Compatibility Study between ISO 18026 CD, Spatial Reference Model (SRM) and ISO 19111, Geographic information – Spatial referencing by coordinates.

Introduction

Study scope

An assessment of the compatibility of the Spatial Reference Model and ISO 19111, *Geographic information – Spatial referencing by coordinates* is provided in this document. This assessment will determine the compatibility of the concepts and data elements described in these documents.

Structure

Section 1 – Conceptual compatibility

This section contains a discussion of the conceptual and scope differences between the SRM and ISO 19111.

Section 2 – SRM to ISO 19111 Element Mapping

This section takes all the "…specifications fields" tables from the SRM and align these fields with fields from the "Requirements for describing…" tables from ISO 19111. Each pair of fields includes a description of any incompatibilities or other limitations between the fields.

Section 3 – ISO 19111 to SRM Element Mapping

This section is structured similar to Section 2 except that fields from ISO 19111 are the primary fields that are paired with SRM fields. Once again, comments are provided for the comparison.

Section 4 – ISO 19111 Annex E examples represented as SRM data elements

Mappings from nine examples.

Conceptual Compatibility

This section contains a discussion of the conceptual differences between the SRM and ISO 19111 schemas. ISO 19111 and the SRM both address the basic concepts of spatial reference systems, including coordinate systems, datums, and ellipsoids. However, there are significant differences between them in level of detail, scope, terminology, and other details.

Intended Applications

ISO 19111 is part of a set of standards related to geographic information. Its primary focus is on coordinate systems used in geographic information systems and on maps and charts to store and depict geographic information. It is written in the traditional terminology(s) of geographic information (geodesy, cartography, geography, photogrammetry, etc.)

Aspects of the SRM have applicability to, but are not limited to:

a. mapping, charting, geodesy, photogrammmetry and imagery;
b. topography;
c. location-based services;
d. oceanography;
e. meteorology and climatology;
f. interplanetary and planetary sciences;
g. embedded systems; and
h. modelling and simulation.

The SRM application domains may be dynamic and include real time distributed processing. Such systems may involve interoperating components of live, virtual or constructive federations requiring high fidelity representations of spatial operations. A rich set of object reference models must be supported for both real and conceptual objects. High precision and fidelity is required to minimize risk to live participants.

Scope of the Standards

The spatial domain of ISO 19111 is limited to locations on or near the Earth. The reference surfaces employed all pertain to the Earth.

The Spatial Reference Model (SRM) contains a rigorous definition of a framework for defining systems that assign numerical coordinates to positions. It also provides detailed definitions of a large number of coordinates systems used in Earth, metrology and astronomic sciences. The SRM explicitly provides support for spatial reference systems associated with celestial bodies other than the Earth. Additionally, the SRM explicitly supports spatial reference systems that are used to describe phenomena that are not fixed to the Earth, such as the solar wind, and spatial reference systems that are based on other types of objects including abstract, CAD/CAM and virtual worlds. The framework provides a means of extending the SRM through a registration process. SRM extensibility includes virtually any type of coordinate system or spatial reference frame.

ISO 19111 elements are intended to be both human- and machine-readable. The SRM paradigm uses a system of labels and codes in a precisely defined semantic context that supports and promotes computational interoperability. In particular, the SRM provides an API for coordinate operations relative to spatial directions, model instancing, distance and azimuth computations. The ISO 19111 does not specify an API. The SRM API intrinsically supports SRM extensibility.

Conceptually, the SRM can be viewed as a super-type of ISO 19111. The subset of SRM coordinate systems that are suitable for use with geographic information should, in theory, equate with the coordinate systems supported by ISO 19111. The SRM concept of Object Reference Model (ORM) is a super set of the datum concept. SRM 19111 defines an abstraction for binding that includes geodesy as well as many other scientific disciplines.

Terminology

ISO 19111 was created to support the needs of geographic information producers and users. Therefore, ISO 19111 is written in the traditional terminology of geographic information systems (geodesy, cartography, geography, photogrammetry, etc.). ISO 19111 provides new terminology for some concepts that have always been understood in the geographic information community but not explicitly defined. This new terminology is generally described in terms that are familiar to the geographic information community.

The SRM uses precisely defined terminology and an increased level of abstraction to provide common ground for a broader range of application disciplines. This precision of terminology is also needed to support computational interoperability and unambiguous API functionality. The rigorous and explicit language of the SRM is less subject to interpretation (or misinterpretation) than ISO 19111.

Level of standardization

ISO 19111 provides a conceptual framework for describing coordinate systems used for the exchange of geographic information, i.e., the minimum set of information required to use a set of geographic information. ISO 19111 is a very generic model. It cannot be implemented directly. The SRM is a more specific, but still very general, model that supports specific collections of spatial reference frames, object reference models for the Earth and other celestial bodies, and coordinate system types. It includes tables of object reference models for celestial bodies, including models of the Moon, and the other planets in the solar system, as well as multiple models of the Earth. ISO 19111 is based on traditional concepts and mathematical formulations of geodesy. Most mathematical formulations are handled by reference to published sources. Since there is considerable variance in formulations in publications, this implies there could be many versions of a projection having the same identifier, for example, transverse Mercator. The SRM has a more complete mathematical foundation and formulations are explictly specified for all spatial operations. Most of this mathematical foundation is transparent to the users of the SRM implementation since the SRM API hides these supporting concepts.

Differences in Terminology

ISO 19111 defines a coordinate reference system to consist of a coordinate system and a datum. The SRM uses the term spatial reference frame to describe a coordinate system that has been referenced to a model of a particular object, often, but not necessarily, a celestial body. The coordinate system and datum (or object reference model) types defined in each model vary considerably. ISO 19111 defines five types of coordinate systems: Cartesian, geodetic, projected, polar, and gravity-related, and three types of datums: geodetic, vertical, and engineering. The SRM defines spatial reference frame types that include celestiocentric, celestiodetic, local space rectangular, local tangent space Euclidean, map projection-based, celestiomagnetic, celestiocentric nonfixed, and heliocentric. There are also numerous minor differences in the interpretations of terms such as coordinate system, datum, etc. Due to its extended scope, the SRM attempts to avoid Earth-specific terms that begin with the prefix "geo-", instead using terms such as "celestiodetic", "celestiocentric", etc.

Dimensions

ISO 19111 includes support for both one-, two-, and three-dimensional coordinate reference systems, as well as "compound" coordinate reference systems, in which a 2D horizontal coordinate reference system is combined with a 1D vertical coordinate reference system.

The SRM explicitly supports both 2D and 3D spatial reference frames, including "augmented" projection-based spatial reference frames, in which a vertical coordinate is combined with a two-dimensional projection. The SRM does not support transformation between SRFs where the relationship between the RD for the 2D ORM and the RD for the height coordinate is not known, e.g., local datum ellipsoid and mean sea level.

Coordinate Transformations and Conversions

Both of these standards are quite similar in their general approach to coordinate transformation operations. They both use the terms "coordinate conversion" for operations that change the coordinate system in which a location is expressed, while retaining the same datum, and "coordinate transformation" for operations that change the datum, while leaving the coordinate system unchanged.

Labels and Codes

All instances of SRM concepts that are standardized or registered have a human readable label and a machine-readable code. These are unique within the scope of each individual SRM concept. The label of a concept instance is logically equivalent to the code for that instance. Both serve the purpose of uniquely identifying the specification of a standard or registered instances. In ISO19111 various elements using data type RS_Identifier serve a similar function of identifying an instance of a concept. ISO19111 does not appear to require uniqueness for these individual element values. ISO 19111 clause 6.8 states: "In most cases, it is necessary to identify the coordinate system type and datum type before the relevant attribute set can be distinguished."

Spatial Reference Model to ISO 19111

Spatial Reference Model Coordinate Systems (clause 5)

Coordinate system fields

The SRM groups most of this information into a single table. The ISO 19111 uses multiple tables to provide a bit more normalization of the information about coordinate systems. ISO 19111 treats the equations as part of a coordinate operation rather than an inherent part of the coordinate system itself.

Table 1. Coordinate system specification fields

Field	Specification	ISO 19111	Comments
Description	A description of the CS including any common name.	**coordinate system** remarks [remarks]	This is an open field in ISO 19111 that can serve as a "catch-all" for information about a coordinate system.
Label	The label (see 12.2.2).	**coordinate system** remarks [remarks]	ISO 19111 does not require a comparable field but it could be specified in the remarks field.
Code	The code (see 12.2.3).	**coordinate system** identifier [CSID]	The code must be unique. A CSID does not have this requirement.
Function type	Either "generating function" or "map projection".	**coordinate operation** method name [methodName] (two) If generating function: = <*this CS*> into Cartesian and = Cartesian into <*this CS*> If mapping equations: = geodetic into <*this CS*> and: = <*this CS*> into geodetic	Although this is not an exact match, it would be straightforward to categorize the method names with "generating function" or "map projection." A map projection mapping equation corresponds to a coordinate operation formula when the operation is "projection". Coordinate operations "into Cartesian" correspond to a generating function. Coordinate operations "Cartesian into" correspond to an inverse generating function.

Field	Specification	ISO 19111	Comments
CS type	One of: 3D linear, 3D curvilinear, surface linear, surface curvilinear, map projection, 2D linear, 2D curvilinear, 1D linear, 1D curvilinear, or surface (map projection) and 3D (augmented map projection).	**coordinate system** type [type] and **coordinate system** dimension [dimension]	ISO 19111 lists Cartesian, geodetic, projected, polar, and gravity-related but does not restrict this field to these options. SRM is more restrictive. The formal types are: 1D, plane curve, space curve, 2D, surface, and 3D. The modifiers linear/curvilinear is a CS property rather than a type. The "surface (map projection) and 3D (augmented map projection)" is a special case of type 3D.
Properties	Either "None" or a list of one or more properties of the CS chosen from the following: orthogonal, not orthogonal, orthonormal, not orthonormal, conformal, or not conformal. Conformal and not conformal only apply to map projections.	**coordinate system axis** direction [axisDirection]	This is not an exact match because the ISO 19111 field does not address map projection properties like conformal. The ISO 19111 **coordinate operation** identifies a map projection by name, which implies some of these properties.
CS parameters and constraints	The parameters (if any) that control aspects of the CS and constraints on how those parameters interrelate.	**coordinate operation** method number of parameters [numberOfParameters] **coordinate operation** parameter name [name]	To a large extent, ISO 19111 integrates this kind of information into the **coordinate operation** and **coordinate operation parameters** entities. The **coordinate operation parameters** entity provides the name of each parameter its value and remarks about the parameter.
Coordinates	Coordinate symbols and common names.	**coordinate system axis** name [axisName]	This is not an exact match. The axis name may or may not be related to the coordinate name/symbol. This construct in ISO 19111 provides the flexibility of specifying coordinates in any sequence since their meaning can be determined by the ordering of instances of **coordinate system axis**. ISO 19111 does not restrict symbolization of coordinates. The SRM states that coordinate components may be presented in any order provided the component are identified by name of symbol.
Domain of the generating function or mapping equations	The domain of the CS generating function or mapping equations.	**coordinate operation** valid area [validArea]	ISO 19111 specifies are region where a coordinate operation is valid. This correspond can serve the same purpose as the domain information in the SRM. The SRM tends to be based on the mathematical limitations of the formulas involved whereas ISO 19111 is more focused on the actural region of the Earth where the coordinate operation is used. The ISO 19111 valid area would frequently be a subset of the domain from SRM.

Field	Specification	ISO 19111	Comments
Generating function or mapping equations	The CS generating function or mapping equations.	**coordinate operation** method name [methodName] If generating function: = <*this CS*> into Cartesian If mapping equations: = geodetic into <*this CS*> **coordinate operation** method formula(s) [formula]	ISO 19111 incorporates this information into the coordinate operation entity rather than making it part of the coordinate system itself. ISO 19111 also provides the flexibility citing a reference for the formulas rather than explicitly including them in the table. This recognizes that there are many implementations of different map projections, datum transformations, etc. and that the exact formulas used in creating a data set should be identified. The SRM does not provide this level of flexibility except through registration of new coordinate systems.
Domain of the inverse of the generating function or mapping equations	The domain of the inverse of the CS generating function or mapping equations.	**coordinate operation** valid area [validArea]	ISO 19111 defines this as a different coordinate operation. The same comment applies here as for "Domain of the generating function or mapping equations."
Inverse of the generating function or mapping equations	The inverse of the CS generating function or mapping equations.	**coordinate operation** method name [methodName] If generating function: = Cartesian into <*this CS*> If mapping equations: = <*this CS*> into geodetic **coordinate operation** method formula(s) [formula]	ISO 19111 defines this as a different coordinate operation. The same comment applies here as for "Generating function or mapping equations."
Figure(s)	Zero or more figure(s) that explain and illustrate the CS.	none	ISO 19111 does not provide for graphical elements in its descriptions. However, it could be handled through a reference to a publication in **coordinate operation** method formula(s).
Notes	Additional, non-normative information concerning the CS.	**Coordinate system** remarks [remarks] **Coordinate operation** method remarks [remarks] **Coordinate operation parameter** remarks [remarks]	There are remarks fields scattered throughout the ISO 19111 entities that cover the coordinate system territory.
References	The references (see 12.2.5).	**coordinate operations** method formula(s) **identifiers** **citations**	ISO 19111 provides a very complete mechanism for citing of references that are linked to various identifiers within the ISO 19111 entities. ISO 19111 allows a detailed reference to substitute for actual entries in the various tables.

Coordinate System Specifications

ISO 19111 does not address the details of all the coordinate systems. The only formulas given in ISO 19111 are in Annex D section D.2 that provides the coordinate conversions between geodetic 3D and Euclidean 3D coordinates. ISO 19111 specifies the common iterative solution for the geodetic to Euclidean function. The corresponding formula as given in Table 5.14 of the SRM is in closed form.

Temporal Coordinate Systems

ISO 19111 in section 6.2.2 states, "For the purposes of this International Standard, a coordinate reference system shall not change with time." Therefore, ISO 19111 does not provide any specifications for describing temporal coordinate systems.

Table 2. Temporal coordinate system specification fields

Field	Specification	ISO 19111	Comments
Description	A description of the temporal coordinate system, including any common name.	none	
Label	The label (see 12.2.2).	none	
Code	The code (see 12.2.3).	none	
Epoch	The time that specifies the origin.	none	
Unit of duration	The physical quantity that corresponds to an abstract unit of duration.	none	
Relationship to UTC	The conversions to and from the specified temporal coordinate system and UTC.	none	
References	The references (see 12.2.5).	none	

Reference datums, embeddings, and object reference models (clause 6)

There is a great deal of information in SRM clause 6 that deals with various types of bindings and embeddings. ISO 19111 does not explicitly use these concepts. Geodetic and vertical datums are bound through the Earth in a relatively small number of ways. The necessary parameters to describe these bindings are included in ISO 19111 entities.

Reference datum

It is important to note that datum is used differently in SRM and ISO 19111. In ISO 19111 a datum is more closely aligned with object reference model in the SRM. ISO 19111 does not, for the most part; call out points, lines, curves, planes, surfaces, etc. as distinct classes. They are treated within the context of other objects. Engineering datums are related to plane RDs

Table 3. RD specification fields

Field	Specification	ISO 19111	Comments
RD label	The label (see 12.2.2).	none	
Description	A description of the RD including any common name for the concept.	none	
Position-space representation	The analytic formulation of the RD in position-space	none	ISO 19111 does not deal with this level of abstraction because it is focused on geographic information.
RD code	The code (see 12.2.3).	none	

Table 4. Physical object RD specification fields

Field	Specification		ISO 19111	Comments
RD label	The label (see 12.2.2).			
Description	Description including name as published or as commonly known.		**ellipsoid** alias [alias]	
Physical object	The name of the physical object.		none	In ISO 19111 the object is always the Earth.
Parameters	Oblate spheroid case	Major semi-axis, a Inverse flattening, f^{-1}	**ellipsoid** semi-major axis [semiMajorAxis] **ellipsoid** inverse flattening [inverseFlattening]	ISO 19111 uses the term semi-major axis rather than major semi-axis as this is the more common usage in mapping, charting, and geodesy; i.e., those disciplines most closely associated with geospatial information.
	Sphere case	Radius, r	**ellipsoid** shape [ellipsoidShape] **ellipsoid** semi-major axis [semiMajorAxis]	In ISO 19111, if the ellipsoidShape parameter is true then the ellipsoid is oblate; if false, it is a sphere.
	Prolate spheroid case	Minor semi-axis, a; Major semi-axis, b	none	In ISO 19111, 4.11 the note states "In this International Standard, ellipsoids are always oblate, meaning that the axis of rotation is always the minor axis."
	Tri-axial spheroid case	Semi-axis, a; Semi-axis, b; Semi-axis, c	none	Same as prolate spheroid case
RD code	The code (see 12.2.3).		**ellipsoid** identifier [ellipsoidID]	The ISO 19111 element ellipsoidID serves the same purpose as RD code in the SRM. ISO 19111 does not restrict the ID to a numeric value.
References	The references (see 12.2.5).		**ellipsoid** remarks [remarks] **ellipsoid** identifier [ellipsoidID] **identifiers** **citations**	The general element remarks can be used to capture this information or more formally by linking the ellipsoidID to an instance of **identifiers** that links to an instance of **citations**.

Object reference model

The SRM object reference model (ORM) is similar to an ISO 19111 geodetic or engineering datum, though it is not an exact match. A vertical datum is not an instance of an ORM. ISO 19111 defines datum in traditional geodesy terms and allows for horizontal and vertical datums that have historically been developed independently. Vertical datums are related to SRM Vertical Offset Surfaces (VOS).

The most significant difference between an ORM and a geodetic datum is that a static ORM requires that the relationship of the ORM to a reference ORM be defined. ISO 19111 does not go so far as to recommend/specify a standard reference system for the Earth. This seems to be a deficiency since spatial data sets cannot be merged unless the relationship between their respective coordinates is known.

Table 5. ORMT specification fields

Field	Definition		ISO 19111	Comments
ORMT label	The label (see 12.2.2).		none	ISO 19111 does not require the ORM Template concept since it essentially combines the ORMT_3D_SPHERE and ORMT_3D_OBLATE_SPHERIOD to deal with Earth reference models only.
ORMT specification	Description	A description of an ORM realization of the template.	none	Same
	RD set	A list of RDs in the set.	none	Same
	Binding constraints	Binding constraints.	none	Same
	Notes	Notes.	none	Same
ORMT code	The code (see 12.2.3).		none	Same

Dynamic binding categories

Binding categories are ORMTs that have additional specific binding rules related to certain physical properties of specific types of spatial objects. These are used to facilitate the specification of ORMs such as: equatorial inertial, solar ecliptic, solar equatorial, heliocentric Aries ecliptic, heliocentric planet ecliptic, heliocentric planet equatorial, celestiomagnetic, solar magnetic ecliptic, and solar magnetic dipole ORMs. Those that appear in the SRM are all dynamic and there is no support (nor requirement) for these in ISO 19111.

Table 6. ORM specification fields

Field	Definition	ISO 19111	Comments
Label	The label (see 12.2.2).	**datum** alias [alias]?	This is not an exact match. Description is really a closer match.
Code	The code (see 12.2.3).	**datum** identifier [datumID]	
Date published	Publication date	**datum** realization epoch [realizationEpoch]	The ISO 19111 date reference is really the reference epoch for the datum (i.e., the date of the binding) whereas the Date published implies the publication of some kind of report. The reports are typically published sometime after the binding is defined. It might be more appropriate for SRM to define a date more like the date defined in ISO 19111.
Reference ORM	The label of the reference ORM for this object. If this ORM is the reference ORM for this object, then this field shall contain the object name preceded by the phrase "This is the reference ORM for ".	none	Earth is the only object of concern to ISO 19111 so this field is not required. No compatibility issues.
Published name	The name(s) given to the concept embodied in this ORM in the reference(s).	**datum** alias [alias]	
Region	The approximate subset of object-space to which the model applies expressed as either a spatial extent or the description as specified in the reference.	**datum** valid area [validArea]	
ORMT	The ORM template label.	none	ISO 19111 does not use or require the template concept.
RD parameterization	The label of the ellipsoidal RD, if any; otherwise "N/A".	**ellipsoid**	ISO 19111 would have a corresponding instance of **ellipsoid** for datums that need it.

Field	Definition	ISO 19111	Comments
Binding notes	If the ORM is dynamic, or a time fixed (object fixed) instance of a dynamic ORM, the label of the dynamic binding category (see 7.5). If the ORM is object fixed and the spatial object is a physical object, the date that the ORM component RDs were bound in object-space. This case includes time fixed instances of dynamic ORMs for a physical object. If the ORM is object fixed and the spatial object is Earth, if Greenwich, UK is not contained in the *x*-positive *xz*-half-plane of the embedding, then the significant location contained in the *x*-positive *xz*-half-plane of the embedding shall be specified. Specification of any required binding constraints on the component RDs. Optional binding notes. In the case of abstract ORMs, the string "none".	**datum** anchor point [point] **prime meridian identifier** [meridianID] **prime meridian remarks** [remarks] **coordinate operation** **coordinate operation parameters**	ISO 19111 specifies bindings to the Earth for each datum through anchor points. Geodesists refer to the set of anchor points that bind a datum to the Earth as a terrestrial reference frame. ISO 19111 also specifies a prime meridian when the datum does not reference the Greenwich meridian.
Reference transformation	If the ORM is object fixed, or a time fixed (object fixed) instance of a dynamic ORM, one or more reference transformation specifications (see table 7.16)	See Table 7 below.	ISO 19111 does not specify a standard datum for the Earth so the bindings are not defined through transformation parameters to the standard datum.
Reference	The references (see 12.2.5).	**identifiers** **citations**	References are identified through links to **identifiers** and **citations** using the datumID.

Reference transformation specification

Table 7. Reference transformation specification fields

Field	Definition	ISO 19111	Comments
RT label	The label (see 12.2.2).	**coordinate operation** identifier [coordinateOperation ID] **coordinate operation** version [version]	In the case of Earth ORMs, an RT corresponds to a similarity transformation coordinate operation from the corresponding datum (ORM)/(*x, y, z*) to WGS 1984/(*x, y, z*). There may be several distinct RTs for a given ORM depending on the region and version.
RT Code	The code (see 12.2.3).		
RT Region	A description of the extent and/or the spatial bounds of the region for which this reference transformation is applicable	**coordinate operation** valid area [validArea]	

Field	Definition	ISO 19111	Comments
RT Parameters	The values of the seven parameters shall be specified by value or by reference (see 12.2.5). If by value, the values of the seven parameters $\Delta x, \Delta y, \Delta z, \omega_1, \omega_2, \omega_3,$ and Δs specifying the reference transformation $\boldsymbol{H}_{\mathbf{SR}}$ (see Table 10.1) shall be specified. These values shall be followed by a error estimate expressed in one of the following forms: a. error estimate: unknown b. error estimate: assumed precise c. error estimate (1σ): <parameter name>:<error value> EXAMPLE error estimate (1σ): $\Delta x : 25, \Delta y : 25, \Delta z : 25$. If by reference, this field shall contain a citation(s) for the values of the seven parameters $\Delta x, \Delta y, \Delta z, \omega_1, \omega_2, \omega_3,$ and Δs and error estimates. Terms appearing in the references that are cited for a value shall be enclosed in brackets ({ }). Any parameter value that is not specified in the citation(s) shall be specified as in the "by value" case. To avoid loss of precision, $\omega_1, \omega_2,$ and ω_3 are expressed in arc seconds(") and, in cases of a large rotation, in arc degrees (°). NOTE The rotations $\omega_1, \omega_2,$ and ω_3 must be converted to radians when used in Clause 10 and Clause 11 formulations and in the Bursa-Wolf equation (see Annex B).	**coordinate operation** method name [methodName] = similarity transformation **coordinate operation** method name alias [methodNameAlias] = Helmert transformation **coordinate operation** method formula(s) [formula] = See FCD ISO/IEC 18026 **coordinate operation** method number of parameters [numberOfParameters] = 7 **coordinate operation** parameter name [name] = 1. *x*-axis translation 2. *y*-axis translation 3. *z*-axis translation 4. *x*-axis rotation 5. *y*-axis rotation 6. *z*-axis rotation 7. scale factor **coordinate operation** parameter value [value] = 1. Δx m 2. Δy m 3. Δz m 4. ω_1 radians 5. ω_2 radians 6. ω_3 radians 7. Δs **prime meridian Greenwich longitude** [GreenwichLongitude] = ω_3 radians	Parameter error estimates may be captured as **coordinate operation** parameter remarks [remarks]

Field	Definition	ISO 19111	Comments
Date published	The date that the RT was published.	**coordinate operation** method remarks [methodRemarks]	
References	The references (see 12.2.5), or "none" if defined in this International Standard.	**coordinate operation** method remarks [methodRemarks]	

Spatial Reference Frames (clause 8)

The SRM concept of a spatial reference frame (SRF) shares the same hierarchical location in the SRM as the coordinate reference system (CRS) holds in the ISO 19111 model. Both the SRF and CRS collect together all the information required to define a specific coordinate system for an object (Earth only in the case of ISO 19111). ISO 19111 does not support the related concepts of SRF Templates, SRF Sets, and SRF Set Members that allow SRFs to be grouped into logical collections. An SRF template (SRFT) is an abstraction of a set of specifications of SRFs that share the same CS and coordinate component names, whose ORM components are similar, that model the same type of spatial object, and that share the same CS parameter binding rules. An SRFT facilitates the specification of individual SRFs. It is not a requirement to use an SRFT to specify an SRF.

Table 8. SRFT specification elements

Element	Definition	ISO 19111	Comments
Label	The label (see 12.2.2).	none	
Code	The code (see 12.2.3).	none	
Description	A description including name as published or as commonly known.	none	
Object type	One or more of: abstract, physical, Earth, planet, satellite, and Sun; and, optionally, additional restrictions.	none	ISO 19111 deals only with the Earth so this concept is not used or required.
ORM constraint	Criteria for allowable ORMs.	none	
CS label	The label of a CS of compatible type.	none	
CS coordinate names and/or symbols	SRF-specific names and/or symbols for the k^{th}-coordinate component names and/or symbols. If all coordinate component names and symbols are the same as the CS, the phrase "Same as the CS." shall be used. The vertical coordinate component shall be designated in this field if applicable.	none	The vertical coordinate component is explicitly identified because the origin of the vertical coordinate component may be offset to a VOS (clause 9). This allows for compound CRS vertical datum functionality. The VOS is undefined for many local geodetic datums that utilize independently determined local mean sea level heights.
Template parameters	CS and RD parameters, if any, and/or SRF parameters that are not specified by a CS parameter binding rule.	none	

Element	Definition	ISO 19111	Comments
CS parameter binding rules	A set of rules for binding for CS parameters and RD class parameters, if any, and/or SRF parameters.	none	
Coordinate valid region	Optional restriction of the domain of the CS to a valid region. If a valid region is specified, optionally an extended valid region. If both are unspecified, then there are no additional constraints on coordinate validity.	none	
Notes	Optional, additional, non-normative information such as a description of the SRF structure, modelled region, intended use, and/or application domain.	none	
References	The references (see 12.2.5).	none	

Table 9. SRF specification elements

Element	Definition	ISO 19111	Comments
Label	The label (see 12.2.2).		
Code	The code (see 12.2.3).	**coordinate reference system** identifier [CRSID]	This element from serves the same purpose as the SRF Code but ISO 19111 does not restrict it to a numeric code. This is a match only to the extent that an SRF corresponds to a CRS.
Short name	A short name as published or as commonly known and an optional description.	**coordinate reference system** alias [alias]	
SRF Template	The label of the applicable SRF template.	none	This concept is not used in ISO 19111. Given the scope of ISO 19111, this concept is probably not necessary.
ORM	The label of the applicable ORM.	**datum** identifier [datumID]	

Element	Definition	ISO 19111	Comments
Valid-region	Optional restriction of the domain of the CS to a valid-region description and/or a valid-region specification. If a valid-region is specified, optionally, an extended valid-region may be specified. Valid-region specifications and extended valid-region specifications are specified by value or by reference. Terms appearing in the references that are cited for a value shall be enclosed in brackets ({ }).	**coordinate reference system** valid area [validArea]	This is a match.
Parameter values	The SRF template parameter values specified by value or by reference. If by reference, this field shall contain a citation(s) for the SRF template parameters values. Terms appearing in the references that are cited for a value shall be enclosed in brackets ({ }). Any parameter value that is not specified in the citation(s) shall be specified by value.	**coordinate operation** **coordinate operation parameters**	In ISO 19111, the parameters of map projection SRFs are considered to be coordinate conversion parameters. ISO 19111 associates coordinate operations with CRSs and defines parameters based on the definitions of the CRS.
Notes	Optional, additional, non-normative information concerning the SRF, such as description of its structure, modelled region, intended use, and/or application domain.	**coordinate reference system** scope [scope]	ISO19111 is more restricted on this field in that it only provides information about the application of the CRS not the additional information supported by the SRF Notes element.
References	The references (see 12.2.5).	**identifiers** **citation**	References are handled in ISO 19111 through the identifiers and citation entities.

Table 10. SRF set specification elements

Element	Definition	ISO 19111	Comments
Label	The label (see 12.2.2).	none	
Code	The code (see 12.2.3).	none	
Short name	A short name as published or as commonly known and an optional description.	none	
SRFT	The label of the applicable SRFT.	none	

Element	Definition	ISO 19111	Comments
ORM constraints	Criteria for allowable ORMs. Specifying a single ORM indicates that only that ORM shall be used.	none	
Coverage description	Optional description of the region corresponding to the union of the valid regions of all of the set members	none	
SRF set membership	A specification of the parameterization of the set members, by listing or parameter algorithm. A specification of the parameterization of the set members by listing or parameter algorithm, and valid-region descriptions or valid-region specifications. If valid-region specifications are included, extended valid-region specifications may also be included.	none	
Notes	An optional description of the structure, modelled region, intended use, and/or application domain of the SRF set.	none	
References	The reference type (see 12.2.5).	none	

Table 11. SRF set member specification elements

Element	Definition	ISO 19111	Comments
SRF set label	The label of the SRF set (see 12.2.2).	none	
Label	The label (see 12.2.2).	none	
Code	The code (see 12.2.3); the set member parameter.	none	
Description	A description including name as published or as commonly known.	none	
Region	A valid region description. Optionally an extended valid region description.	none	
Parameter values	The SRFT parameter values.	none	
Notes	Optional, additional, non-normative information concerning the SRF set member.	none	

Vertical Offset Surfaces (clause 9)

ISO 19111 treats vertical references surfaces as vertical datums (reference for height coordinate only). Therefore, the same structure is used to capture information about vertical reference surfaces as is used to describe horizontal systems. This is the basis for the compound coordinate reference system that combines a 2D geodetic system with a gravity-related height (mean sea level, orthometric height, etc.). This construct is required to deal with the fact that many local datums establish horizontal and vertical coordinates through virtually independent processes. When this is the case, height above the local datum ellipsoid is undefined and the conversion to Euclidean 3D coordinates is problematic. SRM does not account for this problem. The SRM treats these heights as an operation on ellipsoidal height that offsets the axis origin. In these cases the SRM API ChangeCoordinate3DSRF methods deals with ellipsoidal height only, so that a 3D coordinate cannot be inter-converted unless the offset value is known. However, using the same SRFs, the ChangeSurfaceCoordinateSRF method operates independently of any vertical offset values.

A VOS is conceptually equivalent to the set of zero heights in a vertical datum CRS. However, the zero heights in a vertical datum CRS are frequently not related to an ellipsoid (RD) but to one or more tide gauge stations. Ellipsoidal heights are generally only available for geocentric datums like WGS 84, ITRF, etc.

Table 12. Vertical offset surface specification elements

Element	Definition	ISO 19111	Comments
Label	The label (see 12.2.2).	none	ISO 19111 does not use this concept.
Code	The code (see 12.2.3).	**datum** identifier [datumID]	ISO 19111 allows characters?
Description	The published name of the vertical offset surface.	**datum** alias [alias]	
ORM	The ORM reference.	none	ISO 19111 allows for a vertical datum to be defined independent of a local horizontal datum. This type of reference is not required
Global/local	Specifies whether the vertical offset surface is only a local vertical offset surface.	**datum** valid area [validArea]	ISO 19111 allows more specificity than SRM.
Notes	Additional, non-normative information.	**datum** remarks	
References	The references (see 12.2.5).	**datum** identifier [datumID] **identifiers** **citations**	

ISO 19111 to Spatial Reference Model

Table 13. Type of coordinate reference system

Element	Definition	Spatial Reference Model	Comments
Coordinate reference system type code [typeCode]	Code denoting the type of coordinate reference system: 1 – a single coordinate reference system 2 – a compound coordinate reference system	None	1 indicates an SRF 2 indicates an SRF plus VOS
Coordinate reference system remarks [remarks]	Comments on the coordinate reference system including source information.	Table 8.29 SRF specification elements Field: Notes	This ISO 19111 element is optional.

Table comments: (ISO 19111 Table 1). The SRM does not define compound coordinate systems, but it does define the concept of using a vertical offset for the origin of a vertical coordinate component.

Table 14. Coordinate reference system

Element	Definition	Spatial Reference Model	Comments
Coordinate reference system identifier [CRSID]	Identifier of the coordinate reference system.	SRF Label/Code ***or*** SRF Set and SRF Set Member Labels/Codes ***or*** SRF Template Label/Code + SRF Template parameter values including ORM Label/Code	Any of these completely specifies an SRF and thereby identifies a specific SRF.
Coordinate reference system alias [alias]	Alternative name or identifier by which this coordinate reference system is known.	Table 8.29 SRF specification elements Field: Short name	Field definition: "A short name as published or as commonly known and an optional description." This ISO 19111 element is optional.
Coordinate reference system valid area [validArea]	Area for which the coordinate reference system is valid.	SRF Region	Direct correlation between ISO 19111 and the SRM.
Coordinate reference system scope [scope]	Application for which the coordinate reference system is valid.	Table 8.29 SRF specification elements Field: Notes	Field definition: " Optional, additional, non-normative information concerning the SRF, such as a description of its structure, modelled region, intended use, and/or application domain." This ISO 19111 element is optional.

Table comments: (ISO 19111 Table 2). A Coordinate Reference System (CRS) is not synonymous with an SRF because it does not contain all the elements present in the SRF. An SRF is essentially an instance of CRS along with any concatenated coordinate operations or coordinate operations required to relate the CRS coordinates to Earth-centered, Earth-fixed Cartesian coordinates

Table 15. Compound coordinate reference system

Element	Definition	Spatial Reference Model	Comments
Compound coordinate reference system identifier [CCRSID]	Identifier of the compound coordinate reference system.	None	A VOS has a label and code.
Compound coordinate reference system alias [alias]	Alternative name or identifier by which this compound coordinate reference system is known.	None	VOS Description field includes the published name.
Compound coordinate reference system valid area [validArea]	Area for which the compound coordinate reference system is valid.	None	VOS Local/Global and Notes fields.
Compound coordinate reference system scope [scope]	Application for which the compound coordinate reference system is valid.	None	VOS Notes field.

Table comments: (ISO 19111 Table 3, all elements in this table are optional). This concept is not completely supported by the SRM. The SRM does allow for height origins to be offset based on the surface implied by a vertical datum. Most local geodetic datums define only the latitude and longitude with respect to the reference ellipsoid. Heights are determined independently with respect to some realization of mean sea level. The relationship between the local ellipsoid and mean sea level is generally unknown. When this relationship is known, then coordinate operations are fully supported since these heights can be inter-converted to ellipsoidal height. When this relationship is unknown, then many SRF operations are not supported.

Table 16. Datum

Element	Definition	Spatial Reference Model	Comments
Datum identifier [datumID]	Identifier of the datum.	ORM Code/Label; VOS Code/Label	
Datum alias [alias]	Alternative name or names by which this datum is known.	ORM Published name. VOS description	ORM Field definition: “The name(s) given to the concept embodied in this ORM in the reference(s).” VOS Field definition: “The published name” This ISO 19111 element is optional.

Element	Definition	Spatial Reference Model	Comments
Datum type [type]	Type of datum. Valid values are: ▪ geodetic, ▪ vertical, or ▪ engineering	ORM or VOS.	SRM is much more restrictive with respect to vertical datums in that requires them to be referenced somehow to an ellipsoid. For many elevation data sets, this relationship is unknown. Some lococentric SRFs have an implied engineering datum. This ISO 19111 element is optional.
Datum anchor point [point]	Description including coordinates of the point or points used to anchor the datum to the Earth.	None. This information could be include in ORM field Binding information under "Optional binding notes"	This ISO 19111 element is optional. The SRM is concerned with the relationships between datums but not with the details of the process used to establish a datum.
Datum realization epoch [realizationEpoch]	Epoch of realization of the datum.	ORM field: Date published	This ISO 19111 element is optional. The date reference is really the reference epoch for the datum (i.e., the date of the binding) whereas the Date published implies the publication of some kind of report. The reports are typically published sometime after the binding is defined. It might be more appropriate for SRM to define a date more like the date defined in ISO 19111.
Datum valid area [validArea]	Area for which the datum is valid.	ORM field:Region; VOS fields:Global/local and Notes.	ORM reference transformations (RT) also have a Region field. This ISO 19111 element is optional.
Datum scope [scope]	Application for which the datum is valid.	None	This ISO 19111 element is optional.
Datum remarks [remarks]	Comments on the datum including source information.	ORM field:References VOS fields: Notes, References	This ISO 19111 element is optional.

Table comments: (ISO 19111 Table 4). An ISO 19111 geodetic or engineering datum is a special case of an SRM object reference model (ORM). The zero height surface of an ISO 19111 vertical datum corresponds to an SRM vertical offset surface. It is important to note that the relationship between a vertical datum and the ellipsoid associated with the local horizontal datum is frequently unknown. This condition limits the operations that can be performed on such an SRF within the SRM.

Table 17. Prime meridian

Element	Definition	Spatial Reference Model	Comments
Prime meridian identifier [meridianID]	Identifier of the prime meridian	(Part of) ORM field: Binding information	"If the ORM is object fixed and the spatial object is Earth, if Greenwich, UK is not contained in the *x*-positive *xz*-half-plane of the embedding, then the significant location contained in the *x*-positive *xz*-half-plane of the embedding shall be specified."

Element	Definition	Spatial Reference Model	Comments
Prime meridian Greenwich longitude [GreenwichLongitude]	Longitude of the prime meridian measured from the Greenwich meridian, positive eastward. If the datum type is geodetic and the prime meridian name is not supplied, then the prime meridian is taken to be "Greenwich" and the prime meridian longitude is taken to be "0°".	(Part of) Reference transformation field "RT parameters" for the ORM: The value of RT parameter ω_3.	
Prime meridian remarks [remarks]	Comments on the prime meridian including source information	(Part of) ORM Binding information. ORM field: References	This ISO 19111 element is optional.

Table comments: (ISO 19111 Table 5). An SRM prime meridian is always the half ellipse formed by the intersection of the ellipsoid with the *x*-positive *xz*-half-plane. An ISO 19111 prime meridian is a full ellipse as defined in 4.25 although the note to 4.25 allows that the term may be used to refer to the pole-to-pole arc.

Table 18. Ellipsoid

Element	Definition	Spatial Reference Model	Comments
Ellipsoid identifier [ellipsoidID]	Identifier of the ellipsoid for the datum.	RD Code/Label;	
Ellipsoid alias [alias]	Alternative name or names of the ellipsoid.	RD Code/Label; Celestial object RD Description	Description field definition: "The description including the name as published or as commonly known." This ISO 19111 element is optional.
Ellipsoid semi-major axis [semiMajorAxis]	Length of the semi-major axis of the ellipsoid.	(Part of) Physical object RD field Parameters: major semi-axis *a* ***or*** radius *r*.	SRM uses the mathematically correct term major semi-axis. However, the term semi-major axis is so prolific in the field of geodesy that common use may prevail and ISO 19111 retain this terminology. It is important to note that OGC retained this term in their revision of ISO 19111.
Ellipsoid shape [ellipsoidShape]	Boolean = TRUE when the reference surface is an ellipsoid, FALSE when the reference surface is a sphere.	(Part of) Physical object RD field Parameters: oblate ellipsoid or sphere	ISO 19111 restricts itself to oblate ellipsoids with the special case of a sphere where flattening is zero.
Ellipsoid inverse flattening [inverseFlattening]	Inverse flattening of the ellipsoid. Unitless. Condition 1 (cd 1): Mandatory if *ellipsoid shape* is true.	(Part of) Physical object RD field Parameters: inverse flattening	
Ellipsoid remarks [remarks]	Comments on or information about the ellipsoid.	Physical object RD field: References (This is not a direct match.)	This ISO 19111 element is optional.

Table comments: (ISO 19111 Table 6). An ISO 19111 ellipsoid is corresponds to a type of SRM reference datum (RD), which forms part of an ORM binding. This type of RD is commonly used in the SRM to model celestial objects.

Table 19. Coordinate system

Element	Definition	Spatial Reference Model	Comments
Coordinate system identifier [CSID]	Identifier of the coordinate system.	Coordinate system Code/Label Coordinate system field: Description	Description field definition: "A description of the CS including any common name."
Coordinate system type [type]	Type of the coordinate system. The most commonly used entries are: ▪ Cartesian ▪ geodetic ▪ projected ▪ polar ▪ gravity-related Do not use Cartesian if the system is projected.	(Part of) CS Type	SRM defines coordinate system types of 3D linear, 3D curvilinear, surface linear, surface curvilinear, map projection, 2D linear, 2D curvilinear, 1D linear, or 1D curvilinear
Coordinate system dimension [dimension]	Number of coordinates {3,2,1} in the set.	Coordinate system field: CS_Type	1 -> CS_Type: 1D ***or*** plane curve ***or*** space curve 2 -> CS_Type: 2D ***or*** surface 3 -> CS_Type: 3D
Coordinate system remarks [remarks]	Comments on or information about the coordinate system.	Coordinate system fields: Figure Notes References	This ISO 19111 element is optional.

Table comments: (ISO 19111 Table 7). An ISO 19111 coordinate system is similar to an SRM coordinate system. ISO 19111 models the coordinate system axes, operations, and operation parameters as distinct objects, rather than as properties of the coordinate system.

Table 20. Coordinate system axis

Element	Definition	Spatial Reference Model	Comments
Coordinate system axis name [axisName]	Name of the coordinate system axis.	Coordinate system field: Coordinate components. (This is not an exact match.) Also SRF field: CS coordinate component names and/or symbols	Field definition: "Coordinate component symbols and common names." Example: ISO19111 axis name "N" corresponds to SRM "northing: *u*" An SRF may specify alternate names and/or sysmbols.

Element	Definition	Spatial Reference Model	Comments
Coordinate system axis direction [axisDirection]	Direction of the coordinate system axes (or, in the case of Cartesian or projected coordinates, the direction of the coordinate system axis at the origin). Examples: north, east, up	None	A CS Code/Label identifies a complete specification with respect to position-space. This information is fully determined when a coordinate system is combined with an ORM as part of an SRF.
Coordinate system axis unit identifier [axisUnitID]	Identifier of the unit for the coordinate system axis.	Metre or radian unless specifically identified otherwise.	Units are treated as a coordinate operation in ISO 19111. In the SRM units are treated as part of the specification of a value.

Table comments: (ISO 19111 Table 8). ISO 19111 coordinate system axes do not map to distinct SRM objects, but map to some of the properties of SRM coordinate systems.

Table 21. Coordinate operation

Element	Definition	Spatial Reference Model	Comments
Coordinate operation identifier [CoordinateOperationID]	Identifier of the coordinate operation.	API method name	SRM coordinate system operations are not distinct objects.
Coordinate operation valid area [validArea]	Area for which the coordinate operation is valid.	CS Domain of the generating function or mapping equations; CS Domain of the inverse of the generating function or mapping equations.	Change SRF operations use Valid region specifications of the source and target SRFs. This ISO 19111 element is optional.
Coordinate operation scope [scope]	Application for which the coordinate operation is valid.	None	SRM operations are generic. This ISO 19111 element is optional.
Source coordinate reference system identifier [sourceID]	Identifier of the source coordinate reference system. Condition 2 (cd 2): Mandatory if describing a coordinate transformation	SRF API object	An SRF API object instantiation has an HSR_Code (representing an RT) as a conditional input.
Target coordinate reference system identifier [targeteID]	Identifier of the target coordinate reference system. cd 2	SRF API object	An SRF API object instantiation has an HSR_Code (representing an RT) as a conditional input.
Coordinate operation version [version]	Version of the coordinate operation between the source coordinate reference system and the target coordinate reference system. cd 2	None	Some operations require HSR_Codes which may represent several versions of a datum RT.

Element	Definition	Spatial Reference Model	Comments
Coordinate operation method name [methodName]	Name of the algorithm used for the coordinate operation. Example (in case of coordinate transformation): - Abridged Molodenski - Similarity transformation Example (in case of coordinate conversion): - Cartesian into ellipsoidal - Universal Transverse Mercator - Mercator - Lambert Conformal Conic - Albers equal area - Stereographic - meters to feet - radians to degrees Condition 3 (cd 3): Mandatory either (i) if describing a projected coordinate system and none of *coordinate reference system citation*, *coordinate system citation*, or *coordinate operation citation* is supplied, or (ii) if describing a single coordinate conversion or a coordinate transformation.	CS Function Type; (Part of) CS Properties	Abridged Molodenski is not supported in the SRM. Projection methods are specified as part of a CS specification (mapping and inverse mapping equations). Unit specifications are not treated as an operation.
Coordinate operation method name alias [methodNameAlias]	Alternative name or names of the coordinate operation method identifier.	None	This ISO 19111 element is optional.
Coordinate operation method formula(s) [formula]	Formula(s) used by the coordinate operation method. This may be a reference to a publication.	CS Generating function or mapping equations; CS Inverse of the generating function or mapping equations; CS References	API functionality is fully specified within the SRM. Part of the formulation required for some ISO 19111 operations appear as part of an SRM coordinate system specification. A map projection mapping equation corresponds to a coordinate operation formula when the operation is "projection". Coordinate operations "to Cartesian" correspond to a generating function. Coordinate operations "from Cartesian" correspond to an inverse generating function.

Element	Definition	Spatial Reference Model	Comments
Coordinate operation method number of parameters [numberOfParameters]	Number of parameters required by this coordinate operation method.	N/A	
Coordinate operation remarks [remarks]	Comments on or information about the coordinate operation method. It is often useful to include an example. This may define a time dependent parameter such as epoch.	None.	This ISO 19111 element is optional.

Table comments: (ISO 19111 Table 9). ISO 19111 coordinate operations do not map to distinct SRM objects, but map to some of the properties of SRM coordinate systems.

Table 22. Coordinate operation parameters

Element	Definition	Spatial Reference Model	Comments
Coordinate operation parameter name [name]	Identifier of the coordinate operation parameter that is defined or used with this coordinate operation method. The parameters differ among coordinate operation methods. Example (in case of coordinate transformation): - geocentric *x* translation - geocentric *y* translation - geocentric *z* translation Example (in case of coordinate conversion): - latitude of origin - longitude of origin - scale factor - false easting - false northing	Projection parameters: SRF parameters and constraints. Similarity transformation: Source and target HSR_Code ***or*** an H_{ST} API object.	Some parameters are named in a corresponding SRF Template (example: all map projection SRFTs). Conditional HST instances have parameter values named in the HST data structure. Some operations require a coordinate(s) or directions. These are represented by data types with named elements.
Coordinate operation parameter value [value]	Value of the coordinate operation parameter	Various SRM API object creation inputs.	API units are metres and radians. Conforming implementations may accommodate other units.
Coordinate operation parameter remarks [remarks]	Comments on or information about the coordinate operation parameter.	(Part of) SRF parameters and constraints; (Part of) SRF Notes	This ISO 19111 element is optional.

Table comments: (ISO 19111 Table 10). ISO 19111 coordinate operation parameters do not map to distinct SRM objects, but map to (parts of) some of the properties of SRM SRFs and other objects.

Table 23. Concatenated coordinate operation

Element	Definition	Spatial Reference Model	Comments
Concatenated coordinate system operation identifier [concatOpID]	Identifier of the concatenated coordinate operation.	None	
Concatenated coordinate system operation number of steps [numberOfSteps]	Number of steps in the concatenated coordinate operation.	None	
Concatenated coordinate system operation step sequence [stepID]	Identifier for each of the steps in this concatenated coordinate operation. The order is significant and shall reflect the order in which the steps shall be performed. The number provided shall be consistent with the value for *concatenated coordinate operation number of steps*.	None	
Concatenated coordinate system operation valid area [validArea]	Area for which the coordinate operation is valid.	None	This ISO 19111 element is optional.
Concatenated coordinate system operation scope [scope]	Application for which the coordinate operation is valid.	None	This ISO 19111 element is optional.
Concatenated coordinate system operation remarks [remarks]	Comments on or information about the concatenated coordinate operation.	None	This ISO 19111 element is optional.

Table comments: (ISO 19111 Table 11) ISO 19111 concatenated coordinate operations do not map to any type of SRM object.

Table 24. Identifiers

Element	Definition	Spatial Reference Model	Comments
Identifier [identifier]	Name or identifier of the class or attribute.	Label or Code	This element is a character-string and may be human-readable.
Citation [citation]	Citation.		This ISO 19111 element is optional.

Table comments: (ISO 19111 Table 12). All SRM labels and codes are unique in their separate code spaces. An SRM labels are intended to be a human readable equivalent of a machine-readable code.

Table 25. Citation

Element	Definition	Spatial Reference Model	Comments
Citation title [title]	Name by which the cited information is known, e.g., the author or authors of the cited source, the title of the cited source or publication.		
Citation alternative title [alternativeTitle]	Alternative title or subtitle of cited source.		This ISO 19111 element is optional.
Citation date [data]	Date of cited source or publication.		Typographic error: UML identifier should be “date” not “data”
Citation edition [edition]	The number of edition.		This ISO 19111 element is optional.
Citation edition date [editionDate]	Date of the edition.		This ISO 19111 element is optional.
Citation identifier [identifier]	Place of publication, publishing house.		Does not seem like an appropriate element name for this definition. This ISO 19111 element is optional.
Citation identifier type [identifierType]	Reference form of the identifier.		It is not clear from the definition what information the element contains. This ISO 19111 element is optional.
Citation cited responsible party [citedResponsibleParty]	Responsible party for citation.		Is this the party responsible for the citation or the cited publication? This ISO 19111 element is optional.
Citation presentation form code [presentationFormCode]	Mode in which the data is presented.		Need examples! This ISO 19111 element is optional.

Element	Definition	Spatial Reference Model	Comments
Citation series name [seriesName]	Name of a series of the cited source.		This ISO 19111 element is optional.
Citation issue identification [issueIdentification]	Issue number of periodical		This ISO 19111 element is optional.
Citation collective title [collectiveTitle]	Common title with holdings note.		This ISO 19111 element is optional.
Citation page [page]	Details, on which pages of the periodical the article was published.		This ISO 19111 element is optional.
Citation ISBN [ISBN]	International Standard Book Number		This ISO 19111 element is optional.
Citation ISSN [ISSN]	International Standard Serial Number		This ISO 19111 element is optional.
Citation other citation details [otherCitationDetails]	Comments on the cited source.		This ISO 19111 element is optional.

Table comments: (ISO 19111 Table 13). SRM standard citations appear in the normative references clause or in the Bibliography.

ISO 19111 Annex E examples represented as SRM data elements

EXAMPLES E.1 and E.2

An SRF specified as:

a) Short name: NAD27/Alaska zone 27
b) SRFT: TRANSVERE_MERCATOR
c) ORM: N_AM_1927
d) SRFT template parameter values
    a. longitude of origin 54 arc degrees
    b. latitude of origin -150 arc degrees
    c. central scale 0.9999
    d. false easting 500000(12/39.37)m
    e. false northing 0
e) Valid region: -
f) Notes: Corresponds to ESPG coordinate reference system identifier 26734

EXAMPLE E.3

An SRF specified as:

SRF GEODETIC_WGS_1984

This SRF label is equivalent to its specification in the SRM:

a) SRF Label: GEODETIC_WGS_1984
b) SRF Code: 6
c) Short name: Geodetic WGS 1984
d) SRFT: CELESTIODETIC
e) ORM: WGS_1984
f) Valid-region: Valid-region description: Earth, global
g) SRFT Parameter values: none
h) Notes: Mass centered.
i) References: [83502T, Chapter 3]

The ORM label is equivalent to its specification in the SRM:

a) ORM Label WGS_1984
b) ORM Code: 274
c) Published name: World Geodetic System
d) Reference ORM: This is the reference ORM for Earth.
e) Binding information: 1984 Note: The x-positive *xz*-half-plane contains Greenwich, UK.
f) Region: Earth, global
g) ORMT: OBLATE_ELLISPOID
h) RD Parameterization: RD WGS_1984
i) References [83502T]

The RD label is equivalent to its specification in the SRM:

a) RD label: WGS_1984
b) RD Code: 145
c) Description: World Geodetic System
d) Major semi-axis: 6 378 137
e) Inverse flattening: 298,257 223 563
f) Error estimate: Assumed precise
g) Date: 1984
h) References: [83502T, App. A-1, "WE"]

EXAMPLE E.4

An SRF specified as:
SRF GEOCENTRIC_WGS_1984

This SRF label is equivalent to its specification in the SRM:
a) SRF Label: GEOCENTRIC_WGS_1984
b) SRF Code: 4
c) Short name: Geocentric WGS 1984
d) SRFT: CELESTIOCENTRIC
e) ORM: WGS_1984
f) Valid-region: Valid-region description: Earth, global
g) SRFT Parameter values: none
h) Notes: Mass centred.
i) References: [83502T, Chapter 2.1]

EXAMPLE E.5

An SRF specified as:
a) Short name: OSGB36
b) SRFT: CELESTIODECTIC
c) ORM: OSGB_1936
d) Valid-region: -
e) SRFT Parameter values: none
f) Notes: Corresponds to ISO 19111 Example E.5
g) References: [ISO 19111]

plus VOS (Ordnance datum Newlyn is not specified or registered in the SRM). Ordnance Datum Newlyn cannot be registered as a VOS because its relationship to the RD for OSGB_1936 is unknown. This example cannot be completely mapped to SRM data elements.

EXAMPLE E.6

a) Source SRF specified as
SRF WGS_1984
b) Target SRF specified as
a. SRFT CELESTIOCENTRIC
b. ORM EUROPE_1950
c. RT MEAN_SOULTION
c) API Method ChangeCoordinate3DSRF

The RT label for ORM EUROPE_1950 is equivalent to its specification in the SRM:
a) RT Label: MEAN_SOLUTION
b) RT Code: 16
c) RT Region: Mean Solution (Austria, Belgium, Denmark, Finland, France, FRG, Gibraltar, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden and Switzerland);
$+30^{o} \leq \phi \leq +80^{o}$;
$+5^{o} \leq \lambda \leq +33^{o}$
d) RT parameters: $\Delta x = 87$, $\Delta y = 98$, $\Delta z = 121$, $\omega_1 = \omega_2 = \omega_3 = 0''$: precise, $\Delta s = 0$: precise
e) Date published: 1950
f) References: [83502T, App. B.5, "EUR-M"]

EXAMPLE E.7

Example E.7 is a compound CRS.

The first CRS corresponds to the 3D SRF specified as:
a) Short name: ETRS89/(x, y, z)

b) SRFT CELESTIOCENTRIC
c) ORM ETRS_1989
d) Valid-region: Valid-region description: Europe
e) Notes: Corresponds to ISO 19111 Example E.7
f) References: [ISO 19111]

The second CRS is 1-D CRS corresponding to the specification of a VOS.
VOS United European Leveling Network-95/98 is not specified or registered in the SRM.

The dimension of the compound CRS is 4 = 3+1. The SRM does not support 4 dimensional spatial SRFs.

This is an unusual example because it provides a 3D position and a normal height. Normal height is ellipsoidal height of a point Q along the plumbline through point P where the actual gravity potential at point P (W_P) is equal to the ellipsoidal gravity potential at point Q (U_Q). Normal heights are very commonly used in vertical datum definitions in Europe. They are close to, but not identical, to heights relative to the geoid. If the celestiocentric coordinate is converted to 3D geodetic, then the VOS can be computed for UELN-95/98. This is, in fact, example E.8.

EXAMPLE E.8

The formula for relating Ellipsoidal height to a vertical offset height is given in clause 9 of the SRM.
Note that example formula appears to use an elevation (UELN) with an unrelated VOS separation (EGG97). Note that the European Gravimetric Quasigeoid (EGG97) and UELN are both relative to the same ellipsoid. The quasigeoid is the height difference between the point P on the surface of the Earth and the point Q along the plumbline through the point P where the ellipsoidal gravity potential is equal to the true gravity potential at point P, i.e., the difference between the ellipsoidal height and normal height of a given point.

EXAMPLE E.9

This example is by citation.
Note: It is not clear how a pair of 2 dimensional CRSs can be treated as a (single) source CRS within the ISO 19111 framework.

Engineering coordinate reference systems are represented by the following SRFTs:
LOCAL_SPACE_RECTANGULAR_3D
LOCAL_SPACE_RECTANGULAR_2D
LOCAL_TANGENT_SPACE_EUCLIDEAN
and others.

This is a standard photogrammetric model for extracting 3D coordinates from two separate 2D projections of the 3D space. This construction is not currently supported by the SRM.