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Ersatz für
DIN EN ISO 19111:2005-05**Geoinformation –
Koordinatenreferenzsysteme (ISO 19111:2007);
Englische Fassung EN ISO 19111:2007**

Geographic information –
Spatial referencing by coordinates (ISO 19111:2007);
English version EN ISO 19111:2007

Information géographique –
Système de références spatiales par coordonnées (ISO 19111:2007);
Version anglaise EN ISO 19111:2007

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Nationales Vorwort

Der Text von ISO 19111:2007 wurde vom Technischen Komitee ISO/TC 211 „Geographic information/Geomatics“ erarbeitet und als EN ISO 19111:2007 vom Technischen Komitee CEN/TC 287 „Geoinformation“ übernommen, dessen Sekretariat vom NEN (Niederlande) gehalten wird.

Der Text von ISO 19111:2007 wurde von CEN als EN ISO 19111:2007 ohne Änderungen angenommen.

Der für die deutsche Mitarbeit zuständige Arbeitsausschuss im DIN Deutsches Institut für Normung e. V. ist der als Spiegelausschuss zum CEN/TC 287 und ISO/TC 211 eingesetzte Arbeitsausschuss NA 005-03-03 AA „Kartographie und Geoinformation“ des Normenausschusses Bauwesen (NABau).

Das Präsidium des DIN hat mit seinem Beschluss 1/2004 festgelegt, dass von dem in den Regeln der europäischen Normungsarbeit von CEN/CENELEC verankerten Grundsatz, wonach Europäische Normen in den drei offiziellen Sprachen Deutsch, Englisch und Französisch veröffentlicht werden, in begründeten Ausnahmefällen abgewichen und auf die deutsche Sprachfassung verzichtet werden kann.

Die Genehmigung dafür hat die DIN-Geschäftsleitung entsprechend ihren in Anlage 1 zu dem DIN-Rundschreiben A 5/2004 festgelegten Kriterien für die vorliegende Norm auf Antrag des NABau-FB 03 „Vermessungswesen; Geoinformation“ erteilt.

Allgemeines

Die Position auf oder in der Nähe der Erdoberfläche kann

- durch die Angabe von Koordinaten oder
- durch (geographische) Identifikatoren

bestimmt werden.

In dieser Norm wird die Georeferenzierung durch Koordinaten eines Koordinatenreferenzsystems einschließlich deren Transformationen in andere Systeme beschrieben.

Zentraler Begriff der Georeferenzierung ist dabei der des Koordinatenreferenzsystems (En: coordinate reference system - Abkürzung: CRS), in der Geodäsie auch als Bezugs- oder Referenzsystem bezeichnet. Ein Koordinatenreferenzsystem ist ein spezielles Koordinatensystem, das durch ein so genanntes Datum in Relation zur Erde gesetzt wird. Es werden geodätische, vertikale oder lokale Koordinatenreferenzsysteme definiert, die entsprechende Datume sowie kartesische, ellipsoidische, polare, lineare und andere Koordinatensysteme benutzen. Beim Übergang zwischen verschiedenen Koordinatenreferenzsystemen wird zwischen Datumstransformation (Übergang von einem Datum zu einem anderen) sowie Koordinatenumformung (unter Beibehaltung des Datums) unterschieden.

Änderungen

Gegenüber DIN EN ISO 19111:2005-05 wurden folgende Änderungen vorgenommen:

- a) Erweiterung und Präzisierung der „Einleitung“ (en: Introduction) und des Abschnittes 1 „Anwendungsbereich“ (en: Scope);
- b) weitere Begriffe in Abschnitt 3 aufgenommen;
- c) fachliche Überarbeitung der Abschnitte und Anhänge sowie Aufnahme weiterer Abschnitte;
- d) „Literaturhinweise“ (en: Bibliography) aufgenommen;
- e) insgesamt: neue Strukturierung des Dokumentes.

Frühere Ausgaben

DIN EN ISO 19111: 2005-05

Nationaler Anhang NA (informativ)

Englisch-deutsche Fachwörterliste

affine coordinate system	Affines (geradliniges) Koordinatensystem
cartesian coordinate system	Kartesisches Koordinatensystem
compound coordinate reference system	Aus mehreren Komponenten zusammengesetztes Koordinatenreferenzsystem
concatenated operation	Zusammengesetzte Operation
coordinate	Koordinate
coordinate conversion/ coordinate operation/coordinate transformation	Koordinatenumwandlung
ANMERKUNG Die Verwendung dieser drei englischen Benennungen ist wie folgt: — coordinate conversion - Koordinatenumwandlung Umrechnung von Koordinaten, die auf dem gleichen Datum basieren (Koordinatenumformung); — coordinate transformation - Koordinatentransformation Umrechnung von Koordinaten, deren Koordinatenreferenzsysteme auf unterschiedlichen Datumen basieren (Datumstransformation); — coordinate operation - Koordinatenoperation Oberbegriff von Koordinatenkonversion und Koordinatentransformation.	
coordinate reference system	Koordinatenreferenzsystem
coordinate set	Satz (Menge) von Koordinaten
coordinate system	Koordinatensystem
coordinate tuple	Koordinatentupel
cylindric coordinate system	Zylindrisches Koordinatensystem
datum	Datum (Plural: Datume)
depth	Tiefe
easting E	Easting E (Rechtswert)
ellipsoid	Ellipsoid
ellipsoidal coordinate system	Ellipsoidisches Koordinatensystem
ellipsoidal height (geodetic height) h	Ellipsoidische Höhe h
engineering coordinate reference system	Lokales Koordinatenreferenzsystem
engineering datum; local datum	Lokales Datum
flattening f	Abflachung f
geodetic coordinate system	Geodätisches Koordinatensystem
geodetic datum	Geodätisches Datum

geodetic latitude (ellipsoidal latitude)	Geodätische Breite
geodetic longitude	Geodätische Länge
geoid	Geoid
gravity-related height H	Gravitationsabhängige Höhe H
height h (ellipsoidal) or H (gravity-related)	Höhe h (ellipsoidisch) oder H (gravitationsabhängig)
image coordinate reference system	Bildkoordinatenreferenzsystem
image datum	Bilddatum
linear coordinate system	Lineares Koordinatensystem
map projection	Kartenprojektion
mean sea level	Mittlere Meereshöhe
meridian	Meridian (Längengrad)
northing N	Northing N (Hochwert)
polar coordinate system	Polares Koordinatensystem
prime meridian (zero meridian)	Nullmeridian
projected coordinate reference system	Projiziertes Koordinatenreferenzsystem
semi-major axis a	Große Halbachse a
semi-minor axis b	Kleine Halbachse b
sequence	Folge
spatial reference	Räumlicher Bezug
spherical coordinate system	Sphärisches Koordinatensystem
unit	Maßeinheit
vertical coordinate reference system	Vertikales Koordinatenreferenzsystem
vertical coordinate system	Vertikales Koordinatensystem
vertical datum	Vertikales Datum (Höhendatum)

English Version

Geographic information -
Spatial referencing by coordinates (ISO 19111:2007)

Information géographique -
Système de références spatiales par coordonnées
(ISO 19111:2007)

Geoinformation -
Koordinatenreferenzsysteme
(ISO 19111:2007)

This European Standard was approved by CEN on 30 June 2007.

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Foreword

This document (EN ISO 19111:2007) has been prepared by Technical Committee ISO/TC 211 „Geographic information/Geomatics“ in collaboration with Technical Committee CEN/TC 287 „Geographic Information“, the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2008, and conflicting national standards shall be withdrawn at the latest by January 2008.

This document supersedes EN ISO 19111:2005.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Endorsement notice

The text of ISO 19111:2007 has been approved by CEN as EN ISO 19111:2007 without any modifications.

Introduction

Geographic information contains spatial references which relate the features represented in the 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 [4]. This International Standard describes the data elements, relationships and associated metadata required for spatial referencing by coordinates. It describes the elements that are necessary to fully define various types of coordinate systems and coordinate reference systems applicable to geographic information. The subset of elements required is partially dependent upon the type of coordinates. This International Standard also includes optional fields to allow for the inclusion of non-essential coordinate reference system information. The elements are intended to be both machine and human readable.

The traditional separation of horizontal and vertical position has resulted in coordinate reference systems that are horizontal (2D) and vertical (1D) in nature, as opposed to truly three-dimensional. It is established practice to define a three-dimensional position by combining the horizontal coordinates of a point with a height or depth from a different coordinate reference system. In this International Standard, this concept is defined as a compound coordinate reference system.

The concept of coordinates can be expanded from a strictly spatial context to include time. ISO 19108 describes temporal schema. Time can be added as a temporal coordinate reference system within a compound coordinate reference system. It is even possible to add two time-coordinates, provided the two coordinates describe different independent quantities.

EXAMPLE An example is the time/space position of a subsurface point of which the vertical coordinate is expressed as the two-way travel time of a sound signal in milliseconds, as is common in seismic imaging. A second time-coordinate indicates the time of observation, usually expressed in whole years.

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 elevation 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 are beyond the scope of this International Standard. However, the modelling constructs described within this International Standard can be applied through a profile specific to a community.

In addition to describing a coordinate reference system, this International Standard provides for the description of a coordinate transformation or a coordinate conversion between two different coordinate reference systems. With such information, spatial data referred to different coordinate reference systems can be related to one specified coordinate reference system. This facilitates spatial data integration. Alternatively, an audit trail of coordinate reference system manipulations can be maintained.

1 Scope

This International Standard defines the conceptual schema for the description of spatial referencing by coordinates, optionally extended to spatio-temporal referencing. It describes the minimum data required to define one-, two- and three-dimensional spatial coordinate reference systems with an extension to merged spatial-temporal reference systems. It allows additional descriptive information to be provided. It also describes the information required to change coordinates from one coordinate reference system to another.

In this International Standard, a coordinate reference system does not change with time. For coordinate reference systems defined on moving platforms such as cars, ships, aircraft and spacecraft, the transformation to an Earth-fixed coordinate reference system can include a time element.

This International Standard is applicable to producers and users of geographic information. Although it is applicable to digital geographic data, its principles can be extended to many other forms of geographic data such as maps, charts and text documents.

The schema described can be applied to the combination of horizontal position with a third non-spatial parameter which varies monotonically with height or depth. This extension to non-spatial data is beyond the scope of this International Standard but can be implemented through profiles.

2 Conformance requirements

This International Standard defines two classes of conformance, Class A for conformance of coordinate reference systems and Class B for coordinate operations between two coordinate reference systems. Any coordinate reference system claiming conformance to this International Standard shall satisfy the requirements given in A.1. Any coordinate operation claiming conformance to this International Standard shall satisfy the requirements given in A.2.

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/TS 19103, *Geographic information — Conceptual schema language*

ISO 19108, *Geographic information — Temporal schema*

ISO 19115, *Geographic information — Metadata*

Normative reference to ISO 19115 is restricted as follows. In this International Standard, normative reference to ISO 19115 excludes the MD_CRS class and its component classes. ISO 19115 class MD_CRS and its component classes specify descriptions of coordinate reference systems elements. These elements are modelled in this International Standard.

NOTE The MD_CRS class and its component classes were deleted from ISO 19115:2003 through Technical Corrigendum 1:2006.

4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

4.1

affine coordinate system

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

4.2

Cartesian coordinate system

coordinate system which gives the position of points relative to n mutually perpendicular axes

NOTE n is 2 or 3 for the purposes of this International Standard.

4.3

compound coordinate reference system

coordinate reference system using at least two independent **coordinate reference systems**

NOTE Coordinate reference systems are independent of each other if coordinate values in one cannot be converted or transformed into coordinate values in the other.

4.4

concatenated operation

coordinate operation consisting of sequential application of multiple **coordinate operations**

4.5

coordinate

one of a **sequence** of n numbers designating the position of a point in n -dimensional space

NOTE In a coordinate reference system, the coordinate numbers are qualified by units.

4.6

coordinate conversion

coordinate operation in which both **coordinate reference systems** are based on the same **datum**

EXAMPLE Conversion from an ellipsoidal coordinate reference system based on the WGS 84 datum to a Cartesian coordinate reference system also based on the WGS 84 datum, or change of units such as from radians to degrees or feet to meters.

NOTE A coordinate conversion uses parameters which have specified values that are not determined empirically.

4.7

coordinate operation

change of **coordinates**, based on a one-to-one relationship, from one **coordinate reference system** to another

NOTE Supertype of coordinate transformation and coordinate conversion.

4.8

coordinate reference system

coordinate system that is related to an object by a **datum**

NOTE For geodetic and vertical datums, the object will be the Earth.

4.9

coordinate set

collection of **coordinate tuples** related to the same **coordinate reference system**

4.10**coordinate system**

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

4.11**coordinate transformation**

coordinate operation in which the two **coordinate reference systems** are based on different **datums**

NOTE A coordinate transformation uses parameters which are derived empirically by a set of points with known coordinates in both coordinate reference systems.

4.12**coordinate tuple**

tuple composed of a **sequence** of **coordinates**

NOTE 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.

4.13**cylindrical coordinate system**

three-dimensional **coordinate system** with two distance and one angular **coordinates**

4.14**datum**

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

4.15**depth**

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

NOTE A depth above the reference surface will have a negative value.

4.16**easting**

E

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

4.17**ellipsoid**

surface formed by the rotation of an ellipse about a main axis

NOTE In this International Standard, ellipsoids are always oblate, meaning that the axis of rotation is always the minor axis.

4.18**ellipsoidal coordinate system**

geodetic coordinate system

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

4.19**ellipsoidal height**

geodetic height

h

distance of a point from the **ellipsoid** measured along the perpendicular from the **ellipsoid** to this point, positive if upwards or outside of the **ellipsoid**

NOTE Only used as part of a three-dimensional ellipsoidal coordinate system and never on its own.

4.20

engineering coordinate reference system

coordinate reference system based on an engineering datum

EXAMPLES Local engineering and architectural grids; coordinate reference system local to a ship or an orbiting spacecraft.

4.21

engineering datum

local datum

datum describing the relationship of a **coordinate system** to a local reference

NOTE Engineering datum excludes both geodetic and vertical datums.

EXAMPLE A system for identifying relative positions within a few kilometres of the reference point.

4.22

flattening

f

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

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

4.23

geodetic coordinate reference system

coordinate reference system based on a geodetic datum

4.24

geodetic datum

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

4.25

geodetic latitude

ellipsoidal latitude

φ

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

4.26

geodetic longitude

ellipsoidal longitude

λ

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

4.27

geoid

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

4.28

gravity-related height

H

height dependent on the Earth's gravity field

NOTE This refers to in particular orthometric height or normal height, which are both approximations of the distance of a point above the mean sea level.

4.29 height

h, H

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

NOTE A height below the reference surface will have a negative value.

4.30 image coordinate reference system coordinate reference system based on an image datum

4.31 image datum engineering datum which defines the relationship of a **coordinate system** to an image

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

EXAMPLES Distances along a pipeline; depths down a deviated oil well bore.

4.33 map projection coordinate conversion from an **ellipsoidal coordinate system** to a plane

4.34 mean sea level average level of the surface of the sea over all stages of tide and seasonal variations

NOTE 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. Mean sea level in a global context differs from a global **geoid** by not more than 2 m.

4.35 meridian intersection of an **ellipsoid** by a plane containing the shortest axis of the **ellipsoid**

NOTE This term is often used for the pole-to-pole arc rather than the complete closed figure.

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

4.37 polar coordinate system two-dimensional **coordinate system** in which position is specified by distance and direction from the origin

NOTE For the three-dimensional case, see **spherical coordinate system** (4.44).

4.38 prime meridian zero meridian **meridian** from which the longitudes of other **meridians** are quantified

4.39

projected coordinate reference system

coordinate reference system derived from a two-dimensional **geodetic coordinate reference system** by applying a **map projection**

4.40

semi-major axis

a

semi-diameter of the longest axis of an **ellipsoid**

NOTE This equates to the semi-diameter of the ellipsoid measured in its equatorial plane.

4.41

semi-minor axis

b

semi-diameter of the shortest axis of an **ellipsoid**

NOTE The shortest axis coincides with the rotation axis of the ellipsoid and therefore contains both poles.

4.42

sequence

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

[ISO 19107]

4.43

spatial reference

description of position in the real world

NOTE This may take the form of a label, code or coordinate tuple.

4.44

spherical coordinate system

three-dimensional **coordinate system** with one distance measured from the origin and two angular **coordinates**, commonly associated with a **geodetic coordinate reference system**

NOTE Not to be confused with an ellipsoidal coordinate system based on an ellipsoid 'degenerated' into a sphere.

4.45

tuple

ordered list of values

[ISO 19136]

4.46

unit

defined quantity in which dimensioned parameters are expressed

NOTE In this International Standard, the subtypes of units are length units, angular units, time units, scale units and pixel spacing units.

4.47

vertical coordinate reference system

one-dimensional **coordinate reference system** based on a **vertical datum**

4.48

vertical coordinate system

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

4.49**vertical datum**

datum describing the relation of **gravity-related heights** or **depths** to the Earth

NOTE In most cases, the vertical datum will be related to mean sea level. Ellipsoidal heights are treated as related to a three-dimensional ellipsoidal coordinate system referenced to a geodetic datum. Vertical datums include sounding datums (used for hydrographic purposes), in which case the heights may be negative heights or depths.

5 Conventions**5.1 Symbols**

a	semi-major axis
b	semi-minor axis
E	easting
f	flattening
H	gravity-related height
h	ellipsoidal height
N	northing
λ	geodetic longitude
φ	geodetic latitude
E, N	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 or geodetic coordinate reference system

5.2 Abbreviated terms

CC	change coordinates (package abbreviation in UML model)
CD	coordinate datum (package abbreviation in UML model)
CCRS	compound coordinate reference system
CRS	coordinate reference system
CS	coordinate system (also, package abbreviation in UML model)
IO	identified object (package abbreviation in UML model)
MSL	mean sea level

pixel	a contraction of “picture element”, the smallest element of a digital image to which attributes are assigned
RS	reference system (package abbreviation in UML model)
SC	spatial referencing by coordinates (package abbreviation in UML model)
SI	le Système International d’unités
UML	Unified Modeling Language
URI	Uniform Resource Identifier
1D	one-dimensional
2D	two-dimensional
3D	three-dimensional

5.3 UML notation

In this International Standard, the conceptual schema for describing coordinate reference systems and coordinate operations is modelled with the Unified Modelling Language (UML). The basic data types and UML diagram notations are defined in ISO/TS 19103 and ISO/IEC 19501 [9].

In this International Standard, the following stereotypes of UML classes are used:

- a) `<<DataType>>` a descriptor of a set of values that lack identity (independent existence and the possibility of side effects); a `DataType` is a class with no operations whose primary purpose is to hold the information;
- b) `<<Type>>` a class used for specification of a domain of objects together with operations applicable to the objects;
- c) `<<CodeList>>` a flexible enumeration that uses string values for expressing a list of potential values;
- d) `<<Union>>` contains a list of attributes where only one of those attributes can be present at any time.

The following data types defined in ISO/TS 19103 are used:

- Angle amount of rotation required to bring one line or plane into coincidence with another;
- Boolean a value specifying TRUE or FALSE;
- `CharacterString` a sequence of characters;
- Date a character string which comprises year, month and day in the format as specified by ISO 8601;
- `GenericName` a generic name structure in the context of namespaces, defined in ISO/TS 19103;
- Integer an integer number;
- Length the measure of distance;

- Measure result from performing the act or process of ascertaining the extent, dimensions or quantity of some entity;
- Number abstract class that can be subtyped to a specific number type (real, integer, decimal, double, float);
- Scale the ratio of one quantity to another;
- Unit of Measure any of the systems devised to measure some physical quantity.

In addition, a Sequence type of collection is used, which contains an ordered list of values with the specified data type. The format used is “Sequence<DataType>”.

In the UML diagrams in this International Standard, grey boxes indicate classes from other packages.

5.4 Attribute status

In this International Standard, attributes 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.

In this International Standard, the Maximum Occurrence column indicates the maximum number of occurrences of attribute values that are permissible, with N indicating no upper limit.

6 Spatial referencing by coordinates — Overview

6.1 Relationship between coordinates and coordinate reference system

In this International Standard, 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 International Standard.

A *coordinate tuple* is an ordered list of n coordinates that define the position of a single point. In this International Standard, the coordinate tuple shall be composed of one, two or three spatial coordinates. The coordinates shall be mutually independent and their number shall be equal to the dimension of the coordinate space.

EXAMPLE A coordinate tuple cannot contain two heights.

Coordinates are ambiguous until the system to which those coordinates are related has been fully defined. Without the full specification of the system, coordinates are ambiguous at best and meaningless at worst. A *coordinate reference system* (CRS) defines the coordinate space such that the coordinate values are unambiguous. In this International Standard, the order of the coordinates within the coordinate tuple and their unit(s) of measure shall be parts of the coordinate reference system definition.

In this International Standard, a *coordinate set* shall be a collection of coordinate tuples referenced to the same coordinate reference system. A CRS identification or definition in accordance with this International

Standard shall be associated with every coordinate tuple. If only one point is being described, the association shall be direct. 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. The conceptual relationship of coordinate tuple and coordinate set to coordinate reference system is shown in Figure 1.

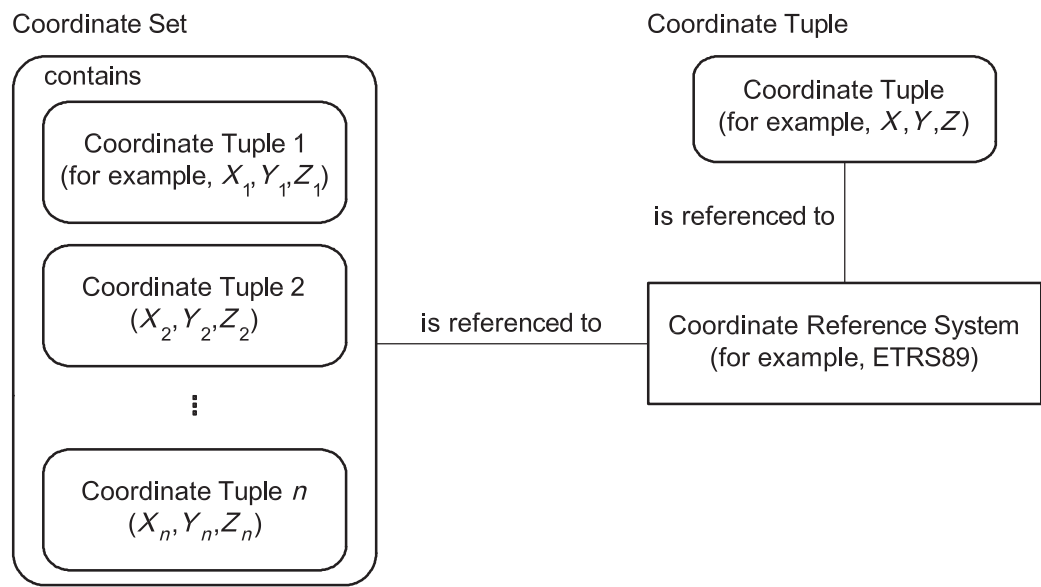


Figure 1 — Conceptual relationship of coordinates to coordinate reference system

The semantic meaning of coordinate tuple and coordinate set is reflected in the modelling of classes DirectPosition and GM_Object respectively; this modelling is in ISO 19107 [3].

In this International Standard, a coordinate reference system shall be comprised of one coordinate system and one datum (see Figure 2).

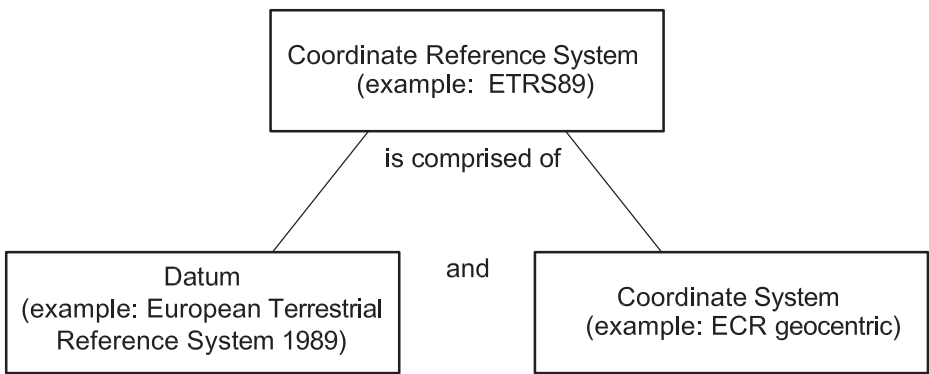
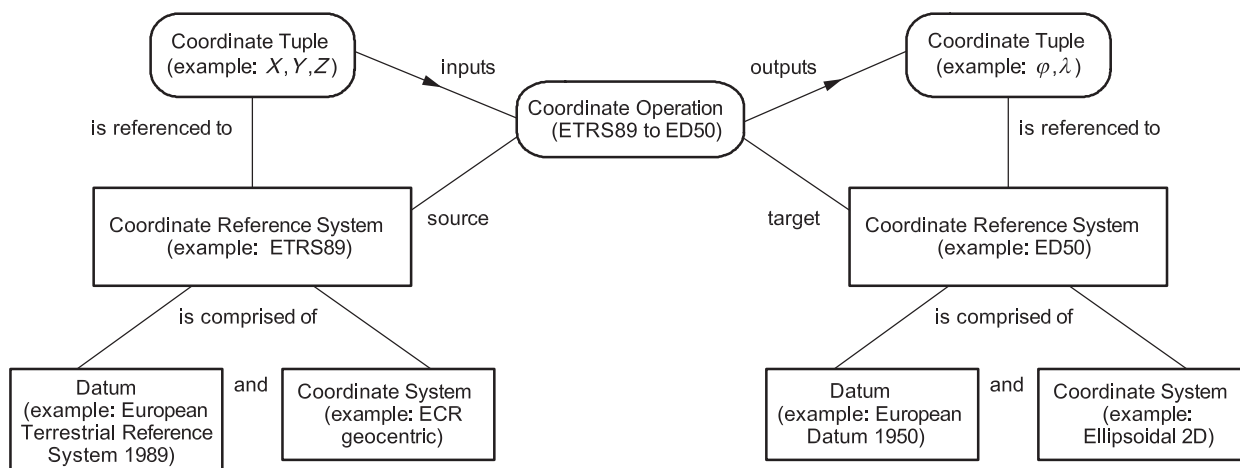


Figure 2 — Conceptual model of a coordinate reference system

The high level abstract model for spatial referencing by coordinates is shown in Figure 3. A coordinate transformation or coordinate conversion operates on coordinates, not on coordinate reference systems. Coordinate operation has been modelled in ISO 19107 [3] by the operation “Transform” of the GM_Object class.



NOTE A coordinate operation may be single or concatenated. Refer to Clause 11.

Figure 3 — Conceptual model for spatial referencing by coordinates

The description of quality of a spatial reference is covered by the provisions of ISO 19115.

6.2 UML model for spatial referencing by coordinates — Overview

The specification for spatial referencing by coordinates is defined in this International Standard in the form of a UML model with supplementary text. The UML model contains five primary UML packages, as shown in Figure 4. Each box represents a package, and contains the package name. Each arrowed line shows the dependency (at the head of the arrow) of one package upon another package.

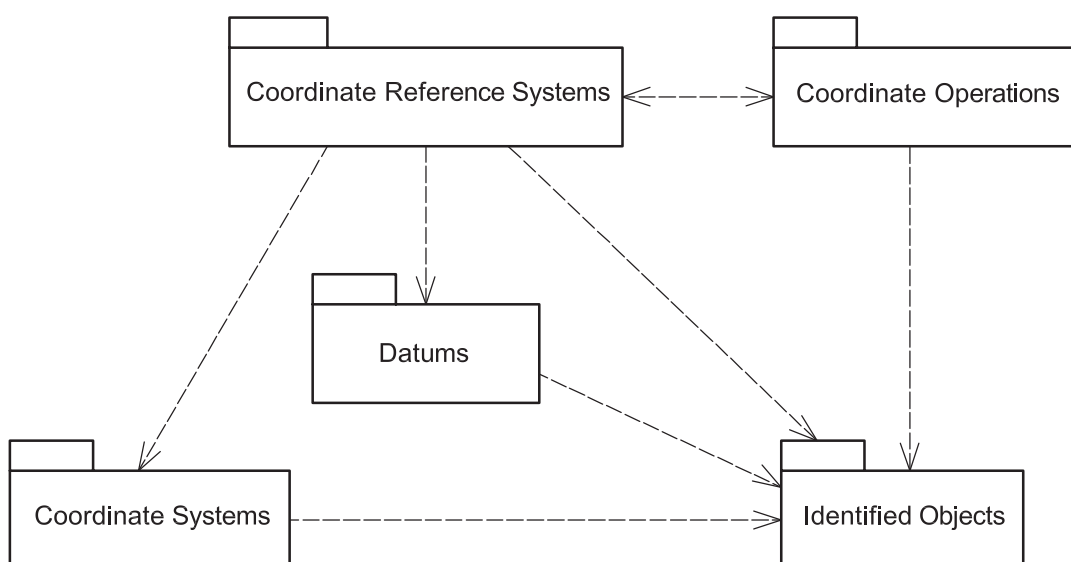


Figure 4 — UML model packages and dependencies

The five UML packages for spatial referencing by coordinates are more completely specified in the Clauses 7 through 11. Further context for the requirements of Clauses 7 through 11 is given in Annex B and some geodetic concepts underpinning spatial referencing by coordinates are given in Annex C. Examples illustrating how this International Standard can be applied when defining a coordinate reference system or a coordinate operation are given in Annex D. Recommendations for referencing to classes defined in this International Standard are given in Annex E.

7 Identified Object package

7.1 General

The Identified Object package contains attributes common to several objects used in spatial referencing by coordinates. These objects – including datum, ellipsoid, coordinate system axis and coordinate operation – inherit attribute values from the Identified Object package.

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

EXAMPLE 1 A datum name might be “North American Datum of 1983” and its abbreviation “NAD83”.

Object primary names have a data type `RS_Identifier` which is defined in ISO 19115 whilst aliases have a data type `GenericName` which is defined in ISO/TS 19103.

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

EXAMPLE 2 A register of geodetic codes and parameters might give the NAD83 datum a unique code of “6269”.

Identifiers have a data type of `RS_Identifier`.

In addition to the use of an identifier as a reference to a definition in a register of geodetic codes and parameters, it may also be included in an object definition to allow reference to the object.

Object identification shall be through

- a) a full object description as defined in this International Standard, or
- b) reference to a full object description in a register of geodetic parameters (the reference is made to the register's object identifier), or
- c) both full description and reference to a description in a register. If there is a conflict between the two, the register description shall prevail.

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

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

NOTE Implementers are warned that in any register, errors in the data may be corrected in accordance with rules specific to that register and defined by the responsible registration authority. The rules for dealing with erroneous data need to be recognized by applications referencing the register in order to be able to find the data that is required, i.e. usually the most up-to-date register information, but sometimes, because historically it was used to transform spatial data that is still in use, the erroneous information from the past.

7.2 UML schema for the Identified Object package

Figure 5 shows the UML class diagram of the `IO_IdentifiedObject` package. The definition of the object classes are provided in Tables 1 and 2.

NOTE Through its subclassing from `RS_ReferenceSystem` which is defined in ISO 19115, `SC_CRS` inherits the attribute *name*. Because of this inheritance, the `SC_CRS` class does not use `IO_IdentifiedObject` for its primary name. But like other classes described in this International Standard, it may use the alias attribute from `IO_IdentifiedObjectBase` for aliases.

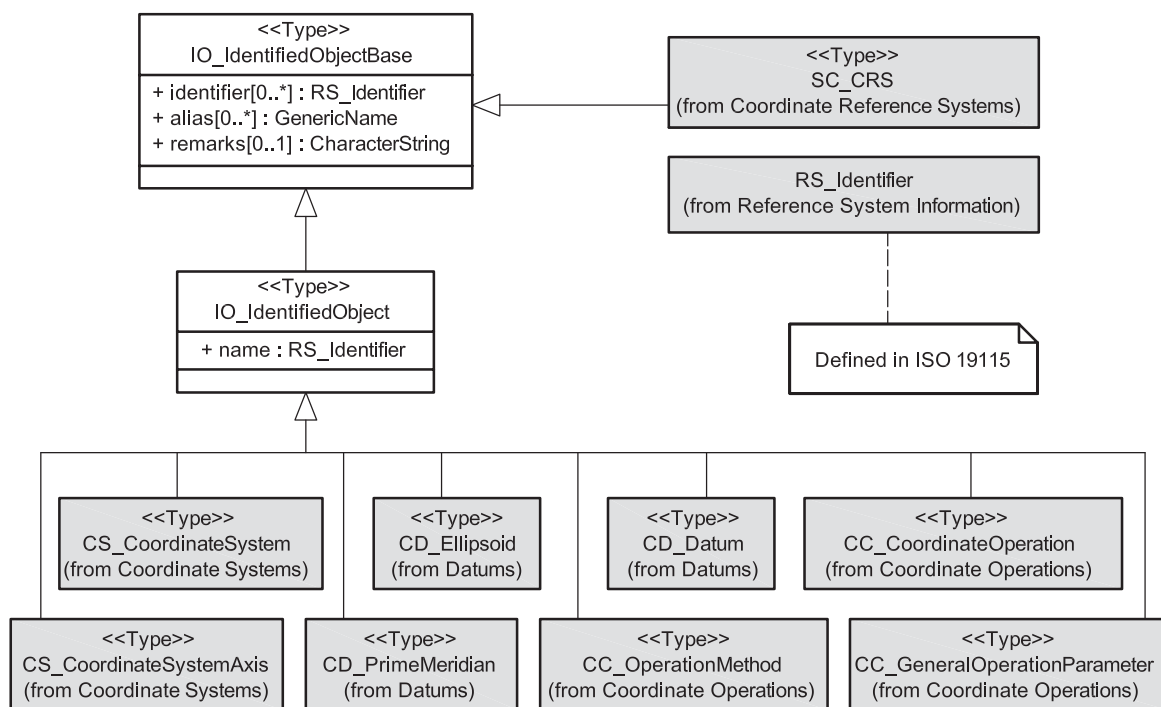


Figure 5 — IO_IdentifiedObject package

Table 1 — Defining elements of IO_IdentifiedObjectBase class

Description:	Supplementary identification and remarks information for a CRS or CRS-related object.				
Stereotype:	Type				
Class attribute:	Abstract				
Inheritance from:	(none)				
Association roles:	(none)				
Used by:	SC_CRS CS_CoordinateSystem CS_CoordinateSystemAxis CD_Datum CD_Ellipsoid CD_PrimeMeridian CC_CoordinateOperation CC_OperationMethod CC_GeneralOperationParameter				
Public attributes:					
Attribute name	UML identifier	Data type	Obligation	Maximum Occurrence	Attribute description
Object alias	alias	GenericName	O	N	An alternative name by which this object is identified.
Object identifier	identifier	RS_Identifier	O	N	An identifier which references elsewhere the object's defining information; alternatively an identifier by which this object can be referenced.
Object remarks	remarks	CharacterString	O	1	Comments on or information about this object, including data source information.

Table 2 — Defining elements of IO_IdentifiedObject class

Description:	Identifications of a CRS-related object.				
Stereotype:	Type				
Class attribute:	Abstract				
Inheritance from:	IO_IdentifiedObjectBase				
Association roles:	(none)				
Used by:	CS_CoordinateSystem CS_CoordinateSystemAxis CD_Datum CD_Ellipsoid CD_PrimeMeridian CC_CoordinateOperation CC_OperationMethod CC_GeneralOperationParameter				
Public attributes:	3 attributes (identifier, alias and remarks) inherited from IO_IdentifiedObjectBase, plus:				
Attribute name	UML identifier	Data type	Obligation	Maximum Occurrence	Attribute description
Object name	name	RS_Identifier	M	1	The primary name by which this object is identified.

8 Coordinate Reference System package

8.1 Reference system

A reference system contains the metadata required to interpret spatial location information unambiguously. Two methods to describe spatial location are distinguished.

- a) Spatial referencing by geographic identifier. Geographic identifiers are location descriptors such as addresses and grid indexes. Such systems fall outside the scope of this International Standard and the associated model. The requirements for spatial referencing by geographic identifier are described in ISO 19112 [4].
- b) Spatial referencing by coordinates. The scope of this International Standard and the associated UML model is confined to the description of position through coordinates.

The RS_ReferenceSystem package and datatypes are described in ISO 19115. Table 3 shows the attributes inherited by the CRS class.

Table 3 — Attributes of RS_ReferenceSystem class inherited from ISO 19115

Attribute name	UML identifier	Data type	Obligation	Maximum Occurrence	Attribute description
Reference system name	name	RS_Identifier	M	1	Value uniquely identifying an object within a namespace.
Reference system validity	domainOfValidity	EX_Extent	O	N	Information about horizontal, vertical and temporal extent.

8.2 Coordinate reference system

8.2.1 General

In this International Standard, a coordinate reference system shall be defined by one coordinate system and one datum. A datum 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 on or near the object's surface by means of coordinates. The object will generally, but not necessarily, be the Earth; for certain coordinate reference systems, the object may be a moving platform.

In this International Standard, a coordinate reference system shall not change with time. For coordinate reference systems defined on moving platforms such as cars, ships, aircraft and spacecraft, the transformation to an Earth-fixed coordinate reference system may include a time element. Time-variability of coordinate reference systems may be covered in the spatial referencing model described in this document by creating different coordinate reference systems, each with a different datum, for consecutive epochs. The date of realization of the datum shall then be included in its definition. Furthermore, it is recommended that the date of realization be included in the names of those datums and coordinate reference systems.

8.2.2 Principal subtypes of coordinate reference system

The classification criterion for subtyping of coordinate reference systems shall be by reference to the type of datum associated with the coordinate reference system. The following principal subtypes of coordinate reference system shall be distinguished:

- a) **Geodetic** – a coordinate reference system that is associated with a geodetic datum;
- b) **Vertical** – a coordinate reference system that is associated with a vertical datum;

- c) **Engineering** – a coordinate reference system that is associated with an engineering datum;
- d) **Image** – an Engineering CRS applied to images. The definition of the associated Image Datum contains two attributes not relevant to other engineering datums.

These principal subtypes of coordinate reference system are described further in B.1.2.

8.2.3 Additional subtypes of coordinate reference system

In addition to the principal subtypes of coordinate reference system, to permit modelling of certain relationships and constraints that exist, three more subtypes shall be distinguished. These additional subtypes are:

- a) **Derived** – a coordinate reference system which is defined by applying a coordinate conversion to another coordinate reference system (A derived CRS inherits its datum from its base CRS);
- b) **Projected** – a coordinate reference system which is derived from a base geodetic CRS by applying the coordinate conversion known as a map projection to latitude and longitude ellipsoidal coordinate values;
- c) **Compound** – a non-repeating sequence of two or more coordinate reference systems none of which can itself be compound.

These subtypes of coordinate reference system are described further in B.1.2. Compound coordinate reference systems are also further detailed below.

8.2.4 Compound coordinate reference system

8.2.4.1 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 shall not contain any duplicate or redundant axes. Valid combinations shall be the following.

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

8.2.4.2 Spatio-temporal compound coordinate reference system

Any single coordinate reference system, or any of the combinations of spatial compound coordinate reference systems listed in 8.2.4.1, 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. Temporal coordinate reference systems are described in ISO 19108.

8.2.4.3 Nesting of compound coordinate reference systems

Nesting of CCRSs shall not be permitted; the individual single systems shall be aggregated together. Figure B.1 in Annex B shows examples of the possible composition of spatial and spatio-temporal compound coordinate reference systems.

8.3 UML schema for the Coordinate Reference System package

Figure 6 shows the UML class diagram of the SC_CoordinateReferenceSystem package. The definition of the object classes of the package are provided in Tables 4 through 14.

The CRS UML class diagram shows an association named `CoordinateSystem` from the `SC_SingleCRS` class to the `CS_CoordinateSystem` class. This association is included to indicate that all of the subclasses of `SC_SingleCRS` have a direct association to `CS_CoordinateSystem` or one of its subclasses, as later detailed in Figure 8 in Clause 9. In two cases, the multiplicity of the target end of these associations is 1 (mandatory). In three cases, a subclass of `SC_SingleCRS` has an indirect association through a union class to one of several alternative subclasses of the `CS_CoordinateSystem` class.

The CRS UML class diagram also shows an association named `DefiningDatum` from `SC_SingleCRS` to the `CD_Datum` class. This association indicates that many, but not all, of the subclasses of `SC_SingleCRS` have a direct association to `CD_Datum` or to one of its subclasses, as later shown in Figure 10 in Clause 10. For the subclasses of `SC_SingleCRS` that have a direct association to `CD_Datum` or one of its subclasses, the multiplicity of the target end of the association is 1 (mandatory). For the subclasses of `SC_SingleCRS` that do not have a direct association to `CD_Datum` or one of its subclasses, the multiplicity of the target end of the association is 0 (no association).

`SC_ProjectedCRS` is modelled separately from `SC_DerivedCRS` to permit description of its specific association characteristics.

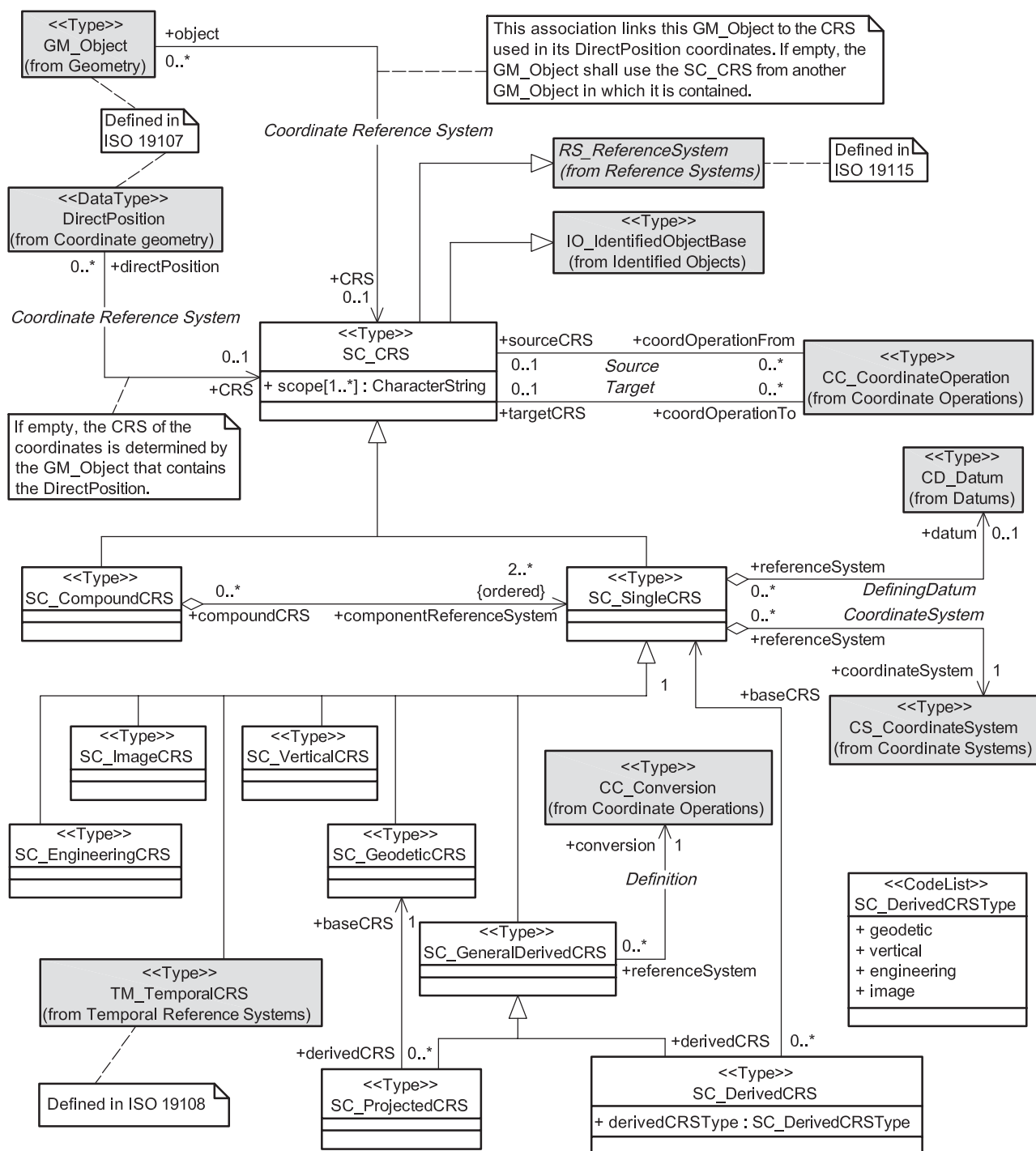


Figure 6 — SC_CoordinateReferenceSystem package