

DIN EN ISO 19111

ICS 35.240.70

Entwurf

Einsprüche bis 2020-01-22
Vorgesehen als Ersatz für
DIN EN ISO 19111:2007-10

**Geoinformation –
Koordinatenreferenzsysteme (ISO 19111:2019);
Englische Fassung prEN ISO 19111:2019**

Geographic information –
Referencing by coordinates (ISO 19111:2019);
English version prEN ISO 19111:2019

Information géographique –
Système de références par coordonnées (ISO 19111:2019);
Version anglaise prEN ISO 19111:2019

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2019-11-22 wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

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

Stellungnahmen werden erbeten

- vorzugsweise online im Norm-Entwurfs-Portal von DIN unter www.din.de/go/entwuerfe bzw. für Norm-Entwürfe der DKE auch im Norm-Entwurfs-Portal der DKE unter www.entwuerfe.normenbibliothek.de, sofern dort wiedergegeben;
- oder als Datei per E-Mail an nabau@din.de möglichst in Form einer Tabelle. Die Vorlage dieser Tabelle kann im Internet unter www.din.de/go/stellungnahmen-norm-entwuerfe oder für Stellungnahmen zu Norm-Entwürfen der DKE unter www.dke.de/stellungnahme abgerufen werden;
- oder in Papierform an den DIN-Normenausschuss Bauwesen (NABau), 10772 Berlin, Saatwinkler Damm 42/43, 13627 Berlin.

Die Empfänger dieses Norm-Entwurfs werden gebeten, mit ihren Kommentaren jegliche relevanten Patentrechte, die sie kennen, mitzuteilen und unterstützende Dokumentationen zur Verfügung zu stellen.

Gesamtumfang 165 Seiten

DIN-Normenausschuss Bauwesen (NABau)

Nationales Vorwort

Der Text von ISO 19111:2019 wurde vom Technischen Komitee ISO/TC 211 „Geographic information/Geomatics“ der Internationalen Organisation für Normung (ISO) erarbeitet und als prEN ISO 19111:2019 durch das Technische Komitee CEN/TC 287 „Geoinformation“ übernommen, dessen Sekretariat von BSI (Vereinigtes Königreich) gehalten wird.

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

Dieser Europäische Norm-Entwurf enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die englische Originalfassung der ISO Norm.

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

ISO 2533:1975	siehe	DIN ISO 2533:1979-12
ISO 19107:2003	siehe	DIN EN ISO 19107:2005-05
ISO 19108	siehe	DIN EN ISO 19108
ISO 19112	siehe	DIN EN ISO 19112
ISO 19115-1:2014	siehe	DIN EN ISO 19115-1:2014-07
ISO 19123	siehe	DIN EN ISO 19123
ISO 19148	siehe	DIN EN ISO 19148
ISO 19157	siehe	DIN EN ISO 19157
ISO 80000-3	siehe	DIN EN ISO 80000-3

Änderungen

Gegenüber DIN EN ISO 19111:2007-10 wurden folgende Änderungen vorgenommen:

- a) Einbeziehung der geltenden modernen geodätischen Terminologie;
- b) Erweiterung zur Beschreibung dynamischer geodätischer Referenzrahmen;
- c) Erweiterung zur Beschreibung geoidbasierter vertikaler Koordinatenbezugssysteme;
- d) Erweiterung, um dreiachsige Ellipsoide für Planetenanwendungen zu ermöglichen;
- e) Erweiterung zur Beschreibung dreidimensional projizierter Koordinatenreferenzsysteme;
- f) Hinzufügung von 'datum ensembles' zur Gruppierung verwandter Realisierungen eines Referenzrahmens, bei denen die Unterschiede für Anwendungen mit geringerer Genauigkeit unerheblich sind;
- g) Klarstellung bei der Modellierung abgeleiteter Koordinatenreferenzsysteme;
- h) Hinzufügen von Anforderungen zur Beschreibung von Koordinatenmetadaten und der Beziehung zwischen Raumkoordinaten;
- i) zusätzliche Modellierung von Komponenten des zeitlichen Koordinatenbezugssystems, die für die räumlich-zeitliche Koordinatenbezugnahme ausreichen;

- j) Konsolidierung der Bestimmungen von ISO 19111-2:2009 (Koordinatenreferenzsysteme - Teil 2: Erweiterung auf parametrisierte Werte) in diesem Dokument;
- k) Änderung des Namens von 'Spatial referencing by coordinates' zu 'Referencing by coordinates' aufgrund der Einbeziehung der Subtypen des nicht-räumlichen Koordinatenreferenzsystems mit parametrischen (von ISO 19111-2) und zeitlichen Eigenschaften;
- l) Korrektur geringfügiger Fehler.

Nationaler Anhang NA (informativ)

Begriffe und Abkürzungen

Die Benummerung der folgenden Begriffe und Abkürzungen ist identisch mit der Benummerung in der englischen Fassung.

3 Begriffe, Symbole und Abkürzungen

3.1 Begriffe

Für die Anwendung dieses Dokuments gelten die folgenden Begriffe.

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

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

3.1.1

affines (geradliniges) Koordinatensystem

Koordinatensystem im euklidischen Raum mit geraden nicht zwingend zueinander senkrechten Achsen

3.1.2

kartesisches Koordinatensystem

Koordinatensystem im euklidischen Raum, das die Position von Punkten in Bezug auf n angibt, wobei alle zueinander senkrechten geraden Achsen dieselbe Maßeinheit haben

Anmerkung 1 zum Begriff: Für die Anwendung dieses Dokuments ist n 2 oder 3.

Anmerkung 2 zum Begriff: Ein kartesisches Koordinatensystem ist ein spezielles affines Koordinatensystem.

3.1.3

aus mehreren Komponenten zusammengesetztes Koordinatenreferenzsystem

Koordinatenreferenzsystem, das mindestens zwei unabhängige Koordinatenreferenzsysteme verwendet

Anmerkung 1 zum Begriff: Koordinatenreferenzsysteme sind voneinander unabhängig, wenn die Koordinatenwerte des einen Systems nicht in Koordinatenwerte des anderen Systems umgerechnet oder umgewandelt werden können.

3.1.4

zusammengesetzte Operation

Koordinatenoperation bestehend aus der sequentiellen Anwendung mehrerer Koordinatenoperationen

3.1.5

Koordinate

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

Anmerkung 1 zum Begriff: In einem räumlichen Koordinatenreferenzsystem sind die Koordinatenzahlen durch Einheiten qualifiziert.

3.1.6

Koordinatenumwandlung

Koordinatenoperation, die Koordinaten in einem Quell-Koordinatenreferenzsystem in Koordinaten in einem Ziel-Koordinatenreferenzsystem umwandelt, in dem beide Koordinatenreferenzsysteme auf demselben Datum basieren

Anmerkung 1 zum Begriff: Eine Koordinatenumwandlung verwendet Parameter mit vorgegebenen Werten.

BEISPIEL 1 Eine Zuordnung ellipsoidischer Koordinaten zu kartesischen Koordinaten durch Kartenabbildung.

BEISPIEL 2 Umrechnung von Einheiten von Radianten in Grad oder Fuß in Meter.

3.1.7

Koordinatenzeit

Zeit, der Koordinaten in einem dynamischen Koordinatenreferenzsystem zugeordnet werden

3.1.8

Koordinatenoperation

Prozess unter Verwendung eines mathematischen Modells auf der Grundlage einer Eins-zu-Eins-Beziehung, der Koordinaten in einem Quell-Koordinatenreferenzsystem in Koordinaten in einem Ziel-Koordinatenreferenzsystem oder Koordinaten einer Quell-Koordinatenzeit in Koordinaten einer Ziel-Koordinatenzeit innerhalb desselben Koordinatenreferenzsystems umrechnet

3.1.9

Koordinatenreferenzsystem

Koordinatensystem, das über ein Datum mit einem Objekt verbunden ist

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

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

3.1.10

Satz (Menge) von Koordinaten

Sammlung von Koordinatentupeln, die demselben Koordinatenreferenzsystem und bei einem dynamischen Koordinatenreferenzsystem auch derselben Koordinatenzeit zugeordnet sind

3.1.11

Koordinatensystem

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

3.1.12

Koordinatentransformation

Koordinatenoperation, die Koordinaten in einem Quell-Koordinatenreferenzsystem in Koordinaten in einem Ziel-Koordinatenreferenzsystem umwandelt, in dem das Quell- und das Ziel-Koordinatenreferenzsystem auf unterschiedlichen Daten basieren

Anmerkung 1 zum Begriff: Eine Koordinatenumwandlung verwendet empirisch abgeleitete Parameter. Jeder Fehler in diesen Koordinaten wird in die Koordinatentransformation eingebettet und bei Anwendung der Koordinatentransformation werden die eingebetteten Fehler in die Ergebniskoordinaten übertragen.

Anmerkung 2 zum Begriff: Eine Koordinatentransformation wird umgangssprachlich manchmal auch als Datumstransformation bezeichnet. Dies ist falsch. Eine Koordinatentransformation wandelt Koordinatenwerte um. Sie ändert nicht die Definition des Datums. In diesem Dokument werden Koordinaten einem Koordinatenreferenzsystem zugeordnet. Eine Koordinatentransformation erfolgt zwischen zwei Koordinatenreferenzsystemen und nicht zwischen zwei Daten.

3.1.13

Koordinatentupel

Tupel bestehend aus Koordinaten

Anmerkung 1 zum Begriff: Die Anzahl an Koordinaten im Koordinatentupel entspricht der Dimension des Koordinatensystems; die Anordnung der Koordinaten im Koordinatentupel und die Anordnung der Achsen des Koordinatensystems sind identisch.

3.1.14

zylindrisches Koordinatensystem

dreidimensionales Koordinatensystem im euklidischen Raum, in dem die Position durch zwei lineare Koordinaten und eine Winkelkoordinate festgelegt wird

3.1.15

Datum

Referenzrahmen

Parameter oder Menge von Parametern, der/die die Position der Herkunft, des Maßstabs und der Ausrichtung eines Koordinatensystems realisiert/realisieren

3.1.16

Datenensemble

Gruppe mehrerer Realisierungen desselben terrestrischen Referenzsystems oder desselben Höhenbezugssystems, die sich hinsichtlich des ungefähren räumlichen Bezugs nicht bedeutend unterscheiden

Anmerkung 1 zum Begriff: Die auf die unterschiedlichen Realisierungen innerhalb eines Datenensembles bezogenen Datensätze dürfen ohne Koordinatentransformation zusammengeführt werden.

Anmerkung 2 zum Begriff: „Ungefähr“ muss durch den Anwender bestimmt werden und ist in der Regel unter einem Dezimeter angeordnet, darf jedoch bis zu zwei Meter betragen.

BEISPIEL „WGS 84“ als undifferenzierte Gruppe von Realisierungen einschließlich WGS 84 (TRANSIT), WGS 84 (G730), WGS 84 (G873), WGS 84 (G1150), WGS 84 (G1674) und WGS 84 (G1762). Auf der Erdoberfläche haben sich die Realisierungen durchschnittlich wie folgt geändert: 0,7 m zwischen TRANSIT und G730, weitere 0,2 m zwischen G730 und G873, 0,06 m zwischen G873 und G1150, 0,2 m zwischen G1150 und G1674 sowie 0,02 m zwischen G1674 und G1762.

3.1.17

Tiefe

Abstand eines Punkts zu einer gewählten Höhenbezugsfläche nach unten entlang einer zu dieser Oberfläche senkrechten Linie

Anmerkung 1 zum Begriff: Die Linienrichtung darf gerade oder abhängig vom Schwerfeld der Erde oder von anderen physikalischen Phänomenen sein.

Anmerkung 2 zum Begriff: Eine Tiefe oberhalb der Höhenbezugsfläche hat einen negativen Wert.

3.1.18

abgeleitetes Koordinatenreferenzsystem

Koordinatenreferenzsystem, das anhand der Anwendung einer spezifischen Koordinatenumwandlung auf Koordinaten innerhalb eines zuvor festgelegten Koordinatenreferenzsystems bestimmt wird

Anmerkung 1 zum Begriff: Das zuvor festgelegte Koordinatenreferenzsystem wird als Basis-Koordinatenreferenzsystem bezeichnet.

Anmerkung 2 zum Begriff: Bei einem abgeleiteten Koordinatenreferenzsystem wird das Datum oder der Referenzrahmen aus dessen Basis-Koordinatenreferenzsystem übernommen.

Anmerkung 3 zum Begriff: Die Koordinatenumwandlung zwischen dem Basis- und dem abgeleiteten Koordinatenreferenzsystem wird mithilfe der in der Definition der Koordinatenumwandlung festgelegten Parameter und Formel(n) durchgeführt.

3.1.19

dynamisches Koordinatenreferenzsystem

Koordinatenreferenzsystem mit einem dynamischen Referenzrahmen

Anmerkung 1 zum Begriff: Koordinaten von Punkten auf oder nahe der Erdkruste, die einem dynamischen Koordinatenreferenzsystem zugeordnet sind, können sich, üblicherweise aufgrund von Krustendeformationen wie tektonischen Verschiebungen oder glazialen isostatischen Anpassungen mit der Zeit verändern.

Anmerkung 2 zum Begriff: Metadaten für einen auf ein dynamisches Koordinatenreferenzsystem bezogenen Datensatz sollten Informationen zur Koordinatenzeit enthalten.

3.1.20

dynamischer Referenzrahmen

dynamisches Datum

Referenzrahmen, in dem die Definitionsparameter die Zeitentwicklung beinhalten

Anmerkung 1 zum Begriff: Die Definitionsparameter mit Zeitentwicklung sind in der Regel ein Satz von Koordinaten.

3.1.21

Easting (Rechtswert)

E

Abstand in einem Koordinatensystem nach Osten (positiv) oder Westen (negativ) einer Nord-Süd-Bezugslinie

3.1.22

Ellipsoid

Referenzellipsoid

<Geodäsie> geometrische Referenzfläche, die in einem durch eine Ellipse geformten dreidimensionalen euklidischen Raum eingebettet ist, die um eine Hauptachse gedreht wird

Anmerkung 1 zum Begriff: Das Ellipsoid für die Erde ist bi-axial mit Drehung um die Polarachse. Das Ergebnis ist ein abgeplattetes Ellipsoid, bei dem sich der Mittelpunkt der Schwerpunkte am nominalen Erdmittelpunkt befindet.

3.1.23

ellipsoidisches Koordinatensystem

geodätisches Koordinatensystem

Koordinatensystem, in dem die Position durch geodätische Breite, geodätische Länge und (bei dreidimensionalen Systemen) ellipsoidische Höhe festgelegt wird

3.1.24

ellipsoidische Höhe

geodätische Höhe

h

positiver Abstand eines Punkts vom Referenzellipsoid entlang der Senkrechten des Referenzellipsoids zu diesem Punkt, falls nach oben gerichtet oder außerhalb des Referenzellipsoids

Anmerkung 1 zum Begriff: Wird nur als Teil eines dreidimensionalen ellipsoidischen Koordinatensystems oder als Teil eines dreidimensionalen kartesischen Koordinatensystems in einem dreidimensional-projizierten Koordinatensystem angewendet, jedoch niemals allein.

3.1.25

lokales Koordinatenreferenzsystem

Koordinatenreferenzsystem, das auf einem lokalen Datum beruht

BEISPIEL 1 System zur Identifizierung relativer nur wenige Kilometer vom Stützpunkt entfernter Positionen, wie z. B. Baustellen.

BEISPIEL 2 Lokales Koordinatenreferenzsystem eines sich bewegenden Objekts, wie z. B. Schiffe oder umkreisende Raumfahrzeuge.

BEISPIEL 3 Internes Koordinatenreferenzsystem für ein Bild. Es verfügt über kontinuierliche Achsen. Es kann als Grundlage für ein Raster dienen.

3.1.26

lokales Datum

Datum, das die Beziehung eines Koordinatensystems zu einer lokalen Referenz beschreibt

Anmerkung 1 zum Begriff: Ein lokales Datum schließt sowohl geodätische als auch vertikale Referenzrahmen aus.

3.1.27

Zeit

<Geodäsie> Zeitpunkt

Anmerkung 1 zum Begriff: In diesem Dokument wird eine Zeit im gregorianischen Kalender als ein Dezimaljahr ausgedrückt.

BEISPIEL Der 25.03.2017 im gregorianischen Kalender ist die Zeit 2017.23.

3.1.28

Abflachung

f

Verhältnis der Differenz zwischen der großen Halbachse (a) und der kleinen Halbachse (b) eines Ellipsoids zur großen Halbachse: $f = (a - b)/a$

Anmerkung 1 zum Begriff: Manchmal wird stattdessen die inverse Abflachung $1/f = a/(a - b)$ angegeben.

3.1.29

Zeit des Referenzrahmens

Zeit der Koordinaten, die einen dynamischen Referenzrahmen bestimmen

3.1.30

geozentrische Breite

Winkel von der Äquatorebene in Richtung eines Ellipsoidmittelpunkts durch einen vorgegebenen Punkt, nach Norden als positiv behandelt

3.1.31

geodätisches Koordinatenreferenzsystem

dreidimensionales Koordinatenreferenzsystem auf Basis eines geodätischen Referenzrahmens mit einem dreidimensionalen kartesischen oder einem sphärischen Koordinatensystem

Anmerkung 1 zum Begriff: In diesem Dokument gilt ein Koordinatenreferenzsystem, das auf einem geodätischen Referenzrahmen basiert und über ein ellipsoidisches Koordinatensystem verfügt, als geographisch.

3.1.32

geodätische Breite

ellipsoidische Breite

φ

Winkel von der Äquatorebene zur Senkrechten zum Ellipsoid durch einen vorgegebenen Punkt, nach Norden als positiv behandelt

3.1.33

geodätische Länge

ellipsoidische Länge

λ

Winkel von der Nullmeridianebene zur Meridianebene eines vorgegebenen Punkts, nach Osten als positiv behandelt

3.1.34

geodätischer Referenzrahmen

Referenzrahmen oder Datum, der/das das Verhältnis eines zwei- oder dreidimensionalen Koordinatensystems zur Erde beschreibt

Anmerkung 1 zum Begriff: Im Datenmodell, das in diesem Dokument beschrieben wird, umfasst die UML-Klasse GeodeticReferenceFrame moderne terrestrische Referenzrahmen und klassische geodätische Daten.

3.1.35

geographisches Koordinatenreferenzsystem

Koordinatenreferenzsystem mit einem geodätischen Referenzrahmen und einem ellipsoidischen Koordinatensystem

3.1.36

Geoid

Äquipotentialfläche des Erdschwerefelds, die senkrecht in Richtung der Schwerkraft ist und der mittleren Meereshöhe entweder lokal, regional oder global am ehesten entspricht

3.1.37

gravitationsabhängige Höhe

H

vom Erdschwerefeld abhängige Höhe

Anmerkung 1 zum Begriff: Dies bezieht sich, u. a. auf die orthometrische Höhe und die Normalhöhe, die beide Schätzungen zum Abstand eines Punkts über mittlerer Meereshöhe darstellen, aber schließt möglicherweise auch normalorthometrische Höhen, dynamische Höhen oder geopotentielle Koten ein.

Anmerkung 2 zum Begriff: Der Abstand der Referenzfläche könnte einer gekrümmten (nicht notwendigerweise geraden) Linie folgen, da diese durch die Richtung der Schwerkraft beeinflusst wird.

3.1.38

Höhe

positiver Abstand eines Punkts zu einer gewählten Referenzfläche nach oben entlang einer Linie senkrecht zu dieser Oberfläche

Anmerkung 1 zum Begriff: Eine Höhe unterhalb der Referenzfläche hat einen negativen Wert.

Anmerkung 2 zum Begriff: Generalisierung der ellipsoidischen Höhe (h) und der schwerkraftbezogenen Höhe (H).

3.1.39

lineares Koordinatensystem

eindimensionales Koordinatensystem, in dem die Achse durch ein lineares Objekt geformt wird

BEISPIEL 1 Abstände entlang der Rohrleitung.

BEISPIEL 2 Tiefen einer abgelenkten Ölbohrung.

3.1.40

Kartenprojektion

Koordinatenumwandlung eines ellipsoidischen Koordinatensystems in eine Ebene

3.1.41

mittlere Meereshöhe (en: mean sea level)

MSL

<Geodäsie> durchschnittliches Niveau der Meeresoberfläche über allen Stufen der Tide und jahreszeitlichen Schwankungen

Anmerkung 1 zum Begriff: Mit der mittleren Meereshöhe in einem lokalen Kontext ist normalerweise die mittlere Meereshöhe für die Region gemeint, die anhand von Beobachtungen an einem oder mehreren Punkten über einen festgelegten Zeitraum berechnet wird. Zur Einhaltung der IHO-Standards sollte es sich bei diesem Zeitraum um einen gesamten Mondzyklus von 19 Jahren handeln. Die mittlere Meereshöhe im globalen Kontext unterscheidet sich höchstens um 2 m von einem globalen Geoid.

3.1.42

Meridian (Längengrad)

Kreuzung eines Ellipsoids durch eine Ebene, die die kürzeste Achse des Ellipsoids enthält

Anmerkung 1 zum Begriff: Dieser Begriff wird im Allgemeinen eher für die Beschreibung des Pol-zu-Pol-Lichtbogens als für das gesamte geschlossene Bild verwendet.

3.1.43

Northing (Hochwert)

N

Abstand in einem Koordinatensystem nach Norden (positiv) oder Süden (negativ) einer Ost-West-Bezugslinie

3.1.44

Zeit der Parameterreferenz

Zeit, während der die Parameterwerte einer zeitabhängigen Koordinatentransformation gültig sind

Anmerkung 1 zum Begriff: Die Parameterwerte der Transformation müssen zunächst auf die Koordinatenzeit ausbreitet werden, bevor die Koordinatentransformation durchgeführt werden kann.

3.1.45

parametrisches Koordinatenreferenzsystem

Koordinatenreferenzsystem, das auf einem parametrischen Datum beruht

3.1.46

parametrisches Koordinatensystem

eindimensionales Koordinatensystem, bei dem die Achseneinheiten Parameterwerte sind, die nicht zwangsläufig räumlich sind

3.1.47

parametrisches Datum

Datum, das die Beziehung eines parametrischen Koordinatensystems zu einem Objekt beschreibt

Anmerkung 1 zum Begriff: Das Objekt ist normalerweise die Erde.

3.1.48

Punkt-Verschiebungsoperation

Koordinatenoperation, die Koordinaten innerhalb eines Koordinatenreferenzsystems aufgrund der Verschiebung des Punkts verändert

Anmerkung 1 zum Begriff: Die Veränderung der Koordinaten zeigt sich im Vergleich der Koordinaten zu einer anfänglichen Zeit mit denen zu einer anderen Zeit.

Anmerkung 2 zum Begriff: In diesem Dokument ist die Punkt-Verschiebung auf tektonische Verschiebungen oder Krustendeformationen zurückzuführen.

3.1.49

polares Koordinatensystem

zweidimensionales Koordinatensystem im euklidischen Raum, in dem die Position durch eine Abstandskoordinate und eine Winkelkoordinate festgelegt wird

Anmerkung 1 zum Begriff: Für das dreidimensionale Koordinatensystem, siehe sphärisches Koordinatensystem.

3.1.50

Nullmeridian

Meridian, von dem aus die Längen anderer Meridiane quantifiziert werden

3.1.51

projiziertes Koordinatenreferenzsystem

mithilfe einer Kartenprojektion aus einem geographischen Koordinatenreferenzsystem abgeleitetes Koordinatenreferenzsystem

Anmerkung 1 zum Begriff: Dieses Koordinatenreferenzsystem kann zwei- oder dreidimensional sein, wobei die Dimension der des geographischen Koordinatenreferenzsystems entspricht, von dem es abgeleitet wurde.

Anmerkung 2 zum Begriff: Bei einem dreidimensionalen Koordinatenreferenzsystem werden die horizontalen Koordinaten (Koordinaten der geodätischen Breite und geodätischen Länge) im Northing und Easting projiziert, während die ellipsoidische Höhe unverändert bleibt.

3.1.52

Referenzrahmen

Datum

Parameter oder Menge von Parametern, der/die die Position der Herkunft, des Maßstabs und der Ausrichtung eines Koordinatensystems realisiert/realisieren

3.1.53

große Halbachse a

a

Radius der längsten Achse eines Ellipsoids

3.1.54

kleine Halbachse b

b

Radius der kürzesten Achse eines Ellipsoids

3.1.55

Folge

finite, geordnete Sammlung zueinander gehörender Elemente (Objekte oder Werte), die sich wiederholen können

3.1.56

räumlicher Bezug

Beschreibung der wirklichen Position

Anmerkung 1 zum Begriff: Dies kann in Form eines Aufklebers, Codes oder Koordinatentupels erfolgen.

3.1.57

räumlich-parametrisches Koordinatenreferenzsystem

kombiniertes Koordinatenreferenzsystem, in dem ein Bestandteil des Koordinatenreferenzsystems ein räumliches Koordinatenreferenzsystem ist und der andere ein parametrisches Koordinatenreferenzsystem

Anmerkung 1 zum Begriff: Normalerweise ist die räumliche Komponente „waagrecht“ und die parametrische Komponente „senkrecht“.

3.1.58

räumlich-parametrisch-zeitbezogenes Koordinatenreferenzsystem

kombiniertes Koordinatenreferenzsystem, das aus räumlichen, parametrischen und zeitbezogenen Koordinatenreferenzsystemen zusammengesetzt ist

3.1.59

räumlich-zeitbezogenes Koordinatenreferenzsystem

kombiniertes Koordinatenreferenzsystem, in dem ein Bestandteil des Koordinatenreferenzsystems ein räumliches Koordinatenreferenzsystem ist und der andere ein zeitbezogenes Koordinatenreferenzsystem

3.1.60

sphärisches Koordinatensystem

dreidimensionales Koordinatensystem im euklidischen Raum, in dem die Position durch eine Abstandskoordinate und zwei Winkelkoordinaten festgelegt wird

Anmerkung 1 zum Begriff: Es ist nicht mit einem ellipsoidischen Koordinatensystem zu verwechseln, das auf einem in eine Sphäre „degenerierten“ Ellipsoid basiert.

3.1.61

statisches Koordinatenreferenzsystem

Koordinatenreferenzsystem mit einem statischen Referenzrahmen

Anmerkung 1 zum Begriff: Koordinaten von Punkten auf oder nahe der Erdkruste, die einem statischen Koordinatenreferenzsystem zugeordnet sind, verändern sich mit der Zeit nicht.

Anmerkung 2 zum Begriff: Metadaten für einen auf ein statisches Koordinatenreferenzsystem bezogenen Datensatz erfordern keine Informationen zur Koordinatenzeit.

3.1.62

statischer Referenzrahmen

statisches Datum

Referenzrahmen, in dem die Definitionsparameter die Zeitentwicklung ausschließen

3.1.63

zeitbezogenes Koordinatenreferenzsystem

Koordinatenreferenzsystem, das auf einem zeitbezogenen Datum beruht

3.1.64

zeitbezogenes Koordinatensystem

<Geodäsie> eindimensionales Koordinatensystem, bei dem die Achse der Zeit entspricht

3.1.65

zeitbezogenes Datum

Datum, das die Beziehung eines zeitbezogenen Koordinatensystems zu einem Objekt beschreibt

Anmerkung 1 zum Begriff: Das Objekt ist normalerweise die Zeit auf der Erde.

3.1.66

terrestrisches Referenzsystem (en: terrestrial reference system)

TRS

Reihe an Konventionen, die Ursprung, Maßstab, Orientierung und Zeitentwicklung eines räumlichen Koordinatenreferenzsystems bestimmen, das sich in seiner täglichen Bewegung im Raum mit der Erde dreht

Anmerkung 1 zum Begriff: Das abstrakte Konzept eines TRS wird durch einen terrestrischen Referenzrahmen realisiert, der üblicherweise aus einer Reihe physischer Punkte mit präzise bestimmten Koordinaten und optional mit deren Veränderungsdaten besteht. In diesem Dokument ist der terrestrische Referenzrahmen im Element des geodätischen Referenzrahmens des Datenmodells inbegriffen.

3.1.67

Zeit der Transformationsreferenz

Zeit, während der die Parameterwerte einer zeitspezifischen Koordinatentransformation gültig sind

Anmerkung 1 zum Begriff: Koordinaten müssen zunächst auf diese Zeit ausgebreitet werden, bevor die Koordinatentransformation durchgeführt wird. Dies unterscheidet sich von einer *Zeit der Parameterreferenz*, bei der die Parameterwerte der Transformation zunächst auf die Koordinatenzeit ausgebreitet werden müssen, bevor die Koordinatentransformation durchgeführt wird.

3.1.68

Tupel

geordnete Liste von Werten

[QUELLE: ISO 19136:2007, 4.1.63]

3.1.69

Maßeinheit

definierte messbare Größe, mit der abgemessene Parameter ausgedrückt werden

Anmerkung 1 zum Begriff: Unterarten von Maßeinheiten sind in diesem Dokument Längeneinheiten, Winkleinheiten, Maßstabseinheiten sowie parametrische und zeitliche Mengen.

3.1.70

vertikales Koordinatenreferenzsystem

eindimensionales Koordinatenreferenzsystem auf Grundlage eines vertikalen Referenzrahmens

3.1.71

vertikales Koordinatensystem

zum Abmessen der gravitationsabhängigen Höhe oder Tiefe eingesetztes eindimensionales Koordinatensystem

3.1.72

vertikaler Referenzrahmen

vertikales Datum (Höhendatum)

Referenzrahmen, der die Beziehung gravitationsabhängiger Höhen oder Tiefen zur Erde beschreibt

Anmerkung 1 zum Begriff: In den meisten Fällen bezieht sich der vertikale Referenzrahmen auf die mittlere Meereshöhe. Vertikale Daten umfassen Lotungsdaten (für hydrographische Zwecke), wobei die Höhen negative Höhen oder Tiefen sein können.

Anmerkung 2 zum Begriff: Ellipsoidische Höhen sind mit einem dreidimensionalen ellipsoidischen Koordinatensystem verbunden, das sich auf einen geodätischen Referenzrahmen bezieht.

3.1.73

Höhenbezugssystem (en: vertical reference system)

VRS

Reihe an Konventionen zur Bestimmung von Ursprung, Maßstab, Orientierung und Zeitentwicklung, die die Beziehung gravitationsabhängiger Höhen oder Tiefen zur Erde beschreibt

Anmerkung 1 zum Begriff: Das abstrakte Konzept eines VRS wird anhand eines vertikalen Referenzrahmens realisiert.

3.2 Symbole

a	große Halbachse eines Ellipsoids
b	kleine Halbachse eines bi-axialen Ellipsoids
E	Easting (Rechtswert)
f	Abflachung
H	gravitationsabhängige Höhe
h	ellipsoidische Höhe
N	Northing (Hochwert)
λ	geodätische Länge
φ	geodätische Breite
$E, N, [h]$	kartesische Koordinaten in einem projizierten Koordinatenreferenzsystem
X, Y, Z	kartesische Koordinaten in einem geodätischen Koordinatenreferenzsystem
$i, j, [k]$	kartesische Koordinaten in einem lokalen Koordinatenreferenzsystem
r, θ	polare Koordinaten in einem zweidimensionalen lokalen Koordinatenreferenzsystem
r, Ω, θ	sphärische Koordinaten in einem dreidimensionalen lokalen Koordinatenreferenzsystem
ANMERKUNG In diesem Dokument ist Ω der polare (Zenit-)Winkel und θ der Azimutwinkel.	
$\varphi, \lambda, [h]$	ellipsoidische Koordinaten in einem geographischen Koordinatenreferenzsystem

3.3 Abkürzungen

CC	Koordinatenumwandlung
CCRS	aus mehreren Komponenten zusammengesetztes Koordinatenreferenzsystem
CRS	Koordinatenreferenzsystem
CT	Koordinatentransformation
MSL	mittlere Meereshöhe
Pixel	Kontamination des englischen Begriffs „picture element“ (Bildelement), dem kleinsten Element eines digitalen Bilds, dem Attribute zugeordnet werden
PMO	Punkt-Verschiebungsoperation
SI	Système International d’unités (Internationales Einheitensystem)
UML	einheitliche Modelliersprache (en: unified modelling language)
URI	einheitlicher Ressourcenbezeichner (en: Uniform Resource Identifier)
1D	eindimensional
2D	zweidimensional
3D	dreidimensional

Nationaler Anhang NB (informativ)

Literaturhinweise

DIN EN ISO 19107:2005-05, *Geoinformation — Raumbezugsschema (ISO 19107:2003); Englische Fassung EN ISO 19107:2005*

DIN EN ISO 19108, *Geoinformation — Zeitliches Schema*

DIN EN ISO 19112, *Geoinformation — Raumbezug mit (geographischen) Identifikatoren*

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

DIN EN ISO 19123, *Geoinformation — Coverage Geometrie- und Funktionsschema*

DIN EN ISO 19148, *Geoinformation — Lineares Bezugssystem*

DIN EN ISO 19157, *Geoinformation — Datenqualität*

DIN EN ISO 80000-3, *Größen und Einheiten — Teil 3: Raum und Zeit*

DIN ISO 2533:1979-12, *Normatmosphäre (ISO 2533:1975)*

— Leerseite —

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*, in close collaboration with the Open Geospatial Consortium (OGC).

This third edition cancels and replaces the second edition (ISO 19111:2007), which has been technically revised. This document also incorporates the provisions of ISO 19111-2:2009, which is cancelled.

The changes in this edition compared to the previous edition are:

- inclusion of applicable modern geodetic terminology;
- extension to describe dynamic geodetic reference frames;
- extension to describe geoid-based vertical coordinate reference systems;
- extension to allow triaxial ellipsoid for planetary applications;
- extension to describe three-dimensional projected coordinate reference systems;
- addition of 'datum ensembles' to allow grouping of related realizations of a reference frame where for lower accuracy applications the differences are insignificant;
- clarification in the modelling of derived coordinate reference systems;
- remodelling of the metadata elements scope and extent;
- addition of requirements to describe coordinate metadata and the relationship between spatial coordinates;
- additional modelling of temporal coordinate reference system components sufficient for spatio-temporal coordinate referencing;
- consolidation of the provisions of ISO 19111-2:2009 (*Spatial referencing by coordinates — Extension for parametric values*) into this document

- change in name from 'Spatial referencing by coordinates' to 'Referencing by coordinates', due to the inclusion of the non-spatial coordinate reference system subtypes of parametric (from ISO 19111-2) and temporal;
- the correction of minor errors.

Further details are given in Annex G.

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

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

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Geographic information is inherently four-dimensional and includes time. The spatial component relates the features represented in geographic data to positions in the real world. Spatial references fall into two categories:

- those using coordinates;
- those based on geographic identifiers.

Spatial referencing by geographic identifiers is defined in ISO 19112[5]. This document describes the data elements, relationships and associated metadata required for spatial referencing by coordinates, expanded from a strictly spatial context to include time. The temporal element is restricted to temporal coordinate systems having a continuous axis. The temporal element excludes calendars and ordinal reference systems due to their complexities in definition and in transformation. The context is shown in Figure 1.

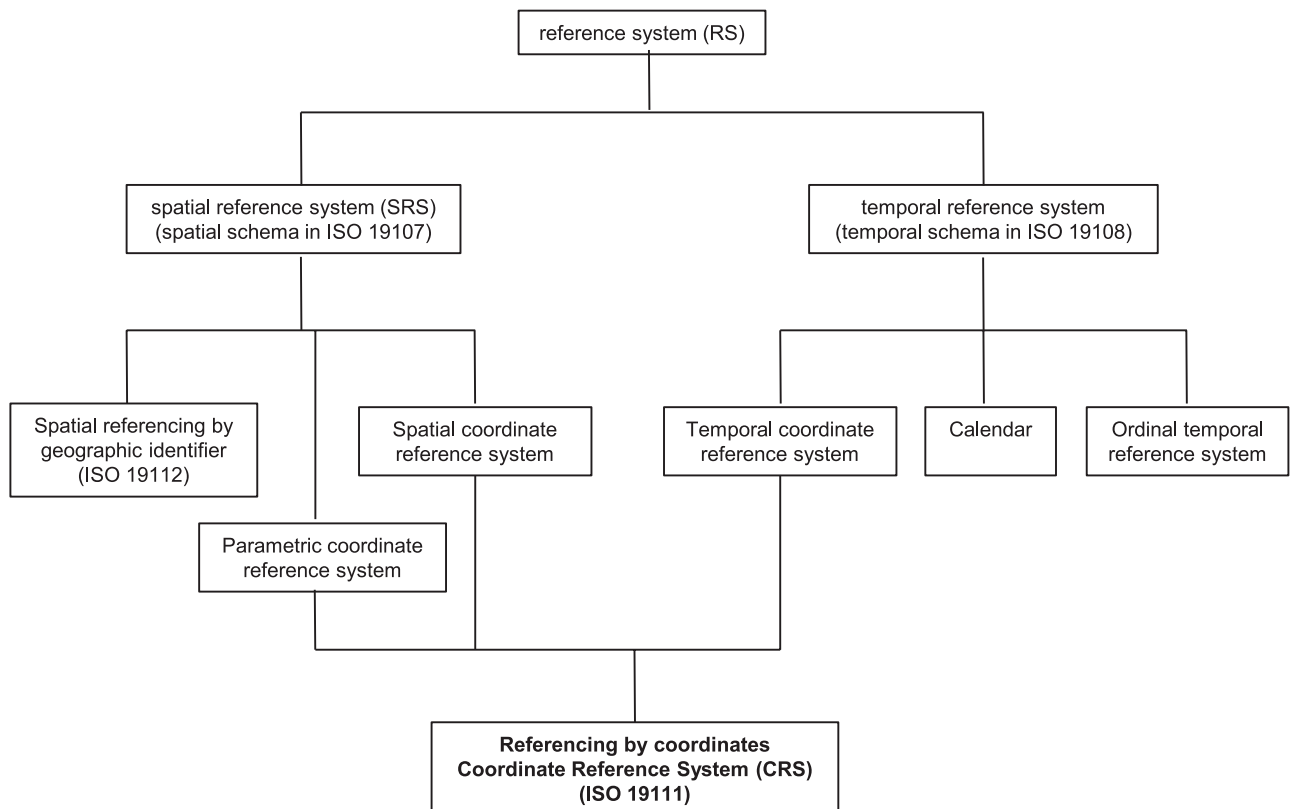


Figure 1 — Context of referencing by coordinates

Certain scientific communities use three-dimensional systems where horizontal position is combined with a non-spatial parameter. In these communities, the parameter is considered to be a third, vertical, axis. The parameter, although varying monotonically with height or depth, does not necessarily vary in a simple manner. Thus conversion from the parameter to height or depth is non-trivial. The parameters concerned are normally absolute measurements and the datum is taken with reference to a direct physical measurement of the parameter. These non-spatial parameters and parametric coordinate reference system modelling constructs were previously described in ISO 19111-2:2009 but have been incorporated into this revision because the modelling constructs are identical to the other coordinate reference system types included in this document.

This document describes the elements that are necessary to fully define various types of coordinate reference systems applicable to geographic information. The subset of elements required is partially dependent upon the type of coordinates. This document also includes optional fields to allow for the

inclusion of metadata about the coordinate reference systems. The elements are intended to be both machine and human readable.

In addition to describing a coordinate reference system, this document provides for the description of a coordinate operation between two different coordinate reference systems or a coordinate operation to account for crustal motion over time. With such information, spatial data referenced to different coordinate reference systems can be referenced to one specified coordinate reference system at one specified time. This facilitates spatial data integration. Alternatively, an audit trail of coordinate manipulations can be maintained.

Geographic information — Referencing by coordinates

1 Scope

This document defines the conceptual schema for the description of referencing by coordinates. It describes the minimum data required to define coordinate reference systems. This document supports the definition of:

- spatial coordinate reference systems where coordinate values do not change with time. The system may:
 - be geodetic and apply on a national or regional basis, or
 - apply locally such as for a building or construction site, or
 - apply locally to an image or image sensor;
 - be referenced to a moving platform such as a car, a ship, an aircraft or a spacecraft. Such a coordinate reference system can be related to a second coordinate reference system which is referenced to the Earth through a transformation that includes a time element;
- spatial coordinate reference systems in which coordinate values of points on or near the surface of the earth change with time due to tectonic plate motion or other crustal deformation. Such dynamic systems include time evolution, however they remain spatial in nature;
- parametric coordinate reference systems which use a non-spatial parameter that varies monotonically with height or depth;
- temporal coordinate reference systems which use dateTime, temporal count or temporal measure quantities that vary monotonically with time;
- mixed spatial, parametric or temporal coordinate reference systems.

The *definition* of a coordinate reference system does not change with time, although in some cases some of the defining parameters can include a rate of change of the parameter. The coordinate values within a dynamic and in a temporal coordinate reference system can change with time.

This document also describes the conceptual schema for defining the information required to describe operations that change coordinate values.

In addition to the minimum data required for the definition of the coordinate reference system or coordinate operation, the conceptual schema allows additional descriptive information - coordinate reference system metadata - to be provided.

This document is applicable to producers and users of geographic information. Although it is applicable to digital geographic data, the principles described in this document can be extended to many other forms of spatial data such as maps, charts and text documents.

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, *Data elements and interchange formats — Information interchange — Representation of dates and times*

ISO 19103, *Geographic information — Conceptual schema language*

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

3 Terms, definitions, symbols 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:

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

3.1.1

affine coordinate system

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

3.1.2

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.

3.1.3

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.

3.1.4

concatenated operation

coordinate operation consisting of the sequential application of multiple coordinate operations

3.1.5

coordinate

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

Note 1 to entry: In a spatial coordinate reference system, the coordinate numbers are qualified by units.

3.1.6

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.

3.1.7

coordinate epoch

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

3.1.8

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

3.1.9

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.

3.1.10

coordinate set

collection of coordinate tuples referenced to the same coordinate reference system and if that coordinate reference system is dynamic also to the same coordinate epoch

3.1.11

coordinate system

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

3.1.12

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.

3.1.13

coordinate tuple

tuple composed of coordinates

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

3.1.14

cylindrical coordinate system

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

3.1.15

datum

reference frame

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

3.1.16

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 and 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).

3.1.17

depth

distance of a point from a chosen vertical reference surface downward along a line that is perpendicular to that surface

Note 1 to entry: The line direction may be straight, or be dependent on the Earth's gravity field or other physical phenomena.

Note 2 to entry: A depth above the vertical reference surface will have a negative value.

3.1.18

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.

3.1.19

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.

3.1.20

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.

3.1.21

easting

E

distance in a coordinate system, eastwards (positive) or westwards (negative) from a north-south reference line

3.1.22

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.

3.1.23

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

3.1.24

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.

3.1.25

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.

3.1.26

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.

3.1.27

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.

3.1.28

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.

3.1.29

frame reference epoch

epoch of coordinates that define a dynamic reference frame

3.1.30

geocentric latitude

angle from the equatorial plane to the direction from the centre of an ellipsoid through a given point, northwards treated as positive

3.1.31

geodetic coordinate reference system

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

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

3.1.32

geodetic latitude

ellipsoidal latitude

φ

angle from the equatorial plane to the perpendicular to the ellipsoid through a given point, northwards treated as positive

3.1.33

geodetic longitude

ellipsoidal longitude

λ

angle from the prime meridian plane to the meridian plane of a given point, eastward treated as positive

3.1.34

geodetic reference frame

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

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

3.1.35

geographic coordinate reference system

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

3.1.36

geoid

equipotential surface of the Earth's gravity field which is perpendicular to the direction of gravity and which best fits mean sea level either locally, regionally or globally

3.1.37

gravity-related height

H

height that is dependent on the Earth's gravity field

Note 1 to entry: This refers to, amongst others, orthometric height and Normal height, which are both approximations of the distance of a point above the mean sea level, but also may include Normal-orthometric heights, dynamic heights or geopotential numbers.

Note 2 to entry: The distance from the reference surface may follow a curved line, not necessarily straight, as it is influenced by the direction of gravity.

3.1.38

height

distance of a point from a chosen reference surface positive upward along a line perpendicular to that surface

Note 1 to entry: A height below the reference surface will have a negative value.

Note 2 to entry: Generalisation of ellipsoidal height (h) and gravity-related height (H).

3.1.39

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.

3.1.40

map projection

coordinate conversion from an ellipsoidal coordinate system to a plane

3.1.41

mean sea level

MSL

<geodesy> average level of the surface of the sea over all stages of tide and seasonal variations

Note 1 to entry: Mean sea level in a local context normally means mean sea level for the region calculated from observations at one or more points over a given period of time. To meet IHO standards that period should be one full lunar cycle of 19 years. Mean sea level in a global context differs from a global geoid by not more than 2 m.

3.1.42

meridian

intersection of an ellipsoid by a plane containing the shortest axis of the ellipsoid

Note 1 to entry: This term is generally used to describe the pole-to-pole arc rather than the complete closed figure.

3.1.43

northing

N

distance in a coordinate system, northwards (positive) or southwards (negative) from an east-west reference line

3.1.44

parameter reference epoch

epoch at which the parameter values of a time-dependent coordinate transformation are valid

Note 1 to entry: The transformation parameter values first need to be propagated to the epoch of the coordinates before the coordinate transformation can be applied.

3.1.45

parametric coordinate reference system

coordinate reference system based on a parametric datum

3.1.46

parametric coordinate system

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

3.1.47

parametric datum

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

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

3.1.48

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.

3.1.49

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.

3.1.50

prime meridian

meridian from which the longitudes of other meridians are quantified

3.1.51

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.

3.1.52

reference frame

datum

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

3.1.53

semi-major axis

a

semi-diameter of the longest axis of an ellipsoid

3.1.54

semi-minor axis

b

semi-diameter of the shortest axis of an ellipsoid

3.1.55

sequence

finite, ordered collection of related items (objects or values) that may be repeated

3.1.56

spatial reference

description of position in the real world

Note 1 to entry: This may take the form of a label, code or coordinate tuple.

3.1.57

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”.

3.1.58

spatio-parametric-temporal coordinate reference system

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

3.1.59

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

3.1.60

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.

3.1.61

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.

3.1.62

static reference frame

static datum

reference frame in which the defining parameters exclude time evolution

3.1.63

temporal coordinate reference system

coordinate reference system based on a temporal datum

3.1.64

temporal coordinate system

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

3.1.65

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.

3.1.66

terrestrial reference system

TRS

set of conventions defining the origin, scale, orientation and time evolution of a spatial reference system co-rotating with the Earth in its diurnal motion in space

Note 1 to entry: The abstract concept of a TRS is realised through a terrestrial reference frame that usually consists of a set of physical points with precisely determined coordinates and optionally their rates of change. In this document terrestrial reference frame is included within the geodetic reference frame element of the data model.

3.1.67

transformation reference epoch

epoch at which the parameter values of a time-specific coordinate transformation are valid

Note 1 to entry: Coordinates first need to be propagated to this epoch before the coordinate transformation is applied. This is in contrast to a *parameter reference epoch* where the transformation parameter values first need to be propagated to the epoch of the coordinates before the coordinate transformation is applied.

3.1.68

tuple

ordered list of values

[SOURCE: ISO 19136:2007, 4.1.63]

3.1.69

unit

defined quantity in which dimensioned parameters are expressed

Note 1 to entry: In this document, the subtypes of units are length units, angular units, scale units, parametric quantities and time quantities.

3.1.70

vertical coordinate reference system

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

3.1.71

vertical coordinate system

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

3.1.72

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.

3.1.73

vertical reference system

VRS

set of conventions defining the origin, scale, orientation and time evolution that describes the relationship of gravity-related heights or depths to the Earth

Note 1 to entry: The abstract concept of a VRS is realised through a vertical reference frame.

3.2 Symbols

a	semi-major axis of ellipsoid
b	semi-minor axis of bi-axial ellipsoid
E	easting
f	flattening
H	gravity-related height
h	ellipsoidal height
N	northing
λ	geodetic longitude
φ	geodetic latitude
$E, N, [h]$	Cartesian coordinates in a projected coordinate reference system
X, Y, Z	Cartesian coordinates in a geodetic coordinate reference system
$i, j, [k]$	Cartesian coordinates in an engineering coordinate reference system
r, θ	polar coordinates in a 2D engineering coordinate reference system
r, Ω, θ	spherical coordinates in a 3D engineering coordinate reference system
NOTE In this document Ω is the polar (zenith) angle and θ is the azimuthal angle.	
$\varphi, \lambda, [h]$	ellipsoidal coordinates in a geographic coordinate reference system

3.3 Abbreviated terms

CC	coordinate conversion
CCRS	compound coordinate reference system
CRS	coordinate reference system
CT	coordinate transformation
MSL	mean sea level
pixel	a contraction of “picture element”, the smallest element of a digital image to which attributes are assigned
PMO	point motion operation
SI	le Système International d’unités (International System of Units)
UML	Unified Modeling Language
URI	Uniform Resource Identifier

- 1D one-dimensional
- 2D two-dimensional
- 3D three-dimensional

4 Conformance requirements

This document defines

- two classes of conformance for relating coordinates to coordinate metadata; and
- twenty six classes of conformance for the definition of a coordinate reference system (CRS) or of a coordinate operation.

These are differentiated by type, as shown in Table 1. Implementations should indicate which conformance classes they comply with. Any implementations claiming conformance shall satisfy the requirements in Annex A.

Table 1 — Conformance classes

Conformance class	Description	Conformance requirements given in	
Conformance for relating coordinates to coordinate metadata		A.2	
1	CRS with static reference frame		
2	CRS with dynamic reference frame		
Conformance of a CRS definition		A.3	
3 4 5	Geodetic CRS with static reference frame with dynamic reference frame derived geodetic CRS		
	6 7 8		Geographic CRS with static reference frame with dynamic reference frame derived geographic CRS
			9 10
11 12 13			
	14 15		Parametric CRS derived parametric CRS
			16 17
18 19 20 21	Temporal CRS dateTime temporal count temporal measure derived temporal CRS		

Table 1 (continued)

Conformance class	Description	Conformance requirements given in
22	CRS with datum ensemble	A.3
23	Compound CRS	
Conformance of a coordinate operation definition		A.4
24	Coordinate conversion	
25	Coordinate transformation	
26	Point motion operation	
27	Concatenated operation	
28	Pass-through operation	

The requirements classes for the definition of a coordinate reference system or a coordinate operation are described in this document through tables grouped by UML package. The requirements are then brought together in the conformance classes in Annex A. This retains the package-based layout for describing requirements used in previous versions of this document.

5 Conventions

5.1 Unified Modeling Language notation

In this document, the conceptual schema for describing coordinate reference systems and coordinate operations are presented in the Unified Modeling Language (UML). ISO 19103 presents the specific profile of UML used in this document.

In the UML diagrams in this document, a grey background surround to boxes indicates classes from other standards.

5.2 Attribute status

In this document the conceptual schema is described in Clauses 6 to 12 through tables. In these tables:

- attributes and associations are given an obligation status:

Obligation	Definition	Meaning
M	mandatory	This attribute shall be supplied.
C	conditional	This attribute shall be supplied if the condition (given in the attribute description) is true. It may be supplied if the condition is false.
O	optional	This attribute may be supplied.

The Maximum Occurrence column in the tables indicates the maximum number of occurrences of attribute values that are permissible, with N indicating no upper limit.

- non-navigable associations are not included in the UML diagrams or tables.

In the event of any discrepancies between the UML diagrams and text, the UML shall prevail.

6 Referencing by coordinates — Data model overview

The specification for referencing by coordinates is described in this document in the form of a UML model with supplementary text. The UML model contains six UML packages, as shown in Figure 2. Each box represents a package, and contains the package name. Each arrowed line shows the dependency of one package upon another package (at the head of the arrow).

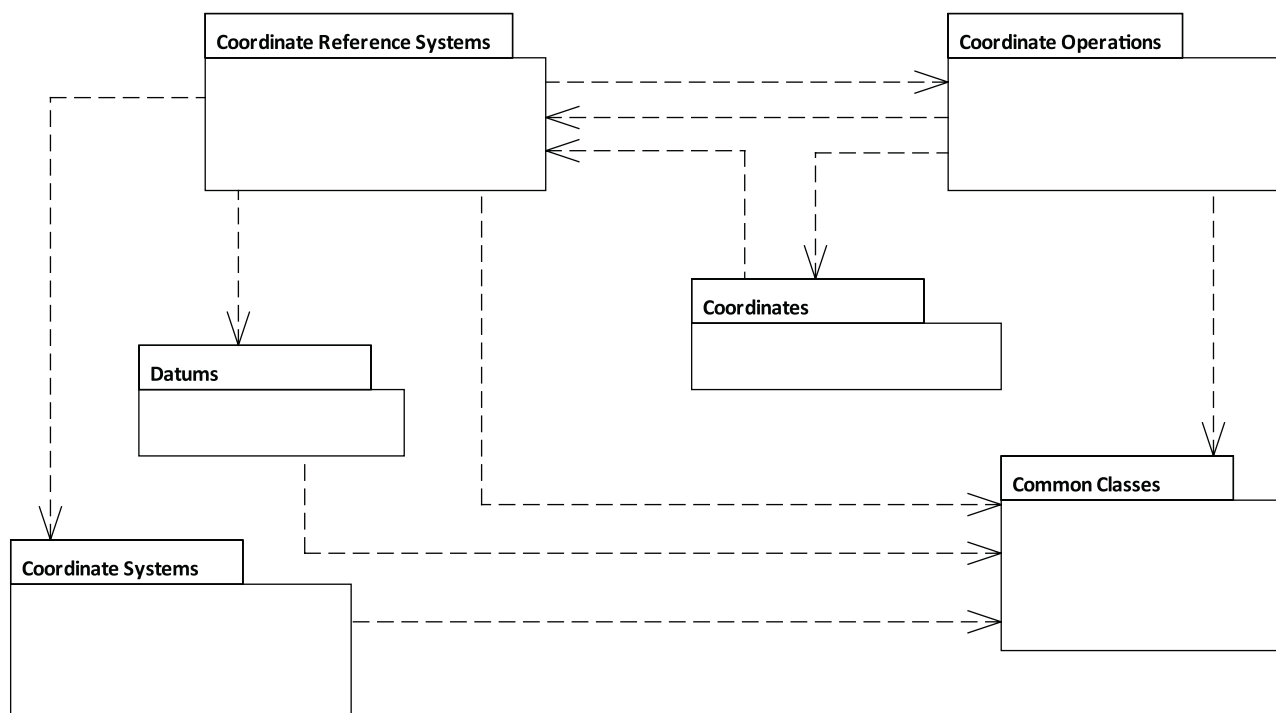


Figure 2 — UML model packages and dependencies

Coordinates require metadata that fully specifies the coordinate reference system to which they are referenced; without this CRS reference the description of position is ambiguous. The UML package for coordinates and their metadata is described in Clause 7. This includes aspects of coordinate operations required to change coordinate values when the coordinate reference system is changed.

A coordinate reference system is usually comprised of two components, one coordinate system and one datum. In modern geodetic terminology the datum is referred to as a reference frame. Some geodetic concepts underpinning spatial referencing by coordinates are given in Annex B. The information required to fully specify a coordinate reference system is described in Clauses 9 to 11, with attributes common to all three packages described in Clause 8.

Some coordinate reference systems have a third component, a defining coordinate conversion from another pre-existing CRS. In this document a CRS having this third component is a derived CRS. The specification for describing coordinate operations, including a defining coordinate conversion, is described in Clause 12.

Further context for the requirements of Clauses 8 to 12 is given in Annexes C and D. Examples illustrating how the specifications of this document can be applied when defining a coordinate reference system or a coordinate operation are given in Annex E. Recommendations for referencing to classes defined in this document are given in Annex F. Changes between this document and the previous version ISO 19111:2007 are described in Annex G.

7 Coordinates package

7.1 Relationship between coordinates and coordinate reference system

In this document, a *coordinate* is one of n scalar values that define the position of a single point. In other contexts, the term *ordinate* is used for a single value and coordinate for multiple ordinates. Such usage is not part of this document.

A *coordinate tuple* is an ordered list of coordinates that define the position of a single point. The coordinates within a coordinate tuple are mutually independent. The number of coordinates in a tuple is equal to the dimension of the coordinate space.

A *coordinate set* is a collection of coordinate tuples referenced to the same coordinate reference system. For a coordinate set, one CRS identification or definition may be associated with the coordinate set and then all coordinate tuples in that coordinate set inherit that association. If only one point is being described, the association between coordinate tuple and coordinate reference system is direct.

The concepts of dynamic and static coordinate reference systems are outlined in B.3. If the coordinate reference system is dynamic, operations on the geometry of the tuples within the coordinate set are valid only if all tuples are referenced to the same coordinate epoch. In this document all coordinate tuples in a spatial coordinate set are referenced to one specified coordinate epoch.

Together the coordinate reference system and the coordinate epoch are the coordinate metadata.

Coordinate sets referenced to one CRS may be referenced to another CRS through the application of a coordinate operation. A coordinate operation operates on coordinates, not on coordinate reference systems. A coordinate operation may be single or concatenated: refer to Clause 12. The high level conceptual model for changing coordinates is shown in Figure 3.

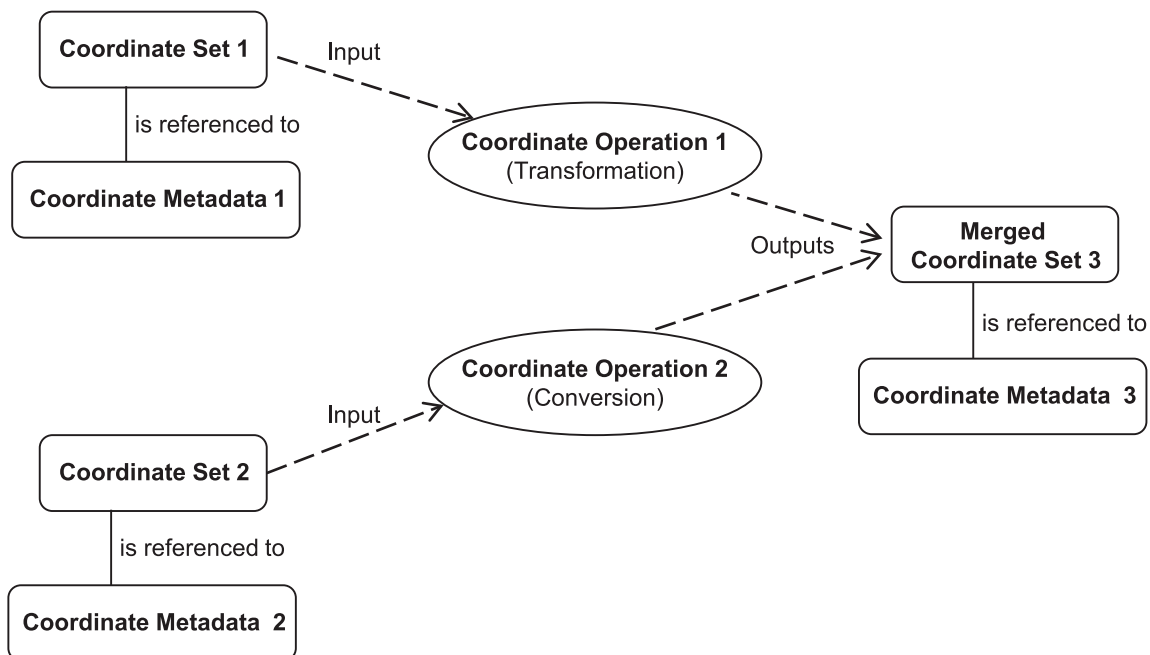


Figure 3 — Conceptual model for coordinate operations to produce a merged coordinate set

Coordinate sets referenced to a dynamic CRS at a given coordinate epoch t_1 may be converted to another coordinate epoch t_2 through a point motion coordinate operation that includes time evolution, often described using velocities, as shown schematically in Figure 4.

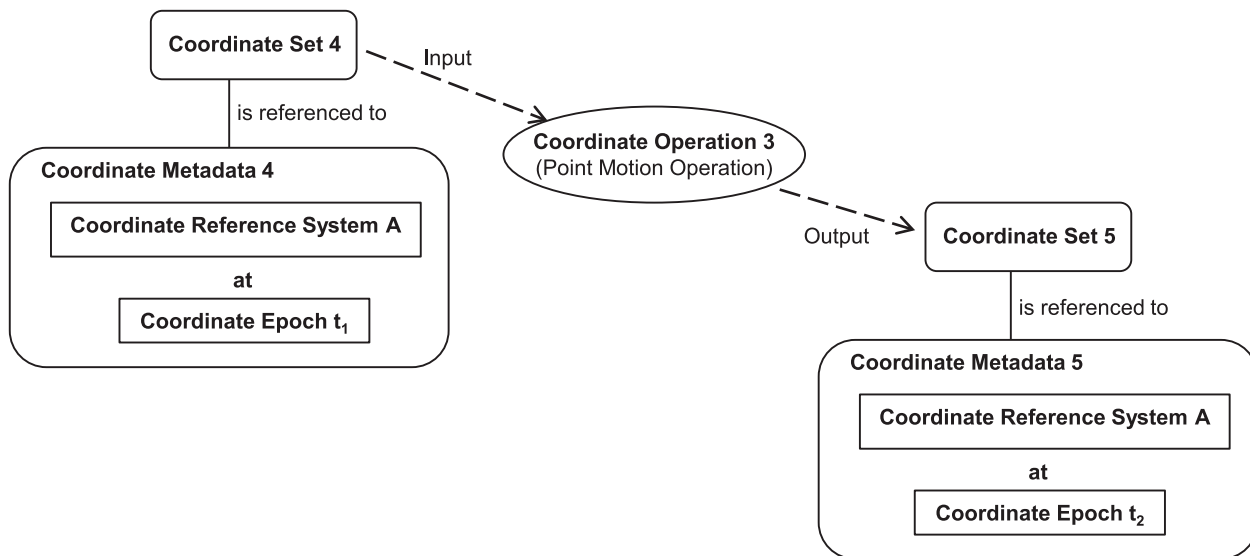


Figure 4 — Conceptual model for a coordinate operation to change coordinate epoch

It is also possible to change coordinates from being referenced to one dynamic CRS at one coordinate epoch to being referenced to another dynamic CRS at another coordinate epoch, or to change coordinates between a dynamic CRS and a static CRS or vice-versa. Further information is in C.1 and C.5.

The description of quality of coordinates is covered by the provisions of ISO 19157[8].

7.2 Coordinate reference system identification

The elements required for the definition of coordinate reference systems and coordinate operations are described in Clauses 8 to 12.

CRS or coordinate operation identification may be through:

- a) a full description, as defined in this document; or
- b) reference to a full description in a register of geodetic parameters (the reference is made to the register and to the identifier of the object description within that register); or
- c) both a full description and a reference to a full description in a register. If there is a conflict between the two, the object full description should prevail over the reference to a register.

a) and b) are alternative means of providing a full description. b) is recommended for simplicity, but if it is not available from a register the description is required to be given explicitly and in full. In both methods, the order of coordinates in each coordinate tuple is required to be as given in the coordinate reference system's coordinate system description.

When using method b), reference to a register, applications that are required only to confirm the *identification* of a CRS or coordinate operation can do so through the register citation and the identifier from that register. They do not need to retrieve the elements that constitute the full description from the register unless there is a need to quote these or to perform a coordinate operation on the coordinate set.

7.3 Requirements for coordinate metadata

7.3.1 Requirements class: Static CRS coordinate metadata

Requirement 1: All coordinate tuples in a coordinate set shall be referenced to the same coordinate reference system.

7.3.2 Requirements class: Dynamic CRS coordinate metadata

CRS is described in Clause 9 and datum or reference frame in Clause 11. The following subtypes of CRS may have a dynamic reference frame and therefore may be dynamic CRSs: geodetic, geographic, vertical, projected and derived variants of these subtypes. Implementers are warned that CRSs of these subtypes are not necessarily dynamic; their reference frame attributes need to be examined to clarify this.

Requirement 2: When the coordinate reference system to which a coordinate set is referenced is dynamic, all coordinate tuples in the coordinate set shall be referenced to the same coordinate epoch.

7.4 UML schema for the Coordinates package

Figure 5 shows the UML class diagram for coordinate metadata. The definition of the classes in the package are provided in Tables 2 to 4.

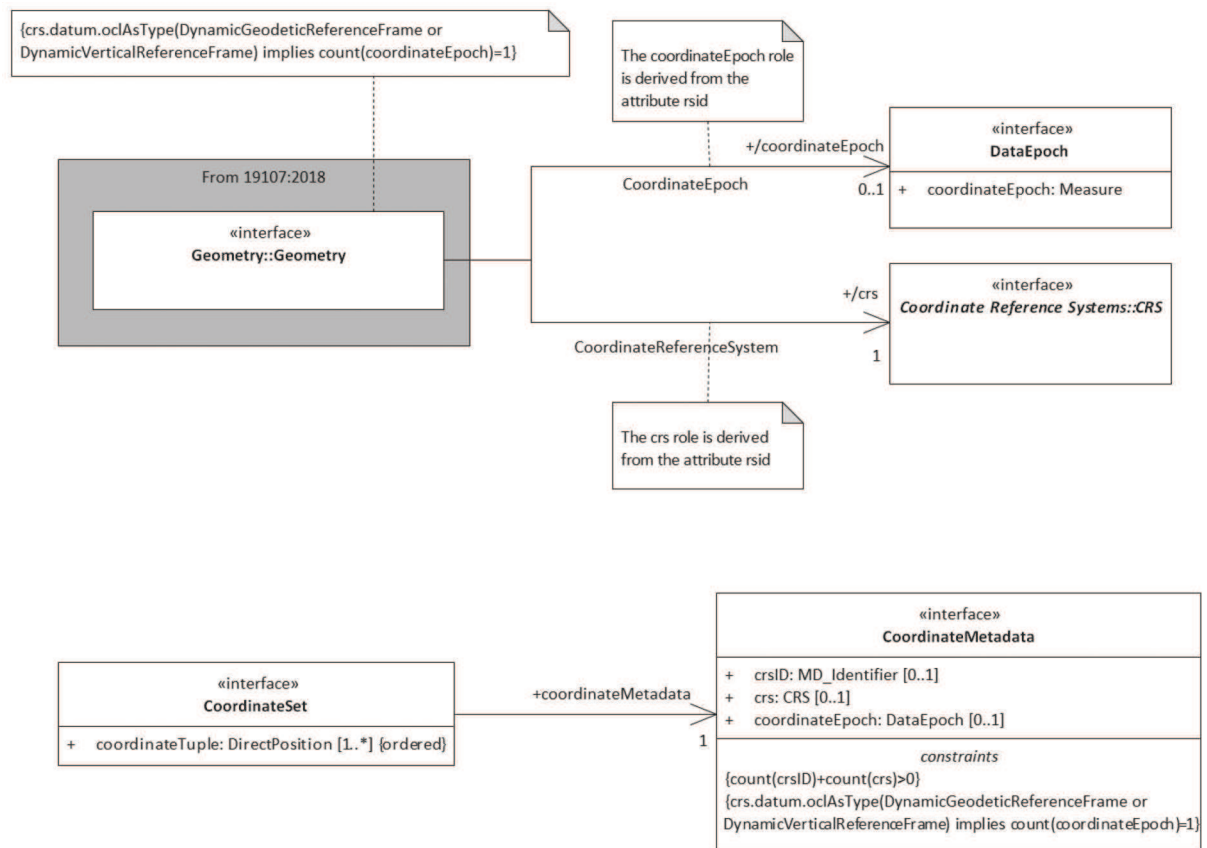


Figure 5 — UML diagram — Relationship of coordinates and coordinate metadata

Table 2 — Defining elements of Coordinates::CoordinateMetadata class

Definition:	metadata required to reference coordinates				
Stereotype:	Interface				
Class attribute:	Concrete				
Inheritance from:	(none)				
Public attributes:					
<u>Attribute name</u>	<u>UML identifier</u>	<u>Data type</u>	<u>Obligation</u>	<u>Maximum Occurrence</u>	<u>Attribute definition</u>
CRS ID	crsID	MD_Identifier	C	1	identifier of the coordinate reference system to which a coordinate set is referenced
CRS definition	crs	CRS	C	1	full description of the coordinate reference system to which a coordinate set is referenced
Coordinate epoch	coordinateEpoch	DataEpoch	C	1	epoch at which a coordinate set referenced to a dynamic CRS is valid NOTE Required if the CRS is dynamic, otherwise should not be given.
Constraints:	{count(crsID)+count(CRS)>0} Remarks: See 7.2. {crs.datum.oclAsType(DynamicGeodeticReferenceFrame or DynamicVerticalReferenceFrame) implies count(coordinateEpoch)=1} Remarks: The constraint provides the conditionality for coordinate epoch.				

The association of a coordinate set to a coordinate reference system (including the special case of a coordinate set containing only one tuple) is mandatory. The defining elements of the coordinate reference system class are described in Clause 9.

The constraint on coordinate metadata (repeated on geometry) specifies that if the coordinate reference system is dynamic then the coordinate set additionally is required to be related to a specified coordinate epoch. This enforces the conditionality of the coordinateEpoch attribute. Whether the CRS is dynamic is determined through the CRS's reference frame definition (Clause 11).

Table 3 — Defining elements of Coordinates::CoordinateSet class

Definition:	description of the coordinate tuples in a coordinate set NOTE A single coordinate tuple is treated as a special case of coordinate set containing only one member.				
Stereotype:	Interface				
Class attribute:	Concrete				
Inheritance from:	(none)				
Association roles:					
<u>Association name</u>	<u>UML identifier</u>	<u>Association with</u>	<u>Obligation</u>	<u>Maximum Occurrence</u>	<u>Association definition</u>
(not named)	coordinateMetadata	CoordinateMetadata	M	1	coordinate metadata to which this coordinate set is referenced
Public attributes:					
<u>Attribute name</u>	<u>UML identifier</u>	<u>Data type</u>	<u>Obligation</u>	<u>Maximum Occurrence</u>	<u>Attribute definition</u>
Coordinate tuple	coordinateTuple	DirectPosition {ordered}	M	N	position described by a coordinate tuple

Table 4 — Defining elements of Coordinates::DataEpoch class

Definition:	time attribute of a coordinate set that is referenced to a dynamic CRS				
Stereotype:	Interface				
Class attribute:	Concrete				
Inheritance from:	(none)				
Used by:	Coordinates::CoordinateMetadata				
Association roles:	(Note attached to association from Geometry::Geometry: "The coordinateEpoch role is derived from the attribute rsid". See ISO 19107).				
Public attributes:					
<u>Attribute name</u>	<u>UML identifier</u>	<u>Data type</u>	<u>Obligation</u>	<u>Maximum Occurrence</u>	<u>Attribute definition</u>
Coordinate epoch	coordinateEpoch	Measure	M	1	date at which coordinates are referenced to a dynamic coordinate reference system, expressed as a decimal year in the Gregorian calendar EXAMPLE 2017-03-25 in the Gregorian calendar is epoch 2017.23.

7.5 UML schema for change of coordinates

Coordinates may be changed to be referenced to a different CRS. If the CRS is dynamic, coordinates also may be referenced to a different coordinate epoch, or to both a different CRS and different coordinate epoch.

In this document the CoordinateOperation class has two purposes:

- to define the requirements for describing a coordinate operation;
- to apply the coordinate operation to change coordinates.

The defining elements for the CoordinateOperation class and its associated classes and their use in the definition of a coordinate operation are given in Clause 12. Only those attributes relevant to the change of coordinates are elaborated here.

Figure 6 shows the UML class diagram for the application of a coordinate operation to coordinate metadata.

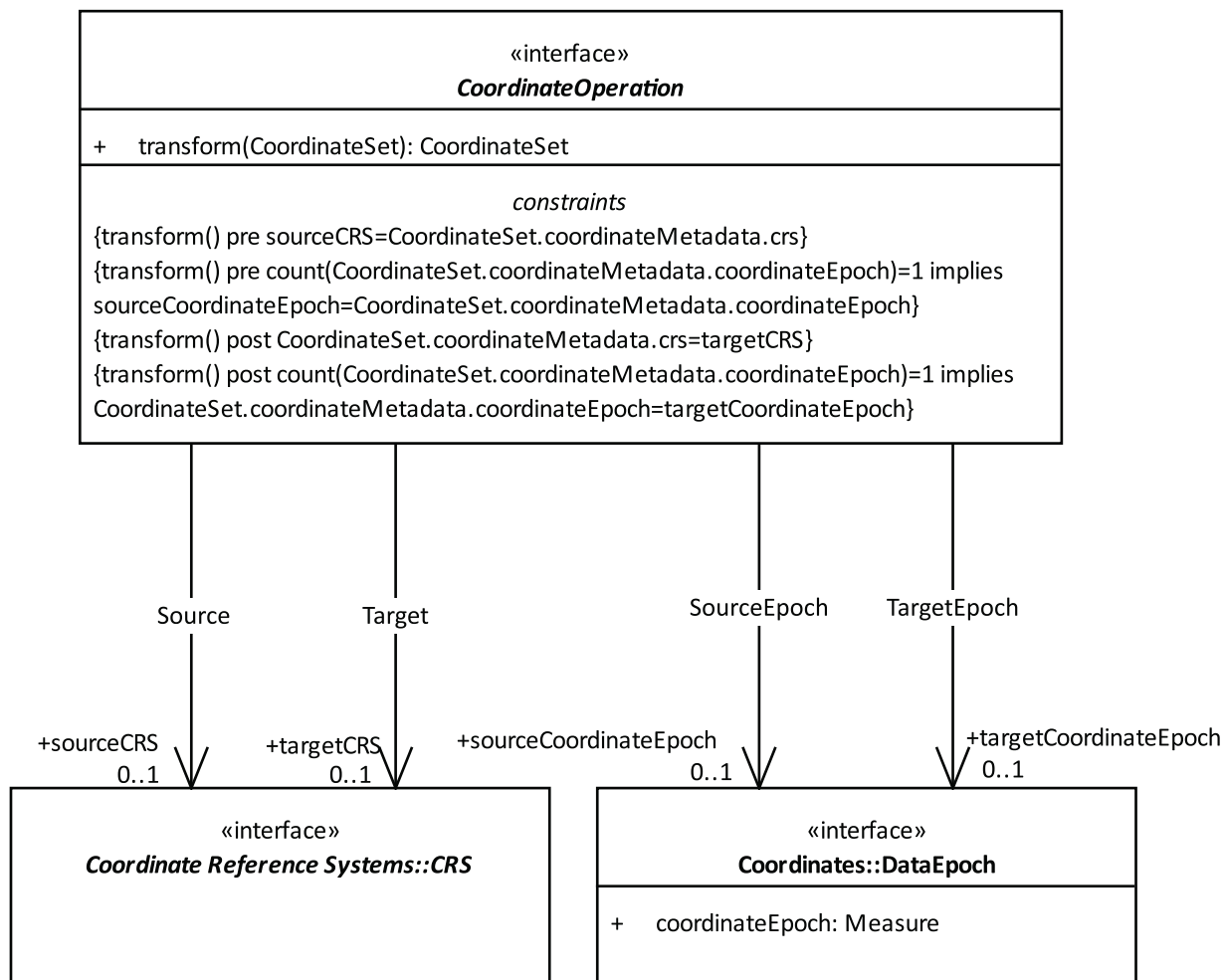


Figure 6 — UML diagram — Relationship of coordinate operation and coordinate metadata

The operation `CoordinateOperation.transform(CoordinateSet)` changes coordinates

- from being referenced to one CRS to being referenced to a second CRS, and/or
- in the case of a dynamic CRS, from being referenced to one coordinate epoch to being referenced to a second coordinate epoch.

Further information regarding commutation is given in C.1.3.

`transform(CoordinateSet)` has four constraints which collectively require that

- the source CRS and/or the source coordinate epoch shall be those to which the input coordinate set is referenced, and that
- the target CRS and/or the target coordinate epoch shall be those associated with the output coordinate set.

`transform(CoordinateSet)` operates on coordinate tuples which have the data type `DirectPosition` and are ordered. This implies that when `transform(CoordinateSet)` is applied to a coordinate set containing multiple coordinate tuples, the order of the tuples in the coordinate set is preserved.

NOTE `transform(CoordinateSet)` operates on coordinate tuples and does not deal with interpolation of the specific geometry types. When a coordinate set is subjected to a coordinate operation, its geometry might or might not be preserved.

8 Common Classes package

8.1 General attributes

8.1.1 Introduction

The Common Classes package contains attributes common to several objects used in referencing by coordinates. These objects – CRS, datum, coordinate system and coordinate operation, together with some of their associated classes – inherit attribute values from the Common Classes package. This facilitates modular programming of names, identifiers and aliases, and of usage (scope and domain of validity).

8.1.2 Name and alias

One of the attributes is the primary name of the object. The object may have alternative names or aliases.

EXAMPLE A datum name might be “North American Datum of 1983” and its abbreviation “NAD83”.

Object primary names have a data type MD_Identifier which is defined in ISO 19115-1:2014. Aliases have a data type GenericName which is defined in ISO 19103.

8.1.3 Identifier

Another attribute is the identifier. This is a unique code used to reference an object in a given place.

EXAMPLE A geodetic registry might give the NAD83 datum a unique code of “6269”.

Identifiers have a data type of MD_Identifier.

In addition to the use of an identifier as a reference to a definition in a geodetic registry, it may also be included in an object definition to allow reference to that object.

8.1.4 Scope and Domain of Validity

Scope is a description of the primary purpose or purposes to which a coordinate reference system, datum or coordinate operation is applied.

DomainOfValidity is described in ISO 19115-1:2014, the introductory text of which is repeated here for convenience:

The datatype in this [EX_Extent] package is an aggregate of the metadata elements that describe the spatial and temporal extent of resources, objects, events, or phenomena. The EX_Extent class contains information about the geographic (EX_GeographicExtent), temporal (EX_TemporalExtent) and the vertical (EX_VerticalExtent) extent of something. EX_GeographicExtent can be subclassed as EX_BoundingPolygon, EX_GeographicBoundingBox and EX_GeographicDescription. The combined spatial and temporal extent (EX_SpatialTemporalExtent) is an aggregate of EX_GeographicExtent. EX_SpatialTemporalExtent is a subclass of EX_TemporalExtent. The full package is specified in ISO 19115-1:2014, Figure 19.

The EX_Extent class has three optional roles named “geographicElement”, “temporalElement”, and “verticalElement” and an element called “description”. At least one of the four shall be used. The data dictionary for this diagram is located in ISO 19115-1:2014, Table B.15.

In this document Scope and DomainOfValidity are paired through the ObjectUsage.domain attribute. This facilitates descriptions of usage such as 'Purpose 1 in area A, purpose 2 in area B'.

Scope and DomainOfValidity are optional to facilitate a succinct CRS description using Well-Known Text in accordance with ISO 19162^[10]. However it is strongly recommended that, in geodetic registries, the

entries for coordinate reference systems, datums and coordinate operations should include at least one Scope-DomainOfValidity pairing. Additional Scope-DomainOfValidity pairings may optionally be given.

8.2 UML schema for the Common Classes package

Figure 7 shows the UML class diagram of the Common Classes package. The definition of the classes in the package are provided in Tables 5 to 7.

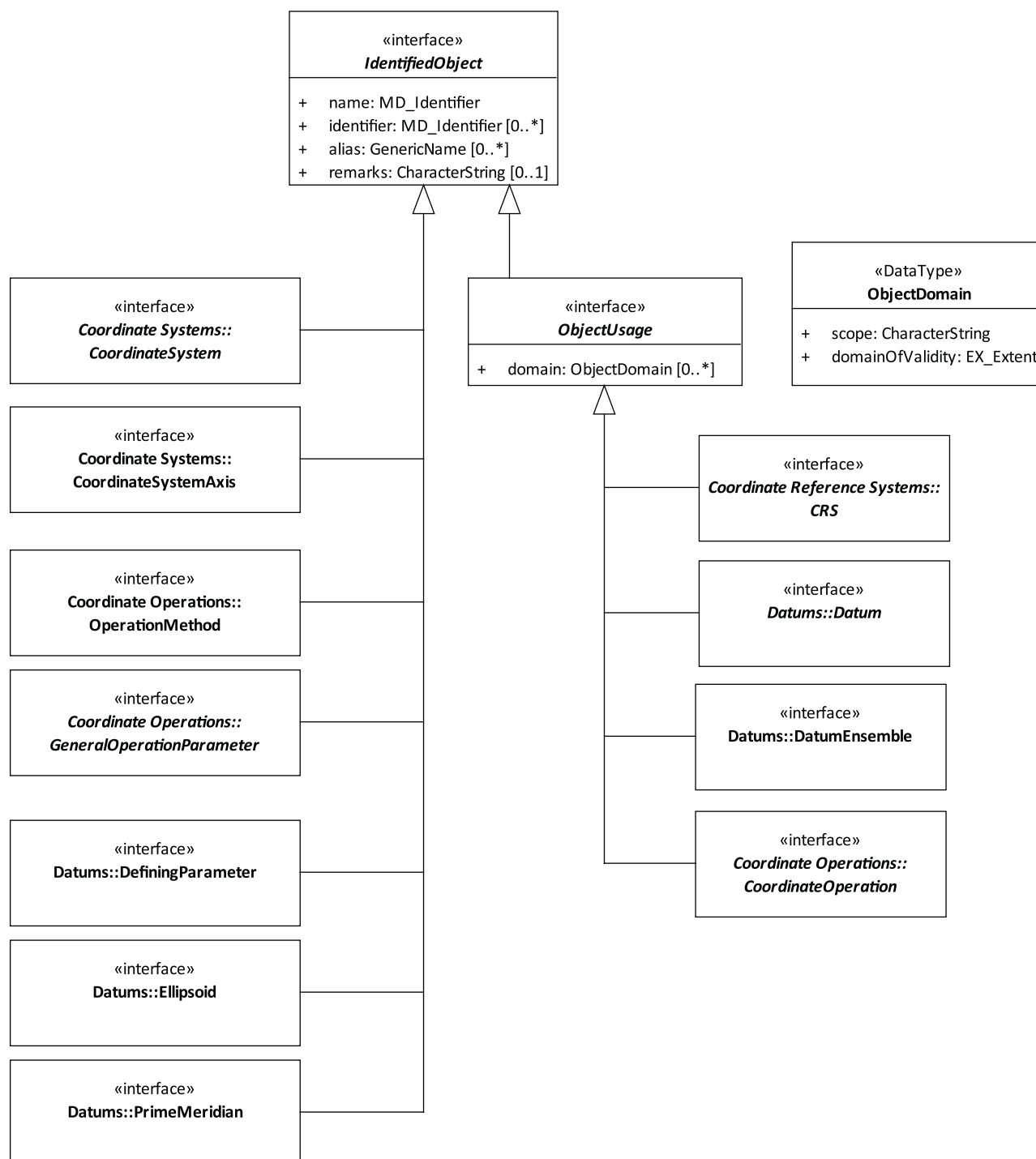


Figure 7 — UML diagram — Common Classes package

The data types MD_Identifier and EX_Extent are defined in ISO 19115-1:2014. The UML class diagram for the attributes in these classes which are of particular relevance to this document are shown in

Figure 8. The EX_Extent class contains information about the geographic, vertical and temporal extent. EX_GeographicExtent can be subclassed as EX_BoundingPolygon, EX_GeographicBoundingBox and EX_GeographicDescription.

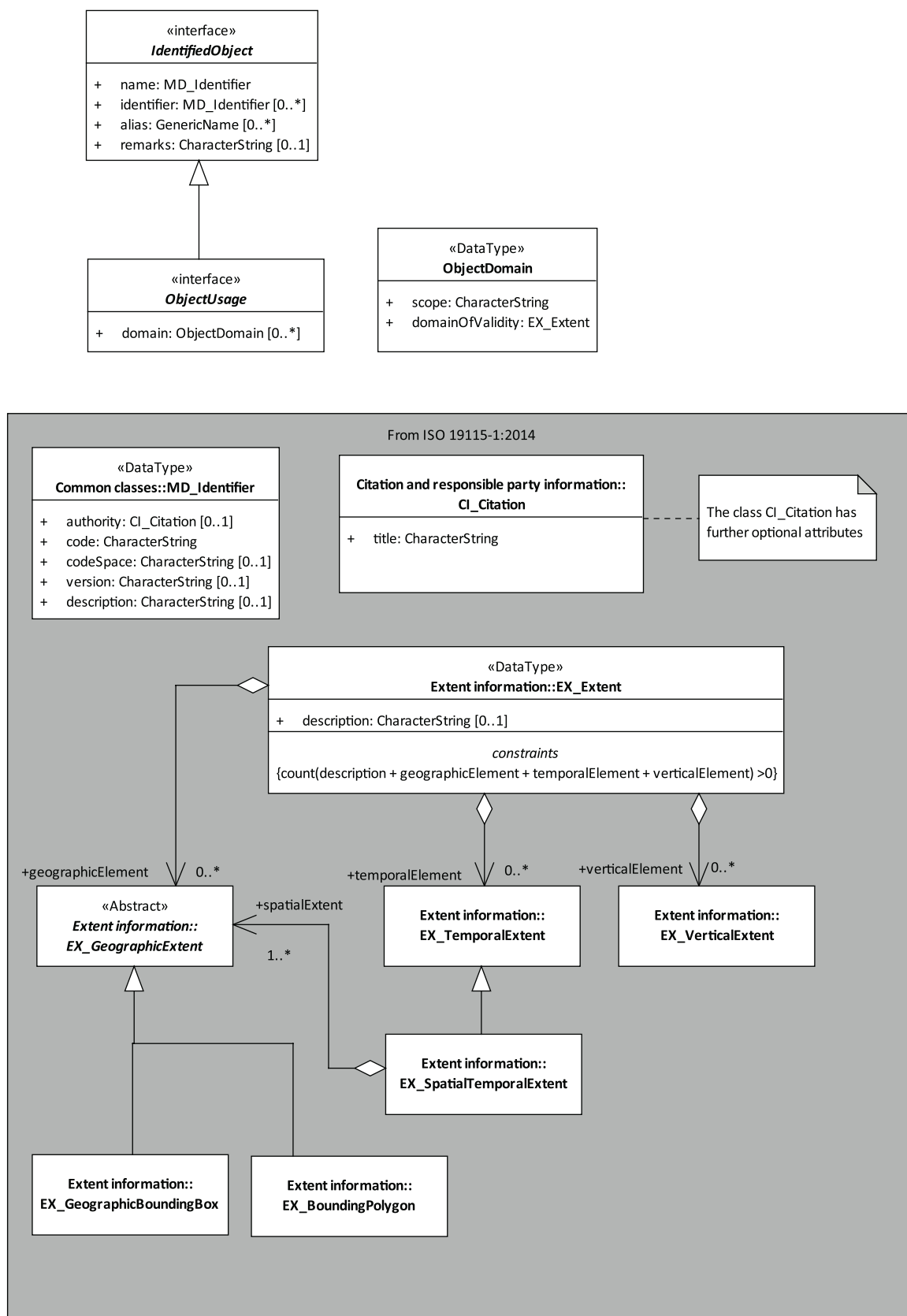


Figure 8 — UML diagram — Data types from ISO 19115-1:2014 (Metadata)

Table 5 — Defining elements of Common Classes::IdentifiedObject class

Definition:	identifications of a CRS-related object				
Stereotype:	Interface				
Class attribute:	Abstract				
Inheritance from:	(none)				
Generalization of:	ObjectUsage, Coordinate Systems::CoordinateSystem, Coordinate Systems:: CoordinateSystemAxis Datums::DefiningParameter, Datums::Ellipsoid, Datums::PrimeMeridian Coordinate Operations::GeneralOperationParameter, Coordinate Operations::OperationMethod				
Public attributes:					
<u>Attribute name</u>	<u>UML identifier</u>	<u>Data type</u>	<u>Obligation</u>	<u>Maximum Occurrence</u>	<u>Attribute Definition</u>
Object name	name	MD_Identifier	M	1	primary name by which this object is identified
Object identifier	identifier	MD_Identifier	O	N	identifier which references elsewhere the object's defining information; alternatively an identifier by which this object can be referenced
Object alias	alias	GenericName	O	N	alternative name by which this object is identified
Object remarks	remarks	CharacterString	O	1	comments on or information about this object, including data source information

Table 6 — Defining elements of Common Classes::ObjectUsage class

Definition:	usage of a CRS-related object				
Stereotype:	Interface				
Class attribute:	Abstract				
Inheritance from:	IdentifiedObject				
Generalization of:	Coordinate Reference Systems::CRS, Datums::Datum, Datums::DatumEnsemble, Coordinate Operations::CoordinateOperation				
Public attributes:	4 attributes (name, identifier, alias and remarks) inherited from IdentifiedObject, plus:				
<u>Attribute name</u>	<u>UML identifier</u>	<u>Data type</u>	<u>Obligation</u>	<u>Maximum Occurrence</u>	<u>Attribute Definition</u>
Object usage	domain	ObjectDomain	O	N	scope and validity of a CRS-related object

Table 7 — Defining elements of Common Classes::ObjectDomain class

Definition:	scope and validity of a CRS-related object				
Stereotype:	DataType				
Class attribute:	Concrete				
Inheritance from:	(none)				
Used by:	ObjectUsage				

Table 7 (continued)

Public attributes:					
<u>Attribute name</u>	<u>UML identifier</u>	<u>Data type</u>	<u>Obligation</u>	<u>Maximum Occurrence</u>	<u>Attribute Definition</u>
Object scope	scope	CharacterString	M	1	description of usage, or limitations of usage, for which this object is valid NOTE If unknown, enter "not known".
Object validity	domainOfValidity	EX_Extent	M	1	spatial and temporal extent in which this object is valid

9 Coordinate Reference Systems package

9.1 Coordinate reference system

9.1.1 General

In this document, a coordinate reference system (CRS) definition generally consists of two components: one coordinate system (CS, Clause 10) and either one datum or one datum ensemble (Clause 11). Derived coordinate reference systems have a third component: a coordinate conversion (Clause 12). Each of these components has a number of attributes.

A datum (in modern geodesy, a reference frame) specifies the relationship of a coordinate system to an object, thus ensuring that the abstract mathematical concept “coordinate system” can be applied to the practical problem of describing positions of features by means of coordinates. The object will generally, but not necessarily, be the Earth or a feature on the Earth such as a building. For certain coordinate reference systems, the object may be a moving platform such as a car, ship, aircraft or spacecraft.

In this document, the *definition* of a coordinate reference system does not change with time. For coordinate reference systems where the object to which they are related is a moving platform, the transformation from the platform CRS to an Earth-fixed CRS may include a time element. For a dynamic coordinate reference system, locations on or near the surface of the Earth will move (very slowly) within the CRS due to crustal motion or deformation and then the CRS's reference frame definition may include time evolution and/or the CRS may have an associated crustal deformation model.

9.1.2 Principal subtypes of coordinate reference system

The classification criteria for the subtyping of coordinate reference system is firstly by type of datum associated with the coordinate reference system, and, in some cases, secondly by type of coordinate system. The following principal subtypes of coordinate reference system are distinguished:

- a) **Geodetic** – a two- or three-dimensional coordinate reference system used to describe spatial location over the whole Earth or substantial parts of it.

It has one subtype, **geographic**, when its coordinate system type is ellipsoidal.

- b) **Engineering** – a coordinate reference system used locally for which three broad categories are recognised:

- 1) coordinate reference systems used to describe spatial location over small areas of the Earth using a flat-Earth approximation of the Earth's surface: corrections for Earth-curvature are not applied. Typical applications are for civil engineering construction and building information management.

NOTE 1 These applications are not restricted to using engineering CRSs: they often utilise projected and sometimes geodetic CRSs.

- 2) coordinate reference systems used to describe spatial location on moving objects such as road vehicles, vessels, aircraft or spacecraft.

- 3) coordinate reference systems used to describe spatial location internally on an image.

NOTE 2 The CRS internal to the image is not geo-referenced. The image can be georeferenced by relating the engineering CRS to a geodetic or projected CRS through a coordinate transformation. In this document engineering coordinate reference systems for images have continuous axes. Grids based on these CRSs are described in ISO 19123^[6].

- c) **Vertical** – a one-dimensional coordinate reference system making use of the direction of gravity to define height or depth.
- d) **Parametric** – a one-dimensional coordinate reference system that uses a parameter or function as a coordinate.

EXAMPLE Pressure used as a vertical coordinate.

- e) **Temporal** – a one-dimensional coordinate reference system that describes time.

These principal subtypes of spatial coordinate reference system are described further in C.2.1.

9.2 Derived coordinate reference system

9.2.1 General

A derived coordinate reference system is defined by applying a coordinate conversion to another pre-existing coordinate reference system which is referred to as the base CRS. The derived CRS inherits its datum (reference frame) or datum ensemble (Clause 11) from its base CRS. Consequently most derived CRSs are of the same CRS type as their base CRS. Most derived CRSs have a coordinate system which must be of the same CS type as is allowed for principal CRSs of that CRS type.

EXAMPLE 1 A derived geographic CRS will have an ellipsoidal CS because a geographic CRS must have an ellipsoidal CS.

EXAMPLE 2 A derived parametric CRS will have a parametric CS because a parametric CRS must have a parametric CS.

NOTE An exception is a CRS derived from a projected CRS - see 9.2.2.

Further information on derived coordinate reference systems is given in C.2.2.2.

9.2.2 Projected coordinate reference system

A projected CRS is a coordinate reference system which is derived from a base geographic CRS by applying the coordinate conversion known as a map projection to latitude and longitude ellipsoidal coordinate values. Projected CRSs are modelled as a special case of derived CRS because of their importance in geographic information. A projected CRS is constrained to have a Cartesian coordinate system. In the 3D case the ellipsoidal height from the base CRS is retained to form a three-dimensional Cartesian coordinate system.

A projected CRS may act as the base CRS for a derived projected CRS. A derived projected CRS is not constrained to have a Cartesian coordinate system: it may have one of several other types of coordinate system.

NOTE The term 'derived projected CRS' is used for consistency in the 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 inherits the projection distortions of its base projected CRS.

9.3 Compound coordinate reference system

9.3.1 General

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

EXAMPLE 1 A projected CRS having easting and northing coordinates with a vertical CRS having a gravity-related height as a coordinate.

EXAMPLE 2 A geographic CRS having latitude and longitude coordinates with a parametric CRS having pressure as a coordinate.

Nesting of compound coordinate reference systems is not permitted; the individual single systems are aggregated together. Further information on compound coordinate reference system is given in C.2.2.3.

9.3.2 Spatial compound coordinate reference system

For spatial coordinates, a number of constraints exist for the construction of compound CRSs. Coordinate reference systems that are combined are required to not contain any duplicate or redundant axes. Valid combinations shall be the following.

- a) Geographic 2D + Vertical.
- b) Geographic 2D + Engineering 1D (near vertical).
- c) Projected 2D + Vertical.
- d) Projected 2D + Engineering 1D (near vertical).
- e) Engineering (horizontal 2D) + Vertical.
- f) Engineering (1D linear) + Vertical.

9.3.3 Spatio-temporal compound coordinate reference system

Any single spatial coordinate reference system, or any of the combinations of spatial compound coordinate reference systems listed in 9.3.2, may be associated with a temporal coordinate reference system to form a spatio-temporal compound coordinate reference system. More than one temporal coordinate reference system may be included if these axes represent different time quantities: examples are given in E.4.4 and E.4.5.

9.3.4 Spatio-parametric compound coordinate reference system

A spatio-parametric coordinate reference system is a compound CRS in which one component is a geographic 2D, projected 2D or engineering 2D CRS, supplemented by a parametric CRS to create a three-dimensional CRS: an example is included in E.3.3. More than one parametric coordinate reference system may be included if these represent independent parametric quantities.

9.3.5 Spatio-parametric-temporal compound coordinate reference system

Any of the above-listed combinations of spatial, parametric and temporal CRSs may be associated to form a spatio-parametric-temporal compound coordinate reference system.

9.4 UML schema for the Coordinate Reference Systems package

Figure 9 shows the UML class diagram of the Coordinate Reference Systems package. Subtypes of derived CRS are detailed in Figure 10. The definition of the object classes of the package are provided in Tables 8 to 25.

The CRS package UML class diagram shows an association named `CoordinateSystem` from the `SingleCRS` class to the `CoordinateSystem` class. This association is included to indicate that all of the subclasses of `SingleCRS` have a direct association to `CoordinateSystem` or one of its subclasses, as later detailed in Clause 10. Constraints on associations between CRSs and coordinate systems are detailed in Clause 10.

The CRS UML class diagram also shows an association named `DefiningDatum` from the `SingleCRS` class to the `Datum` class. This association indicates that many, but not all, of the subclasses of `SingleCRS` have a direct association to `Datum` or to one of its subclasses. A single CRS may alternatively be associated with a *datum ensemble* rather than with a datum. Constraints on associations between CRSs and datums or datum ensembles are detailed in Clause 11. Derived CRSs do not use this association to datum or datum ensemble: instead a Derived CRSs inherits its datum or datum ensemble from the base CRS from which it has been derived.

The CRS UML diagram additionally shows an association named `Definition` from the `DerivedCRS` class to the `Conversion` class. This will usually be implemented as a coordinate conversion embedded within the derived CRS definition. A coordinate conversion is a type of coordinate operation. The UML model for coordinate operations is detailed in Clause 12.

Further information on the modelling of CRSs is given in C.2.