiter>

<base engineering crs keyword> ::= BASEENGCRS

<base crs name> ::= <quoted Latin text> *!! See 7.2*

<coordinate system> is described in 7.5; the constraints for engineering CRSs apply to derived engineering CRSs.

<engineering datum> is described in 11.2. <deriving conversion> is described in 14.2; <scope extent identifier remark> in 7.3.

14.7 Derived parametric CRS

Requirement: The WKT representation of a derived parametric coordinate reference system shall be:

<derived parametric crs> ::= <parametric crs keyword> <left delimiter>
 <derived crs name> <wkt separator> <base parametric crs>
 <wkt separator> <deriving conversion>
 <wkt separator> <coordinate system>
 <scope extent identifier remark> <right delimiter>

<parametric crs keyword> ::= PARAMETRICCRS *!! See 12.1*

<derived crs name> ::= <quoted Latin text> *!! See 7.2*

<base parametric crs> ::= <base parametric crs keyword> <left delimiter>
 <base crs name> <wkt separator> <parametric datum>
 [{ <wkt separator> <identifier> }]... <right delimiter>

<base parametric crs keyword> ::= BASEPARAMCRS

<base crs name> ::= <quoted Latin text> *!! See 7.2*

<coordinate system> is described in 7.5; the constraints for parametric CRSs apply to derived parametric CRSs.

<parametric datum> is described in 12.2, <deriving conversion> in 14.2 and <scope extent identifier remark> in 7.3.

14.8 Derived temporal CRS

Requirement: The WKT representation of a derived temporal coordinate reference system shall be:

<derived temporal crs> ::= <temporal crs keyword> <left delimiter> <derived crs name>
 <wkt separator> <base temporal crs>
 <wkt separator> <deriving conversion>
 <wkt separator> <coordinate system>
 <scope extent identifier remark> <right delimiter>

<temporal crs keyword> ::= TIMECRS *!! See 13.1*

<derived crs name>	::=	<quoted Latin text>	!! See 7.2
<base temporal crs>	::=	<base temporal crs keyword> <left delimiter> <base crs name> <wkt separator> <temporal datum> [{ <wkt separator> <identifier> }]... <right delimiter>	
<base temporal crs keyword>	::=	BASETIMECRS	
<base crs name>	::=	<quoted Latin text>	!! See 7.2

<coordinate system> for temporal CRSs is described in 7.5 excluding 7.5.6 and 13.3; the constraints for temporal CRSs apply to temporal derived CRSs.

<temporal datum> is described in 13.2, <deriving conversion> in 14.2 and <scope extent identifier remark> in 7.3.

15 WKT representation of compound coordinate reference systems

15.1 Overview

A compound CRS is a non-repeating sequence of two or more independent coordinate reference systems none of which can be compound.

Requirement: The WKT representation of a compound coordinate reference system shall be:

```

<compound crs> ::= <compound crs keyword> <left delimiter> <compound crs name>
                  <wkt separator> <single crs>
                  <wkt separator> <single crs>
                  [ { <wkt separator> <single crs> } ]...
                  <scope extent identifier remark> <right delimiter>
                  !! ISO 19111 defines valid combinations of single
                  CRS that may form a compound CRS.

<compound crs keyword> ::= COMPOUNDCRS

<compound crs name> ::= <quoted Latin text>                !! See 7.2

<single crs> ::= <geodetic crs> | <derived geodetic crs>
                 | <projected crs> | <derived projected crs>
                 | <vertical crs> | <derived vertical crs>
                 | <engineering crs> | <derived engineering crs>
                 | <parametric crs> | <derived parametric crs>
                 | <temporal crs> | <derived temporal crs>

```

The representation of constituent single CRSs is elaborated in Clauses 8 to 14.

Constraints on axis order for compound CRSs are described in 7.5.5.

<scope extent identifier remark> is described in 7.3.

15.2 Examples of WKT describing a compound CRS

EXAMPLE 1 Spatial compound CRS:

```

COMPOUNDCRS["NAD83 + NAVD88",
  GEOGCRS["NAD83",
    DATUM["North American Datum 1983",
      ELLIPSOID["GRS 1980", 6378137, 298.257222101,
        LENGTHUNIT["metre", 1.0]]
    ],
    PRIMEMERIDIAN["Greenwich", 0],
    CS[ellipsoidal, 2],
    AXIS["latitude", north, ORDER[1]],
    AXIS["longitude", east, ORDER[2]],
    ANGLEUNIT["degree", 0.0174532925199433]
  ],
  VERTCRS["NAVD88",
    VDATUM["North American Vertical Datum 1983"],
    CS[vertical, 1],
    AXIS["gravity-related height (H)", up],
    LENGTHUNIT["metre", 1]
  ]
]

```

EXAMPLE 2 Spatio-parametric compound CRS:

```

COMPOUNDCRS["ICAO layer 0",
  GEOGRAPHICCRS["WGS 84",
    DYNAMIC[FRAMEEPOCH[2005]],
    DATUM["World Geodetic System 1984",
      ELLIPSOID["WGS 84",6378137,298.257223563,
        LENGTHUNIT["metre",1.0]]],
    CS[ellipsoidal,2],
    AXIS["latitude",north,ORDER[1]],
    AXIS["longitude",east,ORDER[2]],
    ANGLEUNIT["degree",0.0174532925199433]
  ],
  PARAMETRICCRS["WMO standard atmosphere",
    PARAMETRICDATUM["Mean Sea Level",
      ANCHOR["Mean Sea Level = 1013.25 hPa"]],
    CS[parametric,1],
    AXIS["pressure (P)",unspecified],
    PARAMETRICUNIT["HectoPascal",100]
  ]
]

```

EXAMPLE 3 Spatio-temporal compound CRS (ellipsoid axis unit is metres as <lengthunit> is omitted):

```

COMPOUNDCRS["2D GPS position with civil time in ISO 8601 format",
  GEOGCRS["WGS 84 (G1762)",
    DYNAMIC[FRAMEEPOCH[2005]],
    DATUM["World Geodetic System 1984 (G1762)",
      ELLIPSOID["WGS 84",6378137,298.257223563]],
    CS[ellipsoidal,2],
    AXIS["(lat)",north,ORDER[1]],
    AXIS["(lon)",east,ORDER[2]],
    ANGLEUNIT["degree",0.0174532925199433]
  ],
  TIMECRS["DateTime",
    TDATUM["Gregorian Calendar"],
    CS[TemporalDateTime,1],AXIS["Time (T)",future]
  ]
]

```

16 WKT representation of coordinate epoch and coordinate metadata

16.1 Coordinate epoch

Coordinate epoch is a mandatory attribute for a coordinate set that is referenced to a dynamic CRS. Coordinate epoch is not part of a CRS definition, it is additional metadata for the coordinates which is required to ensure that they are unambiguous when referenced to a dynamic CRS.

Requirement: The WKT representation of a coordinate epoch shall be:

```
<metadata coordinate epoch> ::= <coordinate epoch keyword> <left delimiter>
                                <coordinate epoch> <right delimiter>

<coordinate epoch keyword>    EPOCH | COORDEPOCH
                                !! In this document for brevity the preferred
                                keyword is EPOCH, but COORDEPOCH is permitted.
                                Implementations should be prepared to read
                                both forms.
                                !! EPOCH shall not be used as the keyword for
                                frame reference epoch, for which FRAMEEPOCH
                                should be used, or as the name of a coordinate
                                operation parameter, for which "Parameter
                                Epoch" or "Transformation Epoch" as
                                appropriate should be used.

<coordinate epoch>           <unsigned integer> [ <period> [ <unsigned integer> ] ]
                                !! See 6.3.2
```

EXAMPLE EPOCH[2016.47]

16.2 Coordinate metadata

Coordinate metadata is the information required to make coordinates unambiguous. For a coordinate set referenced to a static CRS it is the CRS definition. For a coordinate set referenced to a dynamic CRS it is the CRS definition together with the coordinate epoch of the coordinates in the coordinate set.

Requirement: The WKT representation of coordinate metadata shall be:

```
<coordinate metadata> ::= <coordinate metadata keyword> <left delimiter>
                           <static crs coordinate metadata> |
                           { <dynamic crs coordinate metadata> <wkt separator>
                           <metadata coordinate epoch> }
                           <right delimiter>

<coordinate metadata keyword> ::= COORDINATEMETADATA

<static crs coordinate
metadata> ::= <static geodetic crs> | <static geographic crs>
              | <projected crs> | <static vertical crs>
              | <engineering crs> | <parametric crs> | <temporal crs>
              | <derived geodetic crs> | <derived projected crs>
              | <derived vertical crs> | <derived engineering crs>
              | <derived parametric crs> | <derived temporal crs>
              | <compound crs>
              !! A projected CRS is static if its base CRS is
              static.
```

<dynamic crs coordinate metadata > ::= <dynamic geodetic crs> | <dynamic geographic crs> | <projected crs> | <dynamic vertical crs> | <derived geodetic crs> | <derived projected crs> | <derived vertical crs>

!! The inclusion of the keyword DYNAMIC within the CRS description indicates that the CRS is a dynamic CRS. See 7.7

A derived CRS (including a projected CRS) is dynamic if its base CRS is dynamic.

The WKT for these types of coordinate reference system (CRS) is described in clauses 8 to 15.

EXAMPLE Coordinate metadata for a dataset referenced to a dynamic CRS:

```
COORDINATEMETADATA[
  GEOGCRS["WGS 84 (G1762)",
    DYNAMIC[FRAMEEPOCH[2005.0]],
    DATUM["World Geodetic System 1984 (G1762)",
      ELLIPSOID["WGS 84",6378137,298.257223563,LENGTHUNIT["metre",1.0]]
    ],
    CS[ellipsoidal,3],
      AXIS["(lat)",north,ANGLEUNIT["degree",0.0174532925199433]],
      AXIS["(lon)",east,ANGLEUNIT["degree",0.0174532925199433]],
      AXIS["ellipsoidal height (h)",up,LENGTHUNIT["metre",1.0]]
    ],
  EPOCH[2016.47]
]
```

17 WKT representation of coordinate transformations and coordinate conversions excluding map projections

17.1 Coordinate operations

The ISO 19111 data model describes five subtypes of coordinate operation: transformation, conversion, point motion operation, concatenated operation and pass-through operation. ISO 19111 also defines the terms *coordinate transformation* and *coordinate conversion*; these differ through whether the source and target CRSs are referenced to the same or different datums (reference frames). For reasons of backward compatibility, in this document the keyword <coordinate operation> is used specifically for coordinate transformations and coordinate conversions other than deriving conversions including map projections. Deriving conversions are described in Clause 14; map projections are a special case of deriving conversion and part of a projected CRS definition and are described in 9.3. The WKT for point motion operations is described in clause 18. The WKT for concatenated operations is described in Clause 19. This document does not define WKT for pass-through operations.

Requirement: The WKT representation of a coordinate transformation and of a coordinate conversion other than a deriving conversion (including map projection) shall be:

```
<coordinate operation> ::= <operation keyword> <left delimiter> <operation name>
                           [ <wkt separator> <operation version> ]
                           <wkt separator> <source crs> <wkt separator> <target crs>
                           <wkt separator> <operation method>
                           [ { <wkt separator> { <operation parameter>
                               | <operation parameter file> } } ]...
                           [ <wkt separator> <interpolation crs> ]
                           [ <wkt separator> <operation accuracy> ]
                           <scope extent identifier remark> <right delimiter>

<operation keyword>      ::= COORDINATEOPERATION
```

17.2 Transformation and conversion components

17.2.1 Operation name and version

```
<operation name>          ::= <quoted Latin text>                                !! See 7.2

<operation version>       ::= <operation version keyword> <left delimiter>
                              <operation version text> <right delimiter>

<operation version keyword> ::= VERSION

<operation version text>   ::= <quoted Latin text>                                !! See 7.2
```

17.2.2 Source and target CRS

Requirement: The WKT representation of the source and target CRSs of a <coordinate operation> shall be:

```
<source crs>              ::= <source crs keyword> <left delimiter>
                              <coordinate reference system> <right delimiter>

<source crs keyword>      ::= SOURCECRS

<target crs>              ::= <target crs keyword> <left delimiter>
                              <coordinate reference system> <right delimiter>
```

<target crs keyword> ::= TARGETCRS

<coordinate reference system> ::= <single crs> | <compound crs>

Coordinate reference systems are defined in Clauses 8 to 15. <single crs> and <compound crs> are elaborated in 15.1.

17.2.3 Transformation and conversion name and identifier

Coordinate operation encompasses the collection of method and parameter values. Its name is for human readability.

<identifier> is described in 7.3.4. It is an optional attribute. If an identifier is provided as an attribute within the <coordinate operation> object (17.1), because it is expected to describe a complete collection of zone name, method, parameters and parameter values, it shall override any identifiers given within the coordinate operation method and coordinate operation parameter objects.

Requirement: If an identifier is provided as an attribute of a coordinate operation object, it shall override any identifiers given within the component method and parameter objects.

17.2.4 Coordinate operation method

Requirement: The WKT representation of a coordinate operation method shall be:

<operation method> ::= <operation method keyword> <left delimiter>
<operation method name>
[{ <wkt separator> <identifier> }]... <right delimiter>

<operation method keyword> ::= METHOD

<operation method name> ::= <quoted Latin text> *!! See 7.2*

Method name is for human readability. For interoperability it is the method formula that is critical in determining the equivalence of methods; this may be given through an operation method <identifier>.

<identifier> is described in 7.3.4. If an <identifier> is omitted for both coordinate operation (17.1) and operation method, the WKT description is potentially ambiguous, relying on interpretation of method name. It is recommended that either a coordinate operation identifier or a coordinate operation method identifier is included in WKT strings. Identifiers for commonly encountered coordinate transformation methods are given in F.4.

17.2.5 Coordinate operation parameter

Requirement: The WKT representation of a coordinate operation parameter shall be:

<operation parameter> ::= <parameter keyword> <left delimiter> <parameter name>
<wkt separator><parameter value> <wkt separator> <parameter unit>
[{ <wkt separator> <identifier> }]... <right delimiter>

<parameter keyword> ::= PARAMETER

<parameter name> ::= <quoted Latin text> *!! See 7.2*

<parameter value> ::= <signed numeric literal>

<parameter unit> ::= <length unit> | <angle unit> | <scale unit> | <parametric unit> | <time unit>

Units are described in 7.4.

Parameter name is for human readability. For interoperability it is the method formula and its parameters that are critical in determining the equivalence of methods. See Annex F. Identifiers for commonly encountered coordinate operation methods and their parameters are given in F.4; the parameters are listed in F.5. The coordinate operation parameters required are specific to the coordinate operation method and shall be listed sequentially. The order within the sequence is not significant but should be logical. Implementations should be prepared to read any order. For those methods included in Annex F the parameter order given in F.4 is recommended.

Requirements:

- a) In coordinate operation WKT strings <parameter value> shall be given in the sense <source crs> to <target crs>. If the transformation parameter unit is linear its conversion factor shall be to metres and is the number of metres per unit. If the unit is angular its conversion factor shall be to radians and is the number of radians per unit. If the parameter is a scaling unit the conversion factor shall be to unity, for example parts per million (ppm) shall be given as 10^{-6} .

NOTE For commonly-encountered transformation parameters the parameter type is included in F.5.

- b) <identifier> is described in 7.3.4. It is an optional attribute. If an identifier is included as an attribute within the *coordinate operation* object (17.1) or *coordinate operation method* object (17.2.4), it shall take precedence over any identifier within the coordinate operation parameter object.

17.2.6 Coordinate operation parameter file

Requirement: The WKT representation of a coordinate operation parameter file shall be:

```
<operation parameter file> ::= <parameter file keyword> <left delimiter> <parameter name>
                               <wkt separator> <parameter file name>
                               [ { <wkt separator> <identifier> } ]... <right delimiter>

<parameter file keyword> ::= PARAMETERFILE

<parameter name> ::= <quoted Latin text> !! See 7.2

<parameter file name> ::= <quoted Latin text> !! See 7.2
```

For <parameter name> and <identifier> the requirements given in 17.2.5 shall apply.

17.2.7 Interpolation CRS

Some coordinate operation methods require coordinates referenced to a CRS which is neither the source CRS nor the target CRS. For example, in a coordinate operation applying a vertical offset between two vertical CRSs using either the vertical offset and slope method or a grid interpolation method such as VERTCON, horizontal coordinates are required. <interpolation crs> provides the mechanism for defining the CRS to which these coordinates are referenced.

Requirement: The WKT representation of an <interpolation crs> shall be:

```
<interpolation crs> ::= <interpolation crs keyword> <left delimiter>
                       <coordinate reference system> <right delimiter>

<interpolation crs keyword> ::= INTERPOLATIONCRS
```

<coordinate reference system> is defined in 17.2.2.

17.2.8 Coordinate operation accuracy

Operation accuracy is an optional attribute which indicates the typical error the application of a coordinate operation will introduce into transformed target CRS coordinates assuming input of errorless source CRS

coordinates. It is an approximate figure for the area of applicability of the coordinate operation as a whole, given in metres.

Requirement: The WKT representation of an <operation accuracy> shall be:

```

<operation accuracy>          ::=  <operation accuracy keyword> <left delimiter>
                                   <accuracy> <right delimiter>

<operation accuracy keyword>  ::=  OPERATIONACCURACY

<accuracy>                    ::=  <number>                !! <accuracy> is in metres

```

17.2.9 Other coordinate operation attributes

<identifier> is described in 7.3.4. It is an optional attribute.

<scope> is described in 7.3.2 and <extent> in 7.3.3. These are optional attributes describing the applicability of the coordinate operation.

<remark> is described in 7.3.4.

17.3 Examples of WKT describing a coordinate transformation

Line feeds are included in these examples to aid clarity. In several of these examples the full source and target CRS definitions are omitted from the example so that the coordinate transformation elements are more clearly identified.

EXAMPLE 1

```

COORDINATEOPERATION["Tokyo to JGD2000",VERSION["GSI"],
  SOURCECRS[
    GEODCRS["Tokyo",
      DATUM["Tokyo 1918",
        ELLIPSOID["Bessel 1841",6377397.155,299.1528128,
          LENGTHUNIT["metre",1.0]]],
      CS[Cartesian,3],
      AXIS["(X)",geocentricX,ORDER[1]],
      AXIS["(Y)",geocentricY,ORDER[2]],
      AXIS["(Z)",geocentricZ,ORDER[3]],
      LENGTHUNIT["metre",1.0]
    ]
  ],
  TARGETCRS[
    GEODCRS["JGD2000",
      DATUM["Japanese Geodetic Datum 2000",
        ELLIPSOID["GRS 1980",6378137.0,298.257222101,LENGTHUNIT["metre",1.0]]],
      CS[Cartesian,3],
      AXIS["(X)",geocentricX],
      AXIS["(Y)",geocentricY],
      AXIS["(Z)",geocentricZ],
      LENGTHUNIT["metre",1.0]
    ]
  ],
  METHOD["Geocentric translations",ID["EPSG",1031]],
  PARAMETER["X-axis translation",-146.414,
    LENGTHUNIT["metre",1.0],ID["EPSG",8605]],
  PARAMETER["Y-axis translation",507.337,
    LENGTHUNIT["metre",1.0],ID["EPSG",8606]],
  PARAMETER["Z-axis translation",680.507,
    LENGTHUNIT["metre",1.0],ID["EPSG",8607]]

```

EXAMPLE 2

```

COORDINATEOPERATION["AGD84 to GDA94",
  SOURCECRS[...full CRS definition required here but omitted for brevity...],
  TARGETCRS[...full CRS definition required here but omitted for brevity...],
  METHOD["Geocentric translations",ID["EPSG",1031]],
  PARAMETER["X-axis translation",-128.5,LENGTHUNIT["metre",1.0]],
  PARAMETER["Y-axis translation",-53.0,LENGTHUNIT["metre",1.0]],
  PARAMETER["Z-axis translation",153.4,LENGTHUNIT["metre",1.0]],
  OPERATIONACCURACY[5],
  USAGE[SCOPE["Low accuracy applications."],
    AREA["Australia onshore"],BBOX[-43.7,112.85,-9.87,153.68]],
  REMARK["Use NTv2 file for better accuracy"]
]

```

EXAMPLE 3

```

COORDINATEOPERATION["NZGD49 to NZGD2000",
  SOURCECRS[...full WKT definition required here but omitted for brevity...],
  TARGETCRS[...full WKT definition required here but omitted for brevity...],
  METHOD["NTv2",ID["EPSG",9615]],
  PARAMETERFILE["Latitude and longitude difference file","nzgd2kgrid0005.gsb"],
  ID["EPSG",1568,CITATION["LINZS25000"]],
  URI["http://www.linz.govt.nz/geodetic/software-downloads/"],
  REMARK["Coordinate transformation accuracy 0.1-1.0m"]
]

```

EXAMPLE 4

```

COORDINATEOPERATION["Amersfoort to ETRS89 (3)",
  SOURCECRS[...full CRS definition required here but omitted for brevity...],
  TARGETCRS[...full CRS definition required here but omitted for brevity...],
  METHOD["Coordinate Frame"],
  PARAMETER["X-axis translation",565.2369,LENGTHUNIT["metre",1.0]],
  PARAMETER["Y-axis translation",50.0087,LENGTHUNIT["metre",1.0]],
  PARAMETER["Z-axis translation",465.658,LENGTHUNIT["metre",1.0]],
  PARAMETER["X-axis rotation",1.9725,ANGLEUNIT["microradian",1E-06]],
  PARAMETER["Y-axis rotation",-1.7004,ANGLEUNIT["microradian",1E-06]],
  PARAMETER["Z-axis rotation",9.0677,ANGLEUNIT["microradian",1E-06]],
  PARAMETER["Scale difference",4.0812,SCALEUNIT["parts per million",1E-06]],
  ID["EPSG",15739]
]

```

EXAMPLE 5

```

COORDINATEOPERATION["DHHN92 height to EVRF2007 height",
  SOURCECRS[...full WKT definition of DHHN92 required here but omitted for brevity...],
  TARGETCRS[...full WKT definition of EVRF2007 required here but omitted for brevity...],
  METHOD["Vertical Offset and Slope",ID["EPSG",1046]],
  PARAMETER["Inclination in latitude",-0.010,
    ANGLEUNIT["arc-second",4.84813681109535E-06]],
  PARAMETER["Inclination in longitude ",0.002,
    ANGLEUNIT["arc-second",4.84813681109535E-06]],
  PARAMETER["Vertical offset",0.015,LENGTHUNIT["metre",1.0]],
  PARAMETER["Ordinate 1 of evaluation point",51.05,
    ANGLEUNIT["degree",0.0174532925199433]],
  PARAMETER["Ordinate 2 of evaluation point",10.21666666666667,
    ANGLEUNIT["degree",0.0174532925199433]],
  INTERPOLATIONCRS["ETRS89"
    ...full WKT definition of ETRS89 required here but omitted for brevity...],
  OPERATIONACCURACY[0.1],
  REMARK["Determined at 427 points. RMS residual 0.002m, maximum 0.007m"]
]

```

18 WKT representation of point motion operations

A point motion operation describes the change in coordinate values due to motion of the point between two epochs.

Requirement: The WKT representation of a <point motion operation> shall be:

```
<point motion operation> ::= <point motion keyword> <left delimiter> <operation name>
                             [ <wkt separator> <operation version> ]
                             <wkt separator> <source crs>
                             <wkt separator> <operation method>
                             [ { <wkt separator>
                               { <operation parameter> | <operation parameter file> } } ]...
                             [ <wkt separator> <operation accuracy> ]
                             <scope extent identifier remark> <right delimiter>
                             !! This BNF string is very similar to a subset of
                                that for coordinate transformations described in
                                17.1. Differences are the omission of <target crs>
                                and <interpolation crs> and a change in keyword.
```

```
<point motion keyword> ::= POINTMOTIONOPERATION
```

The attributes <operation name>, <operation version>, <source crs>, <operation method>, <operation parameter>, <operation parameter file>, <operation accuracy> and <scope extent identifier remark> are the same as for coordinate transformations and are described in 17.2.

A point motion operation changes coordinate values within a CRS; as such it does not have source or target CRSs. This document uses <source crs> in the BNF for convenience of similarity with coordinate transformations described in clause 17. Although this document allows any type of CRS, in practice a point motion operation will almost always be in a geodetic CRS, geographic CRS or vertical CRS.

EXAMPLE

```
POINTMOTIONOPERATION["Canada velocity grid v6",
  SOURCECRS[...full WKT definition of NAD83(CRS)v6 required here but omitted for brevity...],
  METHOD["Point motion by grid (Canada NTv2_Vel)"],
  PARAMETERFILE["Point motion velocity grid file","cvg60.cvb"],
  OPERATIONACCURACY[0.01]
]
```

19 WKT representation of concatenated coordinate operations

19.1 General

A concatenated coordinate operation is two or more coordinate transformations or coordinate conversions or point motion operations, or combinations of these coordinate operation types, which are applied sequentially. The target CRS for the step n is the source CRS for step $n+1$. The source CRS for the concatenated coordinate operation is the source CRS for step 1. The target CRS for the concatenated coordinate operation is the target CRS for the last step.

Requirement: The WKT representation of a <concatenated operation> shall be:

```

< concatenated operation>      ::=  <concatenated operation keyword> <left delimiter>
                                   <operation name> [ <wkt separator> <operation version> ]
                                   <wkt separator> <source crs> <wkt separator> <target crs>
                                   { <wkt separator> <step keyword> <left delimiter>
                                   { <coordinate operation> | <point motion operation>
                                   | <map projection> | <deriving conversion> }
                                   <right delimiter> }...
                                   [ <wkt separator> <operation accuracy> ]
                                   <scope extent identifier remark> <right delimiter>

<concatenated operation keyword> ::=  CONCATENATEDOPERATION

<step keyword>                  ::=  STEP

<operation name>                ::=  <quoted Latin text>                !! See 7.2

```

<source crs>, <target crs>, <coordinate operation>, <operation version> and <operation accuracy> are defined in 17.1 and 17.2, <point motion operation> is defined in clause 18.

EXAMPLE

```

CONCATENATEDOPERATION["xxxx to zzzz",
  SOURCECRS [...full WKT definition of CRS xxxx required here but omitted for brevity...],
  TARGETCRS [...full WKT definition of CRS zzzz required here but omitted for brevity...],
  STEP [...full WKT definition of operation xxxx to yyyy required here but omitted for brevity...],
  STEP [...full WKT definition of operation yyyy to zzzz required here but omitted for brevity...],
  OPERATIONACCURACY[5]
  USAGE[SCOPE["Concatenated operation scope description."],
    AREA["Concatenated operation area description."]]
]

```

For a concatenated coordinate operation sequence of n coordinate operations:

- source CRS (concatenated coordinate operation) = source CRS (coordinate operation step 1);
- target CRS (coordinate operation step i) = source CRS (coordinate operation step $i + 1$)
where $i = 1 \dots (n - 1)$;
- target CRS (concatenated coordinate operation) = target CRS (coordinate operation step n).

Instead of a forward coordinate operation, an inverse coordinate operation may be used for one or more of the coordinate operation steps mentioned above, if the inverse coordinate operation is uniquely defined by the forward coordinate operation method.

EXAMPLE 1: Changing coordinates from being referenced to CRS A to being referenced to CRS B through coordinate transformation CRS A to CRS C followed by coordinate transformation CRS C to CRS B where the second transformation is documented as CRS B to CRS C but is reversible. In application of the concatenated operation, the second transformation is applied in the direction from CRS C to CRS B.

In these circumstances, it is recommended that:

- a) if the step description includes an identifier from a geodetic registry, the WKT for the step description should reflect the registry entry. In the example above:
- The source CRS and target CRS for the concatenated operation are A and B respectively;
 - The source CRS and target CRS for step 1 are A and C and the transformation parameter values are consistent with this direction;
 - The source CRS and target CRS for step 2 are B and C and the transformation parameter values are consistent with this direction.

This ensures that the parameter values which are documented in the WKT reflect those given in the geodetic registry.

- b) if the step description does not include an identifier from a geodetic registry, the WKT for the step description should reflect the direction in which the coordinate operation is applied, and the parameter values should be appropriate for this direction.

In both cases, for each step the parameter values shall be consistent with the documented direction from source to target.

19.2 Examples of WKT describing a concatenated coordinate operation

EXAMPLE 1 Concatenated operation with two steps, the last of which is documented in the reverse direction to how it is applied in the concatenated operation because a geodetic registry identifier for the step is included in the WKT. The WKT documents the step in the direction given in the registry:

```
CONCATENATEDOPERATION["RT90 to KKJ",
  SOURCECRS[GEOGCRS["RT90",
    ...full WKT definition of concatenated operation source CRS required here but omitted for brevity...]],
  TARGETCRS[GEOGCRS["KKJ",
    ...full WKT definition of concatenated operation target CRS required here but omitted for brevity...]],
  STEP[COORDINATEOPERATION["RT90 to ETRS89",
    SOURCECRS[GEOGCRS["RT90",
      ...full WKT definition of step 1 source CRS required here but omitted for brevity...]],
    TARGETCRS[GEOGCRS["ETRS89",
      ...full WKT definition of step 1 target CRS required here but omitted for brevity...]],
    METHOD[
      ...full WKT definition of operation RT90 to ETRS89 required here but omitted for brevity...
    ],
    ID["EPSG",1437]
  ],
  STEP[COORDINATEOPERATION["KKJ to ETRS89",
    SOURCECRS[GEOGCRS["KKJ",
      ...full WKT definition of step 2 source CRS required here but omitted for brevity...]],
    TARGETCRS[GEOGCRS["ETRS89",
      ...full WKT definition of step 2 target CRS required here but omitted for brevity...]],
    METHOD[["Coordinate Frame rotation",ID["EPSG",9607]]],
    PARAMETER["X-axis translation",-96.062,LENGTHUNIT["metre",1.0]],
    ...full WKT definition of operation KKJ to ETRS89 required here but omitted for brevity...
  ],
  ID["EPSG",10098]
  ],
  USAGE[SCOPE["Concatenated operation scope description."],
    AREA["Concatenated operation area description."]],
  REMARK["Step 2 is applied in reverse direction"]
]
```

EXAMPLE 2 The same concatenated operation as in Example 1, with no geodetic registry ID for the individual step transformations so both steps documented in the direction as applied in the concatenated operation. Note reversal of sign of parameter(s) in second step compared to those in Example 1:

```

CONCATENATEDOPERATION["RT90 to KKJ",
  SOURCECRS[GEOGCRS["RT90",
    ...full WKT definition of concatenated operation source CRS required here but omitted for brevity...]],
  TARGETCRS[GEOGCRS["KKJ",
    ...full WKT definition of concatenated operation target CRS required here but omitted for brevity...]],
  STEP[COORDINATEOPERATION["RT90 to ETRS89",
    SOURCECRS[GEOGCRS["RT90",
      ...full WKT definition of step 1 source CRS required here but omitted for brevity...]],
    TARGETCRS[GEOGCRS["ETRS89",
      ...full WKT definition of step 1 target CRS required here but omitted for brevity...]],
    METHOD[
      ...full WKT definition of operation RT90 to ETRS89 required here but omitted for brevity...
    ],
  ],
  STEP[COORDINATEOPERATION["ETRS89 to KKJ",
    SOURCECRS[GEOGCRS["ETRS89",
      ...full WKT definition of step 2 source CRS required here but omitted for brevity...]],
    TARGETCRS[GEOGCRS["KKJ",
      ...full WKT definition of step 2 target CRS required here but omitted for brevity...]],
    METHOD[["Coordinate Frame rotation",ID["EPSG",9607]]
    PARAMETER["X-axis translation",96.062,LENGTHUNIT["metre",1.0]],
    ...full WKT definition of operation ETRS89 to KKJ required here but omitted for brevity...
  ],
]

```

20 WKT representation of CRS and coordinate operation couplets

20.1 Bound CRS

The definition of a CRS is not dependent upon any relationship to an independent CRS. However in an implementation that merges datasets referenced to differing CRSs, it is sometimes useful to associate the definition of the transformation that has been used with the CRS definition. This facilitates the interrelationship of CRS by concatenating transformations via a common or hub CRS. This document permits the association of an abridged coordinate transformation description with a coordinate reference system description in a single text string. In a bound CRS the abridged coordinate transformation is applied to the source CRS with the target CRS being the common or hub system.

Requirement: The WKT representation of a bound CRS shall be:

```
<bound crs> ::= <bound crs keyword> <left delimiter>
               <source crs> <wkt separator> <target crs>
               <wkt separator> <abridged coordinate transformation>
               <scope extent identifier remark>
               <right delimiter>
```

```
<bound crs keyword> ::= BOUNDCRS
```

Examples are given in 20.3.

The source and target CRSs shall be defined through a full CRS description as described in Clause 8. If the source CRS type is projected and the abridged coordinate transformation operates in the geodetic CRS domain, the transformation is deemed to operate on the projected CRS's base CRS but the projected CRS shall be described.

20.2 Bound CRS components

20.2.1 Abridged coordinate transformation

In the WKT representation of projected coordinate reference systems the units of map projection parameters may be implied (see 9.3). In a similar way the abridged coordinate transformation also omits explicit identification of coordinate transformation parameter unit from the text string. It has several constraints.

Requirements:

- a) The abridged form of coordinate transformation shall only be used as part of a bound CRS.
- b) The abridged transformation shall be described in the sense from <source CRS> to <target CRS>.
- c) The WKT representation of an abridged coordinate transformation shall be:


```

<abridged coordinate transformation> ::= <abridged transformation keyword> <left delimiter>
                                     <operation name>
                                     [ <wkt separator> <operation version> ]
                                     <wkt separator> <operation method>
                                     [ { <wkt separator>
                                       { <abridged transformation parameter>
                                       | <operation parameter file> } } ]...
                                     <scope extent identifier remark> <right delimiter>

<abridged transformation keyword> ::= ABRIDGEDTRANSFORMATION

```

20.2.2 Coordinate operation method in abridged coordinate transformations

In an abridged coordinate transformation description the format for operation method is identical to that for coordinate operation method defined in Clause 17.

20.2.3 Abridged coordinate transformation parameter

Requirement: The WKT representation of an abridged transformation parameter shall be:

```

<abridged transformation parameter> ::= <parameter keyword> <left delimiter>
                                     <parameter name> <wkt separator> <parameter value>
                                     [ { <wkt separator> <identifier> } ]... <right delimiter>

```

The format for abridged transformation parameter is similar to that for coordinate operation parameter defined in 17.2.5 but with the following constraints on parameter values:

Requirements:

- The value of parameters which are linear shall be given in metres.
- The value of parameters which are angular shall be given in arc-seconds (4.848136811095E-06 radian).
- The value of parameters which are scale units shall be given as a number with respect to unity, for example 3.5 parts per million (ppm) shall be given as 1.0000035 and -3.5ppm shall be given as 0.9999965.
- <unit> shall not be given.
- Implementations are expected to identify the parameter value unit type from the parameter name.
- The parameter values shall be described in the sense from source CRS to target CRS.

The parameters required are specific to the coordinate operation method and are listed sequentially. The order within the sequence is not significant but should be logical.

```

EXAMPLE  ABRIDGEDTRANSFORMATION["Tokyo to JGD2000 (GSI)",
                                     METHOD["Geocentric translations",ID["EPSG",1031]],
                                     PARAMETER["X-axis translation",-146.414],
                                     PARAMETER["Y-axis translation",507.337],
                                     PARAMETER["Z-axis translation",680.507]
                                     ]

```

20.2.4 Coordinate operation parameter file

Operation parameter file is defined in 17.2.6.

20.3 Examples of WKT describing a bound CRS

EXAMPLE 1

```

BOUND CRS [
  SOURCE CRS [
    GEO CRS ["NAD27",
      DATUM ["North American Datum 1927",
        ELLIPSOID ["Clarke 1866", 6378206.4, 294.978698213]
      ],
      CS [ellipsoidal, 2],
      AXIS ["latitude", north], AXIS ["longitude", east],
      ANGLE UNIT ["degree", 0.0174532925199433]
    ]
  ],
  TARGET CRS [
    GEO CRS ["NAD83",
      DATUM ["North American Datum 1983",
        ELLIPSOID ["GRS 1980", 6378137, 298.2572221]
      ],
      CS [ellipsoidal, 2],
      AXIS ["latitude", north], AXIS ["longitude", east],
      ANGLE UNIT ["degree", 0.0174532925199433]
    ]
  ],
  ABRIDGED TRANSFORMATION ["NAD27 to NAD83 Alaska",
    METHOD ["NADCON", ID ["EPSG", 9613]],
    PARAMETER FILE ["Latitude difference file", "alaska.las"],
    PARAMETER FILE ["Longitude difference file", "alaska.los"]
  ]
]

```

EXAMPLE 2

```

BOUND CRS [
  SOURCE CRS [...full WKT definition required here but omitted for brevity...],
  TARGET CRS [...full WKT definition required here but omitted for brevity...],
  ABRIDGED TRANSFORMATION ["NAD27 to NAD83(86) National",
    METHOD ["NTv2", ID ["EPSG", 9615]],
    PARAMETER FILE ["Latitude and longitude difference file", "NTv2_0.gsb"]
  ]
]

```

EXAMPLE 3

```

BOUND CRS [
  SOURCE CRS [...full WKT definition required here but omitted for brevity...],
  TARGET CRS [...full WKT definition required here but omitted for brevity...],
  ABRIDGED TRANSFORMATION ["Amersfoort to ETRS89 (3)",
    METHOD ["Coordinate Frame", ID ["EPSG", 1032]],
    PARAMETER ["X-axis translation", 565.2369, ID ["EPSG", 8605]],
    PARAMETER ["Y-axis translation", 50.0087, ID ["EPSG", 8606]],
    PARAMETER ["Z-axis translation", 465.658, ID ["EPSG", 8607]],
    PARAMETER ["X-axis rotation", 0.407, ID ["EPSG", 8608]],
    PARAMETER ["Y-axis rotation", -0.351, ID ["EPSG", 8609]],
    PARAMETER ["Z-axis rotation", 1.870, ID ["EPSG", 8610]],
    PARAMETER ["Scale difference", 1.000004812, ID ["EPSG", 8611]]
  ]
]

```

NOTE Compare the rotation values (here in arc-seconds because they are in an abridged coordinate transformation) with those in the fourth example in 17.3.

Annex A

(normative)

Abstract test suite

A.1 Conformance of a WKT string describing a geodetic or geographic CRS

A.1.1 Structure

- a) Test purpose: to determine whether a text string representation of a geodetic coordinate reference system or of a geographic coordinate reference system conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.1.2 Content

- a) Test purpose: to determine whether a text string representation of a geodetic coordinate reference system conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a geodetic CRS or geographic CRS, and that these use the correct terminology and syntax.
- c) Reference: Clauses 7 and 8.
- d) Test type: capability.

A.2 Conformance of a WKT string describing a projected CRS

A.2.1 Structure

- a) Test purpose: to determine whether a text string representation of a projected coordinate reference system conforms to the characters and syntax required by this document
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.2.2 Content

- a) Test purpose: to determine whether a text string representation of a projected coordinate reference system conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a projected CRS, and that these use the correct terminology and syntax.

- c) Reference: Clauses 7, 8 and 9.
- d) Test type: capability.

A.3 Conformance of a WKT string describing a vertical CRS

A.3.1 Structure

- a) Test purpose: to determine whether a text string representation of a vertical coordinate reference system conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.3.2 Content

- a) Test purpose: to determine whether a text string representation of a vertical coordinate reference system conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a vertical CRS, and that these use the correct terminology and syntax.
- c) Reference: Clauses 7 and 10.
- d) Test type: capability.

A.4 Conformance of a WKT string describing an engineering CRS

A.4.1 Structure

- a) Test purpose: to determine whether a text string representation of an engineering coordinate reference system conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.4.2 Content

- a) Test purpose: to determine whether a text string representation of an engineering coordinate reference system conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for an engineering CRS, and that these use the correct terminology and syntax.
- c) Reference: Clauses 7 and 11.

- d) Test type: capability.

A.5 Conformance of a WKT string describing a parametric CRS

A.5.1 Structure

- a) Test purpose: to determine whether a text string representation of a parametric coordinate reference system conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.5.2 Content

- a) Test purpose: to determine whether a text string representation of a parametric coordinate reference system conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a parametric CRS, and that these use the correct terminology and syntax.
- c) Reference: Clauses 7 and 12.
- d) Test type: capability.

A.6 Conformance of a WKT string describing a temporal CRS

A.6.1 Structure

- a) Test purpose: to determine whether a text string representation of a temporal coordinate reference system conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.6.2 Content

- a) Test purpose: to determine whether a text string representation of a temporal coordinate reference system conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a temporal CRS, and that these use the correct terminology and syntax.
- c) Reference: Clauses 7 and 13.
- d) Test type: capability.

A.7 Conformance of a WKT string describing a derived geodetic or derived geographic CRS

A.7.1 Structure

- a) Test purpose: to determine whether a text string representation of a derived geodetic coordinate reference system of a derived geographic coordinate reference system conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.7.2 Content

- a) Test purpose: to determine whether a text string representation of a derived geodetic CRS or of a derived geographic CRS conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a derived geodetic CRS or for a derived geographic CRS, and that these use the correct terminology and syntax..
- c) Reference: Clauses 7, 8.2, 14.2 and 14.3.
- d) Test type: capability.

A.8 Conformance of a WKT string describing a derived projected CRS

A.8.1 Structure

- a) Test purpose: to determine whether a text string representation of a derived projected coordinate reference system conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.8.2 Content

- a) Test purpose: to determine whether a text string representation of a derived projected coordinate reference system conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a derived projected CRS, and that these use the correct terminology and syntax.
- c) Reference: Clauses 7, 8.2, 9.2, 9.3, 14.2 and 14.4.
- d) Test type: capability.

A.9 Conformance of a WKT string describing a derived vertical CRS

A.9.1 Structure

- a) Test purpose: to determine whether a text string representation of a derived vertical coordinate reference system conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.9.2 Content

- a) Test purpose: to determine whether a text string representation of a derived vertical coordinate reference system conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a derived vertical CRS, and that these use the correct terminology and syntax.
- c) Reference: Clauses 7, 10.2, 14.2 and 14.5.
- d) Test type: capability.

A.10 Conformance of a WKT string describing a derived engineering CRS

A.10.1 Structure

- a) Test purpose: to determine whether a text string representation of a derived engineering coordinate reference system conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.10.2 Content

- a) Test purpose: to determine whether a text string representation of a derived engineering coordinate reference system conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a derived engineering CRS, and that these use the correct terminology and syntax.
- c) Reference: Clauses 7, 11.2, 14.2 and 14.6.
- d) Test type: capability.

A.11 Conformance of a WKT string describing a derived parametric CRS

A.11.1 Structure

- a) Test purpose: to determine whether a text string representation of a derived parametric coordinate reference system conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.11.2 Content

- a) Test purpose: to determine whether a text string representation of a derived parametric coordinate reference system conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a derived parametric CRS, and that these use the correct terminology and syntax.
- c) Reference: Clauses 7, 12.2, 14.2 and 14.7.
- d) Test type: capability.

A.12 Conformance of a WKT string describing a derived temporal CRS

A.12.1 Structure

- a) Test purpose: to determine whether a text string representation of a derived temporal coordinate reference system conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.12.2 Content

- a) Test purpose: to determine whether a text string representation of a derived temporal coordinate reference system conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a derived temporal CRS, and that these use the correct terminology and syntax.
- c) References: Clauses 7, 13.2, 14.2 and 14.8.
- d) Test type: capability.

A.13 Conformance of a WKT string describing a compound CRS

A.13.1 Structure

- a) Test purpose: to determine whether a text string representation of a compound coordinate reference system conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.13.2 Content

- a) Test purpose: to determine whether a text string representation of a compound coordinate reference system conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a compound CRS, and that these use the correct terminology and syntax.
- c) Reference: Clause 15.
- d) Test type: capability.

A.14 Conformance of a WKT string describing coordinate metadata

A.14.1 Structure

- a) Test purpose: to determine whether a text string representation of coordinate metadata conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.14.2 Content

- a) Test purpose: to determine whether a text string representation of coordinate metadata conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for coordinate metadata
- c) Reference: Clause 16.
- d) Test type: capability.

A.15 Conformance of a WKT string describing a coordinate transformation

A.15.1 Structure

- a) Test purpose: to determine whether a text string representation of a coordinate transformation conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.15.2 Content

- a) Test purpose: to determine whether a text string representation of a coordinate transformation conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a coordinate transformation, and that these use the correct terminology and syntax.
- c) Reference: Clause 17.
- d) Test type: capability.

A.16 Conformance of a WKT string describing a point motion operation

A.16.1 Structure

- a) Test purpose: to determine whether a text string representation of a point motion operation conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.16.2 Content

- a) Test purpose: to determine whether a text string representation of a point motion operation conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a point motion operation, and that these use the correct terminology and syntax.
- c) Reference: Clause 18.
- d) Test type: capability.

A.17 Conformance of a WKT string describing a concatenated coordinate operation

A.17.1 Structure

- a) Test purpose: to determine whether a text string representation of a concatenated coordinate operation conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.17.2 Content

- a) Test purpose: to determine whether a text string representation of a concatenated coordinate operation conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a concatenated coordinate operation, and that these use the correct terminology and syntax.
- c) Reference: Clause 19.
- d) Test type: capability.

A.18 Conformance of a WKT string describing a bound CRS

A.18.1 Structure

- a) Test purpose: to determine whether a text string representation of a bound CRS conforms to the characters and syntax required by this document.
- b) Test method: verify that the structure of the WKT string conforms to the requirements of Clause 5 and that text string syntax conforms to the requirements of Clause 6.
- c) Reference: Clauses 5 and 6.
- d) Test type: capability.

A.18.2 Content

- a) Test purpose: to determine whether a text string representation of a bound CRS conforms to the content required by this document.
- b) Test method: verify that the text string includes all of the elements specified for a bound CRS, and that these use the correct terminology and syntax.
- c) Reference: Clause 20.
- d) Test type: capability.

Annex B (informative)

Recommended practice for implementation

B.1 General

This document defines the structure and content of WKT strings. It does not specifically address the requirements for implementations that write or read these strings. Some recommendations for such implementations are given in B.2 to B.8.

B.2 Keywords

B.2.1 Keyword case sensitivity

WKT keywords by definition are case insensitive. KEYWORD is equivalent to keyword is equivalent to KeyWord and to kEYwORD. Where human readability is important (as in the examples in this document) keywords should be written in only the <simple Latin upper case letter> set.

KEYWORD is not equivalent to KEY_WORD. The underscore character is significant.

B.2.2 Alternative keywords

Where alternative keywords are defined, as a minimum, implementations should be able to write the preferred and to read all alternatives.

For geodetic and vertical CRSs two alternative keywords (geodeticDatum / verticalDatum and TRF / VRF) are permitted. For brevity and backward compatibility, datum and vdatum are recommended. Should one of the alternatives be preferred then it is recommended to use geodeticDatum / verticalDatum only for classical datums and TRF / VRF only for modern frames.

B.2.3 Handling of unrecognised keywords

It is recognised that prior to the publication of this document some tokens that are not included in this document have been produced. Parsers reading CRS WKT strings and encountering unrecognised keywords should ignore the token and its content. They should be able to continue parsing the string without throwing an exception.

B.3 Characters

B.3.1 Handling of unrecognised characters

Implementations parsing WKT strings conformant with this document are not required to be able to read non-LATIN1 character sets. But if they are unable to do so they should be able to continue reading the WKT string by ignoring the <remark> token (keyword and content) without throwing an exception.

B.3.2 String length

The length of a WKT string or of its components is not prescribed. However the following maximum lengths are recommended for implementations writing CRS WKT strings:

- The total length of a keyword should not exceed 24 characters.
- The total length of a <name> should not exceed 80 characters.

- The total length of a <quoted Latin text> string should not exceed 255 characters.
- The total length of a <quoted Unicode text> string should not exceed 255 characters.
- The total length of a CRS WKT string should not exceed 4096 characters.

B.4 White space

B.4.1 Insertion of white space

Outside of <quoted Latin text> and <quoted Unicode text> a WKT string written to the requirements of this document contains no white space. However to improve human readability implementations may insert spaces, tabs or line feeds before or after any element of the string. In the examples in this document, line feeds and inset are included to aid clarity in reading this document.

Spaces should not be inserted within keywords or numbers.

B.4.2 Parsing of white space outside of quoted text

Parsers reading CRS WKT strings should ignore white space outside of <quoted Latin text> or <quoted Unicode text>.

B.4.3 Parsing of white space within quoted text

Parsers reading CRS WKT strings should ignore white space at the beginning or end of <quoted Latin text> or <quoted Unicode text>. Parsers may convert consecutive white space characters embedded within the quoted text string into a single <space>.

B.5 Identifiers

B.5.1 Use of identifiers

When an identifier is given for a coordinate reference system, coordinate operation or bound CRS, it applies to the whole object including all of its components.

When an identifier is written into an object definition, all names, values and units for that object and its components which are given in the WKT should be consistent with those given by the authority.

In the event of conflict in values given in the CRS WKT string and given by an authority through an object's name or an identifier, reading software should throw an exception or give users a warning message. The WKT values should be assumed to prevail.

B.5.2 Using names to interpret identity

If comparing the content of two <name> strings, implementations should ignore case, the characters <underscore> "_", <minus sign> "-", <solidus> "/", <left paren> "(" and <right paren> ")".

EXAMPLE "Central_Meridian" should be considered equal to "central-meridian", "Central meridian" and "centralMeridian".

B.6 Numbers

B.6.1 Precision

Best practice is to preserve the original precision as specified by the information source. This may require maintaining 16 digits of precision.

B.6.2 Defining parameters for a sphere

The WKT representation of an ellipsoid requires the two defining parameters to be a and $1/f$. For a sphere the value of $1/f$ is infinite. If the figure of the earth is a sphere it should have an artificial <inverse flattening> value of 0. Implementations should be prepared to read and handle this artificial value.

B.6.3 Implied units

Best practice is to explicitly include units for parameters, and to not use implied units. However for backward compatibility with ISO 19125-1:2004 and OGC 01-009 this document permits some units to be implied. Implied units cannot always be inferred from other attributes. This document therefore requires that implied units are standardised. If omitted and implied then:

Map projection <parameter unit>

- map projection parameters that are lengths should be given in the unit for the projected CRS axes;
- map projection parameters that are angles should be given as decimal degree values;
- map projection parameters that are unitless (for example scale factor) should be given as a number which is close to or is unity (1.0).

Prime meridian IRM longitude values should be given as decimal degree values.

Ellipsoid axis lengths should be given in metres.

B.7 Attribute order

The order of elements in a WKT string is dictated by the BNF in this document. Certain attributes, notably map projection parameters and coordinate transformation parameters, may be included multiple times. The parameters required are specific to the method and will be listed sequentially. The order within the sequence is not significant but should be logical. Implementations should be prepared to read any order. For those methods included in Annex F the parameter order as listed in F.3 for map projections and F.5 for coordinate operations is recommended.

B.8 Version of CRS WKT

Implementations that wish to detect whether a CRS WKT string follows this document or is from a specification earlier than 2015 may do so by checking the first keyword in the string.

Strings conformant to this document begin with or contain one of the following keywords:

- BOUNDCRS, COMPOUNDCRS, ENGCRS, ENGINEERINGCRS, GEODCRS, GEODETICCRS, GEOGCRS, GEOGRAPHICCRS, PARAMETRICCRS, PROJCRS, PROJECTEDCRS, TIMECRS, VERTCRS or VERTICALCRS.

The last characters in these keywords are 'CRS'.

If the WKT begins with or contains any of the following keywords, it is an older format:

- COMPDCS, FITTED_CS, GEOCCS, GEOGCS, LOCAL_CS, PROJCS, VERT_CS.

The last characters in all these keywords are 'CS'.

Implementations that wish to detect whether a CRS string follows the 2015 version of this document should refer to the keyword changes summarised in Annex D, paragraph 2.

Annex C (informative)

Mapping of concepts from previous versions of CRS WKT

C.1 BNF

Annex C describes differences between previous versions of CRS WKT defined in ISO 19125-1:2004 and OGC 01-009 and that defined in this document. In Annex C the syntax of BNF used follows that defined in Clause 5. This differs from that used in both ISO 19125-1:2004 and OGC 01-009, given in Table C.1 for reference.

Table C.1 — Mapping of concepts from previous versions of CRS WKT

ISO 19125-1:2004 and OGC CTS 01-009	This document	Comment
=	::=	Production
< >	< >	Basic type
		Alternative
{ }	[]	Optionality
*	...	Multiplicity
()	{ }	Grouping

Of more relevance is the backward compatibility of the WKT strings themselves; this is described in C.2 to C.6.

C.2 Backward compatibility of CRS common attributes

C.2.1 Name

In both ISO 19125-1:2004 and OGC 01-009 the attribute <name> is, like in this document, defined to be quoted text. However, quoted text is not explicitly defined in these earlier specifications. As a consequence the name attribute in WKT strings written to the earlier specifications may contain characters and character sets not permitted by this document. With this caveat, name attributes should be readable by implementations of this document.

C.2.2 ID (Authority)

This attribute is not defined in ISO 19125-1:2004. In OGC 01-009 the object AUTHORITY was defined as an optional terminating object. In this document the following definition from OGC 01-009 has been deprecated but is included here for the purposes of documenting backward compatibility:

```

<identifier>          ::=  AUTHORITY <left delimiter> <authority name>
                           <wkt separator> <authority unique identifier> <right delimiter>

<authority name>      ::=  <quoted Latin text>

<authority unique identifier> ::=  <quoted Latin text>

```

The keyword AUTHORITY maps to the keyword ID in this document. The attribute <authority unique identifier> in the BNF in this document was called <code> in OGC 01-009 where it was defined to be quoted text, whereas <authority unique identifier> in this document may be either a number (without

quotes) or quoted text. For potential issues with quoted text in WKT strings written to earlier standards see C.2.1.

WKT descriptions of identifier (authority) written to the OGC 01-009 specification should be readable by implementations of this document except when quoted text contains unsupported characters.

Note: <authority> is excluded from the WKT in C.3 and C.4 below.

C.3 Backward compatibility of coordinate reference system components

C.3.1 Ellipsoid

The WKT for describing an ellipsoid is defined in 8.2.1.

In this document the following definition from ISO 19125-1:2004 has been deprecated but is included here for the purposes of documenting backward compatibility:

```
<ellipsoid> ::= ELLIPSOID <left delimiter> <ellipsoid name> <wkt separator>
               <semi-major axis> <wkt separator> <inverse flattening> <right delimiter>
```

In this document the following definition from OGC 01-009 has been deprecated but is included here for the purposes of documenting backward compatibility:

```
<ellipsoid> ::= SPHEROID <left delimiter> <ellipsoid name> <wkt separator>
               <semi-major axis> <wkt separator> <inverse flattening> <right delimiter>
```

Both ISO 19125-1:2004 and OGC 01-009 required that the semi-major axis be given in metres. Neither ISO 19125-1:2004 nor OGC 01-009 allowed for a sphere to be defined (as inverse flattening is infinite).

WKT descriptions of ellipsoids defined in metres and written to the ISO 19125-1:2004 and OGC 01-009 specifications should be readable by implementations of this document.

C.3.2 Prime meridian

The WKT for prime meridian is defined in 8.2.2.

In this document the following definition from both ISO 19125-1:2004 and OGC 01-009 has been deprecated but is included here for the purposes of documenting backward compatibility:

```
<prime meridian> ::= PRIMEM <left delimiter> <prime meridian name>
                   <wkt separator> <irm longitude> <right delimiter>
```

In both ISO 19125-1:2004 and OGC 01-009 <prime meridian> was a mandatory attribute of geographic CRS. (In certain frequently-occurring conditions it may be omitted in this document). The longitude unit was unstated in ISO 19125-1:2004; in OGC 01-009 it was taken to be the angular unit of the geographic CRS in which it was contained or for a geocentric CRS was in degrees.

WKT descriptions of prime meridians written to the ISO 19125-1:2004 and OGC 01-009 specifications should be readable by implementations of this document.

C.3.3 Datum

In this document the following definition from ISO 19125-1:2004 has been deprecated but is included here for the purposes of documenting backward compatibility:

```
<geodetic datum> ::= <left delimiter> <datum name> <wkt separator> <ellipsoid>
                   <right delimiter>
```

where ellipsoid is as described in C.3.1. ISO 19125-1:2004 did not cater for any other datum type.

WKT descriptions of geodetic datums written to the ISO 19125-1:2004 specification should be readable by implementations of this document.

In this document the following definition from OGC 01-009 has been deprecated but is included here for the purposes of documenting backward compatibility:

```
<geodetic datum> ::= DATUM <left delimiter> <datum name> <wkt separator> <ellipsoid>
[ <towgs84> ] <right delimiter>
```

where ellipsoid is as described in C.3.1.

TOWGS84 is a form of abridged coordinate transformation (see 20.2.1) but inappropriately modelled as part of a geodetic datum definition (a geodetic datum definition should not include a relationship to WGS 84). This document has no backward compatibility with the TOWGS84 object. WKT descriptions of geodetic datums written to the OGC 01-009 specification will be readable by implementations of this document only if the optional TOWGS84 object is not contained.

```
<vertical datum> ::= VERT_DATUM <left delimiter> <datum name> <wkt separator>
<datum type> <right delimiter>
```

```
<engineering datum> ::= LOCAL_DATUM <left delimiter> <datum name> <wkt separator>
<datum type> <right delimiter>
```

In OGC 01-009 datum type is a number but is otherwise not defined. This document has no backward compatibility with the datum type object, and as a consequence has no backward compatibility with the keywords and objects VERT_DATUM and LOCAL_DATUM.

WKT descriptions of vertical and engineering datums written to the OGC 01-009 specification are not readable by implementations of this document.

C.3.4 Map projection

Map projection is defined in 9.3.

In this document the following definition from ISO 19125-1:2004 and OGC 01-009 has been deprecated but is included here for the purposes of documenting backward compatibility:

```
<map projection> ::= PROJECTION <left delimiter> <name> <right delimiter>
{ <wkt separator> <projection parameter> }...
```

```
<map projection parameter> ::= PARAMETER <left delimiter> < name> <wkt separator>
<parameter value> <right delimiter>
```

```
<parameter value> ::= <number>
```

EXAMPLE 1

```
PROJECTION["Transverse Mercator",
  PARAMETER["Latitude of origin",0],
  PARAMETER["Central meridian",-123],
  PARAMETER["Scale factor",0.9996],
  PARAMETER["False easting",500000],
  PARAMETER["False northing",0]
```

EXAMPLE 2

```
PROJECTION["UTM zone 10N",
  PARAMETER["Latitude of natural origin",0],
  PARAMETER["Longitude of natural origin",-123],
  PARAMETER["Scale factor at natural origin",0.9996],
  PARAMETER["FE",500000],
  PARAMETER["FN",0]
```

WKT strings that used this definition exhibit the following ambiguities:

- a) in the name attribute there is no clear distinction between the projection (the collection of method plus its parameters) and projection method. In this document the two concepts have separate keywords **CONVERSION** and **METHOD** respectively. Implementations of earlier specifications have differed in their interpretation of name, some giving the projection name (such as "UTM zone 10N") and others the method name (such as "Transverse Mercator").
- b) the method formula, which is critical for interoperability, is implied through the method name, and relies on the method and parameter name strings being interpreted by the receiving application with the same meaning as used in the producing application.
- c) the units for the parameter values are ambiguous.

WKT descriptions of map projections written to the ISO 19125-1:2004 and OGC 01-009 specifications should be readable by implementations but the string may not be interpretable by machine.

C.3.5 Coordinate system

The WKT for describing a coordinate system is defined in 7.5.

NOTE Both ISO 19125-1:2004 and OGC 01-009 use the term coordinate system, but with a different meaning to this document. The term coordinate system as used in those earlier specifications equates to coordinate *reference* system in this document. Coordinate system as defined in ISO 19111 and used in this Document is a different, more limited, concept.

In this document the following definition from ISO 19125-1:2004 has been deprecated but is included here for the purposes of documenting backward compatibility:

`<coordinate system> ::= <cs unit>`

EXAMPLE 1 `UNIT["German legal metre",1.0000135965]`

WKT descriptions of coordinate systems written to the ISO 19125-1:2004 specification give a very incomplete description but should be readable by implementations of this document. However the lack of definition of axis order may lead to ambiguity or serious error in interpretation of coordinates.

In this document the following definition from OGC 01-009 has been deprecated but is included here for the purposes of documenting backward compatibility:

`<coordinate system> ::= [{ <axis> <wkt separator> }]... <cs unit>`

`<axis> ::= AXIS <left delimiter> <name> <wkt separator>
{ north | east | south | west | up | down | other } <right delimiter>`

EXAMPLE 2 `AXIS["northing",north]`

EXAMPLE 3 `AXIS["easting",east]`

EXAMPLE 4 `UNIT["German legal metre",1.0000135965]`

`<axis>` was an optional attribute. If omitted it was implied that there were two axes whose directions were east and north respectively.

In OGC 01-009 the options for axis directions were significantly reduced compared to those in this document. They were sufficient for most but not all geographic and projected CRSs. Provision was made for describing axes for a geocentric CRS but the prescribed directions were incorrectly defined. The provision for describing axes for an engineering (local) CRS were incomplete and usable in only a minority of cases.

WKT descriptions of coordinate systems written to the OGC 01-009 specification may give an incomplete description but should be readable by implementations of this document.

C.4 Backward compatibility of coordinate reference systems

C.4.1 Geodetic CRS

Geodetic CRS is defined in Clause 8. In this document the following definitions from ISO 19125-1:2004 and OGC 01-009 have been deprecated but are included here for the purposes of documenting backward compatibility:

<i><geocentric crs></i>	::=	GEOCCS <i><left delimiter></i> <i><crs name></i> <i><wkt separator></i> <i><datum></i> <i><wkt separator></i> <i><prime meridian></i> [{ <i><wkt separator></i> <i><axis></i> }]... <i><wkt separator></i> <i><axis unit></i> <i><right delimiter></i>
<i><static geographic crs></i>	::=	GEOGCS <i><left delimiter></i> <i><crs name></i> <i><wkt separator></i> <i><datum></i> <i><wkt separator></i> <i><prime meridian></i> [{ <i><wkt separator></i> <i><axis></i> }]... <i><wkt separator></i> <i><axis unit></i> <i><right delimiter></i>
<i><datum></i>	::=	DATUM <i><left delimiter></i> <i>< name></i> <i><wkt separator></i> <i><spheroid></i> <i><right delimiter></i>
<i><spheroid></i>	::=	{ ELLIPSOID SPHEROID } <i><left delimiter></i> <i><ellipsoid name></i> <i><wkt separator></i> <i><semi-major axis></i> <i><wkt separator></i> <i><inverse flattening></i> <i><right delimiter></i>

In WKT strings that followed these definitions, the keyword omits the R in CRS. The inclusion of prime meridian is mandatory in the BNF (but not always included in WKT strings that have been produced!). The ellipsoid cannot be a sphere, and its semi-major axis is to be given in metres. In ISO 19125-1:2004 the keyword is ELLIPSOID whilst in OGC 01-009 it is SPHEROID.

Axis name and direction are part of the OGC 01-009 definition but not included in ISO 19125-1:2004; coordinate system unit (called axis unit in the BNF in the older specifications) was required by both.

EXAMPLE 1 *GEOGCS["NAD83",*
 DATUM["North American Datum 1983",
 ELLIPSOID["GRS 1980",6378137.0,298.257222101]],
 PRIMEM["Greenwich",0],
 UNIT["degree",0.0174532925199433]]

EXAMPLE 2 *GEOGCS["NAD83",*
 DATUM["North American Datum 1983",
 SPHEROID["GRS 1980",6378137.0,298.257222101]],
 PRIMEM["Greenwich",0],
 AXIS["latitude",NORTH],
 AXIS["longitude",EAST],
 UNIT["degree",0.0174532925199433]]

If augmented to recognise the old keywords GEOCCS and GEOGCS, WKT descriptions of geocentric CRSs and geographic 2D CRSs written to the ISO 19125-1:2004 and OGC 01-009 specifications should be readable by implementations of this document but may not be interpretable by machine.

The formal specifications of both ISO 19125-1:2004 and OGC 01-009 did not support WKT descriptions of geodetic CRSs having ellipsoidal 3D coordinate systems.

C.4.2 Projected CRS

Projected CRS is defined in Clause 9. In this document the following definitions from ISO 19125-1:2004 and OGC 01-009 have been deprecated but are included here for the purposes of documenting backward compatibility.

<projected crs> ::= *PROJCS* *<left delimiter>* *<crs name>* *<wkt separator>* *<geogcs>*
<wkt separator> *<projection>*
[{ <wkt separator> *<axis>* *}] ... <wkt separator>* *<axis unit>*
<right delimiter>

<geogcs> and *<projection>* and their limitations are described in C.4.1 and C.3.4 respectively.

EXAMPLE 1 *PROJCS["NAD83 / UTM zone 10N",*
GEOGCS["NAD83",
DATUM["North American Datum 1983",
SPHEROID["GRS 1980",6378137.0,298.257222101]
]
],
PRIMEM["Greenwich",0]
],
PROJECTION["Transverse Mercator"],
PARAMETER["Latitude of origin",0.0],
(four additional parameters omitted for brevity)
UNIT["metre",1.0]
]

EXAMPLE 2 *PROJCS["NAD83 / UTM zone 10N",*
GEOGCS["NAD83",
DATUM["North American Datum 1983",
ELLIPSOID["GRS 1980",6378137.0,298.257222101],
]
PRIMEM["Greenwich",0]
],
AXIS["latitude",NORTH],
AXIS["longitude",EAST]
],
PROJECTION["UTM zone 10N"],
PARAMETER["Latitude of origin",0.0],
(four additional parameters omitted for brevity)
AXIS["easting",EAST],
AXIS["northing",NORTH],
UNIT["metre",1.0]
]

If augmented to recognise the old keyword PROJCS as an alias of PROJCRS, WKT descriptions of projected CRSs written to the ISO 19125-1:2004 and OGC 01-009 specifications should be readable by implementations that read strings conformant to this document but the string may not be interpretable by machine.

C.4.3 Vertical CRS and engineering (local) CRS

ISO 19125-1:2004 did not support these CRS types. The OGC 01-009 specification did do so. In this document the following definitions from OGC 01-009 have been deprecated but are included here for the purposes of documenting backward compatibility:

<vertical CRS> ::= *VERT_CS* *<left delimiter>* *<vertical CRS name>*
<wkt separator> *<vertical datum>* *<wkt separator>* *<length unit>*
[<wkt separator> *<axis>* *] <right delimiter>*

<engineering CRS> ::= *LOCAL_CS* *<left delimiter>* *<engineering CRS name>*
<wkt separator> *<engineering datum>* *<wkt separator>* *<length unit>*
[<wkt separator> *<axis>* *] <right delimiter>*

As a consequence of the lack of backward compatibility with the component keywords and VERT_DATUM and LOCAL_DATUM objects as discussed in C.3.3, implementations reading strings conformant to this document have no backward compatibility with the VERT_CS or LOCAL_CS objects.

C.4.4 Compound CRS

ISO 19125-1:2004 did not support this CRS type. The OGC 01-009 specification did do so. In this document the following definition from OGC 01-009 has been deprecated but is included here for the purposes of documenting backward compatibility:

```
<compound CRS> ::= COMPD_CS <left delimiter> <compound CRS name>
                  <wkt separator> <coordinate reference system>
                  <wkt separator> <coordinate reference system> <right delimiter>
```

This definition allows any combination of CRS types, for example two horizontal CRSs. This document constrains permissible combinations. In practice WKT strings written to the OGC 01-009 specification are likely to be a combination permitted by this document, one of which will be vertical and one of which will probably be geographic 2D or projected but could be engineering (local). However as a consequence of the lack of backward compatibility with the keywords and VERT_DATUM and LOCAL_DATUM objects as discussed in C.3.3 and C.4.3, this document has no backward compatibility with the COMPD_CS object.

C.4.5 Fitted CS

OGC 01-009 describes a FITTED_CS object. This is functionally equivalent to ISO 19111 SC_DerivedCRS with the deriving conversion expressed as a CT_MathTransform and applied in the reverse direction (*to* the base CRS instead than *from* it). CT_MathTransform is basically equivalent to ISO 19111 CC_CoordinateOperation, except that CT_MathTransform is not restricted to operations on coordinates; for this reason CT_MathTransform does not have sourceCRS and targetCRS properties. This document does not attempt to maintain backward compatibility with this FITTED_CS object because of the differences in the modelling.

C.5 Backward compatibility of coordinate operations

OGC 01-009 defines a math transform object.

```
<math transform> ::= <param mt> | <concat mt> | <inv mt> | <passthrough mt>

<param mt> ::= PARAM_MT <left delimiter> <classification name>
              { <wkt separator> <operation parameter> }... <right delimiter>
```

The PARAM_MT object requires a subset of the attributes for <coordinate operation> defined in 17.1. However as it is missing several other attributes mandatory in <coordinate operation> (source and target CRSs, clear distinction between operation and operation method), implementations written to this document have no backward compatibility with the math transform object.

C.6 Mapping of tokens and keywords from previous versions of CRS WKT to this document

A mapping of tokens and keywords from previous versions of CRS WKT to this document is given in Table C.2.

Table C.2 — Mapping of BNF tokens and keywords between previous versions of CRS WKT and this document

19125-1:2004	OGC CTS 01-009	This document	Comment
Coordinate Reference Systems			
<coordinate system>	<coordinate system>	<coordinate reference system>	ISO 19125-1:2004 uses the term SRS (Spatial Reference System). SRS is a superset which includes CRS and spatial referencing by geographic identifier. But in ISO 19125-1 only CRS concepts are described. Previous specifications of CRS WKT have used the term coordinate system for the ISO 19111 concept of coordinate reference system. In ISO 19111 and this document, 'coordinate system' is used for a different concept, limited to describing the axes of a CRS.
<name>	<cs name>	<crs name>	
Geodetic CRS with geocentric Cartesian coordinate system			
<geocentric cs>	<geocentric cs>	<geodetic crs>	
GEOCCS	GEOCCS	GEODCRS GEODETICCRS	
Geodetic CRS with ellipsoidal 3D coordinate system			
		<geodetic crs>	
(see comment)		GEOGCRS GEOGRAPHICCRS	In OGC 06-103r4 this concept appears as an extension to GEOGCS where a third axis is optional
Geodetic CRS with ellipsoidal 2D coordinate system			
<geographic cs>	<geographic cs>	<geodetic crs>	
GEOGCS	GEOGCS	GEOGCRS GEOGRAPHICCRS	
Projected CRS			
<projected cs>	<projected cs>	<projected crs>	
PROJCS	PROJCS	PROJCRS PROJECTEDCRS	
<geogcs>	<geogcs>	<base geodetic crs>	There is a change in the attributes of base crs compared to geogcs to clarify the attributes to be provided. In ISO 19125-1 and OGC 01-009 the axes are omitted in the examples (and in many implementations) but the BNF specification does not permit this.
GEOGCS	GEOGCS	BASEGEODCRS	
<name>	<cs name>	<base crs name>	

Table C.2 (continued)

19125-1:2004	OGC CTS 01-009	This document	Comment
Vertical CRS			
	<vert cs>	<vertical crs>	
	VERT_CS	VERTCRS VERTICALCRS	
Engineering CRS			
	<local cs>	<engineering crs>	
	LOCAL_CS	ENGCRS ENGINEERINGCRS	Conceptually equivalent to ISO 19111's engineering CRS.
Parametric CRS			
		<parametric crs>	Not previously specified.
		PARAMETRICCRS	
Temporal CRS			
		<temporal crs>	Not previously specified.
		TIMECRS	
Compound CRS			
	<compd cs>	<compound crs>	
	COMPD_CS	COMPOUNDCRS	
	<horz cs>	<horizontal crs>	
	<head cs>		This has no equivalent in ISO 19111 which constrains the types of CRS allowed to form compound CRSs. If <head cs> meets the ISO 19111 constraint of being either a geographic 2D or a projected CRS, it can be mapped through <horizontal crs> to <geogCRS> or <projCRS> respectively.
	<tail cs>		This has no equivalent in ISO 19111 which constrains the types of CRS allowed to form compound CRSs. If <tail cs> meets the ISO 19111 constraint of being a vertical CRS it can be mapped to <vertical crs>.
Fitted CRS			
	<fitted cs>		<fitted cs> has no equivalent in this document as it combines the separate concepts of CRS and coordinate operation. Its function is partially covered through derived CRSs – see C.4.5.
	FITTED_CS		
	<to base>		
	<base cs>		

Table C.2 (continued)

19125-1:2004	OGC CTS 01-009	This document	Comment
Datum			
<datum>	<datum>	<geodetic reference frame>	
DATUM	DATUM	DATUM GEODETICDATUM TRF	
	<vert datum>	<vertical reference frame>	
	VERT_DATUM	VDATUM VERTICALDATUM VRF	
	<local datum>	<engineering datum>	
	LOCAL_DATUM	EDATUM ENGINEERINGDATUM	
	<datum type>		Not clear from OGC 01-009 what this concept is. No equivalent in ISO 19111 or this document.
<name>	<name>	<datum name>	
Ellipsoid			
<ellipsoid>	<spheroid>	<ellipsoid>	
ELLIPSOID	SPHEROID	ELLIPSOID SPHEROID	
<name>	<name>	<ellipsoid name>	
<semi-major axis>	<semi-major axis>	<semi-major axis>	
<inverse flattening>	<inverse flattening>	<inverse flattening>	
Prime meridian			
<prime meridian>	<prime meridian>	<prime meridian>	
PRIMEM	PRIMEM	PRIMEM PRIMEMERIDIAN	
<name>	<name>	<prime meridian name>	
<longitude>	<longitude>	<irm longitude>	
Map projection			
<projection>	<projection>	<coordinate operation>	
PROJECTION	PROJECTION	CONVERSION	19125-1 and CTS 01-009 are not clear whether PROJECTION is the coordinate operation or the coordinate operation method. Implementations have differed in their interpretation.
PROJECTION	PROJECTION	METHOD PROJECTION	
<name>	<name>	<map projection name>	
<projection>	<projection>	<map projection method>	
<name>	<name>	<map projection method name>	
<parameter>	<parameter>	<map projection parameter>	
PARAMETER	PARAMETER	PARAMETER	
<name>	<name>	<parameter name>	
<value>	<value>	<parameter value>	
<unit>	<unit>	<map projection parameter unit>	

Table C.2 (continued)

19125-1:2004	OGC CTS 01-009	This document	Comment
Coordinate System			
	<twin axes>	<coordinate system>	
	AXIS	AXIS	
		<axis order>	
	<name>	<axis name>	In this document axis name is constrained by CRS type and in turn axis name constrains axis direction. These constraints were not previously specified.
		<axis abbreviation>	
	(axis direction)		Enumerated list in WKT1.
Unit			
<linear unit>	<linear unit>	<length unit>	
UNIT	UNIT	LENGTHUNIT UNIT	
<angular unit>	<angular unit>	<angle unit>	
UNIT	UNIT	ANGLEUNIT UNIT	
		<scale unit>	
UNIT	UNIT	SCALEUNIT UNIT	
<unit name>	<unit name>	<unit name>	
<conversion factor>	<conversion factor>	<conversion factor>	
Identifier			
	<authority>	<identifier>	
	AUTHORITY	ID	
	<name>	<authority name>	
	<code>	<authority unique identifier>	The types permitted are expanded in this document.
		<version>	
Remark			
		<remark>	New to this document.

Table C.2 (continued)

19125-1:2004	OGC CTS 01-009	This document	Comment
Bound CRS			
		<bound CRS>	
		BOUND CRS	
	<to WGS84>	<abridged coordinate transformation>	
	TOWGS84	ABRIDGEDTRANSFORMATION	Similar concept but modelled completely differently.
	<seven param>		
	<dx>	<parameter name>	
	<dy>	<parameter name>	
	<dz>	<parameter name>	
	<ex>	<parameter name>	
	<ey>	<parameter name>	
	<ez>	<parameter name>	
	<ppm>	<parameter name>	

Annex D (informative)

Backward compatibility with ISO 19162:2015

Subclause 3.1, definitions

Numerous definitions have been added, minor amendments were made to others, tracking changes that were made in ISO 19111:2019.

Subclause 6.6, reserved keywords

The following new reserved keywords have been added:

baseGeogCRS, calendar, concatenatedOperation, coordEpoch, coordinateMetadata, derivedProjectedCRS, dynamic, ensemble, ensembleAccuracy, epoch, frameEpoch, geogCRS, geographic CRS, geoidModel, member, model, pointMotionOperation, step, temporalQuantity, TRF, velocityGrid, VRF.

In addition, the keyword 'triaxial' that was informally recommended has now been reserved.

The following keywords have been deprecated: iDatum, imageCRS, imageDatum.

Subclause 7.3, scope, extent, identifier and remarks

Scope and extent have been changed from being individual attributes to a pairing, the pair being optional zero to many.

WKT readers compliant with the previous version of this document will not recognise multiple occurrences of scope-extent pairings.

Subclause 7.5, coordinate system

- a) The coordinate system type "temporal" is deprecated, replaced by three types: temporalDateTime, temporalCount and temporalMeasure. These are discussed in clause 13.
- b) A new coordinate system type, ordinal, has been added. The coordinate values in an ordinal CS have to be integers.
- c) The missing attribute 'southSouthWest' was added to the list of permissible axis directions.

Subclauses 7.6 and 7.7

Two new constructs, datum ensemble and dynamicCRS subtype, have been added, both potentially used by geodetic or vertical CRSs.

Clause 8, geodetic CRS

- a) Geodetic CRS has been modified if it included an ellipsoidal coordinate system: it now is called a geographic CRS with new keywords geogCRS or geographicCRS. The keywords geodCRS and geodeticCRS remain, but should now include only Cartesian or spherical coordinate systems.
- b) Both geodetic CRS and geographic CRS may now include a new element (keyword *dynamic*) to indicate that they are dynamic. The dynamic element includes an option to associate the CRS with a deformation model. The omission of this additional *dynamic* element implies that they are static. Some older WKT strings with the keyword geodCRS or geodeticCRS may pre-date this addition. The significance of this element to users is that their dataset's metadata should include the coordinate epoch to which the dataset is referenced.
- c) A geodetic CRS or a geographic CRS may now include a datum ensemble (keyword *ensemble*) instead of a geodetic datum.
- d) A geodetic CRS or a geographic CRS may now include the new keyword *TRF* instead of Datum or geodeticDatum.

WKT for geodetic CRSs written to be compliant with the previous version of this document remains compliant with this document. WKT readers compliant with the previous version of this document will not recognise these new elements.

Clause 9, projected CRS

- a) A projected CRS now may be 2D or 3D. WKT compliant with the previous version of this document remains compliant. WKT readers compliant with the previous version of this document may not recognise three axes.
- b) The keyword for the base CRS element of a projected CRS may now be either `baseGeodCRS` as previously, or the new `baseGeogCRS`. This tracks changes in 8 a) above. It has no practical consequence for a WKT definition, as the coordinate system component of its base CRS is not used in WKT. However, as in practice most projected CRSs are derived from a geographic CRS it is anticipated that `baseGeogCRS` will be encountered more frequently than `baseGeodCRS`.

WKT compliant with the previous version of this document remains compliant. WKT readers compliant with the previous version of this document may not recognise this new keyword.

Clause 10, vertical CRS

- a) Vertical CRS WKT strings may now include a new element (keyword *dynamic*) to indicate that it is dynamic. The dynamic element includes an option to associate the CRS with a deformation model. The omission of this additional *dynamic* element implies that the CRS is static. Some older WKT strings with the keyword `vertCRS` or `verticalCRS` may pre-date this addition. The significance of this element to users is that their dataset's metadata should include the coordinate epoch to which the dataset is referenced.
- b) A vertical CRS WKT string may now include a new element (keyword *geoidModel*) to associate the CRS with a geoid model or height correction model used in its derivation.
- c) A vertical CRS may now include a datum ensemble (keyword *ensemble*) instead of a vertical datum.
- d) A vertical CRS may now include the new keyword *VRF* instead of `vDatum` or `verticalDatum`.

WKT compliant with the previous version of this document remains compliant. WKT readers compliant with the previous version of this document will not recognise these new elements.

Clause 11, engineering CRS

- a) An additional subtype of coordinate system — ordinal — has been added. WKT compliant with the previous version of this document remains compliant. WKT readers compliant with the previous version of this document will not recognise this new element.
- b) Further examples illustrating engineering CRSs applied to images have been added.

ISO 19162:2015 Clause 12, image CRS

Image CRS and its components have been removed from this document.

Clause 13, temporal CRS (ISO 19162:2015, Clause 14)

In temporal datum:

- a) The element *temporal origin* has been changed from being optional to mandatory.
- b) A new optional element *calendar* has been added.

In temporal coordinate system:

The CS subtype 'temporal' has been removed and three new subtypes of coordinate system have been introduced, with constraints on their data type and conversion factor to the SI second.

The example given in 19162:2015:

```
CS[temporal,1],AXIS["time (t)",future],TIMEUNIT["second",1.0]
```

is deprecated.

In temporal CRS the example given in 19162:2015:

```
TIMECRS["GPS Time",
TDATUM["Time origin",TIMEORIGIN[1980-01-01T00:00:00.0Z]],
CS[temporal,1],AXIS["time",future],TIMEUNIT["day",86400.0]]
```

is deprecated. Firstly the CS type of 'temporal' has been deprecated. Secondly a timeunit of 'day' should not be related to the SI base unit of second: the number of seconds in a day is not a simple scaling (because some days contain leap seconds) so conversion factor should not be given.

WKT readers encountering a coordinate system of type 'temporal' may interpret it as being a temporalCount coordinate system if the coordinate data type is integer, or as a temporalMeasure coordinate system if the coordinate data type is real.

WKT readers encountering a timeunit conversion factor to seconds may interpret it exactly. However this will lead to discrepancies for calendars that use leap seconds, including the proleptic Gregorian calendar. Better is to throw an exception.

Subclause 14.3, derived geodetic CRS (ISO 19162:2015, 15.3)

A derived geographic CRS subtype has been added (see Clause 8 above).

The keyword for the base CRS element of a derived geodetic CRS or a derived geographic CRS may now be either baseGeodCRS as previously, or the new baseGeogCRS. This tracks changes in 8 a) above. It has no practical consequence for a WKT definition, as the coordinate system component of its base CRS is not used in WKT. However, as in practice most projected CRSs are derived from a geographic CRS it is anticipated that baseGeogCRS will be encountered more frequently than baseGeodCRS.

Subclause 14.5, derived projected CRS

This is a new construct. See derived engineering CRS below.

Subclause 14.6, derived engineering CRS (ISO 19162:2015, 15.5)

This was incorrectly described in 19162:2015. The type of base CRS as either projected or geographic or engineering allowed in 19162:2015 was wrong. It has been entirely remodelled in two distinct parts:

- a derived engineering CRS is to have a base CRS of type engineering (base CRS of projected or geodetic no longer permitted);
- derived projected CRS is to have a base CRS of type projected and hence a geodetic datum.

Clause 16, coordinate metadata

This construct is new.

Clause 17, coordinate transformation

This construct specifically relates only to coordinate transformations and coordinate conversions other than map projections. 19162:2015 did not make this clear. In this document the term *coordinate operation* is retained for backward compatibility despite the term having broader meaning. The source and target CRS elements may now include the additional CRS type *geographic* described above. An operation version attribute has been added.

Clause 18, point motion operations

This construct is new.

Clause 19, concatenated operations

This construct is new.

Subclause 20.2, derived engineering CRS (ISO 19162:2015, 18.2.2)

The constraint on coordinate operation methods that are permitted in an abridged transformation has been removed.

Annex D, Backward compatibility with ISO 19162:2015

(this Annex) added.

Annex E, Triaxial ellipsoid (ISO 19162:2015, Annex D)

Changed from being informative to normative.

Annex E
(normative)

Triaxial ellipsoid

The reference ellipsoid for the Earth for which the WKT string is defined in 8.2.1 is an oblate ellipsoid of revolution. A triaxial ellipsoid (Figure E.1) may be required for planetary mapping and other applications.

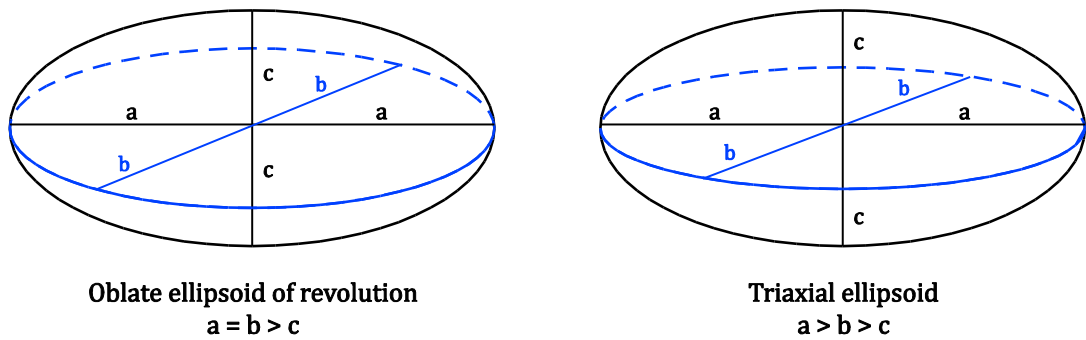


Figure E.1 — Oblate and triaxial ellipsoids

Requirement: The WKT string definition for a triaxial ellipsoid is:

<triaxial ellipsoid>	::=	<triaxial ellipsoid keyword> <left delimiter> <ellipsoid name> <wkt separator> <semi-major axis> <wkt separator> <semi-median axis> <wkt separator><semi-minor axis> <wkt separator> <triaxial ellipsoid unit> [<wkt separator> <identifier>]... <right delimiter>
<triaxial ellipsoid keyword>	::=	TRIAXIAL
<semi-major axis>	::=	<unsigned numeric literal>
<semi-median axis>	::=	<unsigned numeric literal>
<semi-minor axis>	::=	<unsigned numeric literal>
<triaxial ellipsoid unit>	::=	LENGTHUNIT <left delimiter> <unit name> <wkt separator> <conversion factor> [<wkt separator> <identifier>]... <right delimiter>
<unit name>	::=	<quoted Latin text>
<conversion factor>	::=	<signed numeric literal>

The conversion factor shall be to metres and is the number of metres per unit.

EXAMPLE TRIAXIAL["Io 2009 IAU IAG",1829400,1819400,1815700,
 LENGTHUNIT["metre",1]]

Annex F (informative)

Identifiers for coordinate operation methods and parameters

F.1 General

To facilitate interoperability, the sending and receiving applications need to have a common understanding of the semantics of coordinate operation methods and parameters. Previous CRS WKT specifications used name strings as identifiers as the basis for this understanding. Names are often not good enough. The same name, for example "Stereographic" [map projection], may be associated with different formulas, the formula differences being significant. Conversely one shared concept may have very different names which are not readily seen to be synonyms, for example the map projection parameter "longitude of origin" and "central meridian". A further difficulty has been the inconsistency in rendering of names.

Coordinate operation methods and their parameters that are frequently encountered in geographic information systems are documented in F.2 to F.5. These methods and their parameters have been codified in the EPSG Geodetic Parameter Dataset. Each method formula is included within the EPSG Dataset. Applications may use different formulas, but if these give equivalent results as those of EPSG then they are functionally the same.

NOTE Unless otherwise noted, all methods use ellipsoidal formulae

Methods differ in their treatment of reversibility. Some methods use one formula for both forward and reverse computations, with the signs of some or all of the parameter values needing to be changed for the reverse case. Other methods include different forward and reverse formulas both of which utilise the same parameters and parameter values; most map projections are in this category. Yet other methods are not reversible. Some are theoretically not exactly reversible but for earth sciences can be considered to be reversible in practice. Detailed documentation of method formula and parameter reversibility is beyond the scope of Annex E. The EPSG Dataset documents the reversibility of the methods it describes.

Method definition including formula, parameters used in that formula and an example as given in the EPSG Dataset may be obtained by substitution of the relevant method code in the hyperlink:

<https://www.epsg-registry.org/export.htm?gml=urn:ogc:def:method:EPSG::9802>

The EPSG Dataset defines the order in which parameters should be listed. It is recommended that this order be followed in WKT strings.

Table F.1 summarises the methods and parameters given in the remainder of Annex F.

Table F.1 — Coordinate operation methods and parameters

Table	Clause	Content
F.2	F.2	Map projection methods
F.3	F.3	Map projection parameters
F.4	F.4	Coordinate operation (excluding map projection) methods
F.5	F.5	Coordinate operation (excluding map projection) parameters

F.2 Map projection methods

Commonly encountered map projection methods are given in Table F.2. The parameters required by these methods are given in F.3.

Table F.2 — Map projection methods

Coordinate operation method name	Method name alias(es)	EPSG Method code	Codes of parameters used by this method (refer to F.3)
Albers Equal Area	<i>Albers</i>	9822	8821, 8822, 8823, 8824, 8826, 8827
American Polyconic	<i>Polyconic</i>	9818	8801, 8802, 8806, 8807
Cassini-Soldner	<i>Cassini</i>	9806	8801, 8802, 8806, 8807
Hotine Oblique Mercator (variant A)	<i>Rectified skew orthomorphic</i>	9812	8811, 8812, 8813, 8814, 8815, 8806, 8807
Hotine Oblique Mercator (variant B)	<i>Rectified skew orthomorphic</i>	9815	8811, 8812, 8813, 8814, 8815, 8816, 8817
Lambert Azimuthal Equal Area	<i>Lambert Equal Area LAEA</i>	9820	8801, 8802, 8806, 8807
Lambert Conic Conformal (1SP)	<i>Lambert Conic Conformal LCC</i>	9801	8801, 8802, 8805, 8806, 8807
Lambert Conic Conformal (2SP)	<i>Lambert Conic Conformal LCC</i>	9802	8821, 8822, 8823, 8824, 8826, 8827
Mercator (variant A)	<i>Mercator</i>	9804	8801, 8802, 8805, 8806, 8807
Mercator (variant B)	<i>Mercator</i>	9805	8823, 8802, 8806, 8807
Oblique stereographic	<i>Double stereographic</i>	9809	8801, 8802, 8805, 8806, 8807
Transverse Mercator	<i>Gauss-Boaga Gauss-Krüger TM</i>	9807	8801, 8802, 8805, 8806, 8807
Transverse Mercator (South Orientated)	<i>Gauss-Conform</i>	9808	8801, 8802, 8805, 8806, 8807

F.3 Map projection parameters

The parameters required by the map projection methods given in F.2 are described in Table F.3.

Table F.3 — Map projection parameters

Parameter code	Coordinate operation parameter name (alias(es))	Parameter description	Unit type
8801	latitude of natural origin (<i>latitude of origin</i>)	geodetic latitude of the point from which the values of both the geographical coordinates on the ellipsoid and the grid coordinates on the projection are deemed to increment or decrement for computational purposes Alternatively: geodetic latitude of the point which in the absence of application of false coordinates has grid coordinates of (0,0).	angle

Table F.3 (continued)

Parameter code	Coordinate operation parameter name (alias(es))	Parameter description	Unit type
8802	longitude of natural origin (<i>longitude of origin</i>) (<i>central meridian</i>)	geodetic longitude of the point from which the values of both the geographical coordinates on the ellipsoid and the grid coordinates on the projection are deemed to increment or decrement for computational purposes Alternatively: geodetic longitude of the point which in the absence of application of false coordinates has grid coordinates of (0,0).	angle
8805	scale factor at natural origin (<i>scale factor</i>)	factor by which the map grid is reduced or enlarged during the projection process, defined by its value at the natural origin	scale
8806	false easting	value assigned to the abscissa (east or west) axis of the projection grid at the natural origin	length
8807	false northing	value assigned to the ordinate (north or south) axis of the projection grid at the natural origin	length
8811	latitude of projection centre	latitude of the point at which the azimuth of the central line for an oblique projection is defined	angle
8812	longitude of projection centre	longitude of the point at which the azimuth of the central line for an oblique projection is defined	angle
8813	azimuth of initial line	direction (north zero, east of north being positive) of the great circle which is the centre line of an oblique projection The azimuth is given at the projection centre.	angle
8814	angle from rectified to skew grid	angle at the natural origin of an oblique projection through which the natural coordinate reference system is rotated to make the projection north axis parallel with true north	angle
8815	scale factor on initial line	factor by which the map grid is reduced or enlarged during the projection process, defined by its value at the projection centre	scale
8816	easting at projection centre (<i>false easting</i>)	easting value assigned to the projection centre	length
8817	northing at projection centre (<i>false northing</i>)	northing value assigned to the projection centre	length
8821	latitude of false origin (<i>latitude of origin</i>)	geodetic latitude of the point which is not the natural origin and at which grid coordinate values false easting and false northing are defined	angle
8822	longitude of false origin (<i>longitude of origin</i>)	geodetic longitude of the point which is not the natural origin and at which grid coordinate values false easting and false northing are defined	angle
8823	latitude of 1st standard parallel	geodetic latitude of one of the parallels of intersection of the cone with the ellipsoid. It is normally but not necessarily that nearest to the pole Scale is true along this parallel.	angle
8824	latitude of 2nd standard parallel	geodetic latitude of one of the parallels at which the cone intersects with the ellipsoid. It is normally but not necessarily that nearest to the equator Scale is true along this parallel.	angle
8826	easting at false origin (<i>false easting</i>)	easting value assigned to the false origin	length
8827	northing at false origin (<i>false northing</i>)	northing value assigned to the false origin	length

F.4 Coordinate transformation methods

Commonly encountered coordinate transformation methods are given in Table F.4. The parameters required by these methods are given in F.5.

Table F.4 — Coordinate transformation methods

Coordinate operation method name	Method name alias(es)	EPSG Method code	Codes of parameters used by this method (refer to F.5)
Geocentric translations (geocentric domain)	<i>Geocentric translations</i>	1031	8605, 8606, 8607
Position Vector transformation (geocentric domain)	<i>Position Vector 7-param. transformation</i> <i>Bursa-Wolf</i> <i>Helmert</i>	1033	8605, 8606, 8607, 8608, 8609, 8610, 8611
Coordinate Frame rotation (geocentric domain)	<i>Coordinate Frame rotation</i> <i>Bursa-Wolf</i> <i>Helmert</i>	1032	8605, 8606, 8607, 8608, 8609, 8610, 8611
Molodensky-Badekas (geocentric domain)	<i>Molodensky-Badekas</i>	1034	8605, 8606, 8607, 8608, 8609, 8610, 8611, 8617, 8618, 8667
NTv2		9615	8656
NADCON		9613	8657, 8658
NADCON5 (3D)		1075	8657, 8658, 1058
Vertical Offset		9616	8603
Longitude rotation		9601	8602

F.5 Coordinate transformation parameters

The parameters required by the [coordinate transformation](#) methods given in F.4 are described in Table F.5.

Table F.5 — Coordinate transformation parameters

Parameter code	Coordinate operation parameter name (alias(es))	Parameter description
1058	Ellipsoidal height difference file	The name of the [path and] file containing ellipsoidal height differences.
8603	Vertical Offset (dH)	difference between the height or depth values of a point in the target and source coordinate reference systems
8605	X-axis translation (dX) (tX)	difference between the X values of a point in the target and source coordinate reference systems
8606	Y-axis translation (dY) (tY)	difference between the Y values of a point in the target and source coordinate reference systems
8607	Z-axis translation (dZ) (tZ)	difference between the Z values of a point in the target and source coordinate reference systems

Table F.5 (continued)

Parameter code	Coordinate operation parameter name (alias(es))	Parameter description
8608	X-axis rotation (rX)	angular difference between the Y and Z axes directions of target and source coordinate reference systems This is a rotation about the X axis as viewed from the origin looking along that axis. The particular method defines which direction is positive, and what is being rotated (point or axis).
8609	Y-axis rotation (rY)	angular difference between the X and Z axes directions of target and source coordinate reference systems This is a rotation about the Y axis as viewed from the origin looking along that axis. The particular method defines which direction is positive, and what is being rotated (point or axis).
8610	Z-axis rotation (rZ)	angular difference between the X and Y axes directions of target and source coordinate reference systems This is a rotation about the Z axis as viewed from the origin looking along that axis. The particular method defines which direction is positive, and what is being rotated (point or axis).
8611	Scale difference (dS)	the ratio of a length between two points in target and source coordinate reference systems. If a distance of 100 km in the source coordinate reference system translates into a distance of 100.001 km in the target coordinate reference system, the scale difference is 1 ppm (the ratio being 1.000001).
8617	Ordinate 1 of evaluation point	value of the first ordinate of the evaluation point
8618	Ordinate 2 of evaluation point	value of the second ordinate of the evaluation point
8656	Latitude and longitude difference file	name of the [path and] file containing latitude and longitude differences
8657	Latitude difference file	name of the [path and] file containing latitude differences
8658	Longitude difference file	name of the [path and] file containing longitude differences
8667	Ordinate 3 of evaluation point	value of the third ordinate of the evaluation point

Bibliography

- [1] ISO 19103, *Geographic information — Conceptual schema language*
- [2] ISO 19125-1:2004, *Geographic information — Simple feature access — Part 1: Common architecture*
- [3] OGC OpenGIS Project Document 99-036, *OpenGIS Simple Features Specification for SQL, revision 1.1*
- [4] OGC OpenGIS Project Document 06-103r4, *Simple feature access — Part 1: Common architecture*
- [5] OGC OpenGIS Project Document 01-009, *Implementation Specification: Coordinate Transformation Services, revision 1.00*
- [6] OGC Project Document 09-083r3, *GeoAPI 3.0 Implementation Standard*
- [7] ISO/IEC/IEEE 9945:2009, *Information technology — Portable Operating System Interface (POSIX®) Base Specifications, Issue 7*
NOTE The POSIX formula is in 4.16, Seconds Since the Epoch
- [8] http://pubs.opengroup.org/onlinepubs/9699919799/xrat/V4_xbd_chap04.html#tag_21_04_16
- [9] ISO/IEC 9075-1:2016, *Information technology — Database languages — SQL — Part 1: Framework (SQL/Framework)*
- [10] ISO/IEC 9075-2:2016, *Information technology — Database languages — SQL — Part 2: Foundation (SQL/Foundation)*
- [11] ISO 19115-1, *Geographic information — Metadata — Part 1: Fundamentals*