TECHNICAL SPECIFICATION

ISO/TS 19127

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Geographic information — Geodetic codes and parameters

Information géographique — Codes et paramètres géodésiques

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

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Contents

Page

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

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.

ISO/TS 19127 was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

Introduction

ISO 19135 specifies procedures for the registration of items of geographic information. ISO/IEC JTC 1 defines registration as the assignment of an unambiguous name to an object in a way that makes the object available to interested parties.

ISO 19111 describes elements necessary to define fully coordinate reference systems and coordinate systems so that coordinates for positions on or near the Earth's surface can be unambiguously referenced. ISO 19111 also describes elements to define coordinate operations that change coordinate values from one coordinate reference system to coordinate values based on another coordinate reference system.

Currently, many lists of geodetic codes and parameters exist in national standards, standards of liaison organizations, and industrial specifications and software products. Little guidance is provided on applicability and appropriate use of these geodetic codes and parameters. Applicability and appropriate use are of great concern, as geographic information systems become more widely available to non-experts in cartography and geodesy.

This Technical Specification describes how the procedures specified in ISO 19135 are to be applied to registers of elements applicable to spatial referencing by coordinates in compliance with ISO 19111. Some elements that are optional in ISO 19111 become mandatory in this Technical Specification to provide guidance on applicability and appropriate use.

Geographic information — Geodetic codes and parameters

1 Scope

This Technical Specification defines rules for the population and maintenance of registers of geodetic codes and parameters and identifies the data elements, in compliance with ISO 19111 and ISO 19135, required within these registers. Recommendations for the use of the registers, the legal aspects, the applicability to historic data, the completeness of the registers, and a mechanism for maintenance are specified by the registers themselves.

2 Conformance

To conform to this Technical Specification, a register of items of geographic information shall satisfy all of the conditions specified in the Abstract test suite (Annex A).

3 Normative references

The following referenced documents are indispensable for the application 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 19111:2003, *Geographic information — Spatial referencing by coordinates*

ISO 19112, *Geographic information — Spatial referencing by geographic identifiers*

ISO 19135:—[1)], *Geographic information — Procedures for item registration*

4 Terms and definitions

For the purposes of this document, the terms, definitions, symbols, notations and abbreviated terms given in ISO 19111 and ISO 19135 apply.

5 Registers of geodetic codes and parameters

The ISO geodetic registry network is defined as:

a) The ISO register of geodetic registers. This principal register holds a set of items that describe the subregisters described in b) and c);

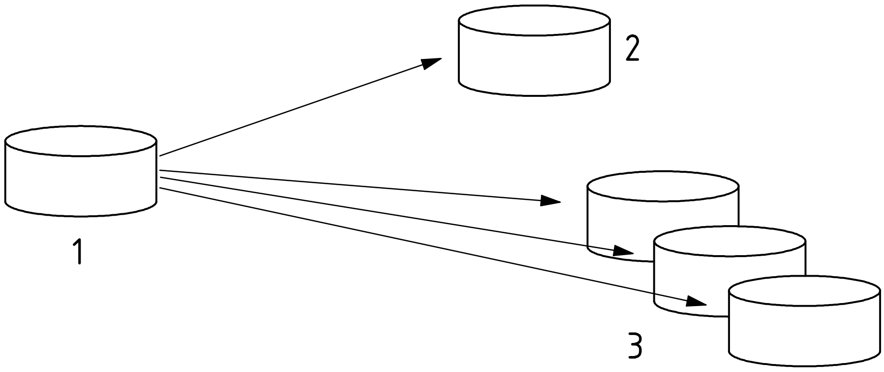
b) The ISO register of geodetic codes and parameters. This subregister shall contain coordinate reference system data and coordinate transformation data that conform to ISO 19111 and are international in

1) To be published.

geographic extent of application, widely used, and well defined. See Tables B.1, B.2 and B.3 for requirements for entries in the ISO register;

c) External subregisters of geodetic codes and parameters. These subregisters shall contain coordinate reference system data and coordinate transformation data that conform to ISO 19111. See Tables B.1, B.2 and B.3 for requirements for entries in the external subregisters of geodetic codes and parameters.

Figure 1 illustrates the ISO geodetic registry network.



Key

1 ISO register of geodetic registers

2 ISO register of geodetic codes and parameters

3 1..n ISO-approved external registers conforming to ISO 19111 and ISO 19135

Figure 1 — The ISO geodetic registry network

6 Management of a register of geodetic codes and parameters

Rules for managing a register of geographical information items, including the submission of information, are found in ISO 19135.

There are additional rules for managing registers of geodetic codes and parameters. The minimum level of information that the register manager shall accept from a submitting organization is complete data for a coordinate reference system or coordinate transformation that conforms to requirements as specified in Clause 7 of this Technical Specification. The register manager shall also accept data for compound coordinate reference systems, single coordinate operations, and concatenated coordinate operations that conform to requirements of ISO 19111 and Clause 7 of this Technical Specification.

Higher-level records for coordinate reference system and coordinate transformation data are dependent on records for entities such as datums, coordinate systems, and coordinate operation parameters. The register manager shall assign individual registration identifiers for records for entities such as datums, coordinate systems, and coordinate operation parameters so that multiple higher-level records can point to them. When a record for an entity such as a datum, coordinate system, or coordinate operation parameter is modified, dependent records also shall be modified, according to rules in ISO 19135.

To promote interoperability among subregisters within the ISO geodetic registry network, register managers are encouraged to adopt the “best practices” in Annex C.

7 Content of a register of geodetic codes and parameters

Data included in a register of geodetic codes and parameters shall conform, at a minimum, to requirements of ISO 19111.

Additional rules for content of a register of geodetic codes and parameters are as follows:

a) Information on scope of coordinate reference system and coordinate operation and their elements in accordance with ISO 19111 is mandatory for acceptance in the register. Some coordinate reference systems have a legal status in their valid area; this status shall be included in the scope.

b) Information on valid area is mandatory for acceptance in the register.

c) If the submitting organization uses geographic identifiers (as documented in ISO 19112) to describe valid area, it shall provide a citation to the source.

d) The geographic area where use of the coordinate reference system is accepted shall be logically consistent with the geographic area where use of the datum is accepted and, if applicable, the geographic area where use of the map projection is accepted.

e) Description of valid area for a coordinate operation shall be logically consistent with the valid areas for the source coordinate reference system and the target coordinate reference system.

f) Information on datum type is mandatory for registration validation purposes.

Requirements for content of a subregister within the ISO geodetic registry network, as required by ISO 19111 and as specified in this clause, are documented in Tables B.1, B.2 and B.3. A mechanism for maintenance is discussed in ISO 19135.

Annex A
(normative)

Abstract test suite

A.1 Management procedures

a) Test Purpose: Verify that the register is managed according to the rules specified in this Technical Specification.

b) Test Method: Check the procedures described in the information distributed by the registration manager.

c) Reference: Clause 6 and ISO 19135, Clause 6.

d) Test Type: Capability.

A.2 Register content

a) Test Purpose: Verify that the register contains the minimum specified content.

b) Test Method: Inspect entries in the register to ensure that they include all elements of information required by ISO 19135 and this Technical Specification.

c) Reference: Clause 7 and ISO 19135, Clause 8.

d) Test Type: Capability.

A.3 Publication of register contents

a) Test Purpose: Verify that the contents of the register are publicly available.

b) Test Method: Check the information distributed by the registration manager. Visit the web site and inspect the information made available.

c) Reference: ISO 19135, 6.4.

d) Test Type: Capability.

Annex B
(normative)

Register of geodetic codes and parameters

This annex contains Tables B.1, B.2 and B.3, which specify information for elements to be included in a subregister within the ISO geodetic registry network. Many of these elements are taken from ISO 19111 and ISO 19135, but this annex contains additional elements and guidance for completing those elements beyond those provided in ISO 19111.

Table B.1 — Requirements for describing an entry for a coordinate reference system

	E N	φ λ h φ λ r Ω Θ r Ω	**X Y Z**	**i j k i j k r Ω Θ r Θ H**	
Datum type:	**Geodetic**	**Geodetic**	**Geodetic**	**Engineering or vertical**	
Coordinate system type:	**Projected**	**Geodetic or spherical polar**	**Cartesian**	**Cartesian or spherical polar or gravity-related height**	
Element name					**Comments**
Coordinate reference system identifier	M[a]	M	M	M	See ISO 19111 for requirements to describe a source citation. Information for source citation as part of the element identifier is mandatory for acceptance into the register.
Coordinate reference system alias	O	O	O	O	
Coordinate reference system valid area	*M*	*M*	*M*	*M*	If the submitting organization uses geographic identifiers (as documented in ISO 19112) to describe valid area, it shall provide a citation for the geographic identifiers.
Coordinate reference system scope	*M*	*M*	*M*	*M*	

Table B.1 (*continued*)

	E N	φ λ h φ λ r Ω Θ r Ω	**X Y Z**	**i j k** **i j** **k r** Ω Θ **r** Θ **H**	
Datum type:	**Geodetic**	**Geodetic**	**Geodetic**	**Engineering or vertical**	
Coordinate system type:	**Projected**	**Geodetic or spherical polar**	**Cartesian**	**Cartesian or spherical polar or gravity-related height**	
Element name					**Comments**
Datum identifier	M	M	M	M	See ISO 19111 for requirements to describe a source citation. Information for source citation as part of the element identifier is mandatory for acceptance into the register.
Datum alias	O	O	O	O	
Datum type	*M*	*M*	*M*	*M*	Mandatory, for acceptance in the register.
Datum anchor point	O	O	O	O	
Datum realization epoch	O	O	O	O	
Datum valid area	*M*	*M*	*M*	*M*	If the submitting organization uses geographic identifiers (as documented in ISO 19112) to describe valid area, it shall provide a citation for the geographic identifiers.
Datum scope	*M*	*M*	*M*	*M*	
Datum remarks	O	O	O	O	
Prime meridian identifier	M	M	M		See ISO 19111 for requirements to describe a source citation. Information for source citation as part of the element identifier is mandatory for acceptance into the register.
Prime meridian Greenwich longitude	M	M	M		
Prime meridian remarks	O	O	O		
Ellipsoid identifier	M	M			See ISO 19111 for requirements to describe a source citation. Information for source citation as part of the element identifier is mandatory for acceptance into the register.
Ellipsoid alias	O	O			

Table B.1 (*continued*)

	E N	φ λ h φ λ r Ω Θ r Ω	**X Y Z**	**i j k** **i j** **k r** Ω Θ **r** Θ **H**	
Datum type:	**Geodetic**	**Geodetic**	**Geodetic**	**Engineering or vertical**	
Coordinate system type:	**Projected**	**Geodetic or spherical polar**	**Cartesian**	**Cartesian or spherical polar or gravity-related height**	
Element name					**Comments**
Ellipsoid semi-major axis	M	M			
Ellipsoid shape	M	M			Boolean TRUE if ellipsoid. Boolean FALSE if sphere.
Ellipsoid inverse flattening[b]	cd 1	cd 1			
Ellipsoid remarks	O	O			
Coordinate system identifier	M	M	M	M	See ISO 19111 for requirements to describe a source citation. Information for source citation as part of the element identifier is mandatory for acceptance into the register.
Coordinate system type	M	M	M	M	
Coordinate system dimension	M	M	M	M	
Coordinate system remarks	O	O	O	O	
Coordinate system axis name[c]	M	M	M	M	
Coordinate system axis direction[c]	M	M	M	M	
Coordinate system axis unit identifier[c]	M	M	M	M	See ISO 19111 for requirements to describe a source citation. Information for source citation as part of the element identifier is mandatory for acceptance into the register.
Coordinate operation identifier	M				See ISO 19111 for requirements to describe a source citation. Information for source citation as part of the element identifier is mandatory for acceptance into the register.

Table B.1 (*continued*)

	E N	φ λ h φ λ r Ω Θ r Ω	**X Y Z**	**i j k** **i j** **k r** Ω Θ **r** Θ **H**	
Datum type:	**Geodetic**	**Geodetic**	**Geodetic**	**Engineering or vertical**	
Coordinate system type:	**Projected**	**Geodetic or spherical polar**	**Cartesian**	**Cartesian or spherical polar or gravity-related height**	
Element name					**Comments**
Coordinate operation valid area	*M*				If the submitting authority uses geographic identifiers (as documented in ISO 19112) to describe valid area, it shall provide a citation for the geographic identifiers.
Coordinate operation scope	*M*				
Source coordinate reference system identifier[b]	cd 2				
Target coordinate reference system identifier[b]	cd 2				
Coordinate operation version[b]	cd 3				
Coordinate operation method name[b]	M				
Coordinate operation method name alias	O				
Coordinate operation method formula(s)	M				
Coordinate operation method parameters number	M				
Coordinate operation method remarks	O				

Table B.1 (*continued*)

	E N	φ λ h φ λ r Ω Θ r Ω	**X Y Z**	**i j k** **i j** **k r** Ω Θ **r** Θ **H**	
Datum type:	**Geodetic**	**Geodetic**	**Geodetic**	**Engineering or vertical**	
Coordinate system type:	**Projected**	**Geodetic or spherical polar**	**Cartesian**	**Cartesian or spherical polar or gravity-related height**	
Element name					**Comments**
Coordinate operation parameter name[d]	M				
Coordinate operation parameter value[d]	M				
Coordinate operation parameter remarks[d]	O				

[a] M – Mandatory (if in italics, differs from obligation in ISO 19111:2003); O – Optional.

[b] Conditions are as follows:
cd 1 – Mandatory if an ellipsoid shape is true.
cd 2 – Mandatory if describing a coordinate transformation.
cd 3 – Mandatory if describing either (i) a projected coordinate system and none of coordinate reference system citation, coordinate system citation, or coordinate operation citation is supplied; or (ii) a single coordinate conversion or coordinate transformation.

[c] Repeat for each coordinate axis.

[d] Repeat for as many parameters are required by the coordinate operation.

Table B.2 — Requirements for describing a coordinate transformation

Element name	Obligation	Rules
Coordinate operation identifier	M	See ISO 19111 for requirements to describe a source citation. Information for source citation as part of the element identifier is mandatory for acceptance into the register.
Coordinate operation valid area	*M*	If the submitting authority uses geographic identifiers (as documented in ISO 19112) to describe valid area, it shall provide a citation for the geographic identifiers.
Coordinate operation scope	M	
Source coordinate reference system identifier	M	
Target coordinate reference system identifier	M	
Coordinate operation version	M	
Coordinate operation method name	M	
Coordinate operation method name alias	O	
Coordinate operation method formula(e)	M	Formula used by the coordinate operation method. This may be a reference to a publication.
Coordinate operation method number of parameters[a]	M	Number of parameters required by this coordinate operation method.
Coordinate operation method remarks	O	
[a] See Annex C for treatment of grid lookup tables.		

Some countries, including the United States, Canada, the United Kingdom, Japan and New Zealand, provide a datum transformation program that looks up and interpolates a table of local transformation parameters given at grid points. In such a case, the total number of parameters can be so large that listing of parameters with the format of Table B.3 becomes unrealistic. For example, a parameter file of TKY2JGD (ver.2.0.5) used for a datum transformation from Tokyo Datum to JGD2000 in Japan, contains latitude and longitude differences at 392,183 grid points.

Therefore, for transformation methods using a grid lookup table, description of parameter names and values can be omitted by denoting “Grid lookup table - too many parameters to be listed below.” in the entry of the coordinate operation method remarks. In the entry of coordinate operation method number of parameters, the total number of parameters in the grid lookup table should be described.

NOTE Examples of transformation methods that use a grid lookup table: NADCON (United States), TKY2JGD (Japan), NTv2 (Canada, Australia, New Zealand) and OSTN02 (United Kingdom).

Table B.3 — Requirements for describing coordinate transformation parameters

Element name	Obligation	Rules
Coordinate operation parameter name	M	Identifier of the coordinate operation parameter that is defined or used with the coordinate operation method. The parameters differ among coordinate operation methods. (Example: ∆E, ∆N)
Coordinate operation parameter value[a]	M	Value of the coordinate operation parameter used in this instance of a coordinate operation.
Coordinate operation parameter remarks	O	

[a] Elements shall be repeated for as many times as there are parameters. See Annex C for treatment of grid lookup tables.

Annex C
(informative)

Best practices for geodetic codes and parameters

C.1 Introduction

Standardization may be considered from two perspectives:

a) in an open way, whereby various conventions in actual use are all permitted and the standard requires that each be unambiguously described but capture the local convention;

b) in a closed way, when a particular convention is mandated.

Advantages and disadvantages are:

a) Open standardization allows data to be recorded as used, without the need for conversion to a closed standard.

b) Closed standardization has the advantage of their being a single defined format and thereby enhances data interchange.

A closed standard reduces the cost of data interchange, particularly if it is introduced in an emerging environment. However, in a mature environment where many conventions have already been adopted, an open standard is more likely to meet with early acceptance.

The key information contained in a registry of geodetic codes and parameters are the values of ellipsoid, coordinate conversion and coordinate transformation parameters. Many independent coordinate operation methods have been and are in use globally. To capture these, a registry of geodetic codes and parameters must of necessity use open standardization.

This annex describes commonly encountered conventions and recommends those to be used.

C.2 The representation of degrees

ISO 1000, the International Standard for angle units, is the radian. Geographic coordinates (latitude and longitude) are usually expressed in whole circle measure [degrees, 1/360th circle, but note that degrees are not the only whole circle units used in geographic applications; a 1/400th circle (grad or gon) is also found]. For geographic information processing, the adoption of the radian as the standard for geographic coordinate system units is inconvenient, requiring the application of π (pi) to convert from whole circle measure to and from radian, with no standard for the precision to which π should be taken. The retention of geographic values in whole circle measure is recommended.

Geographic coordinates (latitude and longitude) are usually expressed as degrees, minutes and seconds with an abbreviation hemisphere suffix (N, S, E or W). This is a natural result of geographic position being correlated with time (given in hours, minutes and seconds). Degrees, minutes, seconds and hemisphere suffixes are inconvenient for data processing, requiring description through four separate fields. However, the conversion of minutes and seconds to decimal degrees can result in rounding problems. For registries of geodetic codes and parameters, there are advantages in retaining original degree-minute-second values. It is recommended that an artificial real number unit, a “sexagesimal degree”, be created as a concatenation of digits. Almost all practical implementations use DD.MMSSss, However ISO 6709 codifies a concatenation in the form DDMMSS.ss (“sexagesimal second”). In either case, for minute and second values of less than 10, inclusion of a leading zero is mandatory. Registries may allow either representation.

C.3 Coordinate systems

C.3.1 Coordinate system axis direction

ISO 6709 is the International Standard for geographic coordinates for positive latitude north of the equator and positive longitude east of Greenwich. Other conventions have been used. The ISO geodetic registry should use the International Standard.

The positive direction of a *geocentric* Cartesian coordinate system with an origin at the centre of the earth is defined by the International Association of Geodesy. Z is along the Earth's rotation axis through the North Pole, X is in the plane of the equator and through the intersection of the prime meridian with the equator, and Y is in the plane of the equator forming a right-handed coordinate system (that is, through the intersection of longitude 90° east with the equator). The ISO geodetic registry should follow this convention.

The positive direction of axes in a projected coordinate reference system is part of the system definition. Although north and east predominate, south and west or north and west are found. To avoid confusion and the need to convert values, an open standard is desirable. The ISO geodetic registry should record actual definition.

C.3.2 Coordinate system axis order and axis abbreviation

This is the order in which n-dimensional coordinates are quoted. Several conventions are found.

For projected coordinate reference systems, there is a bias in English-speaking countries to giving the ordinate (easting) first and the abscissa (northing) second. However, in much of central and eastern Europe and northern Asia, the normal practice is to give the abscissa (northing) first and the ordinate (easting) second. These practices may have followed the local adoption of abbreviations for the axes: in English-speaking countries the ordinate (easting) is often given the abbreviation X and the abscissa (northing) the abbreviation Y, whereas in central Europe the abscissa (northing) is given the abbreviation X and ordinate (easting) the abbreviation Y. In a list of coordinates, in both cases X ordinates precede Y ordinates. Here an open standard which requires the adopted convention to be indicated is needed if local practice is to be reflected. But in certain communities, such as NATO, a de facto closed standard is in use.

However, for other types of coordinate system a closed standard is more applicable. Geocentric Cartesian coordinates should always be given in the order X, Y, Z. Geodetic or geographical coordinates in the geodetic and navigation communities are always given in the order latitude, longitude, but despite ISO 6709 codifying this, some English-language computer applications associate longitude with the projected X direction and give it before latitude, potentially confusing the navigator.

The ISO geodetic registry of coordinate reference systems should have a human interface that follows the following standard for coordinate axis order:

a) Geocentric Cartesian coordinates: X, Y, Z;

b) geographical two-dimensional coordinates: latitude, longitude;

c) geographical three-dimensional coordinates: latitude, longitude, height or depth;

d) projected coordinates: indicate local practice.

C.3.3 Coordinate system units

The units for projected coordinate reference systems will be implicitly defined through the units in which grid origin coordinates (false easting and false northing) are given. The ISO standard for linear units, as given in ISO 1000, is the metre. Historically, projected coordinate reference systems have used a variety of linear units. The non-metric systems have a complex array of conversion factors to metres, and rarely use the foot-metre conversion given in ISO 1000. Some metric systems use metres of different length to the SI metre. An open standard, allowing the coordinates in native units, will avoid the danger of corruption of values caused by misunderstanding of conversion factor.

C.4 Coordinate operations

C.4.1 Coordinate operation methods

Coordinate operation parameter values are only meaningful when properly related to a coordinate operation method formula. Unfortunately, coordinate operation formula names are not sufficient identification of the formula. For instance, the map projection name “oblique stereographic” is found in many mathematical cartography references. Even those which distinguish between spherical and ellipsoidal formulas are not internationally consistent in their treatment of the ellipsoidal method. This is because mapping of the ellipsoid requires assumptions to be made about the relationship of the map plane to the ellipsoid surface. Different approaches have made differing assumptions. A commonly cited U.S. reference for the oblique stereographic map projection calculates intermediate parameters conformal latitude and longitude only at the projection origin, whereas in Europe they are calculated at every point. Both approaches are valid. But they are different, and applying the U.S. formula in Europe will give results that may be up to 100 m different from those calculated by the European formula. Effectively, these are two different ellipsoidal map projection methods sharing the same name.

Coordinate transformation names may also be ambiguous. For example, a three-dimensional similarity transform of geocentric coordinates is often employed for medium accuracy geodetic datum transformations. This may sometimes be called the Bursa-Wolf method. However, there has been and is significant usage of two opposing conventions for the rotation parameters:

a) Rotations to be applied to the point's vector. The sign convention is such that a positive rotation about an axis is defined as a clockwise rotation of the position vector when viewed from the origin of the Cartesian coordinate system in the positive direction of that axis; e.g. a positive rotation about the Z-axis only from source system to target system will result in a larger longitude value for the point in the target system.

b) Rotations to be applied to the coordinate frame. The sign convention is such that a positive rotation of the frame about an axis is defined as a clockwise rotation of the coordinate frame when viewed from the origin of the Cartesian coordinate system in the positive direction of that axis, that is a positive rotation about the Z-axis only from source coordinate system to target coordinate system will result in a smaller longitude value for the point in the target coordinate system.

The rotation parameter values will have been derived using one of these two conventions. They may be validly applied only in algorithms using that convention. Application of the values in algorithms using the opposite convention will give erroneous results. Adopting practices followed by the International Association for Geodesy, ISO 19111 Annex D uses convention (a).

The ISO geodetic registry should include formulas and an example for each coordinate operation method. The registry should define the coordinate operation parameters that are used as variables in those formulas. Coordinate operation parameter values in the registry will be relevant to those formulas.

C.4.2 Coordinate operation reversibility

Many coordinate operation methods can be applied to the reverse operation. Some, for example map projections, require differing forward and reverse formulas but use the same coordinate operation parameters with unchanged coordinate operation parameter values. Some coordinate operation method formulas can be used for both forward and reverse transformations using the same parameters but with the sign of some or all of the parameter values being reversed. The generality is that coordinate operation parameter values are valid with a specific formula for a specific coordinate operation direction.

The ISO geodetic registry of geodetic codes and parameters should indicate whether coordinate operation methods may be used for the reverse operation. Formulas should clearly indicate the forward and (if applicable) reverse directions. Where coordinate operation methods are reversible the registry should indicate whether coordinate operation parameters are used in the reverse operation with the same or reversed sign.

The above provisions allow for coordinate operation parameter values to be stored only once for both forward and reverse operations, except where the method is not reversible.

C.4.3 Coordinate transformation direction

An external subregister may include coordinate transformations between local coordinate reference systems and global coordinate reference systems. The direction for which the parameter values are valid is indicated by the identification of the source and target systems. Recommended practice is to make the local system the source and the global system the target.

C.4.4 Coordinate operation parameter value units

A wide range of linear and angle units are in use in coordinate reference systems and geodetic transformations. Conversion to the ISO 1000 standard (metre and radian) is not trivial, either due to complexities associated with linear conversion ratios or due to uncertainty in the precision of π (pi). An open standard allowing coordinate operation parameter units to be recorded in their native values is required.

For coordinate operation parameter values expressed in degrees (for example, coordinates of a map projection origin) it is recommended that repositories of geodetic codes and parameters store values as "sexagesimal degrees" (see C.2).

The ISO geodetic registry should identify the unit for each parameter and include the conversion ratio required to change that unit to the ISO standard unit (metre and radian for linear and angle units, respectively). Scalars should include the conversion ratio required to change the scalar to unity.

C.4.5 Zoned map projections

There are many instances where a map projection has been applied on a zoned basis, with a subset of the parameter values being unchanged throughout all zones. Whilst human beings can interpret words describing the common elements, machine readability of free text is much more complex.

The ISO geodetic registry should present each set of coordinate reference system information in a machine-readable form. Zoned map projections can be accommodated either by recording each zone individually, or by documenting a coordinate operation method whose formulas and defined parameters account for the zoning. Recording individual zones is the recommended approach.

C.5 Ellipsoid parameters

Ellipsoids have a number of parameters, only two of which are necessary to define the size and shape of the ellipsoid. Some of these parameters such as eccentricity (e) are frequently encountered as variables within coordinate operation formulas. However, such parameters are usually derived and required to more significant digits than users document. The two parameters documented for many old ellipsoids were semi-major axis radius (a) and semi-minor axis radius (b). ISO 19111 requires that ellipsoids be defined through the two parameters semi-major axis radius (a) and inverse flattening (1/f). From these, other required parameters may be derived. The ISO geodetic registry should follow the requirements of ISO 19111. Where inverse flattening (1/f) is derived from other parameters, it should be held to a precision of not less than 10 significant digits.

C.6 Element Naming

C.6.1 General

For human understanding, there needs to be a name associated with the code.

C.6.2 Names and abbreviations

An ideal naming convention would honour locally-accepted names and also ensure that all names are unique. Given the historic practice associated with geodetic parameters, these two aims are mutually exclusive.

C.6.3 Coordinate systems

Coordinate systems do not have well-known names. They should be allocated a name which is descriptive, for example:

Cartesian 2D CS. Axes: easting, northing (E,N). Orientations: east, north. UoM: m.

Ellipsoidal 2D CS. Axes: latitude, longitude. Orientations: east, north. UoM: deg.

C.6.4 Datums

Datums are allocated a name, usually in English, which corresponds to the local naming of the reference frame and realization date. This may be the name of the fundamental point, network adjustment, etc. If the datum type is geodetic, this should be followed by the prime meridian name in parentheses. However, if the prime meridian is Greenwich, it is omitted from the GeogCRS name. For example:

Monte Mario (Rome)	Prime meridian is Rome, i.e. not Greenwich.
Monte Mario	Prime meridian is Greenwich by implication.
European Datum 1950	Prime meridian is Greenwich by implication.

Long names may also be allocated an abbreviation. Example:

datum name = European Datum 1950, datum abbreviation = ED50.

Note that some names may naturally include parentheses. For example,

Australian Height Datum (Tasmania)

Consequently, not all items in parentheses indicate the prime meridian.

C.6.5 Geographic coordinate reference systems

Geographic coordinate reference systems (GeogCRS) are allocated the name of the related geodetic datum abbreviation (if it exists) or else the geodetic datum full name, for example:

ED50

In choosing the geogCRS name, consideration should be given to its use as part of a projected coordinate reference system name (see C.6.8).

Following the provisions of ISO 19111, a change in any part of a coordinate reference system, including units, causes the CRS to be changed. However, latitude and longitude in degrees are an exception. When the latitude and longitude unit is degree, any one of the representations described in C.2 is implied. The registry will record the geogCRS axis unit as degree. The two recognized display formats will not be tabulated as duplicate CRSs.

C.6.6 Geocentric Cartesian coordinate reference systems

Geocentric Cartesian coordinate reference systems are allocated the name of the related geodetic datum abbreviation (if it exists), or else the geodetic datum full name, for example:

ETRS89

Registries should not duplicate geographic and equivalent geocentric Cartesian systems.

C.6.7 Map projections

Map projections are allocated a name which corresponds to the local naming convention. A country prefix or suffix may be added when local naming might result in ambiguity in a global database.

For a Transverse Mercator projection which takes UTM parameter values other than central meridian, the name comprises TM, space, longitude of natural origin value, space, two characters to indicate hemisphere quadrant. For example:

TM 56 SW a projection with origin at 0ºN, 56º W, scale factor of 0,9996, false easting of 500 000 m and false northing of 10 000 000 m.

C.6.8 Projected coordinate reference systems

Projected coordinate reference systems (ProjCRS) are allocated a name comprising the GeogCRS abbreviation (if it exists) or name, space/space, projection abbreviation (if it exists) or name, for example:

ED50 / UTM zone 30N

Most projected coordinate reference systems have defined axis units. Changes of units to an arbitrary user preference will not be tabulated in the ISO 19127 registry. External registries may record such systems using a different code and name. Occasionally, a projected coordinate reference system will be officially used in different units. In these instances, the abbreviation for the units for the secondary usage will be included in the name, for example:

NAD83 / Virginia North	*CRS uses metres*
NAD83 / Virginia North (ftUS)	*CRS uses U.S. survey feet*
NAD83 / Arizona East (ft)	*CRS uses international feet*

C.6.9 Vertical coordinate reference systems

Vertical coordinate reference systems (VertCRS) are allocated the name of the related vertical datum abbreviation (if it exists) or of the vertical datum name.

C.6.10 Compound coordinate reference systems

Compound coordinate reference systems are allocated a name comprising the GeogCRS or ProjCRS abbreviation (if one exists) or name, space+space, VertCRS abbreviation (if one exists) or name, for example:

NAD83 + NAVD88

NAD83 / UTM zone 15N + NAVD88

C.6.11 Coordinate transformations

Coordinate transformations are allocated a name comprising source CRS abbreviation (if one exists) or name, space, “to”, space, target CRS abbreviation (if one exists) or name, space, (transformation variant). For example:

ED50 to ETRS89 (1)

Transformation variant is a sequential number for that source/target pair.

Where transformations are reversible, and a source or target CRS is a realization of the ITRS (e.g. ETRS89), then the transformation should be entered in the direction from local to ITRF, i.e. ED50 to ETRS89, and not ETRS89 to ED50.

C.7 Transformation version

It is recommended that the geogCRS name, and for projected CRSs the geogCRS element of the projCRS name, be modified to the GeogCRS abbreviation (if it exists) or name, space*space, transformation version. For example:

GeogCRS name: *ED50 * IGN-Fra*

ProjCRS name: *ED50 * NMA-Nor N62 2001 / UTM zone 32N*

The ISO geodetic registry should separately document coordinate reference systems and transformations between CRSs. It therefore will not use this naming convention. However, to standardize naming across applications that use the aforementioned practice, transformations should be allocated a transformation version. Transformation versions should be constrained to be unique within any particular pair of source and target CRSs. The version comprises a cryptic indication of the information source for the transformation (usually the organization’s initials), - (hyphen), the ISO three-character country code, and if the transformation is not applicable to a complete country, a cryptic indication of its area or scope. For example:

IGN-Fra a transformation for all France from the Institut Géographique National (IGN).

IGN-Fra NW a transformation for northwest France from the IGN.

To facilitate this, the registry should include a cryptic transformation version for each coordinate transformation.

C.8 Grid Lookup Table

An example of coordinate transformation using a grid lookup table is given in Table C.1.

Table C.1 — Coordinate transformation using a grid lookup table

Element name	Entry	Comment
Coordinate operation identifier	TKY2JGD	
Coordinate operation valid area	Japan	
Coordinate operation scope	Coordinate transformation for surveying and mapping on lands	
Source coordinate reference system identifier	TD / (B, L)	Tokyo Datum
Target coordinate reference system identifier	JGD2000 / (B, L)	Japanese Geodetic Datum 2000
Coordinate operation version	TKY2JGD ver.2.0.5	
Coordinate operation method name	Longitude and latitude differences	
Coordinate operation method name alias	Grid lookup table transformation	
Coordinate operation method formula(e)	Bilinear interpolation of longitude and latitude differences given at surrounding grid points. In: Tobita, M. (2002): “Coordinate transform software ‘TKY2JGD’ from Tokyo Datum to a geocentric system,” Journal of Geographical Survey Institute, No.97, 31-51 (in Japanese).	
Coordinate operation method number of parameters	784 366	Latitude and longitude differences are given at each of 392 183 grid points.
Coordinate operation method remarks	Grid lookup table - too many parameters to be listed below.	

Bibliography

[1] ISO 6709, *Standard representation of latitude, longitude and altitude for geographic point locations*

[2] ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units*

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