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Geographic information — Imagery, gridded and coverage data framework

Information Géographique — Structure de données pour les images, les matrices et les mosaïques

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Foreword

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

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

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order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn.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again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 19129 was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

Introduction

Gridded data, including imagery, is a major form of geographic information. Over the past two decades many, largely incompatible, standards have been developed that are widely used for the interchange of geographic imagery and gridded data. These include standards developed by ISO, as well as those developed by other organizations. With so many different imagery and gridded data standards, each standard aimed at different but overlapping information communities, there is a considerable legacy problem. Working with data encoded using different formats is often difficult because all of the necessary information for interworking has not been recorded using some of these standards. It is not possible to develop a new comprehensive standard to replace what exists or to simply endorse one existing standard (or industrial specification) to "solve" the interworking problem, because very large volumes of data exist in the various formats already in use. The Technical Report ISO/TR 19121:2000 identified the existing work on imagery and gridded data that had been ongoing in ISO and external technical organizations. What is required is a structure that allows for the specification of the content in a manner independent of and compatible with the various different encoding standards.

The area of imagery, gridded and coverage data is one of the most challenging within the field of geographic information. The data appears to be simple; however, there is significant structural complexity. While most data is organized in simple grids, there are many different traversal methods for grids and structures that support the distribution of attributes over a space. Sensor information and associated georeferencing are an important aspect of imagery, gridded and coverage geographic information.

This Technical Specification endeavours to address the harmonization of the broad legacy of existing imagery and gridded data. The approach specified is *not* to build a very flexible standard that encompasses everything with a broad array of options, since that does not create compatibility. One can be fooled into thinking things are standardized, because two data sets use incompatible subsets of the same set of general standards. All that would be accomplished would be to give an ISO label to the existing diversity and incompatibility. Compatibility is required for the underlying structure and primary elements of information content, regardless of how that information content is expressed. The purpose of this Technical Specification is to provide a framework within which interworking can occur. The approach used is to define a set of a few common information content structures for geographic imagery, gridded data and certain types of coverage data, which can be expressed using different encoding mechanisms and different interchange standards. The compatibility results from the common underlying content models that are expressed as a *generic set of UML patterns for application schemas*.

This Technical Specification recognizes that there are many overlapping imagery and gridded data specifications in wide use that differ significantly in how the information content is structured for encoding and in what choices of information form the content model. Different types of encoding may be appropriate in different situations. However, differences in content are difficult to reconcile. The existing different encoding standards do not necessarily conflict because they represent different ways of providing the same information in different contexts. Differences in content are also permitted for different situations, but the content definition must be the same in similar situations for interchange to be achieved without loss of information.

Most of the existing specifications for imagery and gridded data used in industry specify how content is to be expressed, rather than the content itself. They relate content to encoding, encapsulation and transfer of data. Those content descriptions that do appear to vary from one specification to another may not be in conflict or incompatible but reflect different real world situations that require different treatments.

This Technical Specification combines a number of well-defined content structures in accordance with ISO 19123, the International Standard for coverage geometry and functions together with metadata, spatial referencing and other aspects of imagery, gridded and coverage data into a framework. This will foster a convergence at the content model level for existing imagery, gridded and coverage data while allowing for backward compatibility with the identified suite of existing standards.

Geographic information — Imagery, gridded and coverage data framework

1 Scope

This Technical Specification defines the framework for imagery, gridded and coverage data. This framework defines a content model for the content type imagery and for other specific content types that can be represented as coverage data. These content models are represented as a set of generic UML patterns for application schemas.

2 Conformance

Any application schema or profile claiming conformance with this Technical Specification shall pass the requirements described in the abstract test suite, presented in Annex A.

The abstract test suite indicates what is required for an application schema to comply with the framework established in this Technical Specification.

3 Normative references

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

ISO 19107, *Geographic information — Spatial schema*

ISO 19109:2005, *Geographic information — Rules for application schema*

ISO 19115, *Geographic information — Metadata*

ISO 19115-2, *Geographic information — Metadata — Part 2: Extensions for imagery and gridded data*

ISO 19118, *Geographic information — Encoding*

ISO 19123, *Geographic information — Schema for coverage geometry and functions*

4 Terms and definitions

4.1 Terms

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

4.1.1
application schema
conceptual schema for data required by one or more applications

[ISO 19101:2002]

4.1.2
content model
information view of an **application schema**

NOTE The term "information view" comes from the ISO Reference Model for Open Distributed Processing (RM-ODP), as specified in 19101-2.

4.1.3
continuous coverage
coverage that returns different values for the same **feature** attribute at different **direct positions** within a single spatial object, temporal object, or **spatiotemporal object** in its **domain**

[ISO 19123:2005]

NOTE Although the **spatiotemporal domain** of a continuous coverage is ordinarily bounded in terms of its spatial extent, it can be subdivided into an infinite number of **direct positions**.

4.1.4
coordinate
one of a sequence of n-numbers designating the position of a **point** in n-dimensional space

[ISO 19111:2007]

NOTE In a **coordinate reference system**, the numbers must be qualified by units.

4.1.5
coordinate reference system
coordinate system that is related to an object by a datum

[ISO 19111:2007]

NOTE For geodetic and vertical datums it will be related to the Earth.

4.1.6
coverage
feature that acts as a **function** to return values from its **range** for any **direct position** within its spatial, temporal or **spatiotemporal domain**

[ISO 19123:2005]

EXAMPLE Examples include a **raster** image, polygon overlay, or digital elevation **matrix**.

4.1.7
data compaction
reduction of the number of data elements, bandwidth, cost, and time for the generation, transmission, and storage of data without loss of information by eliminating unnecessary redundancy, removing irrelevancy, or using special coding

[ANSI T1.523-2001]

NOTE 1 Whereas data compaction reduces the amount of data used to represent a given amount of information, **data compression** does not.

NOTE 2 Data compaction can be done through aggregation of like values in adjacent **grid** cells, tiling schemes or other means of eliminating information that is not relevant.

4.1.8
data compression
reducing either the amount of storage space required to store a given amount of data, or the length of message required to transfer a given amount of information

NOTE 1 Adapted from ANSI T1.523-2001.

NOTE 2 Data compression is probabilistic in nature based on particular instances of **imagery**, **gridded** or **coverage data** and is related to **encoding** and is outside the scope of this Technical Specification.

4.1.9
data interchange
delivery, receipt and interpretation of data

[ISO 19118:2005]

4.1.10
dataset
identifiable collection of data

[ISO 19115:2003]

4.1.11
direct position
position described by a single set of **coordinates** within a **coordinate reference system**

[ISO 19107:2003]

4.1.12
discrete coverage
coverage that returns the same **feature** attribute values for every **direct position** within any single spatial object, temporal object, or **spatiotemporal object** in its **domain**

[ISO 19123:2005]

NOTE The **spatiotemporal domain** of a discrete coverage consists of a finite set of geometric objects.

4.1.13
domain
well-defined set

[ISO/TS 19103:32005]

NOTE Domains are used to define the domain set and **range** set of attributes, operators and **functions**.

4.1.14
encoding
conversion of data into a series of codes

[ISO 19118:2005]

4.1.15
encoding rule
identifiable collection of conversion rules that define the **encoding** for a particular data structure

[ISO 19118:2005]

4.1.16
feature
abstraction of real world phenomena

[ISO 19101:2002]

NOTE A feature may occur as a type or an instance. Feature type or feature instance should be used when only one is meant.

4.1.17
framework
relationship between the elements of the **content model** and the separate **encoding** and portrayal mechanisms

4.1.18
function
rule that associates each element from a **domain** (source, or domain of the function) to a unique element in another domain (target, co-domain, or **range**)

[ISO 19107:2003]

4.1.19
geographic information
information concerning phenomena implicitly or explicitly associated with a location relative to the Earth

[ISO 19101:2002]

4.1.20
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

[ISO 19123:2005]

NOTE The curves partition a space into grid cells.

4.1.21
grid coordinates
sequence of two or more numbers specifying a position with respect to its location on a **grid**

[ISO 19115-2:2009]

4.1.22
grid point
point located at the intersection of two or more curves in a **grid**

[ISO 19123:2005]

4.1.23
gridded data
data whose attribute values are associated with positions on a **grid coordinate** system

[ISO 19115-2:2009]

4.1.24
imagery
representation of phenomena as images produced by electronic and/or optical techniques

NOTE The term imagery is often used colloquially with various meanings in different contexts. It is often used to describe any set of **gridded**, **point** set or other form of **coverage data** that can be portrayed. This is not a very useful concept because virtually any set of data can be portrayed in some manner. A more precise meaning is given in ISO/TS 19101-2.

[ISO/TS 19101-2:2008]

4.1.25
matrix
rectangular array of numbers

NOTE A matrix is a mathematical term.

4.1.26
metadata
data about data

[ISO 19115:2003]

4.1.27
pixel
smallest element of a digital image to which attributes are assigned

NOTE 1 This term originated as a contraction of "picture element".

NOTE 2 Related to the concept of a **grid** cell.

[ISO/TS 19101-2:2008]

4.1.28
point
0-dimensional geometric primitive, representing a position

[ISO 19107:2003]

NOTE The boundary of a point is the empty set.

4.1.29
point coverage
coverage that has a **domain** composed of **points**

[ISO 19123:2005]

4.1.30
quality
totality of characteristics of a product that bear on its ability to satisfy stated and implied needs

[ISO 19101:2002]

4.1.31
range
⟨coverage⟩ set of **feature** attribute values associated by a **function** with the elements of the **domain** of a **coverage**

[ISO 19123:2005]

4.1.32
raster
usually rectangular pattern of parallel scanning lines forming or corresponding to the display on a cathode ray tube

[ISO 19123:2005]

NOTE 1 A raster is a type of **grid**.

NOTE 2 The term “raster data” is often used colloquially in the field of **geographic information** to identify the whole class of data where the spatial geometry is organized into a grid. A description of what is meant by “raster data” is given in ISO 19123 and the more comprehensive concept of a **coverage** is described.

4.1.33
service
distinct part of the functionality that is provided by an entity through interfaces

[ISO/TR 14252:1996]

4.1.34
spatiotemporal domain
〈coverage〉
domain composed of **spatiotemporal objects**

[ISO 19123:2005]

NOTE The spatiotemporal domain of a **continuous coverage** consists of a set of **direct positions** defined in relation to a collection of spatiotemporal objects.

4.1.35
spatiotemporal object
object representing a set of **direct positions** in space and time

[ISO 19123:2005]

4.1.36
surface
2-dimensional geometric primitive, locally representing a continuous image of a region of a plane

[ISO 19107:2003]

4.1.37
tessellation
partitioning of a space into a set of conterminous subspaces having the same dimension as the space being partitioned

[ISO 19123:2005]

NOTE A tessellation composed of congruent regular polygons or polyhedra is a regular tessellation; one composed of regular, but non-congruent polygons or polyhedra is semi-regular. Otherwise, the tessellation is irregular.

4.1.38
traversal order
sequence in which the cells of a **grid** are enumerated

4.1.39
UML template
parameterized model element that describes or identifies the pattern for a group of model elements of a particular type

[IBM Rational System Developer]

4.2 Abbreviated terms

BIIF	Basic Image Interchange Format
DEM	Digital Elevation Model
GCP	Ground Control Point
GeoTIFF	Geographic TIFF
GIS	Geographic Information System
GML	Geography Markup Language
HDF-EOS	Hierarchical Data Format - Earth Observing System
JPEG	Joint Photographic Experts Group
LUT	Look-Up Table
RGB	Red Green Blue
TIFF	Tagged Image File Format
TIN	Triangulated Irregular Network
UML	Unified Modeling Language
XML	eXtensible Markup Language

4.3 Notation

The conceptual schema specified in this Technical Specification is described using the Unified Modeling Language (UML), following the guidance of ISO/TS 19103.

Several model elements used in this schema are defined in other ISO geographic information standards. By convention within ISO/TC 211, names of UML classes, with the exception of basic data type classes, include a two letter prefix that identifies the standard and the UML package in which the class is defined. UML classes defined in this Technical Specification have the two letter prefix of IF. Table 1 lists the other International Standards and packages in which UML classes used in this Technical Specification have been defined.

Table 1 — Sources of externally defined UML classes

Prefix	Standard	Package
CV	19123	Coverage Core & Discrete Coverages
EX	19115	Metadata extent information
GF	19109	General Feature Model
GM	19107	Geometry Root
MD	19115	Metadata entity set information
MI	19115-2	Metadata entity set imagery

5 Background for the framework

5.1 Legacy concepts and terminology

Any attempt to solve the problem of achieving compatibility between the many existing imagery and gridded data specifications and standards in wide use is hampered by the fact that they use different terminology, or use the same terms to represent different concepts. A variety of meanings have been assigned in the past to the three important terms (imagery, raster, and matrix) resulting in potential confusion. The terms imagery, raster and matrix are defined in Clause 4. The term “matrix data” is sometimes used colloquially to describe a set of measured attribute values organized in a grid. In some contexts this term implies the exclusion of “raster data” or “imagery data”. Using the term “matrix data” in this way is unsatisfactory because the concept conflicts with the concept of gridded data and is ambiguous. Unfortunately, the common or colloquial uses of all of these terms overlap and they provide a poor lexicon. In Clause 4 these terms are given a more precise technical meaning. However, because these terms are often used in external standards or specifications in less precise or different ways it is important to be aware of the broader colloquial meanings sometimes given to them.

5.2 Separation of carrier and content

Many data interchange standards for imagery and gridded data describe the allowed data types, their meaning and their relationships in terms of the encoding format used to carry the data. This approach can be restricting because the limitations of the interchange mechanism — and there are always some limitations — are imposed on the description of the data. The suite of geographic information standards takes a different approach to defining data structures where the allowed data types, their meaning and their relationships are defined in an abstract manner using the UML modeling language. One or several different encoding rules may then be applied to the data to encode for transmission or storage on different data carriers. Of course this approach does not eliminate the limitations inherent in some encoding techniques, it just shifts the problem to the encoding rule used to encode the abstract model into a particular encoding format. This is the correct place for limitations, such as the bit length of numbers, to appear since they can be handled by exceptions in the encoding where necessary. Because of the large volumes of data involved, the separation of the *carrier* from the *content* of imagery, gridded and coverage data is of particular importance.

The ISO/TS 19101-2 reference model for geographic imagery makes use of the concepts of the Reference Model for Open Distributed Processing (RM-ODP) ISO/IEC 10746. The concept of ISO/TS 19101-2 and RM-ODP is to organize systems according to five different views. The “information view” is concerned with the semantics of information and information processing. This is distinct from the “computational view” which is concerned with the interaction between services that are part of a larger system including the encoding of data for interchange. It is also distinct from the “engineering” or “technology” viewpoints that are concerned with implementations and the underlying infrastructure. For a description of the RM-ODP views and their application to imagery see ISO/TS 19101-2:2008, Clauses 6 to 9 and Annex B. ISO/TS 19101-2:2008, 7.3.5.1 also indicated the need to separate carrier from content.

The concepts of the RM-ODP are reinforced by the ISO standards for Open Systems Interconnection (OSI) ISO/IEC 7498-1. The OSI standards divide a system designed for data interchange into seven distinct layers. The two highest layers are the “application layer” and the “presentation (representation) layer”. The application layer addresses the semantic meaning of data interchange and the presentation layer addresses the encoding. The lower layers provide the exchange mechanism. OSI supports the separation of the *carrier* from the *content*.

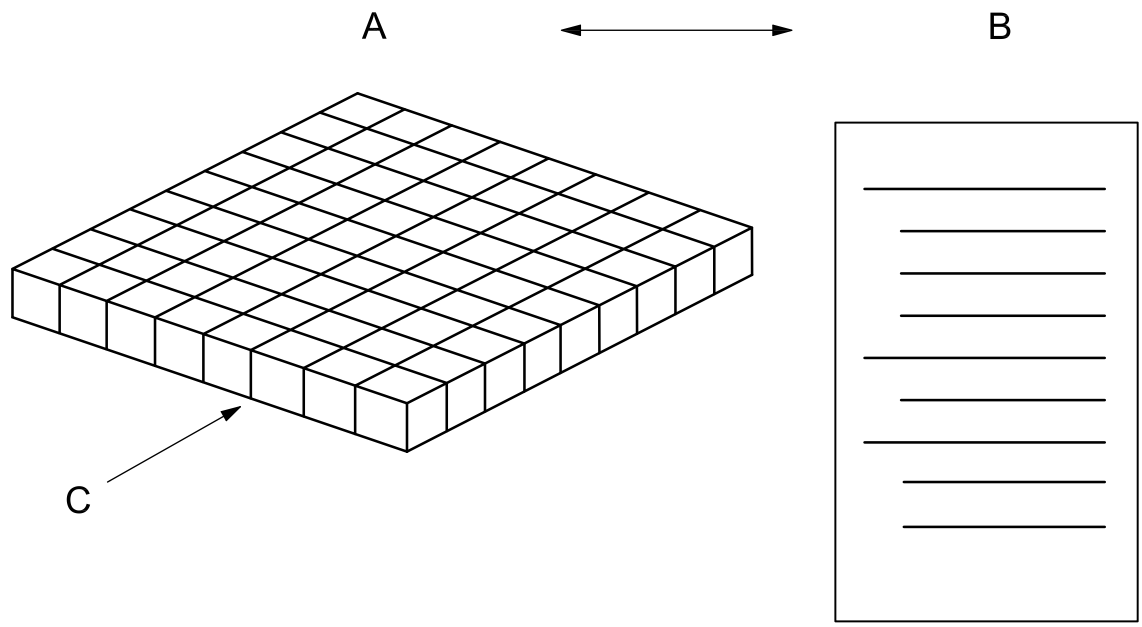
A data set of imagery, gridded or coverage data is structured as a set of coverage value objects consisting of a grid value matrix, TIN triangles, points or geometry value pairs together with a description of the coverage function and associated metadata. This can be described independently from the encoding which may be used for data interchange or data storage.

5.3 Content model

The concept of a "content model" is an important part of this framework document. The ISO geographic information suite of standards makes use of the concept of an application schema. An application schema is the conceptual schema for data required by one or more applications. A content model is the "information view" of an application schema. It addresses only the information needed to describe the semantic meaning of the data, exclusive of the interchange format or portrayal issues.

The content model for a set of gridded data consists of a set of attribute values organized in a grid together with metadata to describe the meaning of the attribute values and spatial referencing information to position the data. The metadata may contain identification information, quality information, and information such as the sensor from which the data was collected. The spatial referencing information contains information about how the set of attribute values is referenced to the Earth. The spatial referencing information itself is expressed as metadata.

Auxiliary information, also expressed as metadata, may assist in portrayal or encoding. However, the basic content may be portrayed in different ways or carried using different interchange mechanisms, in such a way that auxiliary information is not a part of an imagery and gridded data content model. Figure 1 illustrates the simple structure of gridded data.



Key

A Grid value matrix

B Associated metadata

C Attribute value for a grid cell

Figure 1 — Simple structure of gridded data

Other types of coverage data are also inherently simple. They consist of a set of coverage value objects and the description of the coverage function. ISO 19123 supports grid coverage including hexagonal grid coverage, point set, Thiessen polygon, quadrilateral grid coverage as well as segmented curve coverage and triangulated irregular network.

The ISO geographic information suite of standards provides a set of building blocks out of which all types of geographic information, including imagery and gridded data, can be assembled. These building blocks provide information objects that may be associated using an application schema. The emphasis of the application schema is on the data structure and data content and therefore, in the case of imagery, gridded and coverage data on the set of coverage value objects together with associated metadata. The method of encoding and presenting the information structure and content is separate from the data itself. By separating the carrier from the content, the "content model" is defined separately from the encoding rule used to carry or store the data content and from the presentation rule or rules used to portray the content. There may be additional data required to be carried with the content data, to support portrayal. For example, for certain classes of imagery a colour look-up table (colour map) may be defined which assigns presentation colours to coded values in the grid value matrix.

6 General feature model as applied to imagery and gridded data

6.1 Coverages as features

ISO 19109 states that "a fundamental unit of geographic information is called a feature" and indicates that "the formal approach of modeling geographic information shall be conformant with a 4-layer architecture" as described in ISO 19109:2005, Annex B. The general feature model defined in ISO 19109 applies to all geographic information including imagery, gridded and coverage data. In the reference model in ISO 19101 a feature is defined as an "abstraction of real world phenomena".

A coverage is a type of feature. It differs from other types of features in that some of its non-spatial attributes are associated with its spatial attributes through a coverage function that relates the values of those attributes to position, relative to the spatial attributes, whereas the spatial and non-spatial attributes of other types of features are independent of each other.

For a simple gridded image there may be one feature corresponding to the image itself with the geometry defined in accordance to a grid structure. Some thematic attributes of the feature may apply to the feature as a whole whereas other attributes may be determined by the use of a coverage function for any position within the range of the function.

The great advantage of treating all geographic information as feature oriented data is that it allows coverage data to be mixed with "vector" data and other coverage data in a single application schema and therefore in a single data set. The relationships between features of all types may be defined.

As an example of a combined data set, a satellite image may be analysed and the roads identified. The combined data set could include the image together with a vector representation of the roads. The combined data set would consist of the feature corresponding to the image coverage and the features corresponding to the roads. Another example of a combined data set might be the combination of satellite image coverage over land with a hydrographic bathymetric coverage over water. The spatial range of both coverages may be cut at the coast line. The combined data set would consist of the two features corresponding to both the coverages.

6.2 Additional feature relationships

The general feature model described in ISO 19109 indicates that the characteristics of a feature type (GF_FeatureType) are its properties (GF_PropertyType). The three subtypes of the property type are the GF_Operation, the GF_AttributeType and the GF_AssociationRole. The attribute types may be GF_TemporalAttributeType, GF_Spatial AttributeType, GF_LocationAttributeType, GF_MetadataAttributeType, or GFThematic AttributeType. Since ISO 19109 was developed to address primarily vector type data it only identifies spatial attributes of the type GM_Object or TP_Object as defined in the spatial schema in ISO 19107.

7 Framework

7.1 Framework structure

The framework defined in this Technical Specification describes the relationship between the content model and the other information required for interchange and portrayal. This framework is built upon ISO/TS 19101-2 for imagery and gridded data.

This framework provides five patterns for various types of imagery, gridded and coverage data in accordance with ISO 19123. A small choice of patterns is provided in order to define an underlying compatibility between different sets of imagery, gridded and coverage data. This set of pre-defined structures is represented as partial template application schemas, which are UML patterns. Compatibility may be achieved between different imagery and gridded data standards by ensuring that common information content is identified and may be described in accordance with these patterns. As illustrated by the use cases identified in Annex B, four grid based structures and one non-grid coverage structure are described.

Structures are defined for:

a) continuous quadrilateral grid coverage;

b) quadtree grid coverage (Riemann hyperspatial multidimensional grid coverage);

c) TIN coverage;

d) discrete point coverage;

e) discrete surface grid coverage.

The imagery, gridded and coverage data framework makes use of elements defined in other ISO geographic information standards. Figure 2 presents the packages that are applicable to imagery, gridded and coverage data. It shows how elements are related within the framework. Half of the related packages provide metadata that may be used in association with imagery and gridded data.

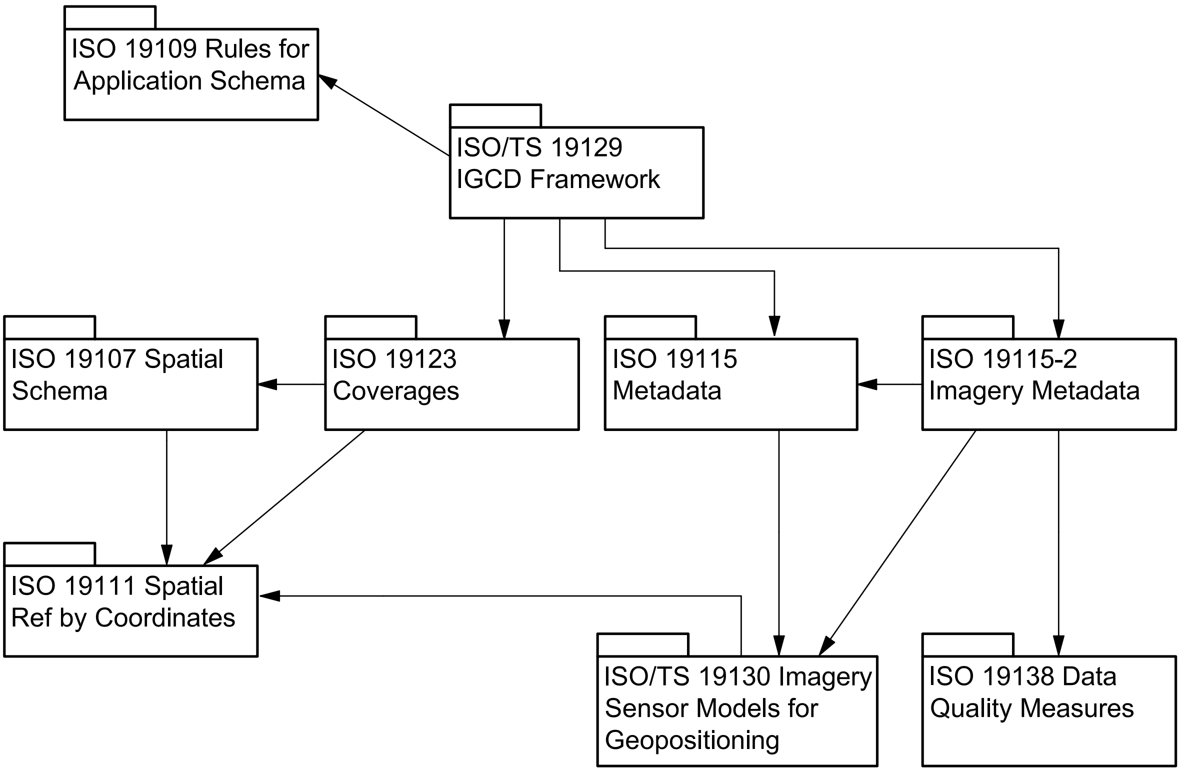


Figure 2 — Overall relationships inside and outside the framework

7.2 Elements of the framework structure

7.2.1 Framework Overview

Imagery, gridded and coverage data can be described at several levels, as shown in Figure 3. These are an abstract level, as addressed in ISO 19123, a content model level and an encoding level. Encoding makes use of the structures defined in ISO 19118. This allows for a neutral XML based encoding as well as allowing for many other specific encoding schemes. Encoding may include GML (ISO 19136) together with JPEG 2000 (ISO 15444), of BIIF (ISO 12087-5) or one of the many other imagery encoding formats identified in ISO/TR 19121.

Most of the existing interchange standards relating to imagery, gridded and coverage data describe information in terms of its representation in an interchange format. The format defines data fields and describes the contents and meaning of these data fields. This implicitly defines the information content that can be carried by this interchange format. Some of the existing standards even separate their “information” from the encoding within the description of the standard, but in the end it is the encoding that defines these standards. The common content models defined in this Technical Specification allow for a mapping to the structures defined in the encoding standards.

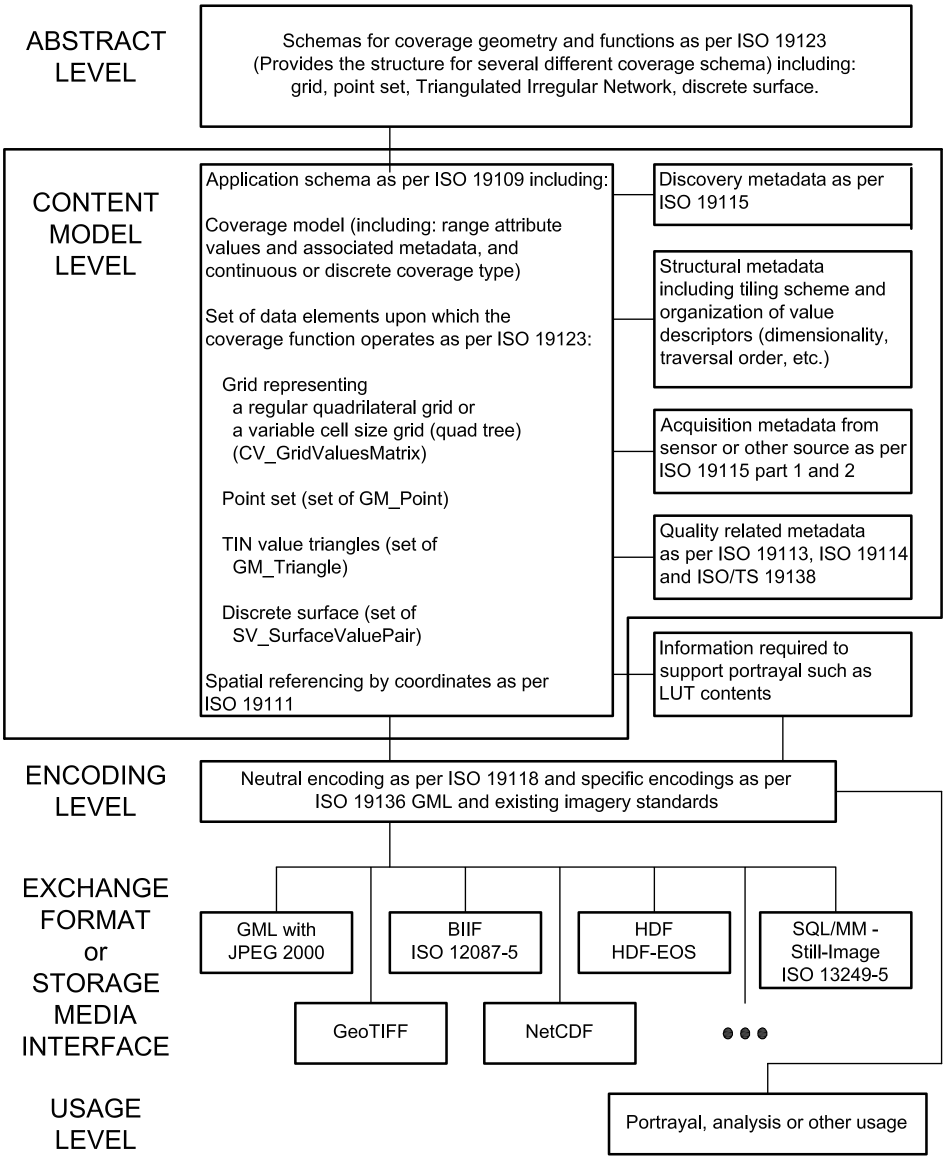


Figure 3 — Overall relationship between the elements of the framework

7.2.2 Abstract level

The abstract level provides a generic abstract structure for all types of coverage geometries including gridded data geometries. This abstract structure is defined in ISO 19123. This Technical Specification takes from ISO 19123 several coverage geometries, including point set, TIN and quadrilateral grid.

7.2.3 Content model level

A content model for imagery, gridded and coverage data is the description of the information content of a set of geographic information, consisting of the spatial schema, feature identification and associated metadata, where other aspects such as quality, geo-referencing, etc., are represented in the metadata. The content model does not include portrayal or encoding or the organization of the data to accommodate various storage or interchange media. Interchange metadata that describes the information about a data interchange is also not part of the information defined by the content model.

The content model level of this framework consists of a set of pre-defined content structures, which can serve as the core for various application schemas to be developed for imagery, gridded and coverage data. The generic content model for gridded data consists of a small set of grids, with associated traversal orders that provide the spatial organization for imagery and gridded data. The TIN and the point set are the only non-grid coverage structures defined at the content model level in this framework. In addition to these grid and non-grid structures are defined metadata, quality and spatial referencing. References are made to the existing ISO geographic information series standards for these elements when they are available.

The feature model defined in ISO 19109 applies to imagery, gridded and coverage data. Although the conventional approach used in many external imagery standards is to consider an image as a unique entity on its own, and to not consider a feature structure, it is better to consider imagery, gridded and coverage data as feature oriented data. In the simplest form, an image, grid or other data set organized as coverage can be considered as a single feature. For example, an entire satellite image could be considered as the representation of the feature that is the “abstraction of real world phenomena” as viewed by the sensor that produced the image. However, it is also possible to do feature extraction on an image, where sets of pixels are the geometric representation of different features. An application schema can contain a feature model, where the geometric component of the feature model consists of sets of geometric points corresponding to the picture elements (pixels) in a grid structure for an image. If a feature structure consisting of more than one feature is associated with an image, it is necessary to provide a method of linking feature IDs to individual pixels in the image. For example, an image may be represented as a simple grid consisting of a set of rows and columns providing organization to a set of pixels. Each pixel contains attributional data such as the colour and light intensity seen at that point. Also, each pixel may contain an additional attribute that indicates the feature ID associated with the pixel, so that the pixels corresponding to the image of a bridge are marked as the feature bridge, and those corresponding to a river are marked as river. Other more efficient structures may also be defined to identify sets of grid cells or pixels as corresponding to a given feature.

An application schema for imagery and gridded data shall comply with the general feature model in ISO 19109, together with the additional relationships as identified in Clause 7, and shall associate the point value pairs driving the coverage function with at least one feature. For imagery and gridded data consisting of more than one feature the application schema shall provide a method of linking feature IDs to individual or sets of point value pairs.

ISO 19123 provides for a very broad range of possible coverage structures. This Technical Specification selects a simple bounded quadrilateral grid as the basic organization of gridded data. In addition, content model structures are defined to support some more complex grids such as grids with variable cell size in 2- and n-dimensions.

Figure 4 illustrates the structure for imagery, gridded or coverage data under this Technical Specification.

The content model includes the spatial structure and the metadata. The encoding structure is separate but related. Data compaction removes information based upon its semantic content, while data compression removes information based upon the bit structure, independent of the meaning. Data compaction is part of the content model whereas data compression is not. An example of data compaction is the removal of information that is known by the application to be not necessary. This would include areas over which there can be no data and the removal of bits of numeric data for lower precision numbers. Data compression removes redundant information that occurs randomly, for example, long runs of 1 bits in a system that can detect and compress run length encoding. Both types of data set size reduction may be applied, but the data compaction is part of the encoding structure, whereas the data compression is part of the content model.

NOTE Metadata occurs at different levels. Context metadata is part of the content model as part of the RM-ODP information viewpoint, whereas encoding and portrayal metadata is part of the RM-ODP engineering viewpoint.

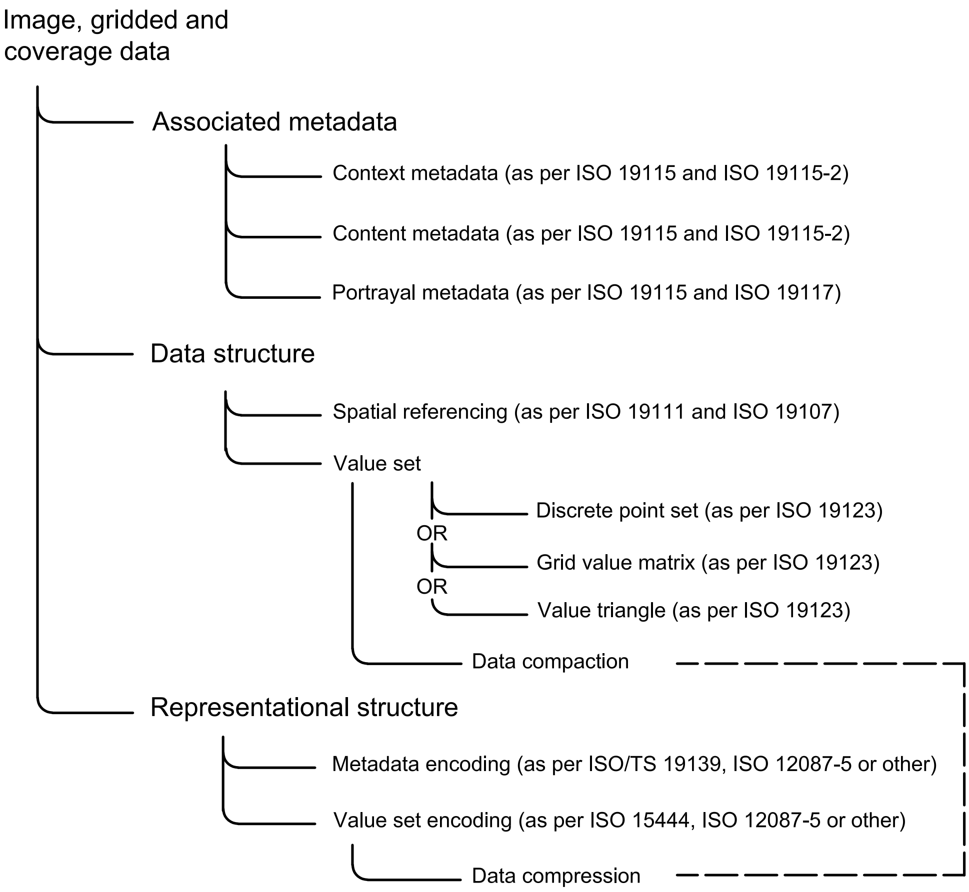


Figure 4 — Image and gridded data component diagram

Figure 5 illustrates an overview of a content model for imagery, gridded and coverage data. This is an expansion of Figure 4, with the representational structure and portrayal information not shown since it is not part of the content model. The mechanism for data compaction is not directly shown because it relates to the structure of the grid value matrix. For example, a tiled grid exhibits data compaction when tiles are only defined for areas where data is possible. Data compaction also exists in a variable size cell structure where adjacent pixels of the same attribute value can be aggregated into a single larger cell.

Data compaction is related to the organization of the data. A quadtree exhibits data compaction due to the variable size cells. This is also true of a TIN with variable size triangles. Compression in general bridges the information and engineering levels. There needs to be the information structure at the content model level in the information viewpoint in order for there to be a reduction in the volume of data due to data compression at the engineering level.

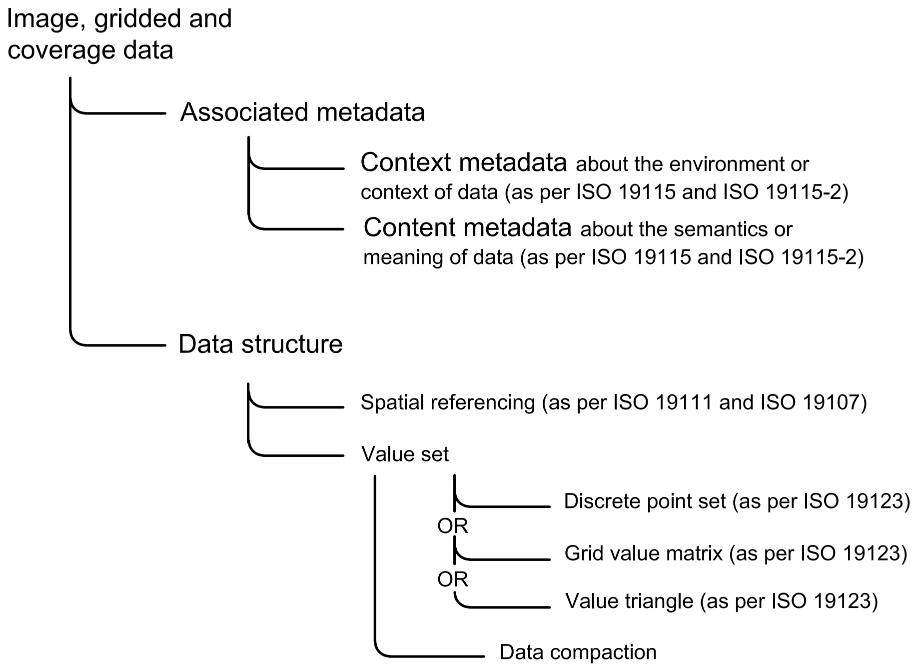


Figure 5 — Imagery and gridded data content model components

7.3 Encoding level

7.3.1 Interchange format and media storage

ISO 19118 defines an encoding rule as “an identifiable collection of conversion rules that defines the encoding for a particular data structure”. The encoding rule specifies the data types to be converted as well as the syntax, structure and coding schemes used in the resulting data structure. An encoding rule is applied to application schema specific data structures to produce system-independent data structures suitable for transport or storage. It also defines an encoding service as a service able to read the input data structure and convert the instances to an output data structure and vice versa.

The content model defines the structure to which an encoding rule may be applied. There are a large number of different encodings used for imagery, gridded and coverage data. Many of these encodings are widely-used standardized interchange formats. ISO/TS 19101-2:2008, 7.3.5 describes four common encodings and six common data compression schemes used with encodings. One encoding is JPEG 2000 with an associated XML file or GML as per ISO 19136 linked to JPEG 2000 data.

Gridded and coverage data is among the simplest data structure for geographic information. However, these data sets are large arrays, containing a large number of picture elements, grid cells, points or TIN value triangles. There are two different sets of information to encode, the value elements (pixels, grid cells, points or value triangles) and the metadata about them. These may be encoded in the same integrated standard, or as two separate linked sets of information. In addition most encoding rules for imagery, gridded and coverage data include data compression rules to reduce the data volume of the value element data.

There are a number of ISO standards that have been developed within ISO/IEC JTC 1 Information Technology that address picture coding and imagery data that can be applied to the content model structures defined in this Technical Specification. The standards that are applicable include the standards from ISO/IEC JTC 1/SC 29 and ISO/IEC JTC 1/SC 24. These standards should be used where applicable. There are also a number of commercially defined standards or standards defined in other organizations that may be used. ISO/TR 19121 reports the results of a survey of these standards.

To promote compatible data interchange it is desirable to have a common neutral encoding format, even if that format is not optimal for the particular data set. A neutral encoding would consist of the use of an XML encoding to describe the metadata aspects of imagery, gridded and coverage data and an appropriate value element encoding mechanism taken from the ISO/IEC JTC 1/SC 29 standards on picture coding that supports compression. In particular ISO 15444 may be used together with XML as a neutral encoding. The details of encoding are outside the scope of this Technical Specification.

7.3.2 Encoding rules

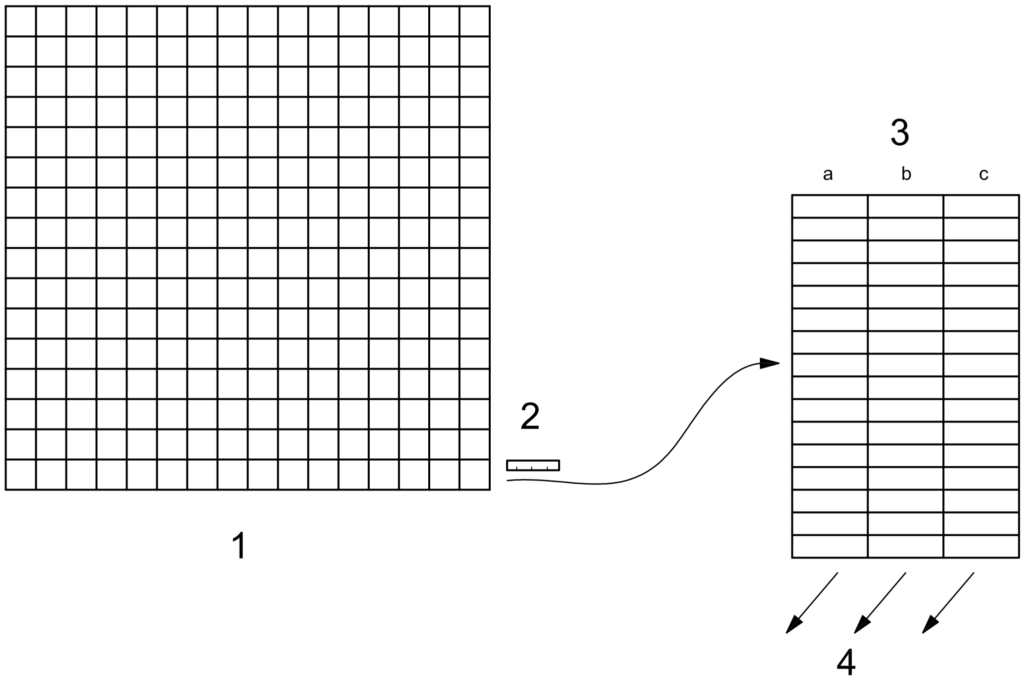
ISO 19118 allows for a number of different encoding rules to be used to encode geographic information in the most appropriate manner for a given context. XML encoding is presented as a neutral encoding to support blind interchange. Encoding techniques assign bit patterns to data elements and encapsulate data to indicate where particular data elements begin and end in a data stream. There are several encapsulation approaches available. The most common are a tag delimiting method, such as is used in XML, or a bit stream length pointer method, such as used in ISO 8211 and ISO 8825. Some other techniques build the encapsulation into the encoding structure. This can be efficient for large arrays of regular data such as gridded data sets. All encapsulation techniques involve additional information to delimit and identify the content elements. This is called the encoding overhead. The large volumes involved in imagery and gridded data requires the use of techniques that minimize this overhead. This Technical Specification does not define encoding rules. The information content described in accordance with application schema described in this Technical Specification can be encapsulated and encoded using different encoding rules as appropriate to the interchange context.

7.4 Imagery and gridded data portrayal

The information driving the portrayal forms part of the content model, even though the mechanism of portrayal falls outside the scope of this Technical Specification. The type of information that may need to be carried with a set of imagery and gridded data to support external portrayal mechanisms includes information about colour systems, and attribute colour values and data values that may need to be loaded into a colour look-up table (LUT).

7.5 Feature relationship for LUTs

Value types in an image may be coded using a colour LUT. The values in the grid are codes corresponding to colours. A code from the value matrix is used as an address into the LUT, which contains the corresponding colour value. The colours in the LUT may be arranged in an algorithmic manner, in which case an interpolation function may be defined for the coverage, or the colours may be defined in an arbitrary order, in which case no interpolation function is possible. Figure 6 illustrates the use of an LUT.



Key

1 matrix of colour coded values

2 colour coded value used as an index into LUT

3 LUT

4 output colour values

a Red.

b Green.

c Blue.

Figure 6 — Use of a colour look-up table (LUT)

Although colour LUTs are intended for the portrayal of colour coded imagery and gridded data, the information pertaining to the LUT shall be carried as associated information together with the value data.

8 Spatial referencing of imagery, gridded and coverage data

Spatial referencing for gridded data, point set data and TIN data are handled differently. Point set data includes a coordinate direct position for each point in the point set. Gridded data references the grid as a whole. TIN data includes direct positions for each TIN triangle vertex. The two spatial properties of gridded data describe how the spatial extent was tessellated into small units and spatial referencing to the Earth. Spatial referencing is described in ISO/TS 19101-2 and ISO/TS 19130.

9 Imagery, gridded and coverage data structure

9.1 IGCD structure and metadata

A template for the general structure for a set of imagery, gridded and coverage data is given in Figure 7. It shows that a data set consists of a collection of one or more coverages together with associated metadata. The concept of what a data set is varies significantly between the various exchange formats that may be used to carry the data. For this reason the concept of a transmittal is introduced. A transmittal identifies the information that is exchanged, which may be a data set, a part of a data set, or several data sets. Various exchange formats support the concept of a transmittal, but often in very different manners. In some cases an exchange format allows the exchange of only complete data sets. In other cases it allows for the exchange of a partial data set, in which case the transmittal mechanism shall provide the information needed to identify which part of the data set is being exchanged. An update mechanism is a specialized type of partial data set exchange. Some exchange formats also allow for the exchange of multiple logical data sets in one transmission.

Although the concept of a transmittal may be supported differently in various exchange standards, it is relatively easy to convert data between different transmittal structures. Full data sets may be broken into parts or the various parts of partial data sets aggregated. The form of the transmittal used is highly application dependent. Some formats are more suited to the archiving of large volumes of data and others are suited to the exchange of smaller portions of data in on-line services or through update mechanisms.

The data set itself comprises a collection of one or more coverages. A part of a coverage is itself a coverage. The coverages may be of multiple instances of the same type or of different types.

Associated with each data set and with each collection is metadata. Metadata may be organized in various ways, and the different exchange formats support different metadata elements in different ways. This framework document has arbitrarily divided the metadata associated with imagery, gridded and coverage data into several categories. This assists in mapping metadata between the content model for a particular type of data and the structures supported by exchange formats. The first breakdown is into context metadata that describes the environment or context of the data, and content metadata about the semantics or meaning of the data. This can be further broken down into: discovery, structural, acquisition, and quality metadata. Unfortunately there is no firm barrier that absolutely assigns a metadata element into any of these categories. An attribute in one exchange format may appear as metadata in another. At one level all the information, other than the set of value objects, is metadata. The metadata that remains invariant with respect to the exchange format or storage media is content metadata and the rest is context metadata. The breakdown into the four types also relates to the ISO standard used to describe the metadata. Discovery metadata is described in ISO 19115, and structural metadata is described in ISO 19115 and ISO 19115-2. ISO 19115 and ISO 19115-2 are extensive lists of potentially applicable metadata elements. Acquisition and quality metadata elements may also be taken from these lists. ISO/TS 19130 and ISO/TS 19138 also provide additional metadata elements. Discovery metadata may apply to a data set so that any data set may be identified. All metadata including discovery metadata may apply to a collection.

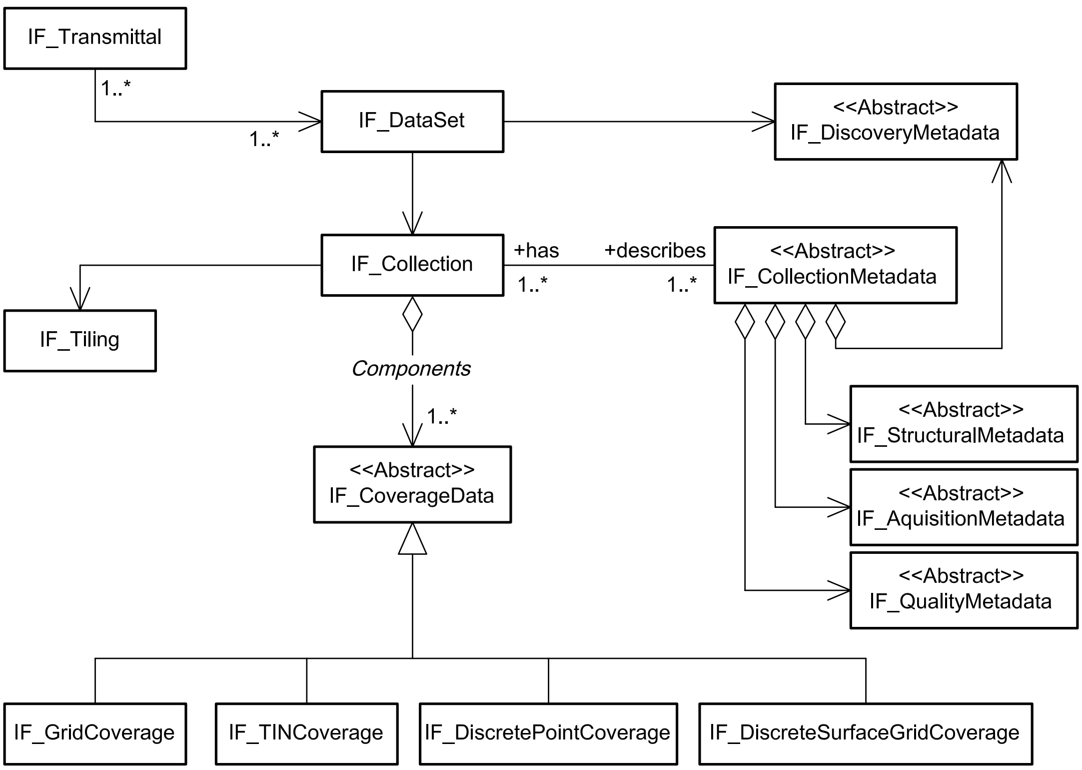


Figure 7 — IGCD structure and metadata

9.2 Framework structure classes

9.2.1 IF_DataSet

A data set is an identifiable collection of data that can be represented in an exchange format or stored on a storage media. A data set can represent all or part of a collection and may include one or many tiles of data. The content of a data set is defined by the product specification for that particular type of data product and is normally suited to the use of that data. A product specification for a particular type of data product needs to describe the organization of that data product. For example, a simple imagery product may have only one grid coverage, and a tiling scheme that indicates that every data set contains one tile. More complex products may include several collocated coverages and more complex tiling schemes such as a quadtree based variable size tiling scheme. The data set is the logical entity that can be identified by the associated discovery metadata, not the physical entity of exchange. An IF_DataSet implements the class DS_DataSet as described in ISO 19115.

9.2.2 IF_Transmittal

A transmittal is the entity used in the encoded exchange format to carry all, part of, or several data sets. It represents the physical entity of exchange. The transmittal is dependent upon the encoding format and the exchange media. A transmittal on a physical medium, such as a DVD, may carry a number of data sets, whereas a transmittal over a low bandwidth telecommunications line may carry only a small part of a data set. Any metadata carried with a transmittal is integral to the transmittal and may be changed by the exchange mechanism to other exchange metadata as required for the routing and delivery of the transmittal. A common exchange mechanism would be to carry a whole data set on one physical medium such as a CD-ROM. Transmittal metadata is not shown because any transmittal metadata, exclusive of the information in the discovery metadata module, is dependent upon the mechanism used for exchange, and may differ from one exchange media or encoding format to another. An example of transmittal metadata would be counts of the number of data bytes in a unit of exchange.

9.2.3 IF_DiscoveryMetadata

Associated with a data set or a collection is a set of discovery metadata that describes the data set so that it can be accessed. It consists of the “core” metadata defined in ISO 19115 and it identifies the data set. This class is indicated as abstract since it is implemented by the metadata classes taken from ISO 19115.

9.2.4 IF_Collection

The class IF_Collection represents a collection of IF_CoverageData and associated metadata. A collection may include multiple different coverage types over a particular area, or multiple coverages of data of the same coverage type, but representing different surfaces. For example, a collection may consist of a grid coverage and a point set over the same area, where the grid coverage represents an elevation surface and the point set a number of more accurately measured elevation points.

9.2.5 IF_CollectionMetadata

Associated with a collection is a set of collection metadata that describes the data product as represented in the collection. It consists of a number of sub-components that include the discovery metadata as well as the structure metadata, the acquisition metadata and the quality metadata. Metadata from the discovery metadata may be applied to a collection so that the entire collection may be discovered. The other metadata modules are descriptive metadata.

9.2.6 IF_StructuralMetadata

A component of a collection is optionally a set of structural metadata that describes the structure of the coverage. In many exchange formats the attributes of the coverage, such as the number of rows and columns in a grid, are carried as structural metadata. Metadata that describes context that is not considered as discovery metadata is considered as structural metadata. This class is indicated as abstract since it is implemented by the metadata classes taken from ISO 19115, ISO 19115-2 or specific attributes defined in a product. The identification of a tile in a tiling scheme may be considered as structural metadata if there is no provision to directly discover the tile in the discovery metadata.

9.2.7 IF_AcquisitionMetadata

A component of a collection is optionally a set of acquisition metadata that describes the source of the data values. This class is indicated as abstract since it is implemented by the metadata classes taken from ISO 19115, ISO 19115-2 or ISO/TS 19130.

9.2.8 IF_QualityMetadata

A component of a collection is optionally a set of quality metadata that describes the quality of the data values. This class is indicated as abstract since it is implemented by the metadata classes taken from ISO 19115, ISO 19115-2 or ISO/TS 19138. The general concept for handling quality in the ISO geographic information series of standards is defined in ISO 19113. The procedures to evaluate quality are defined in ISO 19114. ISO/TS 19138 provides a definitive set of measures.

9.2.9 IF_GridCoverage

The class IF_GridCoverage implements the class CV_ContinuousQuadrilateralGridCoverage from ISO 19123. There are two types of grid coverages defined in this framework. The first is a regular quadrilateral grid with constant cell size and a linear row column sequence rule. The second is a quadtree grid with variable cell size. The quadtree can be extended into a Riemann hyperspatial grid in more than 2-dimensions.

9.2.10 IF_TINCoverage

The class IF_TINCoverage implements the class CV_TINCoverage from ISO 19123.

9.2.11 IF_PointSetCoverage

The class IF_PointSetCoverage implements the class CV_DiscretePointCoverage from ISO 19123.

9.2.12 IF_DiscreteSurfaceCoverage

The class IF_DiscreteSurfaceCoverage implements the class CV_DiscreteSurfaceCoverage from ISO 19123.

9.2.13 IF_Tiling

The class IF_Tiling is used to describe the tiling scheme used within the collection. Identification of the tile is part of the structural metadata. Tiling is described in more detail in a separate clause in this Technical Specification.

10 Templates

10.1 Application schema for imagery and gridded data

Application schemas for imagery and gridded data are governed by the general feature model described in ISO 19109. A coverage is a type of feature, and a grid, triangulated irregular network or point set express spatial characteristics of a feature type. This occurs in exactly the same manner as for “vector data”. Any application schema that complies with the rules of ISO 19109 may be created, including those that mix coverage and vector data together. This Technical Specification does not restrict the development of application schema, but provides templates for the description of a select set of coverage data types within application schema.

Several generic content models are defined, in this clause, to serve as references for different types of imagery and gridded data.

The structures described in 10.2 to 10.7 (two grid structures, the TIN coverage structure, the point set coverage and the discrete surface grid coverage) are in compliance with the structures permitted in ISO 19123. For continuous coverages ISO 19123 allows a set of data values to cover an area, which defines a surface upon which an interpolation function can be applied to generate the value of the coverage function at any location in the space.

This Technical Specification defines specific types of gridded spaces including simple rectilinear grids in two or multiple dimensions organized as bands, or n-dimensional spaces, with uniform or variable size pixels.

Gridded sets of data values may represent imagery picture elements or non-imagery values such as elevations in a digital elevation model (DEM). These values form a value matrix in terms of ISO 19123. This value matrix is organized as a grid. The characteristics of this grid are its regularity (the spacing of the values), the traversal order (the order of the values), the boundary of the grid (rectangular, polygonal or tiled) and the dimensionality (2D, 3D or nD).

There are a very large number of possible structures that may be defined; however, only a few are in common use. The developer of an application schema is free to use any of the possible structures from the allowable geometry defined in ISO 19123. This Technical Specification pre-defines a few of the most common structures in order to establish commonality in the way these common structures are described and used.

10.2 Grid coverages

10.2.1 Grid types

The simple rectilinear grid with uniform cell size and the variable cell size grid are two distinct subtypes of IF_GridCoverage. Both grids may exist in 2- or multiple dimensions. The variable cell size grid is called a quadtree in 2-dimensions. In higher dimensions it is know as a Riemann hyperspatial grid. An example of such a grid is a hydrographic sounding data set that includes dimensions of X, Y, Z (depth) and T (time).

A simple rectilinear grid with uniform cell size only requires the cell size to be defined once for a coverage. The cell can be identified by the order of the data values following a row—column linear scan. Such a grid has cells completely covering the area within the boundaries identified for the coverage.

Fro a variable cell size grid it is necessary to identify the size of each cell. Several traversal orders are possible. The Morton order is identified in this Technical Specification because it generalizes to multidimensions. One can view a quadtree (or multidimensional hypertree) grid as a regular grid with uniform cell size where four adjacent cells that have the same attribute value, and align along the grid traversal pattern, can be aggregated into one larger cell.

Figure 8 illustrates the structure of a 2-dimensional simple rectilinear grid with uniform cell size and a variable cell size (quadtree) grid.

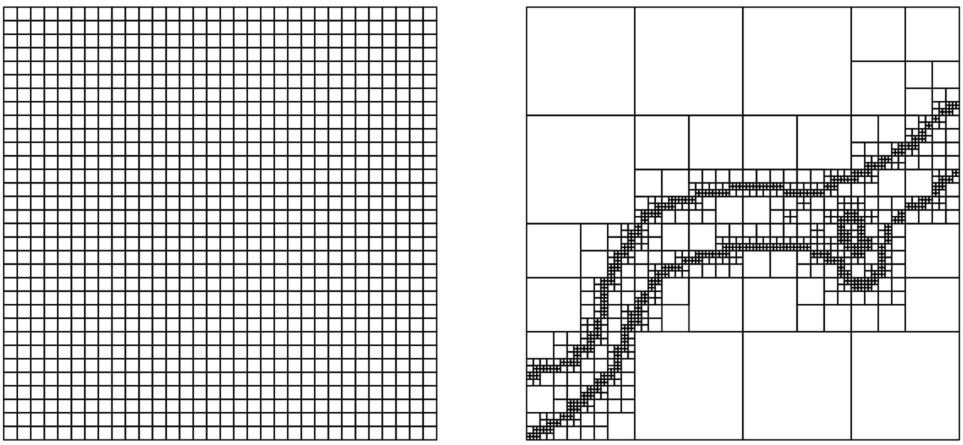


Figure 8 — Regular and variable cell size grids

Figure 9 illustrates the relationship of IF_GridCoverage to the two subtypes IF_QuadGriddedData and IF_RiemannGriddedData. Since both of these grid types inherit from the CV_ContinuousQuadrilateralGridCoverage they have nearly identical attributes. The difference is in the traversal method and the rule by which four adjacent cells along the traversal path aggregate into a larger cell if they have the same attribute value.

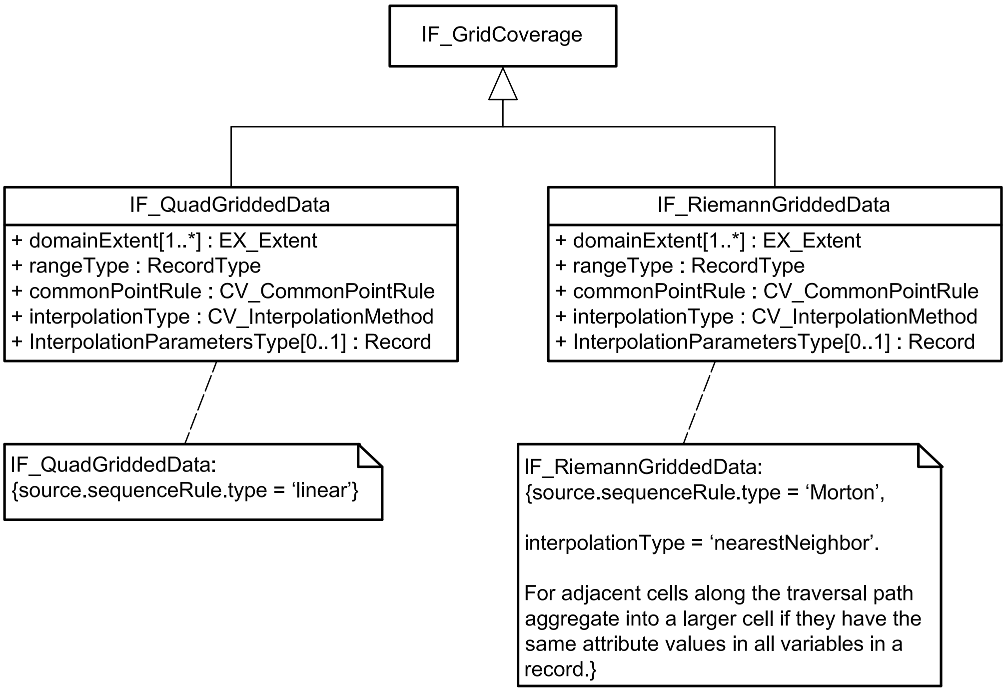


Figure 9 — Grid classes for regular and variable cell size grids

10.2.2 Grid classes

10.2.2.1 IF_QuadGriddedData

The class IF_QuadGriddedData is a subclass of the class IF_GridCoverage which implements the class CV_ContinuousQuadrilateralGridCoverage from ISO 19123. IF_QuadGriddedData defines a regular quadrilateral grid with constant cell size and a linear row column sequence rule. The attributes inherit form CV_ContinuousQuadrilateralGridCoverage. The attribute CV_SequenceRule selects a linear (row–column or column–row) scan.

10.2.2.2 IF_RiemannGriddedData

The class IF_RiemannGriddedData is a subclass of the class IF_GridCoverage which implements the class CV_ContinuousQuadrilateralGridCoverage from ISO 19123. IF_RiemannGriddedData defines a variable cell size grid where adjacent cells that have the same attribute values aggregate along the traversal order. The attributes inherit form CV_ContinuousQuadrilateralGridCoverage. The attribute CV_SequenceRule selects a Morton order scan. This grid is known as a quadtree in 2-dimensions.

10.2.3 The concept of variable sized grid cells

Traditional grids are fixed resolution, most commonly composed of perpendicularly crossing lines of equal spacing on each dimension, creating square or rectangular cells. Gridding is a standard way of generalizing point data sets, by imposing a resolution or grid spacing, and calculating individual grid cell values based on a single attribute of the group of points contained within each cell. Image data is primarily gridded, based on the resolution of the sensor or a uniform arbitrary pixel spacing.

Grids may also be established where the cell size varies within the grid. A common example is the "quadtree" that is commonly used in some geographic information systems (GIS). Having a variable size grid cell allows variable resolution throughout the gridded surface, which is exhibited by the unequal spacing of parallel lines that form the grid, localized to given grid cells. This requires the normalization of data on each dimension and the binary subdivision of each dimension in order to localize any given cell. When applied to point or image data, areas of high variability can be represented by small grid cells. Areas of low variability can be represented by large grid cells. Of course, if the cell size varies in a grid, it must do so in a regular way so that the grid tessellation still covers the bounded area, and the traversal method must be able to sequence the cells in an order. In addition, it is necessary to include information that describes the size of each cell together with the cell.

Data in a grid of variable cell size where adjacent like cells have been aggregated into larger cells maintains the integrity of the original uniformly spaced data, while minimizing storage size. A grid with variable cell size supports null values, so incomplete data – that containing holes – can exist without the need to assign arbitrary values to regions of no data. This allows for a considerable amount of compaction over traditional grids because nothing is stored for cells with no data – they do not exist.

Variable size cells are particularly useful for certain types of sensor data. For example, instead of representing hydrographic bottom cover as soundings (point sets) it can be represented as a set of variable size cells. Each cell can carry several attribute values. Adjacent cells which carry the same attribute values aggregate so the data volume is greatly diminished. Small cells exist where there is a rapid change in attribute value from cell to cell. Shoals, shore line and obstructions result in a number of small cells, where large, relatively constant, or flat areas, such as the bottom of a channel, result in a number of aggregated cells.

The Morton traversal order can handle variable size cells. The traversal progresses as shown in Figure 10. XY Morton order proceeds from left to right, bottom to top, cell by cell, regardless of cell size. It increments in the X coordinate then in the Y. This also extends to multiple dimensions where the increment is in X, then Y then Z, then in each additional dimension. Other variations of Morton order are described in ISO 19123:2005, Annex C.

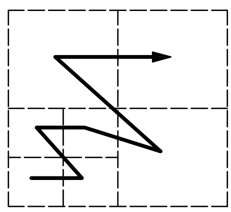


Figure 10 — Morton order (X,Y)

Any space filling curve gives order to a bounded space, but the order imparted by the Morton order preserves nearness. This is a very important property. It means that two points that are spatially close together in the grid are also close together in the traversal order of the grid. This property derives from Riemann's extension of the Pythagorean theorem into multiple dimensions into what is known as Riemann hyperspace. The Riemann diagonal corresponds to the hypotenuse of a Pythagorean triangle.

10.3 Continuous quadrilateral grid coverage

This core content model template (application schema component) defines a quadrilateral grid coverage with associated metadata. The metadata is referenced to ISO 19115 and ISO 19115-2, as shown in Figure 5. A specific choice of metadata has not been made in this schema. The selection of metadata is application dependent.

The gridded data consists of a single feature (the "image") together with associated metadata implemented through the IF_CollectionMetadata class. For the continuous coverage defined in this template schema, the coverage function returns a value for every point in the area covered based on an interpolation function. The grid value matrix is a set of values which drives the interpolation function. In this case the value matrix is a grid traversed according to a linear scan (X,Y) traversal rule. The spatial referencing is defined by the coordinate reference system and represented through metadata.

The template schema illustrated in Figure 11 supports the majority of imagery and gridded data applications.

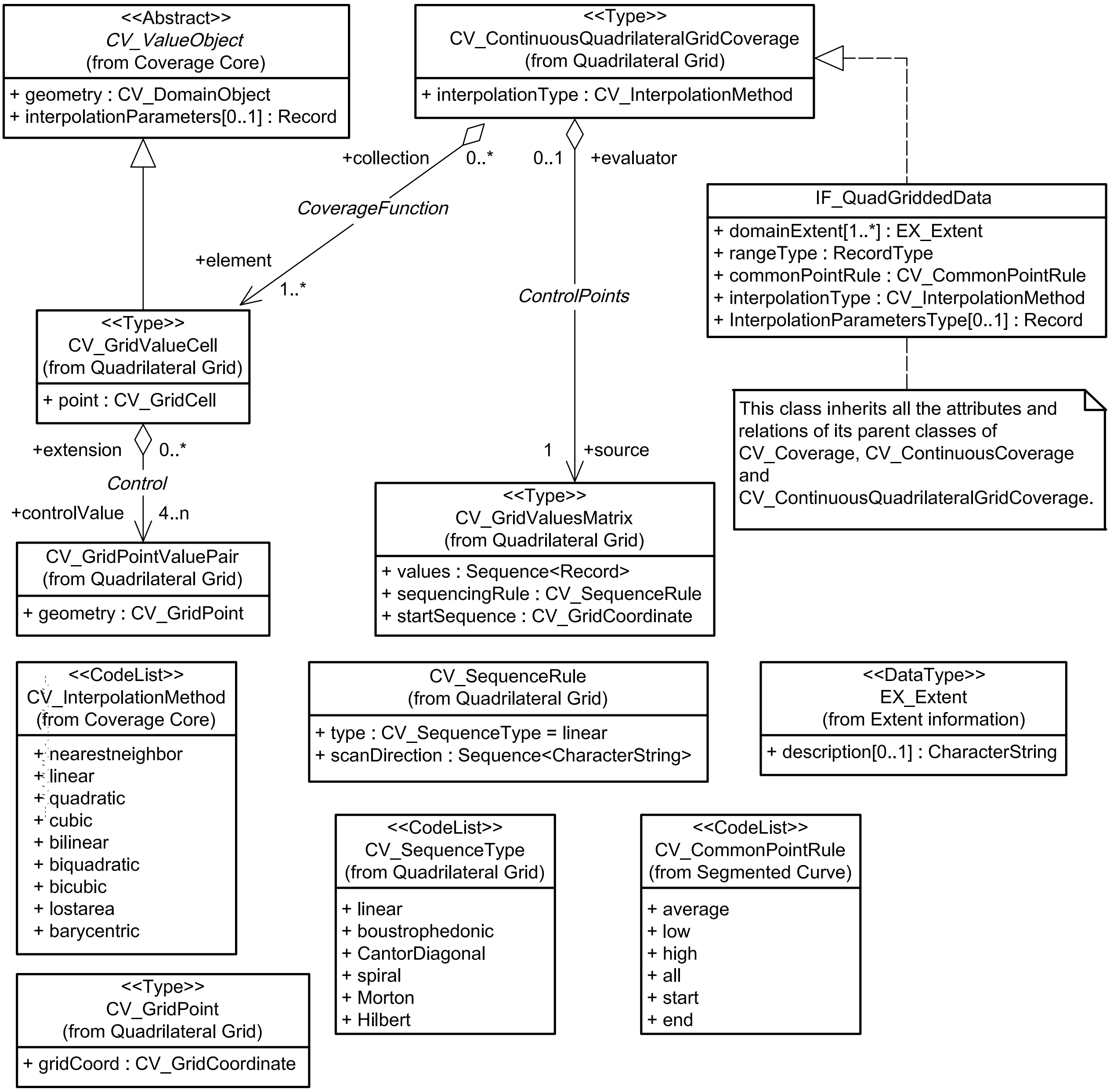


Figure 11 — Template application schema component for a quadrilateral grid

These classes all derive from ISO 19123 except for the class IF_QuadGriddedData which has been described in a previous clause.

10.4 Riemann hyperspatial multidimensional grid coverage

10.4.1 Riemann hyperspatial multidimensional grid coverage template

This core content model (application schema component) describes a grid of variable cell size using the Morton traversal order described in ISO 19123:2005, Annex C. This is of particular use for large volumes of sensor data where many adjacent cells have similar values and can be aggregated into larger cells. The metadata is referenced to ISO 19115 and ISO 19115-2. A specific choice of metadata has not been made in this schema. The selection of metadata is application dependent.

Variable sized cells are actually aggregations of small equally sized cells as defined by CV_GridValueCell. The nature of the Morton order means that only the size of each cell need be stored along with the cell value. The position of each cell is uniquely defined by the cell size and the traversal order. In a simple regular grid the location of each cell is uniquely defined by the row–column traversal order. In a Riemann grid the location of each cell is defined by the cell size (aggregation level) and the Morton order.

The gridded data consists of a single feature, together with associated metadata implemented through the IF_CollectionMetadata class. For the continuous coverage defined in this template schema, the coverage function returns a value for every point in the area covered based on an interpolation function. The grid value matrix is a set of values which drives the interpolation function. In this case, the value matrix is a subclass of CV_GridValuesMatrix that includes the additional parameter defining the cell size as a level of aggregation, that is, 0 represents the base minimum cell size, 1 represents the aggregation of one level of adjacent neighbours, and 2 represents the aggregation of one more level of adjacent neighbouring cells. Some specialized encoding schemes use binary fraction interleaving to represent the position of each cell in a quadtree or Riemann hyperspace, with the cell size encoded as the length (number of bits) representing cell position. Such an encoding scheme is outside the scope of this Technical Specification. The spatial referencing is defined by the coordinate reference system and represented through metadata.

The template application schema for Riemann grid coverage is shown in Figure 12. This template differs from Figure 11 in that the traversal order is Morton and the aggregation rule for adjacent cells is applied. It is necessary to describe the minimum grid cell dimensionality and axis order using the attributes “dimension” and “axisNames” inherited by CV_GridValuesMatrix from CV_Grid.

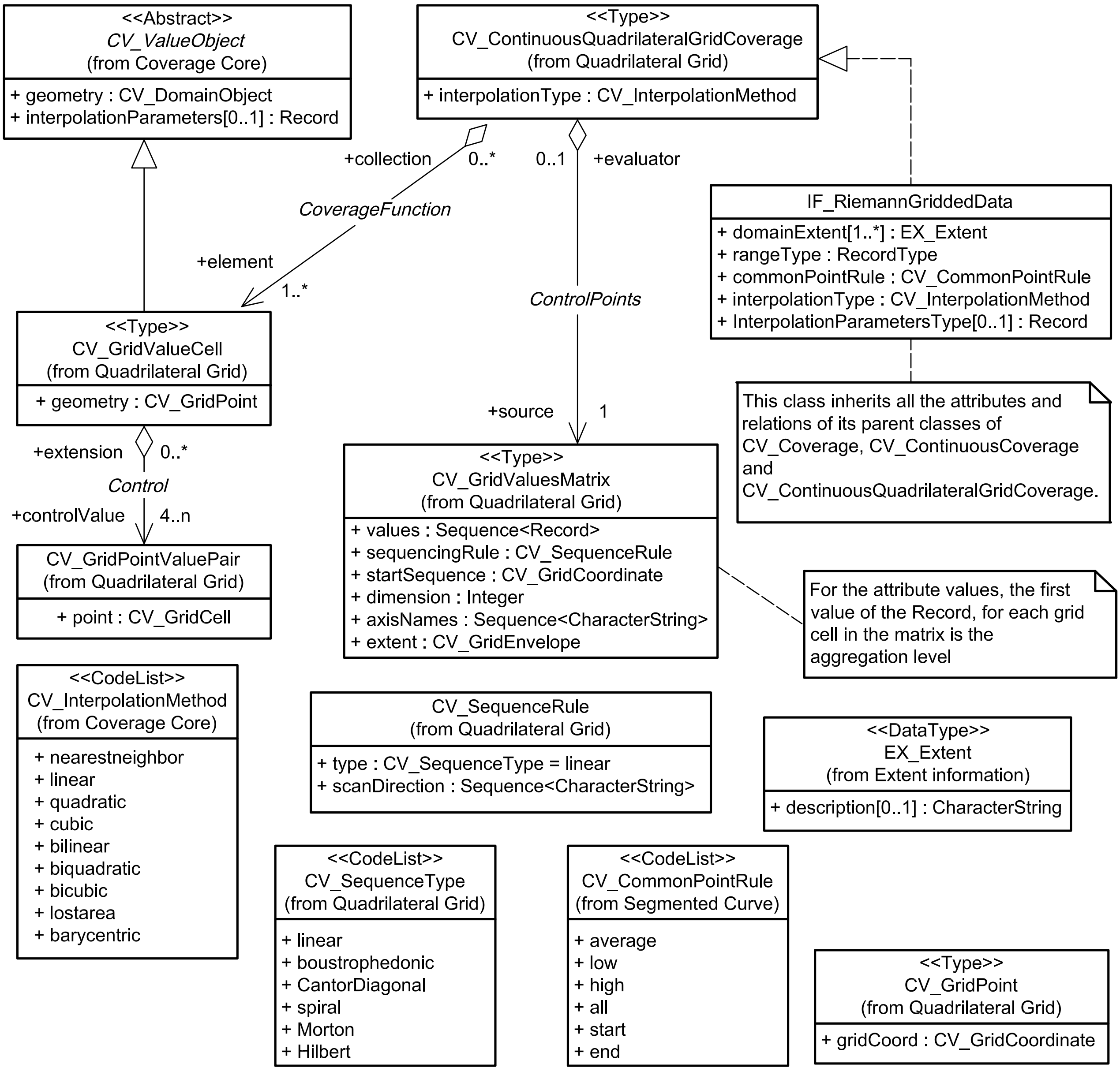


Figure 12 — Template application schema for Riemann grid coverage

10.4.2 Riemann grid classes

10.4.2.1 CV_GridValuesMatrix

The class CV_GridValuesMatrix is defined in ISO 19123. The attribute “dimension” established the minimum grid cell size. The data values for each cell are contained in the attribute “values” which is a sequence of records. For each grid cell in the matrix the first value of the record shall be an integer numbers that describes the aggregation level.

10.4.2.2 IF_RiemannGriddedData

The class IF_RiemannGriddedData is described in 10.2.2.2.

10.4.2.3 Other classes

The other classes and attributes derive directly from ISO 19123.

10.5 TIN coverage

10.5.1 TIN coverage template

The template application schema for a TIN coverage is shown in Figure 13. This core content model (application schema component) describes a TIN coverage in compliance with ISO 19123.

A TIN covers an area with a unique set of non-overlapping triangles where each triangle is formed by three points. The geometry for a TIN is described in ISO 19107 and a TIN coverage is described in ISO 19123. A TIN coverage is of particular use for representing surfaces where calculations such as intervisibility or contour extraction are to be performed. A conversion between a surface represented as a TIN and a grid is possible. Some loss of information results from such a conversion since the boundaries of the grid cells and set of TIN triangles seldom align.

The metadata is referenced to ISO 19115 and ISO 19115-2. A specific choice of metadata has not been made in this schema. The selection of metadata is application dependent.

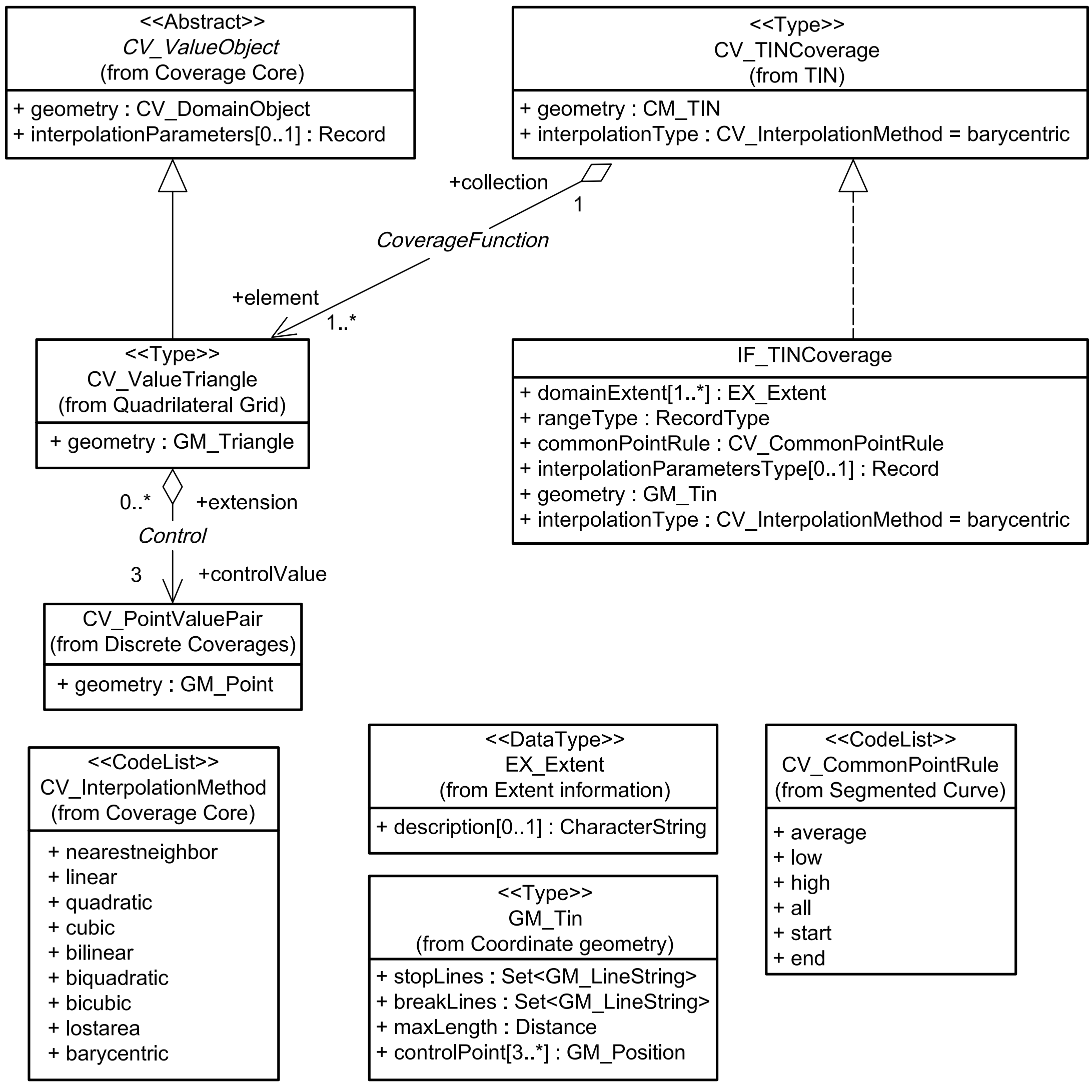


Figure 13 — Template application schema for a TIN coverage

10.5.2 TIN coverage classes

10.5.2.1 IF_TINCoverageData

The class IF_TINCoverageData is a realization of the Type CV_TINCoverage from ISO 19123. It is an aggregation of ElevationTriangles.

10.5.2.2 interpolationType

The attribute *interpolationType* specifies the interpolation method recommended for the evaluation of the IF_TINCoverage where the value is taken from the code list CV_InterpolationMethod with the value "barycentric".

The barycentric position S within a value triangle composed of the CV_PointValuePairs (P1, V1), (P2, V2), and (P3, V3), is (i, j, k), where S = iP1 + jP2 + kP3 and the interpolated attribute value at S is V = iV1 + jV2 +kV3.

10.5.2.3 geometry

The attribute *geometry* contains the network of triangles that form the basis of the TIN. The triangles lie on a 2-dimensional manifold with the X,Y coordinates of the points at the vertices of the triangles representing the position on the manifold and the attribute value representing the deviation from the reference plane.

10.5.2.4 Other classes

The other classes and attributes derive directly from ISO 19123.

10.6 Discrete point coverage

10.6.1 Discrete point coverage template

The template application schema for a discrete point coverage is shown in Figure 14. This core content model (application schema component) defines a discrete point coverage with associated metadata.

The spatial domain of a discrete point coverage is a point set. The difference is that discrete point coverage associates one or more attribute values to each of the points in the point set. The use case identified in Annex B could be supported by either a point set where each point has coordinates X, Y and depth or by a discrete point coverage where each point has coordinates X, Y and is associated with a value for depth. The advantage of a discrete point coverage is that it can be used to associate many attribute values to each point.

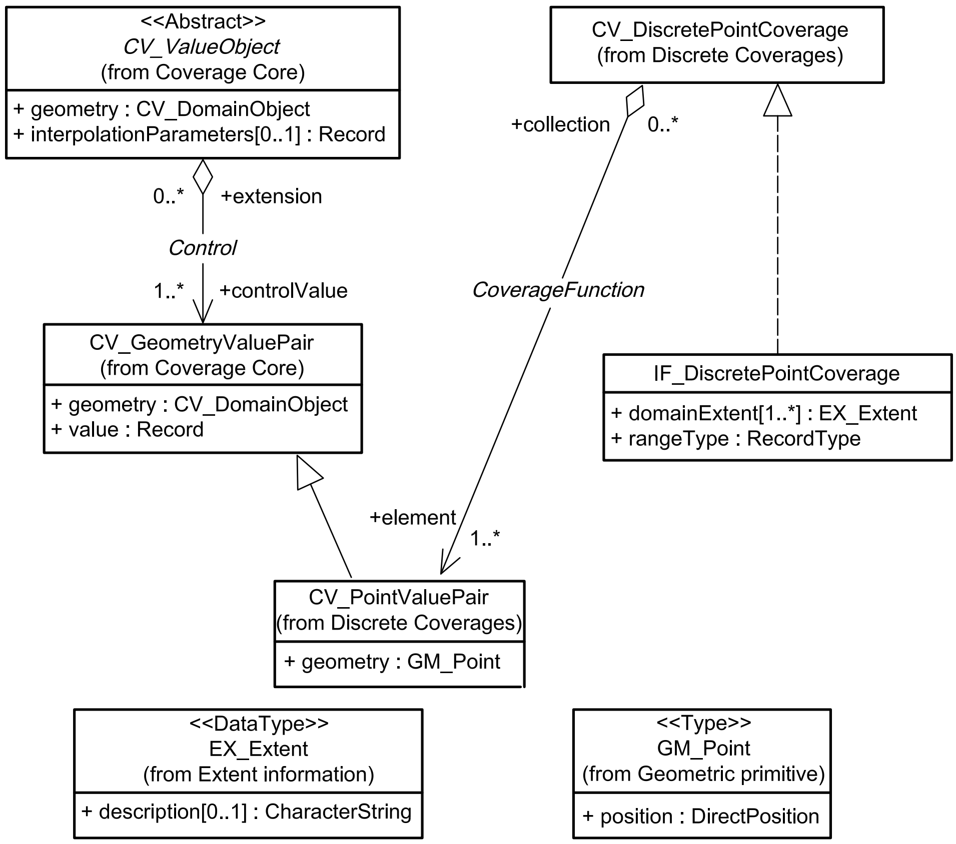


Figure 14 — Template application schema for a discrete point coverage

10.6.2 Discrete point coverage classes

10.6.2.1 IF_DiscretePointCoverage

The class IF_DiscretePointCoverage implements the class CV_DiscretePointCoverage from ISO 19123.

10.6.2.2 Other classes

The other classes and attributes derive directly from ISO 19123.

10.7 Discrete surface grid coverage

10.7.1 Discrete surface grid coverage template

The template application schema for a discrete surface coverage using a grid as its spatial domain is shown in Figure 15. This core content model (application schema component) defines a discrete coverage where each grid cell corresponds to a discrete attribute value. An example of such a discrete grid coverage is a gridded image using a colour look-up table (LUT) where the values of the LUT entries are arbitrary. A second example is a classification scheme based on a grid coverage where each grid cell corresponds to a discrete classifier. If an associated LUT is used, the LUT information can be carried as a table in the metadata. If a classification scheme is used, it can be referenced in the metadata.

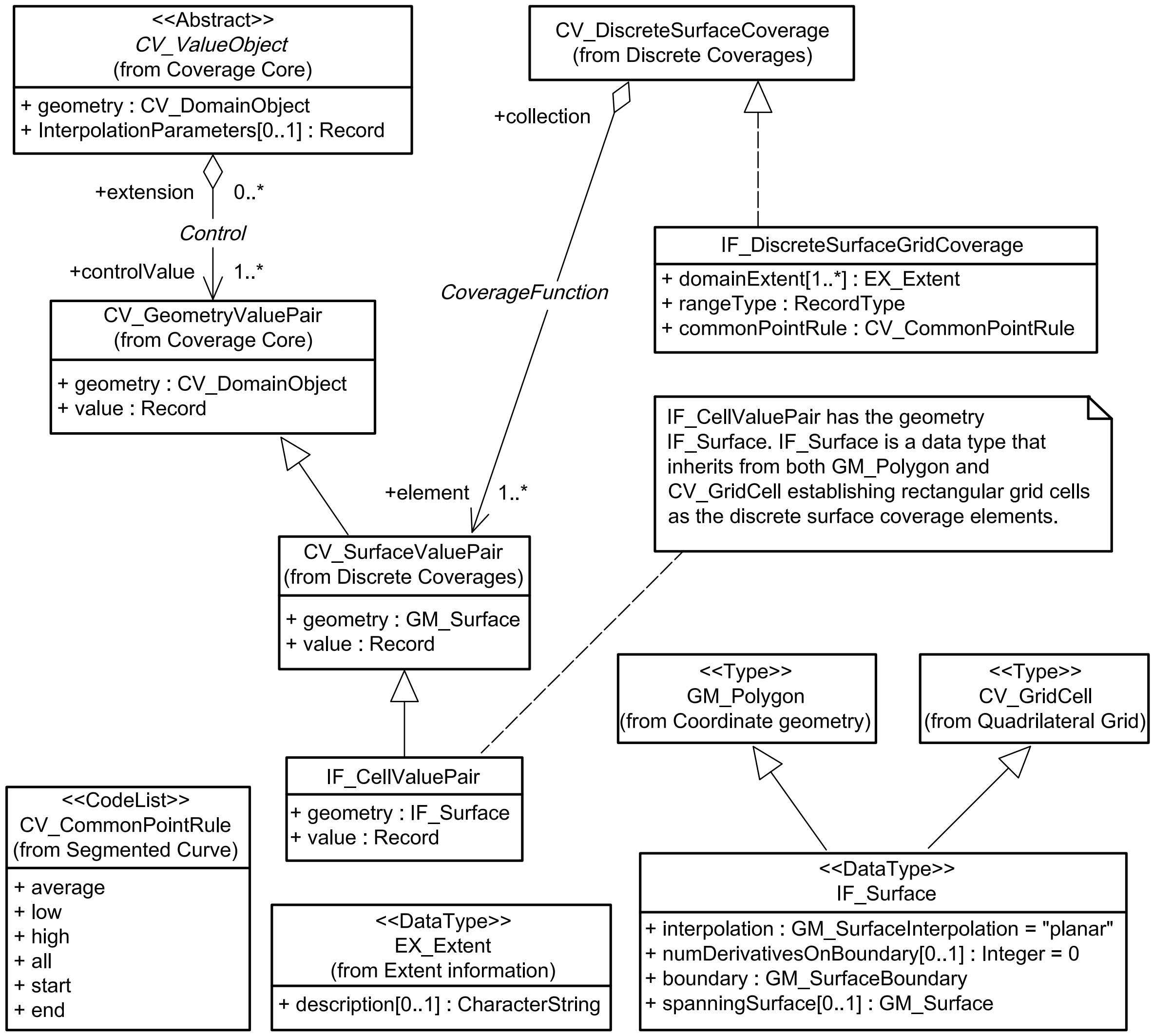


Figure 15 — Template application schema for a discrete surface grid coverage

10.7.2 Discrete surface grid coverage classes

10.7.2.1 IF_DiscreteSurfaceGridCoverage

The class IF_DiscreteSurfaceGridCoverage implements the class CV_DiscreteSurfaceCoverage from ISO 19123 with grid as its spatial domain.

10.7.2.2 IF_CellValuePair

The class IF_CellValuePair inherits from CV_SurfaceValuePair. The attribute “geometry” takes the data type IF_Surface.

10.7.2.3 IF_Surface

The class IF_Surface is a data type that inherits from both GM_Polygon and CV_GridCell. This establishes grid cells that are rectangular surfaces.

10.7.2.4 Other classes

The other classes and attributes derive directly from ISO 19123.

11 Tiling

11.1 Tiled grids

Tiling is a common mechanism to reduce the volume of data in a data set. The data set may be broken into a number of separate parts. A tile is a set of data that is edge-matched with other data within a tiling scheme. The tiling scheme is effectively a discrete coverage where the tiles are the coverage elements. A tiling scheme may be used with either vector, gridded or other coverage data types.

Tiling schemes are of particular value when data is sparse. For example, a raster image map of the United States might be tiled so that it is not necessary to include data over Canada or over the ocean to include the states of Alaska and Hawaii. Figure 16 illustrates a tiled grid. The manner in which a tiling mechanism is implemented may be unique to a particular encoding format, but the concept is part of the content model for a particular data product.

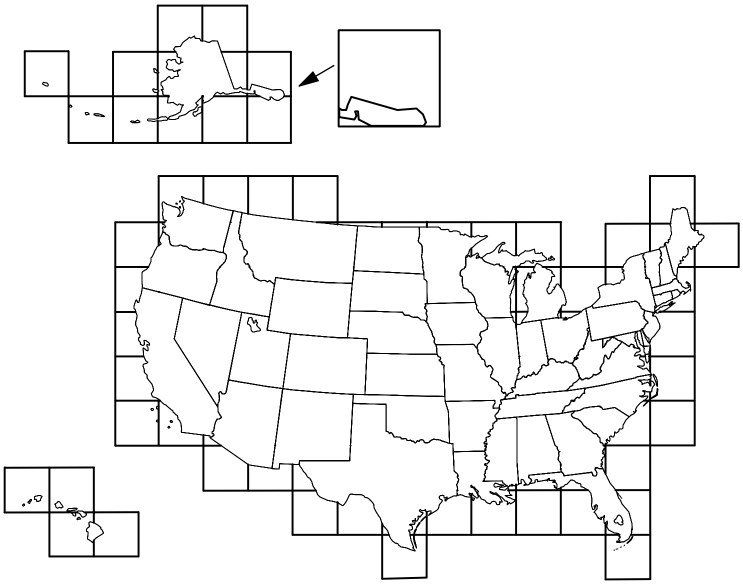


Figure 16 — Grid-based tiling scheme

11.2 Tile densities

The surface of the Earth is not uniform and different volumes of data are required to describe different areas of the Earth. Also, data may vary in resolution or in the number of attributes assigned. Tiling may also be used to handle data of varying density or resolution. Figure 17 illustrates a tiling scheme with three different tile densities.

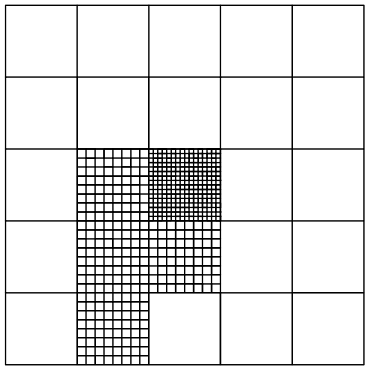


Figure 17 — Example instance of tiling using three tile densities

11.3 Tiling scheme

A tiling scheme is a discrete surface coverage, and if it makes use of a grid it is a type of discrete surface grid coverage, as described in 10.7. The tiling scheme itself is not actually a data set so there is no CV_SurfaceValuePair with a value attribute. The tiled data sets themselves are the instances of the value attribute. Each data set identifies which tile it is within the structural metadata. The class IF_Tiling identifies the tiling scheme, which is described externally to the data set.

Annex A
(normative)

Abstract test suite

A.1 Continuous quadrilateral grid coverage

a) Test purpose: Verify that an application schema instantiates the class IF_QuadGriddedData with the attribute CV_InterpolationMethod = Bilinear, the sequenceRule type = linear, and the classes IF_Dataset and IF_CollectionMetadata and IF_DiscoveryMetadata with metadata elements from ISO 19115 and ISO 19115-2 if applicable, and also the classes CV_GridValueCell, CV_GridPointValuePair and CV_GridValuesMatrix from ISO 19123 with the specified attributes, operations, associations and constraints.

b) Test method: Inspect the documentation of the application schema or profile.

c) Reference: ISO/TS 19129:2009, 9.1 and 10.3, ISO 19123:2005, 18.12, 18.13 and 18.14, ISO 19115, ISO 19115-2.

d) Test type: Capability.

A.2 Riemann hyperspatial multidimensional grid coverage

a) Test purpose: Verify that an application schema instantiates the class IF_RiemannGriddedData with the attribute CV_InterpolationMethod = nearestNeighbour, the sequenceRule type = Morton, and the classes IF_Dataset and IF_CollectionMetadata and IF_DiscoveryMetadata with metadata elements from ISO 19115 and ISO 19115-2 if applicable, and also the classes CV_GridValueCell, CV_GridPointValuePair and CV_GridValuesMatrix from ISO 19123 with the specified attributes, operations, associations and constraints.

b) Test method: Inspect the documentation of the application schema or profile.

c) Reference: ISO/TS 19129:2009, 9.1 and 10.4, ISO 19123:2005, 18.12, 18.13 and 18.14, ISO 19115, ISO 19115-2.

d) Test type: Capability.

A.3 Triangular irregular network coverage

a) Test purpose: Verify that an application schema instantiates the class IF_TINCoverageData with the attribute CV_InterpolationMethod = barycentric and the classes IF_Dataset and IF_CollectionMetadata and IF_DiscoveryMetadata with metadata elements from ISO 19115 and ISO 19115-2 if applicable, and also the classes CV_ValueTriangle and CV_PointValuePair from ISO 19123 with the specified attributes, operations, associations and constraints.

b) Test method: Inspect the documentation of the application schema or profile.

c) Reference: ISO/TS 19129:2009, 9.1 and 10.5, ISO 19123:2005, 10.3 and 6.3, ISO 19115, ISO 19115-2.

d) Test type: Capability.

A.4 Discrete point coverage

a) Test purpose: Verify that an application schema instantiates the class IF_DiscretePointCoverage and the classes IF_Dataset and IF_CollectionMetadata and IF_DiscoveryMetadata with metadata elements from ISO 19115 and ISO 19115-2 if applicable, and also the class CV_PointValuePair from ISO 19123 with the specified attributes, operations, associations and constraints.

b) Test method: Inspect the documentation of the application schema or profile.

c) Reference: ISO/TS 19129:2009, 9.1 and 10.6, ISO 19123:2005, 6.3, ISO 19115, ISO 19115-2.

d) Test type: Capability.

A.5 Discrete grid coverage

a) Test purpose: Verify that an application schema instantiates the classes IF_DiscreteSurfaceGridCoverage and the classes IF_Dataset and IF_CollectionMetadata and IF_DiscoveryMetadata with metadata elements from ISO 19115 and ISO 19115-2 if applicable, and also the classes CV_GridPointValuePair, and CV_GridValuesMatrix from ISO 19123 with the specified attributes, operations, associations and constraints.

b) Test method: Inspect the documentation of the application schema or profile.

c) Reference: ISO/TS 19129:2009, 9.1 and 10.7, ISO 19123:2005, 18.12 and 18.13, ISO 19115, ISO 19115-2.

d) Test type: Capability.

Annex B
(informative)

Use cases

B.1 Illustrative use case

The field of imagery, gridded and coverage data is very large and it is not possible to develop a comprehensive set of all the uses to which these types of data can be applied. During the development of this Technical Specification the project team developed a small set of illustrative use cases that justify the types of predefined content models that are developed. The illustrative use cases identified were:

— Imagery use case;

— Aggregated survey data, e.g. hydrographic survey;

— Surface for calculations, e.g. calculation of intervisibility or generation of contours;

— Measured elevation/depth point use case, e.g. hydrographic soundings;

— Classification of objects covering an area, e.g. land cover classification.

These use cases may be used to define a few common template content models so that different formats may carry the same information content

B.2 Content structures

The content structure for imagery was identified as a continuous quadrilateral grid coverage with an associated grid value matrix associated metadata. If an LUT is employed, then a discrete surface grid coverage may be used.

The content structure for an aggregated survey (hydrographic sonar survey) data is a grid coverage organized as a quadtree and associated metadata. Since depth and time may be represented as dimensions, this grid may be a Riemann hyperspatial multidimensional grid coverage.

The content structure for a surface for calculations was identified as a TIN coverage and associated metadata.

The content structure for measured elevation/depth point (hydrographic sounding) data was identified as a discrete point coverage and associated metadata. When the surface is a known continuous surface, such as for elevation or depth, the discrete point coverage effectively represents samples and an interpolation function may be associated with the coverage.

The content structure for classification of objects covering an area is a discrete coverage and associated metadata.

B.3 Tiling

The organization of any geographic information data set into a set of tiles was identified as a special type of discrete coverage where the coverage elements are subsets of a data set. Tiling may be used to organize both vector and coverage types of data sets. Tiling is a special use case.

Annex C
(informative)

Portrayal of imagery and gridded data

C.1 Use of a colour LUT

Imagery and gridded data makes use of RGB or colour coding for the representation of pixel values. When digitizing a synthetic image such as a map or chart the use of a colour LUT can produce significant advantages in reducing the amount of data, which needs to be communicated. If only a very few colours are used in a printed product, then only that number of colour LUT entries are required, and subsequently only a few bits are required per pixel to address entries in the colour LUT. For example, if a chart used only seven inks when it was originally printed, and if it is possible to distinguish these as seven distinct colours, then a colour LUT could be constructed which specifies each of these seven colours in terms of their exact colour values. Only 3 bits per pixel would be required to be indexed in the colour LUT.

C.2 Attribute colour portrayal

C.2.1 Colour ramps

Colour ramps are continuous colour spectra ranging from a specified start and end point. They can cover the complete visible spectrum or a limited component of it. In addition, a colour ramp can be in grey-scale. Although theoretically continuous, the application of a colour ramp necessitates that the portrayal be a discrete representation of the given spectrum. Large or small ranges of data can be compressed or stretched in the process of ramping the attribute values. In addition, start and end points can be selected on a given spectrum to aid in the best portrayal of data with limited dynamic range.

C.2.2 Colour banding

Colour banding is also referred to as colour tables. It is a list or table containing discrete colour values and attribute value ranges. For every range of an attribute’s value (e.g. 10-20) a specific colour is assigned (e.g. red, or R=255 G=0 B=0). Most often the series of colour assignments follows a progressive path which discretely mimics a ramped colour spectrum, but it is not necessary – there is no need for any progressive pattern. Colour tables can be chosen or designed to best portray certain types of data or to highlight specific aspects.

C.2.3 Object colouring

Colour can also be assigned by object or object type. In this manner, within a given attribute if certain feature types have been objectified, they can be coloured based wholly on their identity. In this manner, boulders (the object “boulder”) could be assigned the colour green (R=0 G=255 B=0), while bridge objects could be assigned some other colour (e.g. R=123 G=55 B=234). This is similar to the colour table approach, except that colours are assigned to individual objects and not an attribute value or range. In addition, several attributes can be used to define a given object and thus colouring is based indirectly on multiple attributes.

Within a given visualization, data can be portrayed using any of these approaches. Combinations can also be used. As an example, bathymetric depth data could be coloured using a colour ramp of the blue spectrum, while objectified boulders are assigned an object colour and portrayed as yellow (R=0 G=255 B=255).

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