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Geographic information — Discrete Global Grid Systems Specifications —

Part 1: **Core Reference System and Operations, and Equal Area Earth Reference System**

ICS: 35.240.70

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2, Revision 8, 2018, (see www.iso.org/directives).

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

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

In accordance with the ISO/IEC Directives, Part 2, 2018, *Rules for the structure and drafting of International Standards*, in International Standards the decimal sign is a comma on the line. However the General Conference on Weights and Measures (*Conférence Générale des Poids et Mesures*) at its meeting in 2003 passed unanimously the following resolution: "The decimal marker shall be either a point on the line or a comma on the line." In practice, the choice between these alternatives depends on customary use in the language concerned. In the technical areas of geodesy and geographic information it is customary for the decimal point always to be used, for all languages. That practice is used throughout this document.

Introduction

Spatial and temporal referencing systems described elsewhere in ISO/TC211 fall into two categories

— referencing by coordinates (ISO 19111:2019)

— referencing by identifiers (geographic in ISO 19112:2019 & ordinal era in ISO 19108:2002)

In spatial referencing by identifiers, an extent is required, but the extent may be as simple as a bounding box, so it need not be well defined and formal geometry is sometimes not defined, but instead follows societal whim. In temporal referencing the topology of ordinal era's are known, but the start and finish times are often only known very approximately and are not required by the data model.

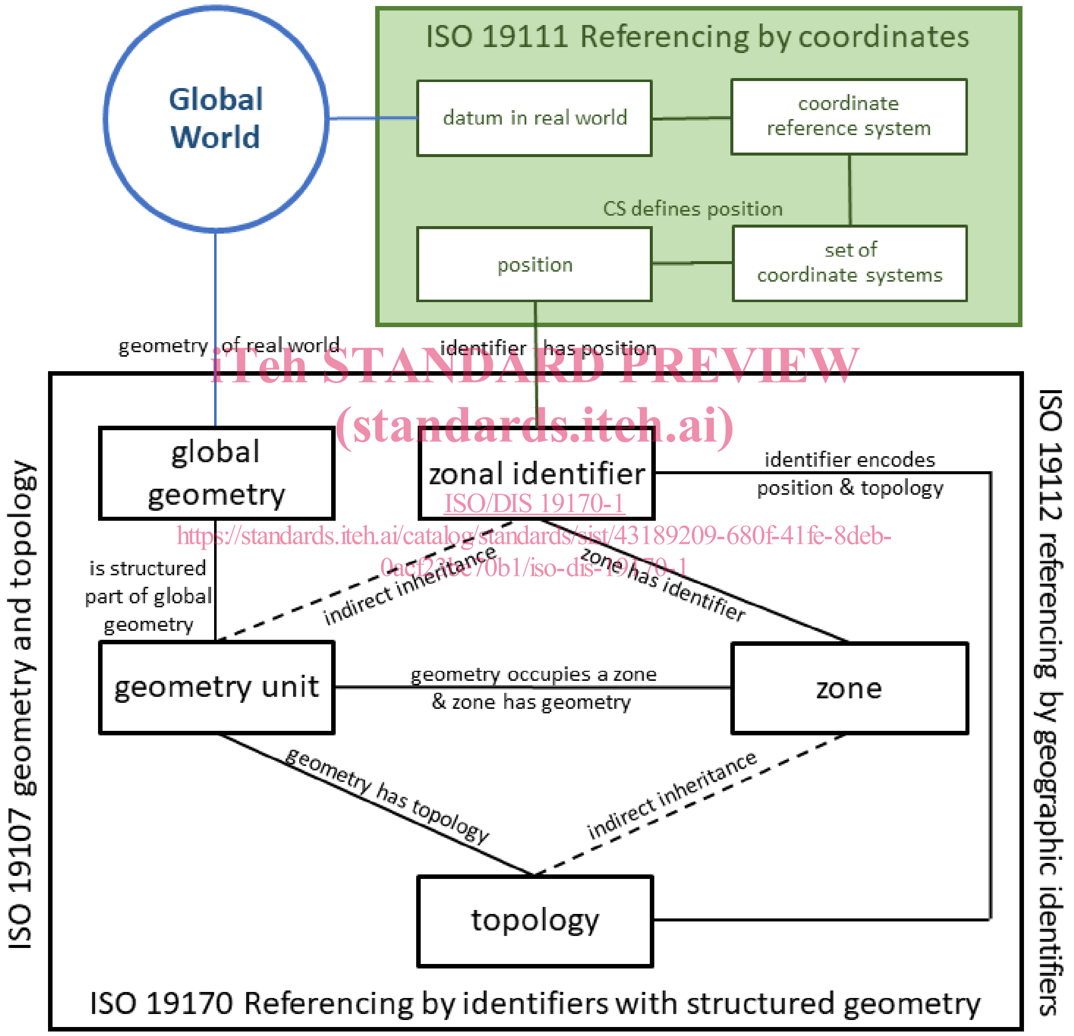

Figure 1 — Referencing by identifiers with structured geometry

DGGS introduces a third category, referencing by identifiers with structured geometry. DGGS geometry is highly structured and drives the formal tessellation of region of space-time addressed by the DGGS. This is illustrated in Figure 1. Coordinate reference systems (3.7) are tied to the real world via a datum 3.10 that specifies the association of the real world to the CRS in terms of its dimensions and orientation. DGGS describe the dimensions and orientation of their Global World in terms of a single parent global geometry. Each reference system defines units of geometry that are tessellated fractions of their parent global geometry. The region occupied by each unit of geometry is called a zone (3.52). Each zone is given a unique name, called a zonal identifier (3.51). Each zonal identifier is associated with a representative spatio-temporal position in a base coordinate reference system defined by a datum for the DGGS's Global World. Best practice is for a zonal identifier to be an encoding of both its position and its topology.

Referencing by identifiers with structured geometry gives rise to Reference systems using zonal identifiers with structured geometry. Geographic information is inherently four-dimensional and includes time. So, a unified spatio-temporal data model for coordinate systems, geometry, topology, identifiers and reference systems using identifiers is a pre-requisite for spatio-temporal DGGS.

In this document, the approach taken to specify a spatio-temporal data model is to start with the data model for spatio-temporal coordinate system and associated coordinate reference systems specified in ISO 19111 (ISO 19111:2019), and use that data model to extended both spatial geometry and topology (ISO 19107:2019), and spatial identifiers and reference systems using identifiers (ISO 19112:2019), to specify a consistent set of Common Spatio-temporal Classes for geometry, topology, identifiers, and reference systems using identifiers. In this spatio-temporal data model, the spatio-temporal scope is constrained to spatial classes that are invariant through all time, and to temporal classes that are invariant throughout space. While this approach excludes certain spatio-temporal situations — such as the geometry of a constant mass of gaseous fluids under changing pressure and temperature, it is flexible enough for a very large body of social and environmental modelling. So for instance, though oceanic, climate and weather modelling need different characteristics, determined by both scientific and performance reasons, and operate outside a DGGS, the results coming from these environmental models could still be stored in DGGS for efficient use with other data.

This part of ISO 19170 specifies a consistent set of Common Classes for Spatio-temporal (CC-ST) data modelling, a Discrete Global Grid Systems (DGGS) Core data model built on the Common Spatio-temporal Classes, and a DGGS Equal Area Earth Reference System (EAERS) data model. The Common classes, DGGS Core, and Equal Area Earth Reference System (EAERS) each have their own conformance classes with their associated specifications and requirements.

The Core comprises Reference System (RS), and Functions for Quantization, Topological Query and Interoperability.

The Core Reference system is a reference system using zonal identifiers with structured geometry located in its real world by coordinates in a base coordinate reference system. The Core Reference system is designed to support: temporal, surface, volumetric and spatio-temporal DGGS; DGGS with different grid constraints; DGGS with different refinement strategies, and DGGS on either the Earth or other celestial bodies.

The DGGS Equal Area Earth RS is a specialisation of the Core RS. It describes a Reference System, comprising a base unit polyhedron, a discrete hierarchical sequence of global grids of *equal-area* cells each with a unique identifier located on a geodetic coordinate reference system 3.20, that is typically a geographic coordinate reference system 3.21. This standard does not prescribe any specific Earth surface model, base polyhedron or class of polyhedra, but is intended to allow for a range of options that produce DGGS with compatible and interoperable functional characteristics.

This standard anticipates:

— Part 2 –- 3D Equal Volume Earth Reference System.

— Part 3 –- Spatio-temporal Earth Reference System.

— Part 4 –- Axis Aligned Reference System with all zone edges parallel to the base CRS's axes.

— Specification for a DGGS-API to formalise client-server, and server-server operations, both between DGGS systems and between DGGS and non-DGGS systems.

— Creation of a register system for DGGS definitions analogous to the register for Coordinate Reference Systems (CRS).

— Additions to other specifications, such as standards for OGC Web-Service (OWS) [52], [54] architectures, spatial features and data formats to support DGGS data structures.

Geographic information — Discrete Global Grid Systems Specifications — Core Reference System and Operations, and Equal Area Earth Reference System

1 Scope

This part of ISO 19170 supports the definition of:

— a Discrete Global Grid System Core comprising

  — a reference system using geometry with zonal identifiers, and

  — functions providing import, export and topological query,

— Common Classes for spatio-temporal geometry, topology, zones, and zonal identifiers based on ISO 19111 coordinate systems. The spatio-temporal scope is constrained to

  — spatial elements that are invariant through all time, and

  — temporal elements that are invariant across all space.

— Equal Area Earth Reference System for DGGS.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8601-1:2019, *Date and time – Representations for information interchange – Part 1: Basic rules*

ISO 19107:2019, *Geographic information – Spatial schema*

ISO 19111:2019, *Geographic information – Referencing by coordinates*

ISO 19112:2019, *Geographic information – Spatial referencing by geographic identifiers*

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

ISO 19123:2005, *Geographic information – Schema for coverage geometry and functions*

ISO 19156:2011, *Geographic information – Observations and measurements*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org

3.1
boundary
set that represents the limit of an entity

Note 1 to entry: *Boundary* is most commonly used in the context of geometry, where the set is a collection of points or a collection of objects that represent those points. In other domains, the term is used metaphorically to describe the transition between an entity and the rest of its domain of discourse.

[SOURCE: ISO 19107:2019, 4.6]

3.2
cell
<DGGS> spatial, spatio-temporal or temporal unit of geometry with dimension greater than 0, associated with a unique *zonal identifier* (3.51)

Note 1 to entry: All *cells* within a DGGS share the dimensionality of the DGGS, and DGGS with dimensionality of 0, are not supported.

Note 2 to entry: *Cells* are the primary container for storing and retrieving data within a *DGGS* implementation.

Note 3 to entry: *DGGS* may instantiate *cells* by reference to their *zonal identifier* (3.51), for instance in databases or through tile nomenclature, and by their geometry, for instance through membership of a grid.

Note 4 to entry: The *zonal identifier* (3.51) of a *cell* provides the coordinates of a representative position for the *cell*, and all feature geometry is represented by sets of *cells*.

3.3
cell refinement
<DGGS> process of subdividing *parent cells* (3.33) into descendant *child cells* (3.4) using a specified *refinement ratio* (3.38) and suite of refinement strategies

Note 1 to entry: Iterative application of *cell refinements* creates a hierarchy of descendant *discrete global grids* (3.12).

Note 2 to entry: *Cell refinement* methods may result in *child cells* that each have a single parent or that have multiple parents.

3.4
child cell
<DGGS> immediate descendant of a *parent cell*

Note 1 to entry: *child cells* are either within a single *parent cell* (3.33) or overlapped by multiple *parent cells*

3.5
class
description of a set of objects that share the same attributes, operations, methods, relationships, and semantics

Note 1 to entry: A *class* may use a set of interfaces to specify collections of operations it provides to its environment. The term was first used in this way in the general theory of object-oriented programming, and later adopted for use in this same sense in UML.

[SOURCE: ISO 19103:2015, 4.27, modified — Note 1 to entry has been added from ISO 19117:2012, 4.2]

3.6
compound coordinate reference system
coordinate reference system (3.7) using at least two independent *coordinate reference systems* (3.7)

Note 1 to entry: *Coordinate reference systems* (3.7) are independent of each other if coordinate values in one cannot be converted or transformed into coordinate values in the other.

[SOURCE: ISO 19111:2019, 3.1.3]

3.7
coordinate reference system
coordinate system that is related to an object by a *datum* (3.10)

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

Note 2 to entry: For geodetic and vertical *datums* (3.10), the object will be the Earth. In planetary applications, geodetic and vertical reference frames may be applied to other celestial bodies.

[SOURCE: ISO 19111:2019, 3.1.9]

3.8
coordinate system
set of mathematical rules for specifying how coordinates are to be assigned to points

<DGGS> *quantization* (3.36) operation where *feature* (3.18) *values* (3.49) are aggregated and clipped to the *Boundary* (3.1) of a *cell* (3.2) and stored as a tile with no resampling or mapping of the individual *feature* (3.18) *values* (3.49) to individual *cells* (3.2)

[SOURCE: ISO 19111:2019, 3.1.11]

3.9
data type
specification of a *value* (3.49) domain with operations allowed on values in this domain

EXAMPLE Integer, Real, Boolean, String, Date (conversion of a date into a series of codes).

Note 1 to entry: Data types include primitive predefined types and user-definable types. All instances of a data type lack identity.

[SOURCE: ISO 19103:2015, 4.14, modified — Note 1 to entry has been added from ISO 19156, 4.3]

3.10
datum
reference frame
parameter or set of parameters that realize the positions of the origin, the scale, and the orientation of a *coordinate system* (3.8)

[SOURCE: ISO 19111:2019, 3.1.15]

3.11
datum ensemble
group of multiple realizations of the same terrestrial or vertical reference system that, for approximate spatial referencing purposes, are not significantly different

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

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.

[SOURCE: ISO 19111:2019, 3.1.16]

3.12
discrete global grid
<DGGS> set of *cells* (3.2) at the same refinement level (3.37), that uniquely and completely cover a globe

Note 1 to entry: the set of cell *zonal identifiers* (3.51) comprising a *discrete global grid* form a single Zone Class with its associated *refinement level* (3.37).

Note 2 to entry: the configuration of the set of cells comprising a discrete global grid satisfy at least one grid constraint in the DGG_GridConstraint codelist

3.13
discrete global grid system
DGGS
integrated system comprising a *hierarchy* (3.26) of *discrete global grids* (3.12), *spatio-temporal referencing* (3.42) by *zonal identifiers* (3.51) and functions for *quantization* (3.36), *zonal query* (3.50), and *interoperability* (3.28)

3.14
duration
non-negative quantity of time equal to the difference between the final and initial *instants* (3.29) of a time *interval* (3.30)

Note 1 to entry: The duration is one of the base quantities in the International System of Quantities (ISQ) on which the International System of Units (SI) is based. The term "time" instead of "duration" is often used in this context and also for an infinitesimal duration.

Note 2 to entry: For the term "duration", expressions such as "time" or "time interval" are often used, but the term "time" is not recommended in this sense and the term "time interval" is deprecated in this sense to avoid confusion with the concept of "time interval".

Note 3 to entry: The exact duration of a time scale unit depends on the time scale used. For example, the durations of a year, month, week, day, hour or minute, may depend on when they occur [in a Gregorian calendar, a calendar month can have a duration of 28, 29, 30, or 31 days; in a 24-hour clock, a clock minute can have a duration of 59, 60, or 61 seconds, etc.]. Therefore, the exact duration can only be evaluated if the exact duration of each is known.

Note 4 to entry: This definition is closely related to NOTE 1 of the terminological entry "duration" in IEC 60050-113:2011, 113-01-13.

[SOURCE: ISO 8601-1:2019, 3.1.1.8]

3.15
dynamic coordinate reference system
coordinate reference system (3.7) that has a *dynamic reference frame* (3.16)

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.

[SOURCE: ISO 19111:2019, 3.1.19]

3.16
dynamic reference frame
dynamic datum
reference frame (3.10) in which the defining parameters include time evolution

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

[SOURCE: ISO 19111:2019, 3.1.20]

3.17
error budget
<metric> statement of or methodology for describing the nature and magnitude of the errors which affect the results of a calculation

[SOURCE: ISO 19107:2019, 4.35, modified — Note 1 to entry has been removed]

3.18
feature
abstraction of real-world phenomena

Note 1 to entry: A *feature* may occur as a type or an instance. In this document, *feature* instance is meant unless otherwise specified.

[SOURCE: ISO 19101-1:2014, 4.1.11, modified — Note 1 to entry has been added from ISO 19156, 4.6]

3.19
feature type
class (3.5) of *features* (3.18) having common characteristics

[SOURCE: ISO 19156:2011, 4.7]

3.20
geodetic coordinate reference system
three-dimensional *coordinate reference system* (3.7) 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* (3.7) based on a geodetic reference frame and having an ellipsoidal coordinate system is geographic.

[SOURCE: ISO 19111:2019, 3.1.13]

3.21
geographic coordinate reference system
coordinate reference system (3.7) that has a geodetic reference frame and an ellipsoidal coordinate system

[SOURCE: ISO 19111:2019, 3.1.35]

3.22
geographic identifier
spatial reference (3.41) in the form of a label or code that identifies a *location* (3.31)

EXAMPLE “Spain” is an example of a label (country name); “SW1P 3AD” is an example of a code (postcode).

[SOURCE: ISO 19112:2019, 3.1.2]

3.23
geometric primitive
geometric object representing a single, *connected,* homogeneous (isotropic) element of space

Note 1 to entry: *Geometric primitives* are non-decomposed objects that present information about geometric configuration. They include points, curves, surfaces, and solids. Many geometric objects behave like primitives (supporting the same interfaces defined for *geometric primitives*) but are actually composites composed of some number of other primitives. General collections may be aggregates and incapable of acting like a primitive (such as the lines of a complex network, which is not connected and thus incapable of being traceable as a single line). By this definition, a *geometric primitive* is topological open, since the boundary points are not isotropic to the interior points. Geometry is assumed to be closed. For points, the boundary is empty.

[SOURCE: ISO 19107:2019, 4.50]

3.24
globe
<DGGS> celestial body

Note 1 to entry: In this document globe is used in its most general form to refer to any celestial body that may be referenced by a DGGS. When a specific body, such as the Earth is referred to, an explicit term is used.

3.25
grid
network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in an algorithmic way

Note 1 to entry: The curves partition a space into *grid* cells.

[SOURCE: ISO 19123:2005, 4.1.23]

3.26
hierarchy
<DGGS> organization and ranking of successive levels of *cell refinement* (3.3) of *discrete global grids* (3.12)

3.27
initial discrete global grid
<DGGS> *discrete global grid tessellation* created by circumscribing a defined path along the chosen surface model of the Earth between the vertices of the scaled *base unit polyhedron*

3.28
interoperability
capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units

Note 1 to entry: in this standard *interoperability* specifically refers to functions that initiate and process transfers of data from a DGGS system.

3.29
instant
<DGGS> temporal geometry primitive representing a point in time

Note 1 to entry: On *temporal coordinate systems* as specified in (3.46), the temporal *geometric primitives* (3.23) *instant* and *interval* (3.30) are the equivalent of points and lines as specified in (ISO 19107:2019).

3.30
interval
<DGGS> temporal geometry primitive representing a line in time

Note 1 to entry: On *temporal coordinate systems* as specified in (3.46), the temporal *geometric primitives* (3.23) *instant* (3.29) and *interval* are the equivalent of points and lines as specified in (ISO 19107:2019).

3.31
location
particular place or position

EXAMPLE "Madrid", "SW1P 3AD".

Note 1 to entry: A *location* identifies a geographic place.

Note 2 to entry: In the context of DGGS, *locations* have dimension greater than one, and so are not points.

[SOURCE: ISO 19112:2019, 3.1.3, modified — Note two has been added and an additional example provided]

3.32
observation
act of measuring or otherwise determining the *value* (3.49) of a property

[SOURCE: ISO 19156:2011, 4.11]

3.33
parent cell
<DGGS> cell in a higher refinement level of discrete global grid with immediate descendants

Note 1 to entry: *parent cells* either overlap or contain their *child cells* (3.4).

3.34
period
<DGGS> particular era or span of time

Note 1 to entry: *Periods* are *intervals* (3.30) named with a *period identifier* (3.35)

3.35
period identifier
<DGGS> temporal reference in the form of a label or code that identifies a *period* (3.34)

Note 1 to entry: *Period identifiers* are the temporal equivalent of *geographic identifiers* (3.22) as specified in (ISO 19112:2019)

3.36
quantization
<DGGS> function assigning data from external sources to cell values

3.37
refinement level
<DGGS> numerical order of a *discrete global grid* (3.12) in the tessellation sequence

Note 1 to entry: The tessellation with the smallest number of cells has a refinement level = 0.

