# Reference frames, deformation models and transformations

# Glossary and description of terms

v04 draft 2021-11-15 – Richard Stanaway (RS) including Roger Lott (RL) comments 2021-11-09 and feedback from Chris Crook (CC) and Kevin Kelly (KK)

**structure of glossary entries**

1. title (bold) – glossary term
2. abbreviation (in bold) (if any)
3. alternate name for term (if any in ( ) )
4. context (within <>) if term has wider usage outside geodesy
5. description – One or two sentence description of term
6. note to entry – Elaboration of the description to provide more context and examples of usage.
7. source (within [ ] ) – citing reference if used in other geodesy standards documents
8. discussion on draft definition

**spelling convention:**

American English - *The Merriam-Webster Dictionary (MWD)* as used by OGC documents

**treatment of synonyms**

Where alternate names are widely used for a glossary term, these are noted below the term title in brackets. To avoid duplication, a description is only provided for the primary title.

**sourcing references:**

*ISO 19111:2019 Geographic information — Referencing by coordinates*

*ISO 19161-1 Geodetic references - Part 1: The international terrestrial reference system (ITRS)*

*IERS Conventions TN36 (2010), revision 1.3.0, 1st April 2019.*

*MWD – Merriam-Webster Dictionary*

*RS Comment: A contextual summary and hierarchy as a preamble would be helpful*

**Glossary**

Cartesian coordinate system

coordinate system in Euclidean space which gives the position of points relative to *n* mutually perpendicular straight axes all having the same unit of measure

Note 1 to entry: *n* is 2 or 3 for the purposes of this document.

Note 2 to entry: A Cartesian coordinate system is a specialisation of an affine coordinate system.

[ISO 19111:2019, 3.1.2]

component

<geodesy>

number that is part of an ordered coordinate or vector quantity

conventional terrestrial reference system

CTRS

generic terrestrial reference system (TRS) specified by a list of conventional rules fixing its origin scale and orientation

[IERS Conventions TN36 (2010)]

coordinate

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

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

[ISO 19111:2019, 3.1.5]

coordinate conversion

coordinate operation that changes coordinates in a source coordinate reference system to coordinates in a target coordinate reference system in which both coordinate reference systems are based on the same datum

Note 1 to entry: A coordinate conversion uses parameters which have specified values.

EXAMPLE 1 A mapping of ellipsoidal coordinates to Cartesian coordinates using a map projection.

EXAMPLE 2 Change of units such as from radians to degrees or from feet to metres.

[ISO 19111:2019, 3.1.6]

coordinate epoch

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

[ISO 19111:2019, 3.1.7]

coordinate operation

process using a mathematical model, based on a one-to-one relationship, that changes coordinates in a source coordinate reference system to coordinates in a target coordinate reference system, or that changes coordinates at a source coordinate epoch to coordinates at a target coordinate epoch within the same coordinate reference system

Note 1 to entry: Generalization of coordinate conversion, coordinate transformation and point motion operation.

[ISO 19111:2019, 3.1.8]

coordinate reference system

CRS

coordinate system that is related to an object by a datum

Note 1 to entry: Geodetic and vertical datums are referred to as reference frames.

Note 2 to entry: For geodetic and vertical reference frames, the object will be the Earth. In planetary applications, geodetic and vertical reference frames may be applied to other celestial bodies.

[ISO 19111:2019, 3.1.9]

**coordinate system**

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

[ISO 19111:2019, 3.1.11]

**coordinate transformation**

(datum transformation)

coordinate operation that changes coordinates in a source coordinate reference system to coordinates in a target coordinate reference system in which the source and target coordinate reference systems are based on different datums

Note 1 to entry: A coordinate transformation uses parameters which are derived empirically. Any error in those coordinates will be embedded in the coordinate transformation and when the coordinate transformation is applied the embedded errors are transmitted to output coordinates.

Note 2 to entry: A coordinate transformation is colloquially sometimes referred to as a 'datum transformation'. This is erroneous. A coordinate transformation changes coordinate values. It does not change the definition of the datum. In this document coordinates are referenced to a coordinate reference system. A coordinate transformation operates between two coordinate reference systems, not between two datums.

[ISO 19111:2019, 3.1.12]

RS comment: Should a coordinate transformation between two CRS referenced to the same datum be referred to as a coordinate conversion?

**coseismic displacement**

instantaneous or near instantaneous displacement attributable to an earthquake

**coseismic displacement model**

(deformation patch)

model of corrections to a CRS caused by instantaneous coseismic displacement at a specific epoch

**crust**

<Earth>

uppermost layer of the solid Earth

RS comment: Crustal thickness varies according to tectonic position from near zero to 10 km for oceanic crust and up to 70 km thick for continental crust. The Earth's crust is divided into tectonic plates which move over the underlying mantle. The boundary zones between tectonic plates are deforming zones.

RS comment: Crust is implied as the Earth surface at the level of bedrock or stable substratum.

**crust-based terrestrial reference frame**

TRF currently determined within the IERS activities, either by analysis centers or by combination centers, and ultimately as IERS products

[IERS Conventions TN36 (2010) Ch. 4]

RS comment: Crust-based means a reference frame with monuments that are fixed to the Earth’s surface.

**crust-fixed reference frame**

**CFRF**

(semi-kinematic reference frame)

(semi-dynamic datum)

reference frame where coordinates of points fixed to the crust do not change during interseismic periods

RS comment: A deformation model is usually required to transform coordinates between a CFRF and a dynamic CRS.

Examples: NZGD2000, JGD2000, PNG94.

RS comment: Typically the interseismic velocity element within the deformation model is described with respect to either the predominant plate-fixed or a terrestrial reference system within the plate boundary zone.

datum

(reference frame)

<geodesy>

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

[ISO 19111:2019, 3.1.15]

**datum ensemble**

group of multiple realizations of the same terrestrial or vertical reference system that, for approximate spatial referencing purposes, are not significantly different

Note 1 to entry: Datasets referenced to the different realizations within a datum ensemble may be merged without coordinate transformation.

Note 2 to entry: ‘Approximate’ is for users to define but typically is in the order of under 1 decimetre but may be up to 2 metres.

EXAMPLE “WGS 84” as an undifferentiated group of realizations including WGS 84 (TRANSIT), WGS 84 (G730), WGS 84 (G873), WGS 84 (G1150), WGS 84 (G1674), WGS 84 (G1762 and WGS 84 (G2139). At the surface of the Earth these have changed on average by 0.7m between the TRANSIT and G730 realizations, a further 0.2m between G730 and G873, 0.06m between G873 and G1150, 0.2m between G1150 and G1674 and 0.02m between G1674 and G1762 and 0.03m between G1762 and G2139.

[ISO 19111:2019, 3.1.16] amended: updated for G2139

**datum transformation**

(coordinate transformation)

Note: the terminology is erroneous since the coordinates are being transformed between two different datums. The datums themselves are unchanged.

**deformation**

<geodesy>

change in shape, position or orientation of a point or set of points with respect to an inertial reference system

**deformation model**

(trajectory model)

<geodesy>

model of point velocities, non-linear elements and episodic displacements that enable prediction of displacement of points between two epochs within a dynamic CRS

**deformation model functional model**

**DMFM**

set of operational functions and conditions that express a deformation model

**deformation patch**

(coseismic displacement model)

**deforming zones**

portions of the Earth's crust which are undergoing deformation (not considering periodic tidal or seasonal loading effects)

RS comment: Deforming zones are mostly located near plate boundaries where relative movement of adjacent tectonic plates induces crustal strain. Deforming zones can also be located where glacial isostatic adjustment, volcanic activity, resource extraction or water abstraction are occurring.

RS comment: Tidal and seasonal loading effects generally include: solid Earth tides, ocean tide loading, atmospheric loading, periodic hydrological loading, non-tidal ocean loading and pole tide loading. These loading effects are generally modelled implicitly within geodetic applications and data processing and are perhaps beyond the scope of inclusion in deformation models for normal positioning applications and coordinate transformations.

depth

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

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

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

[ISO 19111:2019, 3.1.17]

**displacement**

change in coordinates of a point within a CRS due to deformation

RS comment: Displacement can be episodic (e.g. earthquake related), periodic (e.g. tidal or seasonal) or continuous (secular interseismic motion). Earthquake related displacements are coseismic (defined at the epoch of the event) and postseismic (elastic creep, slow-slip displacement and viscoelastic relaxation that occurs after an earthquake). Postseismic displacement can be represented by a combination of logarithmic, exponential amplitude and decay time parameters and transient velocity changes. Postseismic displacement can be evident for decades following large earthquakes.

**distortion**

<geodesy>

change in shape of a reference frame from its initial realisation where no deformation is modelled

RS comment: Distortion is usually an artefact of measurement imprecision and positional uncertainty rather than deformation in stable plate settings.

**distortion grid**

grid of apparent displacements from known to truth

RS comment: In most instances the displacement is an artefact due to improved measurement or positional uncertainty rather than deformation. If the displacement results from deformation that is not known or modelled then the distortion grid can conflate both distortion and deformation components. A distortion grid can also be used for CRS transformations where either or both CRS have heterogeneous data that precludes the use of a conformal transformation on its own.

dynamic coordinate reference system

coordinate reference system related a dynamic reference frame

Note 1 to entry: Coordinates of points on or near the crust of the Earth that are referenced to a dynamic coordinate reference system may change with time, usually due to crustal deformations such as tectonic motion and glacial isostatic adjustment.

Note 2 to entry: Metadata for a dataset referenced to a dynamic coordinate reference system should include coordinate epoch information.

[ISO 19111:2019, 3.1.19]

dynamic datum

(dynamic reference frame)

(kinematic reference frame)

(time-dependent reference frame)

(kinematic datum)

dynamic reference frame

(kinematic reference frame)

(time-dependent reference frame)

(dynamic datum)

(kinematic datum)

reference frame or datum in which the defining parameters include time evolution

Note 1 to entry: The defining parameters that have time evolution are usually a coordinate set.

Note 2 to entry: This definition describes what in physics is called a kinematic reference frame. It excludes a description of the force that leads to the time evolution. In physics, a dynamic reference frame includes a description of the cause of the motion. The IERS Conventions follow the definition from physics. This document has adopted dynamic rather than kinematic because it is felt that it better compliments static when explaining the time dependency of coordinates, including when to use coordinate epoch, to lay users.

[ISO 19111:2019, 3.1.20] amended: Note 2 added

**Earth-fixed datum**

(terrestrial reference frame)

(Earth-fixed reference frame)

**Earth-fixed reference frame**

(terrestrial reference frame)

(Earth-fixed datum)

elastic creep

slow displacement of a point after an earthquake resulting from residual stress.

element

<deformation model>

constituent part of displacement attributed to a specific model

ellipsoid

<geodesy>

geometric reference surface embedded in 3D Euclidean space formed by an ellipse that is rotated about a main axis

Note 1 to entry: For the Earth the ellipsoid is bi-axial with rotation about the polar axis. This results in an oblate ellipsoid with the midpoint of the foci located at the nominal centre of the Earth.

[ISO 19111:2019, 3.1.22]

ellipsoidal coordinate system  
(geodetic coordinate system)

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

[ISO 19111:2019, 3.1.23]

ellipsoidal height

(geodetic height)

*h*

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

Note 1 to entry: Only used as part of a three-dimensional ellipsoidal coordinate system or as part of a three-dimensional Cartesian coordinate system in a three-dimensional projected coordinate reference system, but never on its own.

[ISO 19111:2019, 3.1.24]

epoch

<geodesy>

point in time

Note 1 to entry: In this document an epoch is expressed in the Gregorian calendar as a decimal year.

EXAMPLE 2017-03-25 in the Gregorian calendar is epoch 2017.23.

[ISO 19111:2019, 3.1.27]

**frame reference epoch**

epoch of coordinates that define a dynamic reference frame

[ISO 19111:2019, 3.1.29]

**functional model**

<deformation model>

mathematical model that estimates displacement between two epochs by use of parameters and interpolated grid values

**geocenter**

center of mass (CM) of the Earth

**geocentric terrestrial reference system**

**GTRS**

CTRS whose origin coincides with the geocenter and co-rotates with the Earth, considered for the whole Earth system including the oceans and atmosphere

system of geocentric space-time coordinates within the framework of General Relativity, co-rotating with the Earth and related to the Geocentric Celestial Reference System by a spatial rotation which takes into account the Earth's orientation parameters

[IERS conventions ch. 4]

[ISO 19161-1 (Geodetic References - The ITRS)]

RS comment: an example of a GTRS is the ITRS

**geodetic coordinate reference system**

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

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

[ISO 19111:2019, 3.1.31]

geodetic datum

(geodetic reference frame)

geodetic reference frame

(geodetic datum)

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

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

[ISO 19111:2019, 3.1.34]

geoid

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

[ISO 19111:2019, 3.1.36]

geographic coordinate reference system

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

[ISO 19111:2019, 3.1.35]

**glacial isostatic adjustment**

**GIA**

movement of the Earth's crust as a response to loading or unloading of ice sheets and glaciers

RS comment: GIA has also been referred to as post-glacial rebound. The displacement is predominantly vertical with a smaller horizontal component and is secular on annual to decadal time-scales.

gravity-related height

*H*

height that is dependent on the Earth’s gravity field

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

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

[ISO 19111:2019, 3.1.37]

height

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

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

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

[ISO 19111:2019, 3.1.38]

RS comment: an orthometric height follows a curved path normal to equipotential surfaces, so not a straight line from the reference surface.

**inertial reference system**

reference system that is invariant with time

**International Terrestrial Reference Frame**

**ITRF**

geocentric terrestrial reference frame (GTRF) used by the IERS that realizes the ITRS, through the realization of its origin, orientation axes and scale

[IERS conventions]

RS comment: ITRF is time-dependent in that the positions that define the ITRF have velocities and epoch specific offsets and postseismic parameters applied. Positions and velocities are defined at a reference epoch. ITRF is updated periodically as the precision of realization of the ITRS improves.

**International Terrestrial Reference System**

**ITRS**

geocentric terrestrial reference system (GTRS) adopted by the IERS

[IERS conventions]

Note to entry: According to IUGG 2007 Resolution 2, the ITRS is the specific GTRS for which the orientation is operationally maintained in continuity with past international agreements (BIH orientation).The co-rotation condition is defined as no residual rotation with regard to the Earth's surface, and the geocenter is understood as the center of mass of the whole Earth system, including oceans and atmosphere (IUGG 1991 Resolution 2). For continuity with previous terrestrial reference systems, the first alignment was close to the mean equator of 1900 and the Greenwich meridian. The ITRS was adopted (IUGG 2007 Resolution 2) as the preferred GTRS for scientific and technical applications and is the recommended system to express positions on the Earth. [NFA Glossary], p. 34.

**interpolation CRS**

coordinate reference system to which a grid is referenced and in which interpolation of the grid is performed

**interseismic**

period between seismic events

RS comment: point motion is usually secular during the interseismic period, although ongoing effects of postseismic displacement are often evident over long time scales. In some instances postseismic displacement some time after the seismic event is conflated with interseismic displacement, although ideally it should be modelled separately.

**interseismic velocity**

(point velocity)

(secular velocity)

linear rate of change (or displacement rate) of a position between episodes of non-linear seismic deformation (coseismic displacement) in a dynamic CRS

**intraplate velocity**

velocity of a point in a plate-fixed reference system

RS comment: intraplate velocities are close to zero within stable portions of a tectonic plate but increase near plate boundaries or other deforming zones.

kinematic datum

(dynamic datum)

(dynamic reference frame)

(kinematic reference frame)

(time-dependent reference frame)

(kinematic datum)

**kinematic reference frame**

(dynamic datum)

(dynamic reference frame)

(kinematic reference frame)

(time-dependent reference frame)

(kinematic datum)

mean sea level

**MSL**

<geodesy>

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

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

[ISO 19111:2019, 3.1.41]

**nested grid**

denser grid spatially contained within a coarser parent grid

RS comment: The denser grid node spacing must be a divisor of the parent grid resolution. Ideally, the boundary node values of the nested grid should be estimated by interpolation of the parent grid to avoid model interpolation discontinuities across the parent/nested grid boundary.

Comments: - Other conditions (e.g. when denser grid partially lies outside parent grid?).

parameter reference epoch

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

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

[ISO 19111:2019, 3.1.44]

**parent grid**

grid that contains one or more denser nested grids

**plate-fixed reference frame**

**PFRF**

realization of a PFRS

RS comment: PFRF point coordinates are conventionally defined within a TRS at the PFRF reference epoch. PFRF point velocities are described with respect to the pole of rotation of the PFRS by subtraction of the predicted PFRS velocity using a PMM from the velocity defined in a No-Net-Rotation defined TRS.

Example: ETRF89, ETRF2014

**plate-fixed reference system**

**PFRS**

reference system fixed to the stable portion of a rotating tectonic plate

RS comment: The PFRS can be defined by its pole and rate of rotation within a TRS. A PMM relates the PFRS to a TRS. PFRS point velocities on a stable plate are close to zero. Intraplate strain results in non-zero point velocities.

**plate motion model**

**PMM**

model that defines the pole and rotation rate of a tectonic plate

RS comment: Also known as an Euler pole using Euler’s theorem. A plate is assumed to be a rigid body in the form of a spherical cap. The model can also be expressed as a rate of rotation about the Cartesian axes defining a terrestrial reference system.

**point motion operation**

coordinate operation that changes coordinates within one coordinate reference system due to the motion of the point

Note 1 to entry: The change of coordinates is from those at an initial epoch to those at another epoch.

Note 2 to entry: In this document the point motion is due to tectonic motion or crustal deformation.

[ISO 19111:2019, 3.1.48]

**point velocity**

(interseismic velocity)

(secular velocity)

**postseismic displacement**

displacement in excess of interseismic displacement that occurs after an earthquake

**reference frame**

(datum)

<geodesy>

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

[ISO 19111:2019, 3.1.52]

**reference system**

<geodesy>

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

Note: A reference system is essentially a definition of the axes used to define a coordinate system.

**secular velocity**

(interseismic velocity)

(point velocity)

**semi-dynamic datum**

(crust-fixed reference frame)

(semi-kinematic reference frame))

**semi-kinematic reference frame**

(crust-fixed reference frame)

(semi-dynamic datum)

**slow-slip displacement**

displacement caused by a slow-slip event or ongoing postseismic displacement

**slow-slip event**

**SSE**

nearly aseismic deformation occurring over longer time periods (hours to years)

RS comment: SSE displacement can be modelled by a hyperbolic tangent function, or more simplistically for shorter period SSE by a ramp function.

spatial function

<deformation model>

Requires a definition

**spatial reference system**

**SRS**

ISO 19123 system for identifying position in the real world

static coordinate reference system

coordinate reference system related to a static reference frame

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

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

[ISO 19111:2019, 3.1.61]

RS commentary: Coordinates of points within a static CRS may change as a consequence of improved measurements and geodetic network readjustments. Where a known displacement has occurred (e.g. due to a seismic or subsidence event) coordinates in affected areas may also be updated.

**static datum**

(static reference frame)

static reference frame

(static datum)

reference frame in which the defining parameters exclude time evolution

[ISO 19111:2019, 3.1.62]

**strain**

<geodesy>

ratio describing the change in length between two points

**strain rate**

<geodesy>

rate of change of strain

**sub-grid**

a separate grid from the parent grid that may not be nested, a divisor of, or spatially contained within the parent grid

**tectonic plate**

a larger portion of the Earth's crust that rotates over the underlying mantle

RS commentary: The rotation of the plate is defined by a plate motion model (PMM) (see note).

**terrestrial reference frame**

**TRF**

(Earth-fixed datum)

(Earth-fixed reference frame)

realization of a terrestrial reference system (TRS), by specifying its origin, orientation, scale, and its time evolution

Note 1 to entry: The realization is achieved through a set of physical points with precisely determined coordinates in a specific coordinate system, which may include the rate of coordinate change. It is also designated as a crust-based TRF when physical points are anchored to the Earth's surface

Note 2 to entry: The realization is called static when no rates of coordinate change are defined, and kinematic when rates of coordinate change are defined without considering the underlying forces causing the motion. The realization may be called dynamic when these external forces are considered. “Dynamic” is also used colloquially to describe both the dynamic and kinematic cases without distinction.

[ISO 19161-1:2019, 3.5]

RS comment: Coordinates referenced to a CRS defined by an Earth-fixed reference frame are valid only at the reference epoch unless a velocity model or deformation model is specified for the reference frame.

terrestrial reference system

TRS

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

Note 1 to entry: The abstract concept of a TRS is realized through a terrestrial reference frame that usually consists of a set of physical points with precisely determined coordinates and optionally their rates of change.

Note 2 to entry: In such a system, positions of points attached to the solid surface of the Earth have coordinates which undergo only small variations with time, due to geophysical effects (tectonic or tidal deformations). In the Newtonian framework, the physical space is considered as a Euclidean affine space of dimension 3, with an origin,

a scale and an orientation.

[SOURCE: ISO 19111:2019, 3.1.66 - modified: Note 1 to entry has been modified; Note 2 to entry has been added from IERS Conventions 2010 - [18]]

RS comment: Sub-categories of TRS include the geocentric terrestrial reference system (GTRS) (refer to separate entry) and the International Terrestrial Reference System (ITRS) (refer to separate entry).

RS comment: A TRS does not necessarily have to be geocentric.

**time-dependent reference frame**

(dynamic datum)

(dynamic reference frame)

(kinematic reference frame)

(time-dependent reference frame)

(kinematic datum)

**time function**

<deformation model>

Description required

**trajectory model**

(deformation model)

**transformation reference epoch**

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

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

[ISO 19111:2019, 3.1.67]

**uncertainty**

<geodesy>

parameter, associated with the result of measurement, that characterizes the dispersion of values that could reasonably be attributed to the measurement

Note 1 to entry: When the quality of accuracy or precision of measured values, such as coordinates, is to be characterized quantitatively, the quality parameter is an estimate of the uncertainty of the measurement results. Because accuracy is a qualitative concept, one should not use it quantitatively, that is associate numbers with it; numbers should be associated with measures of uncertainty instead.

[ISO 19116:2019, 3.28]

**velocity**

<geodesy>

secular rate of change of position within a defined dynamic CRS

**velocity model**

<geodesy>

model of secular velocities within a defined dynamic CRS

Note: Velocities are preferably defined within interseismic periods. Velocities can be with respect to a Earth-fixed TRS or plate-fixed reference system.

vertical coordinate reference system

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

[ISO 19111:2019, 3.1.70]

vertical coordinate system

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

[ISO 19111:2019, 3.1.71]

**vertical datum**

(vertical reference frame)

**vertical reference frame**

(vertical datum)

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

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

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

[ISO 19111:2019, 3.1.72]

RS comment: Heights (elevations) are described relative to the surface using a specified path. The path can be an orthometric height (continuously normal to the geoid and intervening equipotential surfaces and therefore geometrically curved), normal height (normal to the ellipsoid surface).

vertical reference system

**VRS**

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

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

[ISO 19111:2019, 3.1.73]

**viscoelastic relaxation**

<geodesy>

postseismic displacement that has both elastic and viscous elements. The viscous element is permanent displacement once crustal stress relaxes to zero

**Concepts by viewpoint**

**Geographic information viewpoint**

This viewpoint was first proposed by the CRS wg within CEN, the European Standards Committee, in the late 1980s. It was adopted by ISO TC211 from the mid 1990s as:

* A reference system (RS) may be
  + spatial
  + temporal
* A spatial reference system (SRS) may be by
  + coordinates
  + geographic identifier

(geographic identifier is a location description through anything other than coordinates, for example country name "Spain" or post code "SW1P 3AD").

* A coordinate reference system (CRS) is
  + a coordinate system ...
  + ... related to an object through a datum
  + where a coordinate system (CS) is an abstract concept of a collection of axes without any location.

It has subsequently been modified so that

* a SRS has a third component, parametric CRS (coordinates are measures, e.g. pressure)
* a CRS may be compound, with multiple spatial (horizontal and vertical), temporal or parametric components.

**Geodesy viewpoint**

Historically:

* ellipsoid fixed to Earth through deviations of the vertical at a datum point

Modern geodesy:

* a reference system is a concept (set of conventions) ...
* ... realized by a reference frame
* Terrestrial reference system conventions include a right-handed 3D Cartesian coordinate system

**Discussion**

The distinction between a reference frame, datum and a reference system.

Kinematic and dynamic.