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Information Technology – Geographic Information Framework Data Content Standard

Part 3, Elevation

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Foreword

Geographic information, also known as geospatial information, both underlies and is the subject of much of the political, economic, environmental, and security activities of the United States. In recognition of this, the United States Office of Management and Budget issued Circular A-16 (revised 2002), which established the Federal Geographic Data Committee (FGDC) as a coordinating organization.

Work on this standard started under the Geospatial One-Stop e-Government initiative. The standard was developed with the support of the member agencies and organizations of the FGDC and aids in fulfilling a primary objective of the National Spatial Data Infrastructure (NSDI), that is, creation of common geographic base data for seven critical data themes. The seven core data themes are considered framework data of critical importance to the geographic data infrastructure.

The increasing need to coordinate collection of new data, identify applicability of existing data, and exchange data at the national level led to the submission of this standard to the ANSI process to become an American National Standard. The national standard contained in this document and its parts was sponsored by Technical Committee L1, Geographic Information Systems, of the InterNational Committee for Information Technology Standards (INCITS), an ANSI-accredited standards development organization.

As the Geographic Information Framework Data Content Standard was developed using public funds, the U.S. Government will be free to publish and distribute its contents to the public, as provided through the Freedom of Information Act (FOIA), Part 5 United States Code, Section 552, as amended by Public Law No. 104-231, “Electronic Freedom of Information Act Amendments of 1996”.

Introduction

The primary purpose of this draft standard is to describe geospatial elevation data models in the support of the exchange of elevation information. This document also seeks to establish a common baseline for the semantic content of elevation databases for public agencies and private enterprises. It seeks to decrease the costs and simplify the exchange of elevation data among local, Tribal, State, and Federal users and producers. That, in turn, discourages duplicative data collection. Benefits of adopting the standard also include the long-term improvement of the geospatial elevation data through the establishment of Web data services for elevation data and maps within the community.

Framework Data Content Standard – Elevation

1 Scope, purpose, and application

This part of the Framework Data Content Standard defines the geospatial data model entities and attributes that permit the exchange of digital elevation data consistent with the National Spatial Data Infrastructure's (NSDI) framework for elevation data. This standard is consistent with ISO 19123 Geographic Information – Schema for coverage geometry and functions and the Open Geospatial Consortium Abstract Specification for Coverage Type and its Subtypes. The standard includes an application schema expressed in the Unified Modeling Language (UML).

This part of the Framework Data Content Standard identifies the geospatial data model elements required for digital elevation data to be used for the NSDI framework. The standard was written to be as inclusive of the common geospatial elevation data models (point, grid, contour, triangulated irregular network, and profile) and to not restrict anyone wishing to contribute their elevation data to the NSDI. The standard supports both topographic elevation data (above a reference datum) and bathymetric elevation data (below a reference datum). Collecting and sharing NSDI digital elevation data that are consistent with this standard will assure the user community accurate and reliable access to the data. Furthermore, the principles described in this standard may be extended to other geographic entities to facilitate the exchange of other geospatial thematic data.

2 Conformance

Each geospatial elevation model of this standard includes a data dictionary based on the conceptual application schema presented in that model. To conform to this standard, an elevation dataset shall satisfy the requirements of the data dictionary for that geospatial data model.

3 References

This standard contain provisions, which through reference in this text constitute provisions of this DRAFT American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

Annex A lists normative references to standards that are applicable to this standard. The Base Document, Part 0, Annex A lists normative references applicable to all of the parts. Annex D lists informative references to standards that are applicable to this standard. The Base Document, Part 0, Annex D lists informative references applicable to all of the parts.

4 Maintenance authority

4.1 Level of responsibility

The U.S. Department of the Interior, United States Geological Survey (USGS), National Geospatial Programs Office is the responsible organization for coordinating work on the Geographic Information Framework Data Content Standard, Part 3, Elevation and is directly responsible for the development and maintenance of this document. The USGS is responsible for the Elevation framework data theme as documented in Office of Management and Budget Circular A-16.

4.2 Contact information

Address questions concerning this standard to:

Associate Director for Geographic Information
United States Geological Survey, MS 108

12201 Sunrise Valley Drive
Reston, VA 20192

Telephone: (703) 648-5747

Facsimile: (703) 648-7031

5 Terms and definitions

The following terms and definitions are specific to this standard and are applicable for purposes of this standard. Refer to the Base Document (Part 0) for terms common to two or more standards.

5.1
coordinate reference system

coordinate system which is related to the real world by a datum [ISO 19111]

5.2
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]

EXAMPLES A raster image, a polygon overlay, or a digital elevation matrix.

5.3
coverage geometry

configuration of the domain of a coverage described in terms of coordinates [ISO 19123]

5.4
direct position

position described by a single set of coordinates within a **coordinate reference system** [ISO 19107]

5.5
elevation

distance measured upward along a plumb line between a point and the geoid

NOTE The elevation of a point is normally the same as its orthometric height. This is the “official” geodesy definition of elevation, but the term “elevation” is also used more generally for height above a specific vertical reference, not always the geoid.

5.6
geometry value pair

ordered pair composed of a **spatial object**, a temporal object, or a **spatiotemporal object** and a **record** of feature attribute values [ISO 19123]

5.7
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]

NOTE The **curves** partition a space into grid cells.

5.8
point coverage

coverage that has a domain composed of **points** [ISO 19123]

5.9
range

set of feature attribute values associated by a function with the elements of the domain of a **coverage**

5.10
record

finite, named collection of related items (objects or values) [ISO 19107]

NOTE Logically, a record is a set of pairs <name, item>.

5.11
spatial object

object used for representing a spatial characteristic of a feature [ISO 19107]

5.12
tessellation

partitioning of a space into a set of conterminous spatial, temporal, or spatiotemporal objects having the same dimension as the space being partitioned [ISO 19123]

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 a semi-regular tessellation. Otherwise the tessellation is irregular.

5.13
triangulated irregular network (TIN)

tessellation composed of triangles [ISO 19123]

5.14
vector

quantity having direction as well as magnitude [ISO 19123]

NOTE A directed line segment represents a vector if the length and direction of the line segment are equal to the magnitude and direction of the vector. The term vector data refers to data that represents the spatial configuration of features as a set of directed line segments.

6 Symbols, abbreviated terms, and notation terms

The following symbols, abbreviations, and notation terms are specific to this standard and are applicable for purposes of this standard. Refer to the Base Document (Part 0) for symbols, abbreviated terms, and notations terms common to two or more standards.

LIDAR – Light Detection and Ranging

TIN – Triangulated Irregular Network

7 Requirements

This standard models elevation data as a geospatial data coverage within the context of five geospatial data models: Point, Grid, TIN, Contour, and Profile as shown in Figure 1. Specifications, defined in this standard, accommodate the level of content and relationships necessary for exchange of all forms and formats of these data in a predictable and repeatable manner.

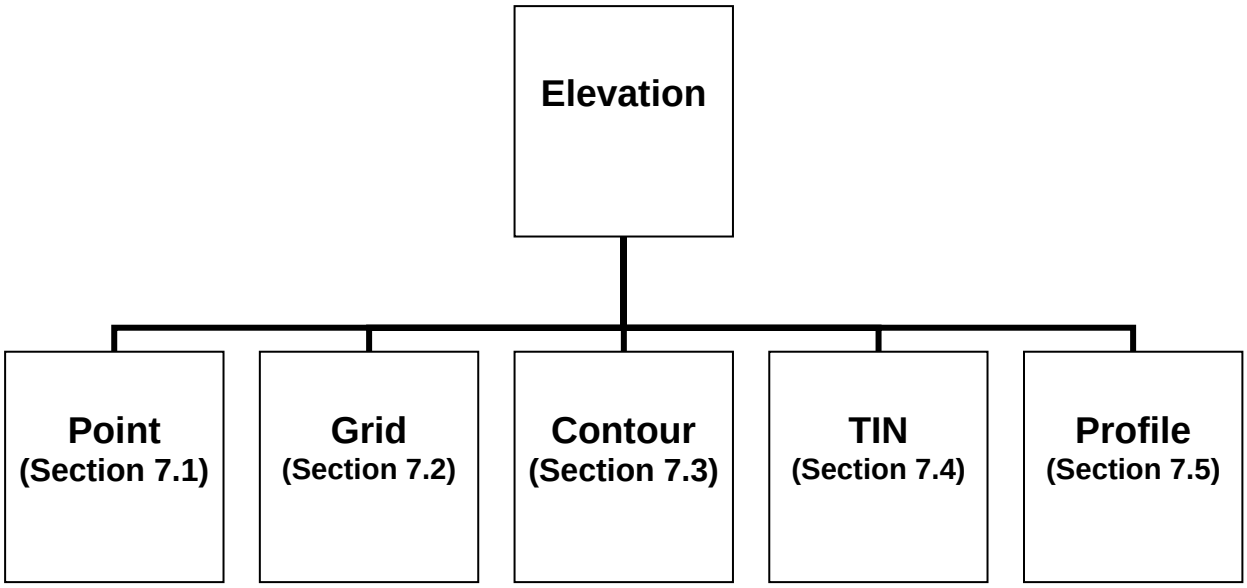

Figure 1 – Elevation

Definitions for, and characteristics of, digital elevation data may be specific to these individual data models, or they may apply to all five geospatial data models. Appendix B provides the application schema for each of these geospatial elevation data models. The National Digital Elevation Program (www.ndep.gov) has developed a set of Guidelines for Digital Elevation Data that describe and provide best practices and examples for each of these geospatial data models.

7.1 Point

Points are the most basic geospatial elevation data model used for modeling terrain and bathymetric elevation data. Points are usually represented by a collection of irregularly, or non-uniformly organized geometry coordinate sets as shown in Figure 2. Each point is identified by a horizontal coordinate geometry pair (X,Y) and an vertical coordinate elevation value (Z). The elevation value (Z) may be explicitly encoded as a triplet (X, Y, Z), known as a pointset (see section B.11 for the PointSet UML application schema and C.6 for the PointSet UML object description) or as an attribute value to the X,Y geometry pair, known as a pointcoverage (see section B.5 for the PointCoverage UML application schema and C.3 for the PointCoverage UML object description). Point coverage attribution could include identification such as a control point reference, reference to the type of surface to which the point applies, or other characteristics specific to the point. The order (if applicable) and definition of these additional attributes shall be specified in the metadata. While points are not necessarily presented in a uniform or structured pattern, they often are acquired in a systematic distribution, which is intended to facilitate accurate representation of the surface or features the data are intended to model. When generated manually, points are ideally chosen so that subtle terrain characteristics, such as gradual variations in slope or aspect, or distinct features such as a levee or river embankment are adequately represented in the data. However, when generated automatically, such as through the use of an active sensing system (LIDAR), point distribution depends upon the characteristics of the sensor used to acquire the data, and its performance in different terrain and land cover types.

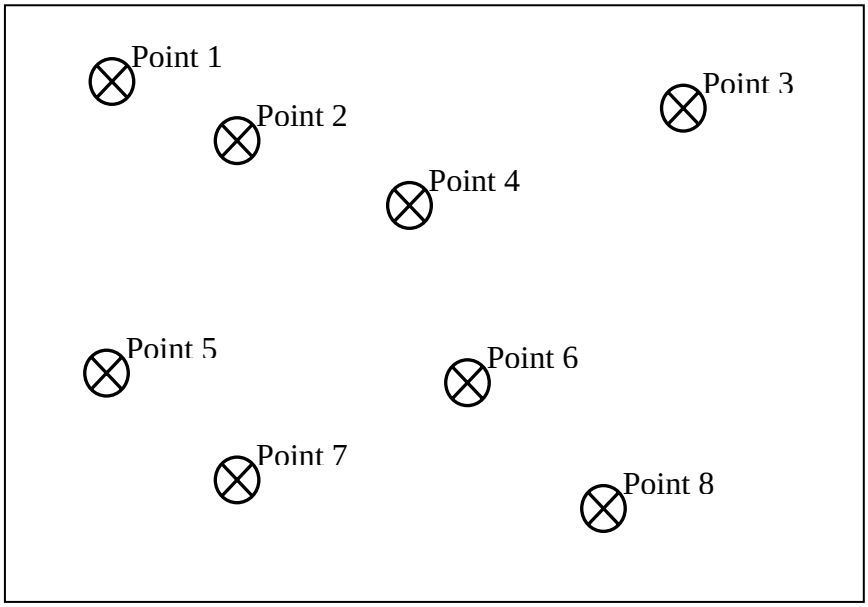

Figure 2 – Example: Point

7.2 Grid

Grids are the most common geospatial data model used for modeling terrain and bathymetric elevation data. Grids are represented by a collection of regularly or uniformly organized points as shown in Figure 3. There are several advantages to grids over other types of elevation geospatial data models. A regular spacing of elevations requires that only one point be referenced to a horizontal coordinate. From this point, in conjunction with coordinate referencing information supplied with the grid, the horizontal location of all other points can be determined. This eliminates the need to explicitly define the horizontal geometry coordinate pairs of each elevation and minimizes file size. The grid is also an efficient structure for data processing. See section B.3 for the GridCoverage UML application schema and C.2 for the GridCoverage UML object description.

The spacing within the grid can be chosen to most efficiently represent the size and frequency of terrain undulations to be modeled. For example, rough or dissected terrain may require a small, narrow grid spacing, while gentle relief may be adequately modeled with a fairly wide grid spacing. Grids may not model all terrain features smaller or narrower than the grid spacing when the feature lies between grid points.

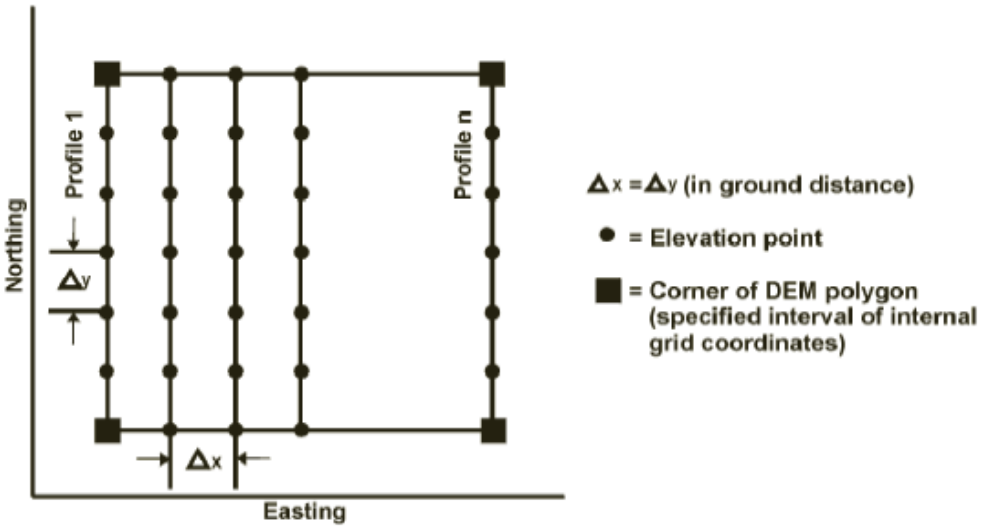

Figure 3 – Example: Grid

7.3 Contour

Three-dimensional vector modeling supports the exchange of constant-elevation features, also referred to as hypsography or contours. See section B.9 for the ContourCoverage UML application schema and C.5 for the ContourCoverage UML object description.

Contours are vectors connecting points of equal elevation and are a common visual representation of topography and bathymetry in mapping applications as shown in Figure 4. The density of x, y coordinate geometry pairs (vertices) along a contour vector are dependent on the characteristics and complexity of the terrain.

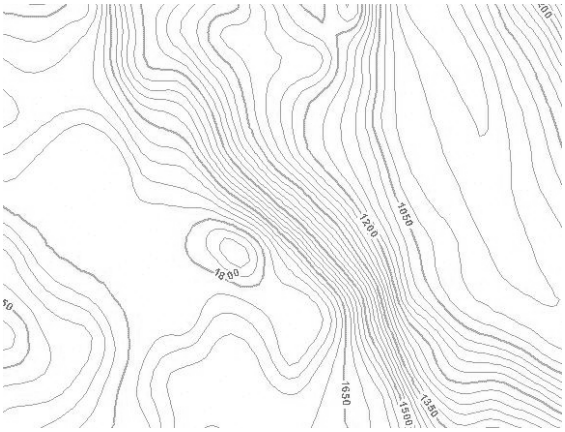

Figure 4 – Example: Contours

7.4 Triangulated irregular network (TIN)

A fundamental data structure frequently used to model points from photogrammetry and LIDAR collection is the triangulated irregular network (TIN). TINs are surface representations derived from irregularly spaced sample points and breakline features (surface discontinuities such as peaks, pits, ridges, and valleys). The main components of a TIN are nodes, edges, and triangles,

494 which are linked by topological structure. TIN datasets include topological relationships between
495 points and their neighboring triangles. Each sample point has an x,y coordinate geometry pair
496 and a surface, or z-value. These points are connected by edges to form a set of non-overlapping
497 triangles used to represent the surface as shown in Figure 5. See section B.7 for the
498 TINCoverage UML application schema and C.4 for the TINCoverage UML object description.

499 TINs are used many times when it is necessary to capture or show complex topographic
500 elevation surfaces. TINs allow for extra data in complex areas and less data in non-complex
501 areas and enable the use of natural topographic features as breaklines. See Figure 5 for an
502 example of a triangulated irregular network.

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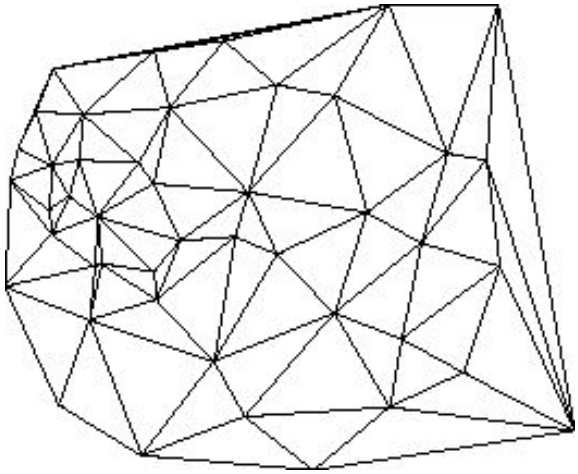

515 **Figure 5 – Example: Triangulated irregular network**

516

517 ## 7.5 Profile

518 Profiles, also known as breaklines or cross sections (also referred to as transects), are lines that
519 connect irregularly spaced points of varying elevation values as shown in Figure 6. Profiles are
520 commonly used to model surface discontinuities such as peaks, pits, ridges, and valleys or may
521 be used to model the elevation information of other linear features such as transportation or
522 pipelines. See section B.14 for the ContourCoverage UML application schema and C.7 for the
523 ProfileCoverage UML object description.

524 They are used for specialized applications to represent a string of elevations along a designated
525 path. Cross sections, which are generally perpendicular to a linear terrain feature, are used for a
526 variety of engineering applications. For example, a cross section of a stream will show the
527 stream channel geometry above and below the water surface for hydraulic engineering purposes
528 and a cross section of a road will show the shape of the road surface including its crown,
529 shoulders, and ditches.

530 Breaklines are lines that are used to model a relatively abrupt change in the slope or continuity of
531 a surface slope or aspect. Breaklines may represent surface breaks observed at a constant
532 elevation or that trend up and down slope.

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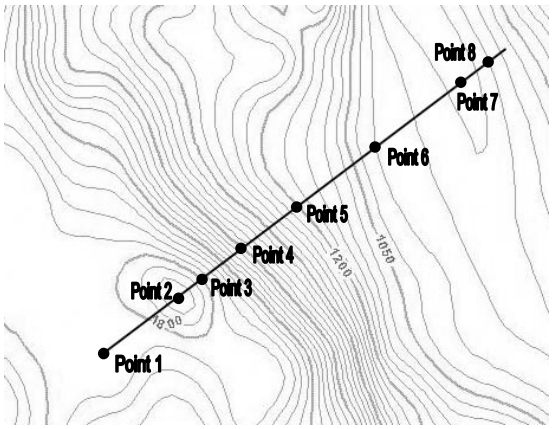


Figure 6 – Example: Profile

Annex A
(normative)
Normative references

ISO/FDIS 19123, Geographic information – Schema for coverage geometry and functions

ISO 19107:2003, Geographic information – Spatial schema

ISO 19111:2003, Geographic information – Spatial referencing by coordinates

ISO 19115:2003, Geographic information – Metadata

FGDC-STD-001-1998, Content standard for digital geospatial metadata (version 2.0)

Annex B
(normative)
UML model,
Application schema for the exchange of framework elevation data

The model object names and notation conform to the names and notation used by ISO Technical Committee 211 - Geographic information/Geomatics.

The coverage schema is organized into seven packages with inter-package dependencies as shown in Figure B.1.

B.1 ElevationCollection

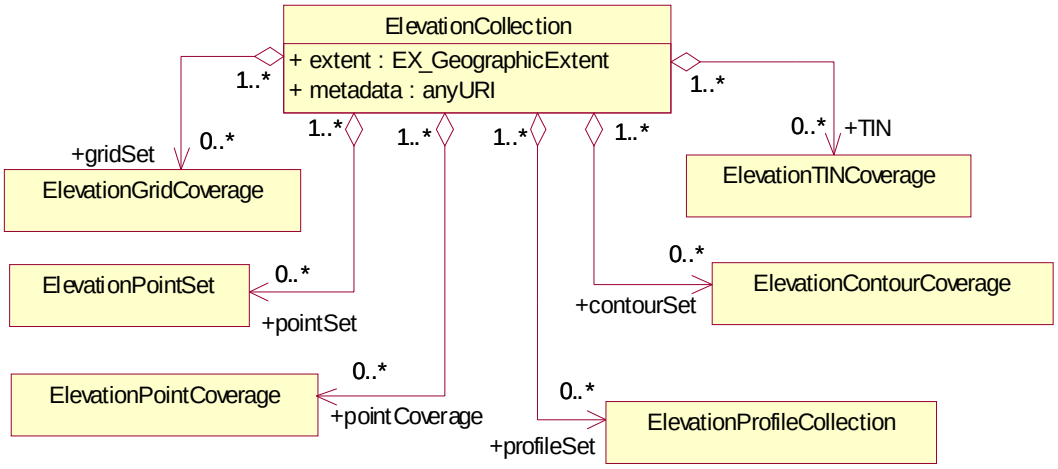


Figure B.1 – Context diagram: ElevationCollection

B.1.1 Semantics

The class ElevationCollection represents a collection of framework elevation data.

B.1.2 extent

The attribute *extent* shall describe the geographic area to which the data in the ElevationCollection applies. The data type EX_GeographicExtent is specified in ISO 19115.

B.1.3 metadata

The attribute *metadata* shall provide a link to metadata that describes the ElevationCollection.

B.1.4 gridSet

The role name *gridSet* shall identify the set of ElevationGridCoverages contained in the ElevationCollection.

B.1.5 pointSet

The role name *pointSet* shall identify the set of ElevationPointSets contained in the ElevationCollection.

B.1.6 pointCoverage

The role name *pointCoverage* shall identify the set of ElevationPointCoverages contained in the ElevationCollection.

B.1.7 contourSet

The role name *contourSet* shall identify the set of ElevationContourCoverages contained in the ElevationCollection.

B.1.8 TIN

The role name *TIN* shall identify the set of ElevationTINCoverages contained in the ElevationCollection.

B.1.9 profileSet

The role name *profileSet* shall identify the set of ElevationProfileCollections contained in the ElevationCollection.

B.2 ElevationCoverage

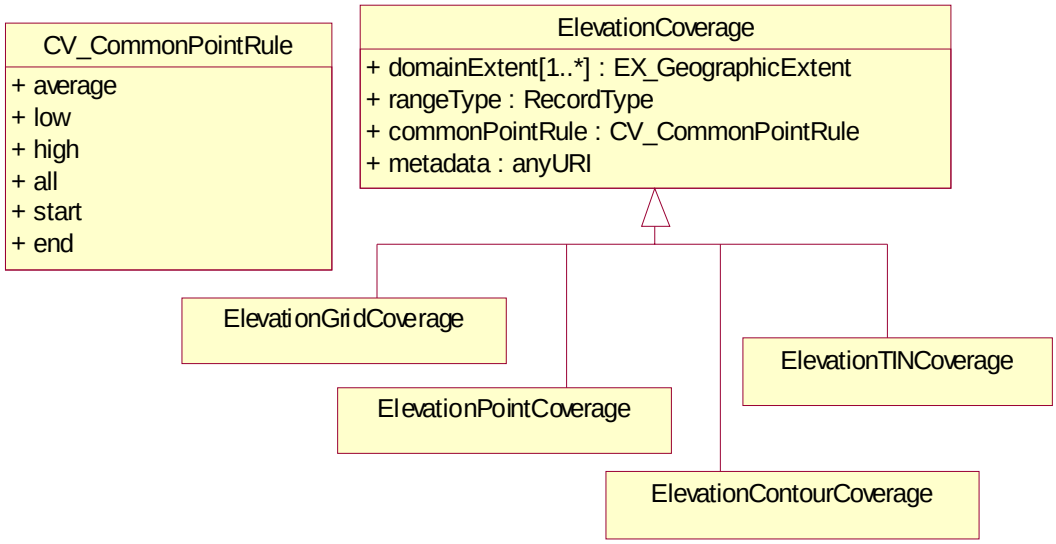


Figure B.2 – Context diagram: ElevationCoverage

B.2.1 Semantics

ElevationCoverage is an abstract class that specifies a set of attributes common to all the kinds of coverages that may be contained in an ElevationCollection. It is a realization of the Type CV_Coverage specified in ISO 19123 and implements attributes specified for that Type.

B.2.2 domainExtent

The attribute *domainExtent* shall describe the spatial extent of the domain of the ElevationCoverage.

B.2.3 rangeType

The attribute *rangeType* shall describe the range of the ElevationCoverage. It uses the data type RecordType specified in ISO/TS 19103. An instance of RecordType is a list of name:data type pairs each of which describes an attribute type included in the range of the coverage. The name field shall be used to identify the type of surface that each elevation value describes.

EXAMPLE The rangeType for an elevation coverage that includes values for bare earth surface elevation and for reflective surface elevation would have the value “bare earth surface elevation:Real, reflective surface elevation:Real”.

B.2.4 commonPointRule

The attribute *commonPointRule* shall identify the procedure recommended for evaluating the ElevationCoverage at a position that falls on a boundary between geometric objects in the domain of the coverage. It takes a value from the code list CV_CommonPointRule specified in ISO 19123. The rule shall be applied to the set of elevation values that results from evaluating the coverage with respect to each of the geometric objects that share a boundary. For elevation coverages, appropriate values of CV_CommonPointRule include “average”, “high”, and “low”.

B.2.5 metadata

The attribute *metadata* shall provide a link to metadata that describes the ElevationCoverage.

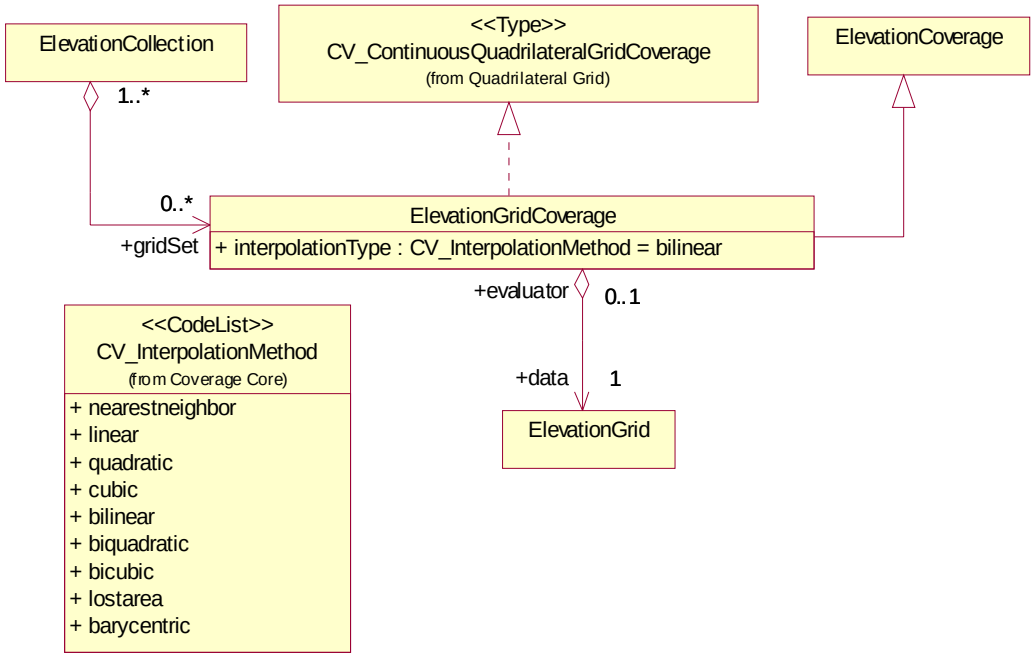


Figure B.3 – Context diagram: ElevationGridCoverage

B.3 ElevationGridCoverage

B.3.1 Semantics

The class ElevationGridCoverage is a subclass of ElevationCoverage that represents a set of elevation values assigned to the points in a 2D grid. The class is a realization of the Type CV_ContinuousQuadrilateralGridCoverage specified in ISO 19123 and implements the attributes and associations specified for that Type as well as those inherited from ElevationCoverage.

B.3.2 interpolationType

The attribute *interpolationType* shall specify the interpolation method recommended for evaluation of the ElevationGridCoverage. The data type CV_InterpolationMethod is a code list specified in ISO 19123. For an ElevationGridCoverage, the value shall be either “bilinear” or “bicubic”.

636 ### B.3.3 data

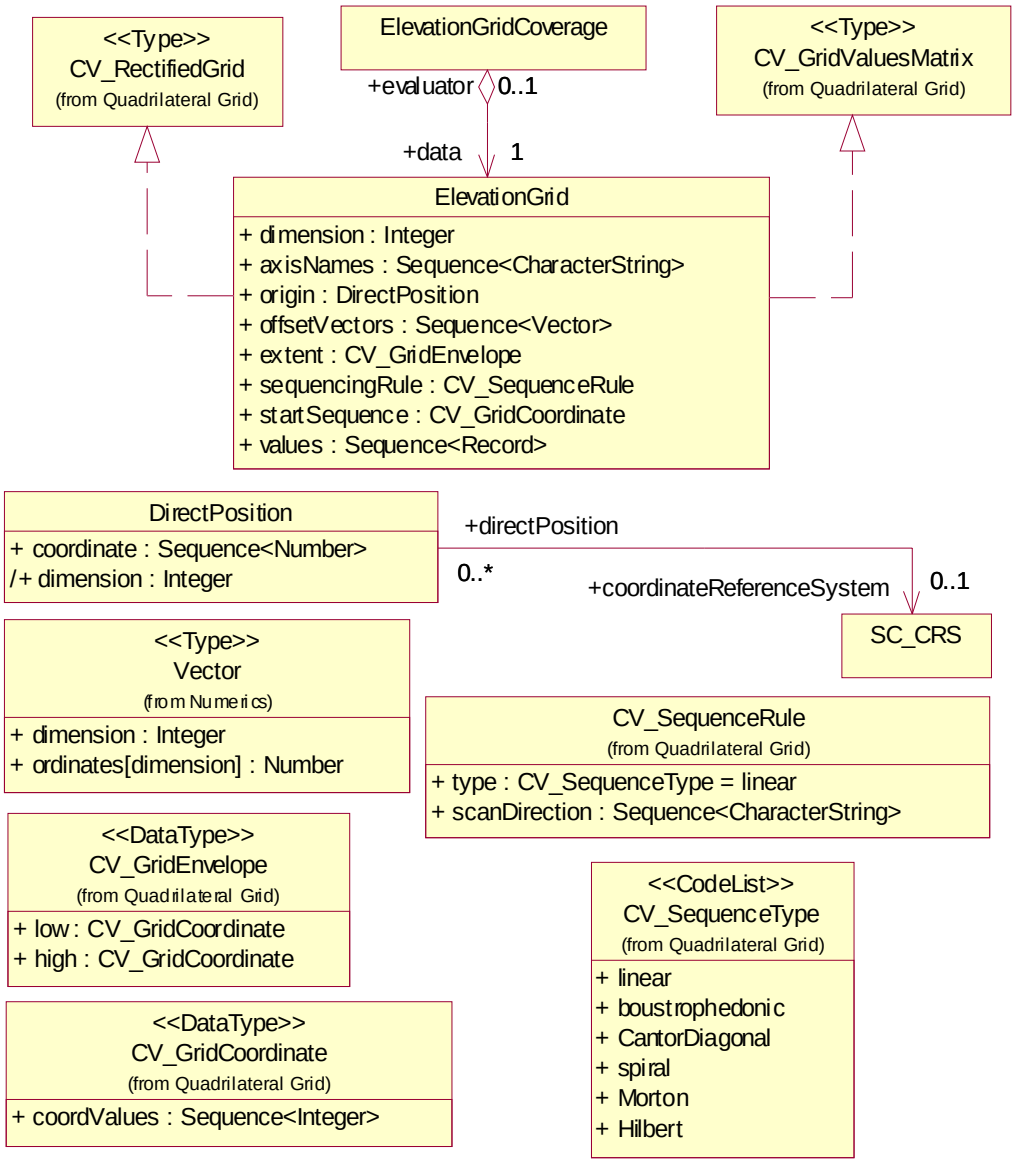
637 The role name *data* shall identify the ElevationGrid that contains the values of the
638 ElevationGridCoverage.

639 ## B.4 ElevationGrid

640 ### B.4.1 Semantics

641 The class ElevationGrid represents the data content of an ElevationGridCoverage. It is a
642 realization of two Types specified in ISO 19123: CV_RectifiedGrid and CV_GridValuesMatrix. As
643 such, it implements the attributes of both of these Types.

644



645

646 **Figure B.4 – Context diagram: ElevationGrid**

B.4.2 dimension

The attribute *dimension* shall specify the dimension of the ElevationGrid. Its value shall be two for all instances of ElevationGrid.

B.4.3 axisNames

The attribute *axisNames* shall list the names of the grid axes.

EXAMPLES “north”, “east” or “latitude”, “longitude”.

B.4.4 origin

The attribute *origin* shall provide the coordinates of the grid origin with respect to an external coordinate reference system. The data type DirectPosition, specified in ISO 19107, has an association though the role name coordinateReferenceSystem to the class SC_CRS specified in ISO 19111. This association shall be used to identify the external coordinate reference system for the ElevationGrid.

B.4.5 offsetVectors

The attribute *offsetVectors* shall specify both the spacing between grid points and the orientation of the grid axes with respect to the external coordinate reference system identified through the attribute *origin*. It uses the data type Vector specified in ISO/TS 19103.

B.4.6 extent

The attribute *extent* shall identify the area of the grid for which elevation data are provided. It uses the data type CV_GridEnvelope specified in ISO 19123 to provide both the CV_GridCoordinates of the corner of that area having the lowest grid coordinate values and the CV_GridCoordinates of the corner of that area having the highest grid coordinate values. CV_GridCoordinate is also specified in ISO 19123.

B.4.7 sequencingRule

The attribute *sequencingRule* shall identify the method to be used to assign values from the sequence of elevation values to grid coordinates. It uses the data type CV_SequenceRule specified in ISO 19123.

B.4.8 startSequence

The attribute *startSequence* shall use a value of CV_GridCoordinate to specify the grid coordinates of the grid point to which the first in the sequence of elevation values is to be assigned.

B.4.9 values

The attribute *values* shall be a sequence of Records each containing one or more elevation values to be assigned to a single grid point. The Record shall conform to the RecordType specified by the *rangeType* attribute of the ElevationGridCoverage with which the ElevationGrid is associated.

B.5 ElevationPointCoverage

B.5.1 Semantics

The class ElevationPointCoverage is a subclass of ElevationCoverage and a realization of the Type CV_DiscretePointCoverage specified in ISO 19123. It is an aggregation of points, each of which is associated with one or more elevation values carried as attributes rather than as coordinates. It implements the attributes and associations inherited from ElevationCoverage as well as those specified for CV_DiscretePointCoverage in ISO 19123.

B.5.2 element

The role name *element* shall identify the set of MultiElevationPoints contained in the ElevationPointCoverage.

B.6 MultiElevationPoint

B.6.1 Semantics

The class MultiElevationPoint is a realization of the Type CV_PointValuePair specified in ISO 19123. It represents a point that has a Record of one or more elevation values associated with it.

B.6.2 geometry

The attribute *geometry* shall contain an instance of GM_Point as specified in ISO 19107. The position of the GM_Point shall be stated with reference to a 2-dimensional coordinate reference system as asserted by the constraint {geometry.position.dimension = 2}.

NOTE Elevation values are carried as attributes of the point rather than as coordinate values.

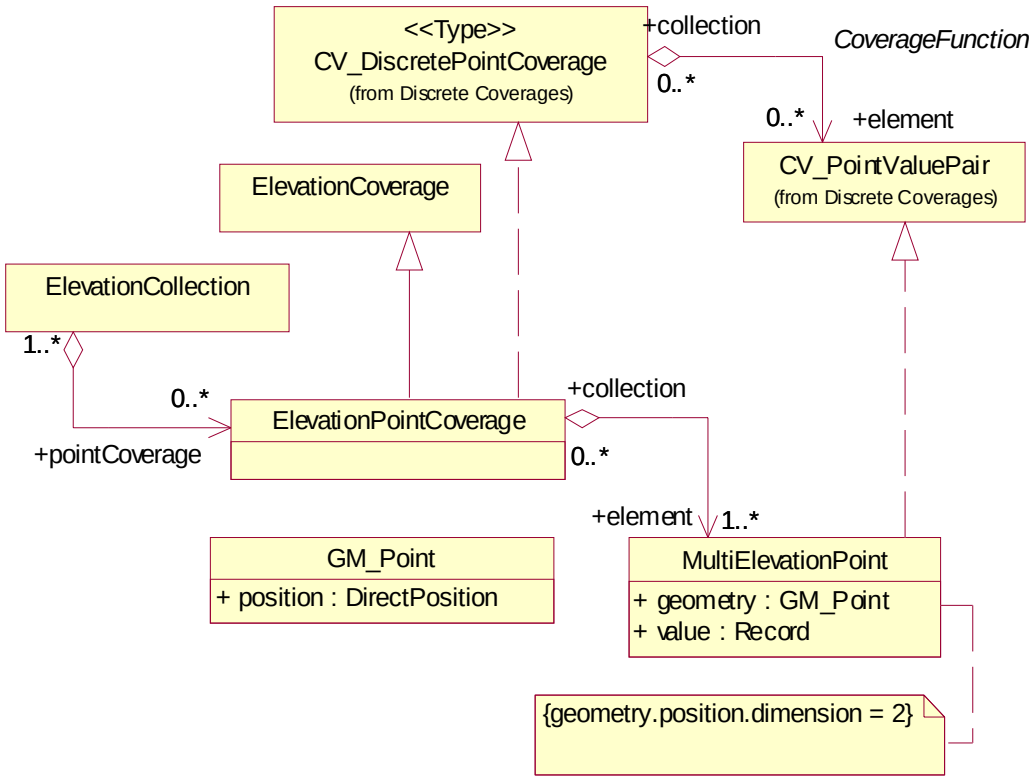


Figure B.5 – Context diagram: ElevationPointCoverage

B.6.3 value

The attribute *value* shall be a Record that contains one or more elevation values as specified by the *rangeType* attribute inherited from ElevationCoverage.

B.7 ElevationTINCoverage

B.7.1 Semantics

The class ElevationTINCoverage is a realization of the Type CV_TINCoverage specified in ISO 19123. It is an aggregation of ElevationTriangles that represents a triangulated irregular network in which the points of known elevation fall on the vertices of the triangles. It is also a subclass of ElevationCoverage that inherits the attributes specified for that class.

B.7.2 interpolationType

The attribute *interpolationType* shall specify the interpolation method recommended for evaluation of the ElevationTINCoverage. The data type CV_InterpolationMethod is a code list specified in ISO 19123. For an ElevationTINCoverage, the value should be “barycentric”.

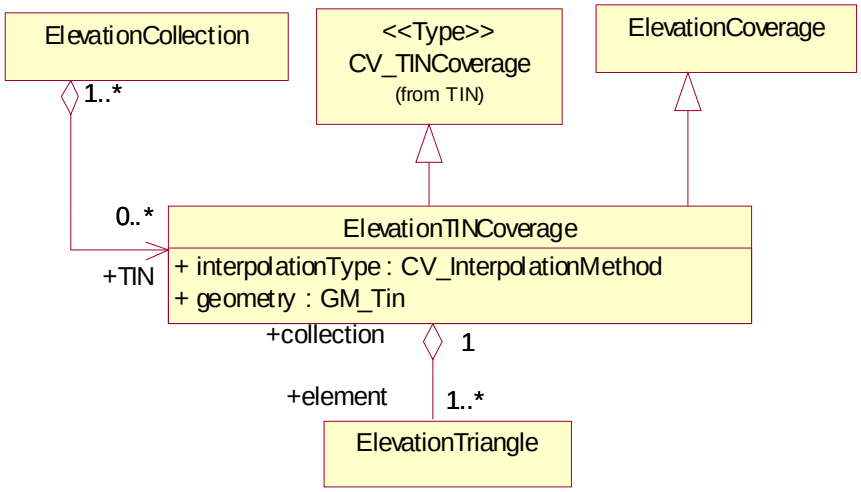


Figure B.6 – Context diagram: ElevationTINCoverage

B.7.3 geometry

The attribute *geometry* shall contain the network of triangles that form the basis of the TIN. The class GM_TIN is specified in ISO 19107. The triangles shall lie on a 2-dimensional surface; the elevation values at the vertices are treated as attributes of the points, not as coordinate values.

B.7.4 element

The role name *element* shall identify the set of ElevationTriangles contained in the ElevationTINCoverage.

B.8 ElevationTriangle

The class ElevationTriangle is a realization of the Type CV_ValueTriangle specified in ISO 19123. It represents one of the triangles of the TIN and the elevation values associated with the vertices of that triangle.

B.8.1 geometry

The attribute *geometry* shall contain the GM_Triangle that is the basis of the ElevationTriangle. The class GM_Triangle is specified in ISO 19107. The constraint {geometry =

collection.geometry.patch} asserts that *geometry* is an instance of GM_Triangle identified by the *patch* attribute of the GM_Tin that is the value of the *geometry* attribute of ElevationTINCoverage.

B.8.2 collection

The role name *collection* shall identify the ElevationTINCoverage to which the ElevationTriangle belongs.

B.8.3 control value

The role name *controlValue* shall identify the set of ElevationPoints at the vertices of the ElevationTriangle.

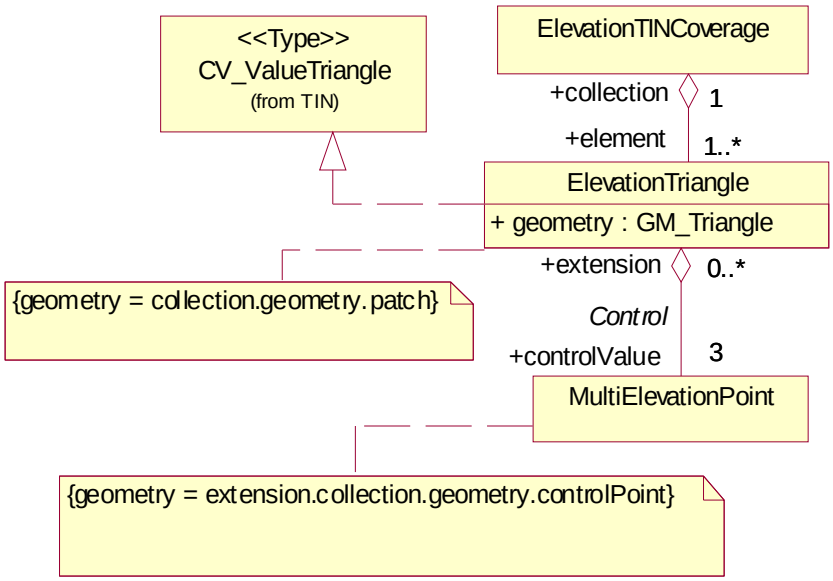


Figure B.7 – Context diagram: ElevationTriangle

B.8.4 MultiElevationPoint

The class MultiElevationPoint is described at 1.6. In the context of ElevationTriangle, it is subject to the additional constraint {geometry = extension.collection.geometry.controlPoint}, which asserts that the value of the *geometry* attribute of ElevationPoint equals one of the values of the attribute *controlPoint* of the GM_TIN that is the value of the *geometry* attribute of the ElevationTINCoverage to which the ElevationTriangle belongs.

B.9 ElevationContourCoverage

B.9.1 Semantics

The class ElevationContourCoverage is a realization of the Type CV_DiscreteCoverage specified in ISO 19123 that represents a set of elevation contours. It is also a subclass of ElevationCoverage that inherits the attributes specified for that class.

B.9.2 element

The role name *element* identifies the set of ElevationContours contained in the ElevationContourCoverage.

B.10 ElevationContour

B.10.1 Semantics

The class ElevationContour is a realization of the Type CV_CurveValuePair specified in ISO 19123. It has two attributes.

B.10.2 geometry

The attribute *geometry* shall contain the instance of GM_Curve that describes the shape of the contour. The constraint {geometry.segment.samplePoint.position.dimension = 2} asserts that the position of the curve is stated with respect to a 2D coordinate reference3 system.

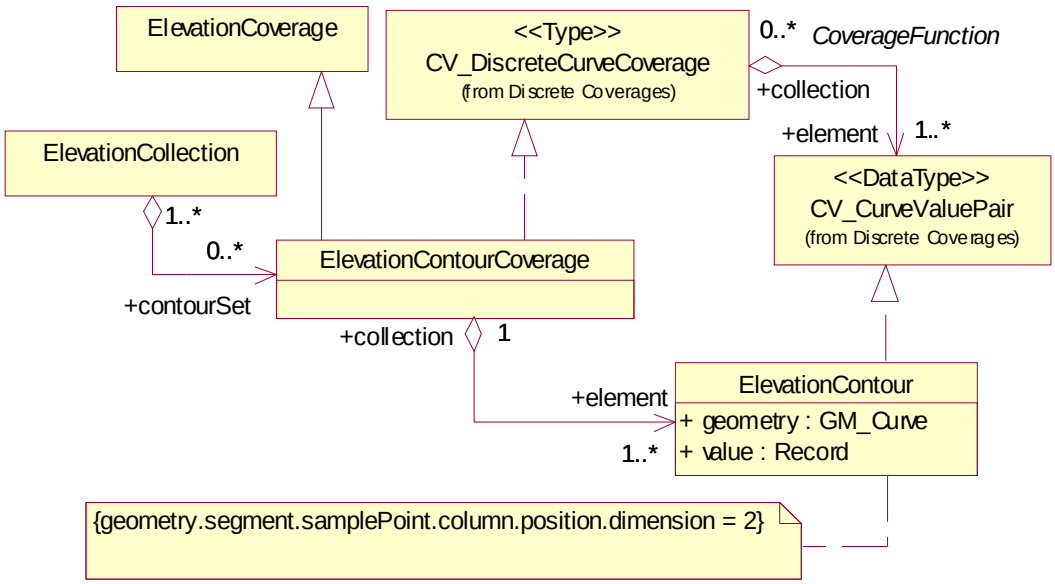


Figure B.8 – Context diagram: ElevationContourCoverage

B.10.3 value

The attribute *value* shall contain a Record consisting of the elevation value associated with the curve.

B.11 ElevationPointSet

B.11.1 Semantics

The class ElevationPointSet represents a collection pf points each related to a 3D coordinate reference system such that the elevation value is carried as one of the coordinates rather than as a distinct attribute of the point.

B.11.2 domainExtent

The attribute *domainExtent* shall specify the spatial extent of the area to which the ElevationPointSet applies.

B.11.3 point

The role name *point* shall identify the ElevationPoints contained in the ElevationPointSet.

B.11.4 metadata

The attribute *metadata* shall provide a link to metadata that describes the ElevationPointSet.

B.12 ElevationPoint

B.12.1 Semantics

The class ElevationPoint represents a point associated with a single elevation surface. Unlike the MultiElevationPoints of an ElevationPointCoverage, each ElevationPoint in an ElevationPointSet has only one elevation value and represents only one elevation surface type.

B.12.2 surfaceType

The attribute *surfaceType* shall identify the type of surface that is described by the ElevationPoint.

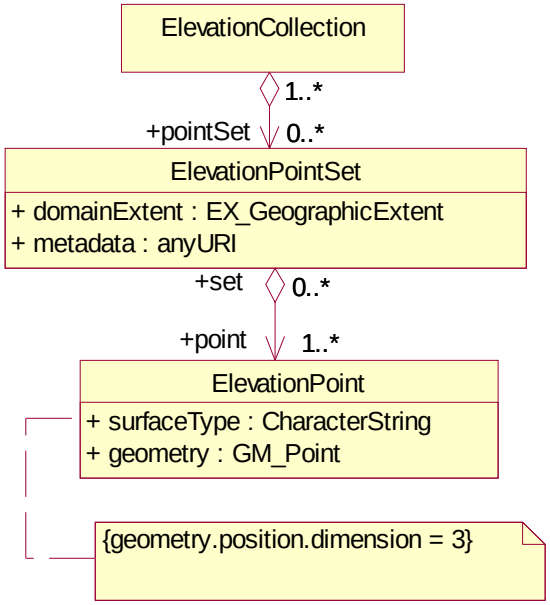


Figure B.9 – Context diagram: ElevationPointSet

B.12.3 geometry

The attribute *geometry* shall contain an instance of GM_Point. The constraint {geometry.position.dimension = 3} asserts that the position of the point shall be described in terms of a 3D coordinate reference system. One of the coordinates shall be the value for the elevation.

B.13 ElevationProfileCollection

B.13.1 Semantics

The class ElevationProfileCollection is an aggregation of ElevationProfiles.

B.13.2 domainExtent

The attribute *domainExtent* shall specify the spatial extent of the area to which the ElevationProfileCollection applies.

B.13.3 metadata

The attribute *metadata* shall provide a link to metadata that describes the ElevationProfileCollection.

B.13.4 profile

The role name *profile* shall identify the set of ElevationProfiles that is contained in the ElevationProfileCollection.

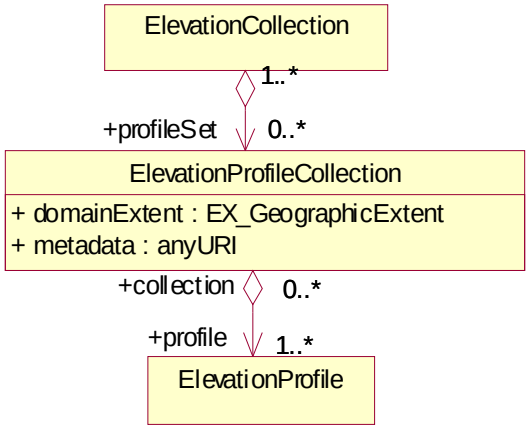


Figure B.10 – Context diagram: ElevationProfileCollection

B.14 ElevationProfile

B.14.1 Semantics

The class ElevationProfile represents a curve lying on an elevation surface. It is a realization of the Type GM_Curve specified in ISO 19107, which is an aggregation of GM_CurveSegments.

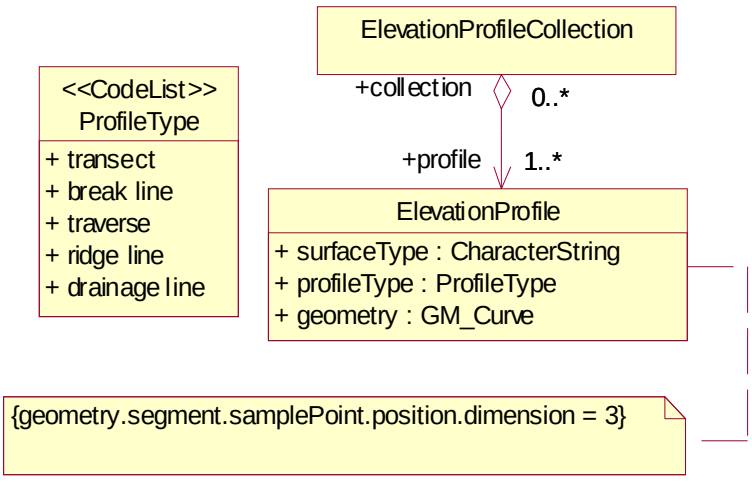


Figure B.11 – Context diagram: ElevationProfile

824

825 ### B.14.2 surfaceType

826 The attribute *surfaceType* shall identify the type of surface that the elevation values describe.
827 The data type CharacterString is specified in ISO/TS 19103.

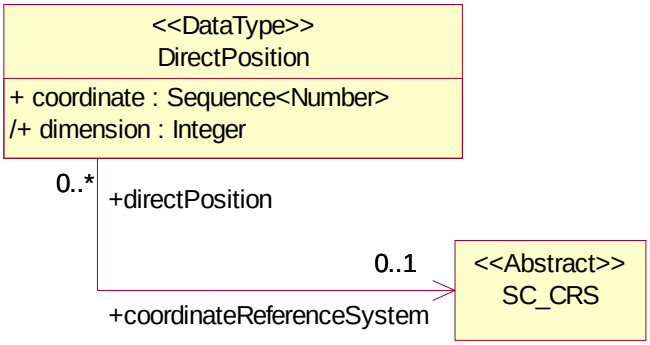
828 ### B.14.3 profileType

829 The attribute *profileType* shall identify the kind of profile from the code list ProfileType.

830 ### B.14.4 geometry

831 The attribute *geometry* shall contain an instance of GM_Curve. The constraint
832 {geometry.segment.samplePoint.position.dimension = 3} asserts that positions of the control
833 points for that curve shall be described in terms of a 3D coordinate reference system. One of the
834 coordinates shall be a value for elevation.

835 ## B.15 DirectPosition



836 **Figure B.12 – Context diagram: DirectPosition**

837

838 ### B.15.1 Semantics

839 The data type DirectPosition, specified in ISO 19107, is used to provide position information for
840 all elevation values in an ElevationCollection.

841 ### B.15.2 coordinate

842 The attribute *coordinate* shall contain the coordinates that identify the spatial position of a point.

843 ### B.15.3 dimension

844 The attribute *dimension* is derived from the dimension of the coordinate reference system and
845 specifies the number of ordinates included in each coordinate value.

846 ### B.15.4 coordinateReferenceSystem

847 The role name *coordinateReferenceSystem* shall identify the SC_CRS to which the position is
848 referred. SC_CRS is specified in ISO 19111 as an abstract class. The appropriate subclass from
849 ISO 19111 shall be used to describe the coordinate reference system used with any framework
850 elevation data set.

Annex C
(normative)
Elevation data UML object description, Data dictionaries for framework elevation data

C.1 ElevationCollection and ElevationCoverage

Table C.1 – Data dictionary for ElevationCollection and ElevationCoverage

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
1	ElevationCollection					Lines 2-9
2	extent	Spatial extent of the collection.	M	1	EX_GeographicExtent	Unrestricted
3	metadata	Data about the ElevationCollection.	M	1	anyURI	Unrestricted
4	Role name: gridSet	A set of elevation grid coverages.	O	*	ElevationGridCoverage	Unrestricted
5	Role name: pointCoverage	A set of elevation point coverages.	O	*	ElevationPointCoverage	Unrestricted
6	Role name: TIN	A set of elevation TIN coverages.	O	*	ElevationTINCoverage	Unrestricted
7	Role name: contourSet	A set of elevation contour coverages.	O	*	ElevationContourCoverage	Unrestricted
8	Role name: profileSet	A set of elevation profile sets.	O	*	ElevationProfileCollection	Unrestricted
9	Role name: pointSet	A set of elevation point sets.	O	*	ElevationPointSet	Unrestricted
10	ElevationCoverage					Lines 11-14
11	domainExtent	Spatial extent of the elevation coverage.	O	*	EX_GeographicExtent	Unrestricted
12	rangeType	Description of the elevation values provided by the elevation coverage.	M	1	RecordType	Unrestricted
13	commonPointRule	Rule to follow in interpolating a value at a point that falls on the boundary between two domain	M	1	CV_CommonPointRule	Average, low, high

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
		objects.				
14	metadata	Data about the ElevationCoverage.	M	1	anyURI	Unrestricted

858

859 ## C.2 ElevationGridCoverage

860

861 **Table C.2 – Data dictionary for ElevationGridCoverage**

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
15	ElevationGridCoverage					Lines 16-17
16	interpolationType	Recommended method for interpolating elevation values at positions between grid points.	M	1	CV_InterpolationType	Bilinear, bicubic
17	Role name: data	Sequence of elevation values.	M	1	ElevationGrid	Unrestricted
18	ElevationGrid					Lines 19-26
19	dimension	Dimension of the elevation grid.	M	1	Integer	2
20	axisNames	Names of the axes of the elevation grid.	M	1	Sequence<CharacterString>	Unrestricted
21	origin	Coordinates, in an external coordinate system, that map to grid coordinates 0, 0.	M	1	DirectPosition	Unrestricted
22	offsetVectors	Vectors that specify the orientation of the grid axes and the dimensions of the grid cells in directions parallel to the axes.	M	1	Sequence<Vector>	Unrestricted
23	extent	Limits of the set of grid points included in the elevation grid.	M	1	CV_GridEnvelope	Unrestricted
24	sequencingRule	Rule for assigning values to grid points.	M	1	CV_SequenceRule	Unrestricted
25	startSequence	Grid point associated with the first record in the values sequence.	M	1	CV_GridCoordinate	Unrestricted

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
26	values	Recorded elevation values.	M	1	Sequence<Record>	Unrestricted
27	CV_GridEnvelope	Grid coordinates for the diametrically opposed corners of the elevation grid.				Lines 28-29
28	low	Minimal grid coordinate values of the part of the grid that contains elevation values.	M	1	CV_GridCoordinate	Unrestricted
29	high	Maximal grid coordinate values of the part of the grid that contains elevation values.	M	1	CV_GridCoordinate	Unrestricted
30	CV_GridCoordinate	Data type for holding the coordinates of a grid point.				Line 31
31	coordValues	Number of grid cell offsets from the origin of the grid parallel to each axis.	M	1	Sequence<Integer>	Unrestricted
32	CV_SequenceRule	Description of how grid points are ordered for association to the elements of the sequence values.				Lines 33-34
33	type	Identifier of the type of sequencing method.	M	1	CV_SequenceType	Unrestricted
34	scanDirection	List of signed axisNames that indicates the order in which grid points shall be mapped to position within the sequence of values.	M	1	Sequence<CharacterString>	Unrestricted

862

863 C.3 ElementPointCoverage

864

865 **Table C.3 – Data dictionary for ElevationPointCoverage**

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
35	ElevationPointCoverage					Line 36
36	Role name: element	A point included in the coverage.	M	*	MultiElevationPoint	Unrestricted

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
37	MultiElevationPoint					Lines 38-39
38	geometry	Geometric description of the elevation point.	M	1	GM_Point	2D
39	value	Elevation at the point.	M	1	Record	Unrestricted

866

867 ## C.4 ElevationTIN

868

869 **Table C.4 – Data dictionary for ElevationTIN**

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
40	ElevationTIN					Lines 41-43
41	interpolationType	Recommended method for interpolating values at points within triangles.	M	1	CV_InterpolationType	Barycentric
42	geometry		M	1	GM_TIN	
43	Role name: element		M	*	ElevationTriangle	Unrestricted
44	ElevationTriangle					Lines 45-46
45	geometry	Geometric description of the elevation triangle.	M	1	GM_Triangle	2D
46	Role name: controlValue	An elevation point at one of the vertices of the elevation triangle.	M	3	MultiElevationPoint	Unrestricted
47	MultiElevationPoint					Lines 48-49
48	geometry	Geometric description of the elevation point.	M	1	GM_Point	2D points
49	value	Set of elevations at the point.	M	1	Record	Unrestricted
50	GM_TIN					Lines 51-55
51	stopLines	Lines where the local continuity or regularity of the surface is questionable. Triangles	M	1	Set<GM_LineString>	Unrestricted

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
		intersecting a stopline are removed from the TIN surface, leaving holes in the surface.				
52	breakLines	Lines of a critical nature to the shape of the surface, representing local ridges, or depressions (such as drainage lines) in the surface. They are included in the TIN although doing so violates the Delaunay criterion.	M	1	Set<GM_LineString>	Unrestricted
53	maxLength	Threshold for eliminating areas where the data is not sufficiently dense. Triangles with sides exceeding maximum length are removed from the surface.	M	1	Distance	Unrestricted
54	controlPoint	The vertices of the triangles of the TIN with their elevation values.	M	*	DirectPosition	Unrestricted
55	Role name: patch	The set of triangles of which the TIN is composed.	M	*	GM_Triangle	Unrestricted
56	GM_Triangle					Lines 57-59
57	corners	Positions of the vertices of the triangle.	M	3	GM_Position	Unrestricted
58	boundary	Boundary of the triangle.	M	1	GM_SurfaceBoundary	Unrestricted
59	interpolation	Method used to interpolate direct positions within the triangle.	M	1	GM_SurfaceInterpolation	“planar”
60	Distance					Lines 61-62
61	value	Value of the distance.	M	1	Number	Unrestricted
62	uom	Unit of measure for the distance.	M	1	UomLength	
63	UomLength					Lines 64-66
64	uomName	Name of the unit of measure.	M	1	CharacterString	
65	uomSymbol	Symbol for the unit of measure.	M	1	CharacterString	
66	measureType	Type of the unit of measure.	M	1	MeasureType	Length

C.5 ElevationContourCoverage

Table C.5 – Data dictionary for ElevationContourCoverage

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
67	ElevationContourCoverage					Line 68
68	Role name: element	Contour included in the coverage.	M	*	ElevationContour	Unrestricted
69	ElevationContour					Lines 70-71
70	geometry	Geometric description of the contour.	M	1	GM_Curve	2D
71	value	Elevation value associated with the contour.	M	1	Record	Unrestricted

C.6 ElevationPointSet

Table C.6 – Data dictionary for ElevationPointSet

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
72	ElevationPointSet					Lines 73-75
73	domainExtent	Spatial extent of the elevation point set.	O	*	EX_GeographicExtent	Unrestricted
74	metadata	Data about the ElevationPointSet.	M	1	anyURI	Unrestricted
75	Role name: point	ElevationPoint contained in the ElevationPointSet.	M	*	ElevationPoint	Unrestricted
76	ElevationPoint					Lines 77-78
77	surfaceType	Type of surface with which the ElevationPoint is associated.	M	1	CharacterString	Unrestricted
78	geometry	Geometric representation of the	M	1	GM_Point	Unrestricted

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
		ElevationPoint.				

878

879 ## C.7 ElevationProfileCollection

880

881 **Table C.7 – Data dictionary for ElevationProfileCollection**

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
79	ElevationProfileCollection				Lines 79-84	Lines 80-81
80	domainExtent	Extent of the elevation profile collection.	M	*	EX_Extent	Unrestricted
81	Role name: element	A profile included in the collection.	M	*	ElevationProfile	Unrestricted
82	ElevationProfile					Lines 83-84
83	profileType	Code identifying a description of what the profile represents.	M	1	ProfileType	Unrestricted
84	geometry	Geometric description of the profile.	M	1	GM_Curve	3D

882

883 **Table C.8 – Data dictionary for GM_Point and DirectPosition**

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
85	GM_Point					Line 86
86	position	Spatial position of the point.	M	1	DirectPosition	Unrestricted
87	DirectPosition					Lines 88-90
88	coordinate	Numerical description of the spatial position.	M	1	Sequence<Number>	Unrestricted
89	dimension	Dimension of the coordinate space.	C	1	Integer	Context dependent
90	Role name:	Spatial reference system to which	C	1	SC_CRS	Unrestricted

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
	coordinateReferenceSystem	the positions is associated.				
91	SC_CRS					Lines 92-93
92	kindCode	Type of coordinate reference system.	M	1	SC_KindCode	1
93	name	Name of the coordinate reference system.	M	1	RS_Identifier	Unrestricted
94	RS_Identifier					Line 95
95	code	Code that identifies the coordinate reference system.	M	1	CharacterString	Unrestricted

884

885 **Table C.9 – Data dictionary for GM_Curve**

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
96	GM_Curve					Lines 97-99
97	orientation	Direction in which the curve is traversed with respect to its sample points.	M	1	Sign	+
98	Role name: segment	Portion of the curve with a distinct interpolation method.	M	*	GM_CurveSegment	Unrestricted
99	Role name: CRS	Coordinate reference system to which the direct positions on the curve are related.	C	1	SC_CRS	Unrestricted
100	GM_CurveSegment					Lines 101-102
101	interpolation	Method used to derive direct positions along the curve.	M	1	GM_CurveInterpolation	Unrestricted
102	samplePoint	Sequence of control points used as the basis for interpolation direct positions along the curve.	M	1	GM_PointArray	Unrestricted
103	GM_PointArray					Line 104
104	Role name: column	Coordinates of a point in the point array.	M	1	DirectPosition	Unrestricted

Annex D
(informative)
Informative references

National digital elevation guidelines, Version 1.0, May 10, 2004

Open Geospatial Consortium, Abstract specification for coverage type and its subtypes, Project document OGC 03-065r6, Version 1.0.0

American Society for Photogrammetry and Remote Sensing, October 2001, Digital elevation model technologies and applications: The DEM users manual