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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 spatial 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 part of the Geospatial Information Framework Data Ccontent Standard is to describe content of geospatial elevation data models to support of the exchange of elevation information. This part seeks to establish a common baseline for the semantic content of elevation databases for public agencies and private enterprises. It also 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 this part of the standard also include the long-term improvement of the geospatial elevation data within the community.

Framework Data Content Standard – Elevation

1 Scope, purpose, and application

The Elevation 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 part of the standard is consistent with ISO 19123 Geographic Information – Schema for Coverage Geometry and Functions and the OGC 03-065r6 Abstract Specification for Coverage Type and its Subtypes. The part includes an application schema expressed in the Unified Modeling Language (UML).

The Elevation part identifies the geospatial data model elements required for digital elevation data to be used for the NSDI framework. The part was written to be 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 part 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 part of the standard will assure a common understanding of the data throughout the user community. 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 the Elevation part includes a data dictionary based on the conceptual application schema presented in that model. To conform to this part of the Framework Data Content Standard, an elevation dataset shall satisfy the requirements of the data dictionary for that geospatial data model.

3 Normative references

Annex A of the Base Document (Part 0) lists normative references applicable to two or more parts of the standard. Informative references applicable only to the Elevation part are listed in Annex C. Annex D of the Base Document lists informative references applicable to two or more of the parts.

4 Maintenance authority

4.1 Level of responsibility

The FGDC is the responsible organization for coordinating work on all parts of the Geographic Information Framework Data Content Standard. The U.S. Department of the Interior, United States Geological Survey (USGS), National Geospatial Programs Office, working with the FGDC, is directly responsible for development and maintenance of the Geographic Information Framework Data Content Standard, Part 3: Elevation.

The FGDC shall be the sole organization responsible for direct coordination with the InterNational Committee for Information Technology Standards (INCITS) concerning any maintenance or any other requirements mandated by INCITS or ANSI.

4.2 Contact information

Address questions concerning this part of the standard to:

Federal Geographic Data Committee Secretariat
c/o U.S. Geological Survey
590 National Center
Reston, Virginia 20192 USA

Telephone: (703) 648-5514
Facsimile: (703) 648-5755

Internet (electronic mail): gdc@fgdc.gov
WWW Home Page: http://fgdc.gov

Or

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

Definitions applicable to the Elevation part are listed below. More general terms and definitions can be found in the Base Document (Part 0). Users are advised to consult that part for a complete set of definitions.

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
line segment

straight line between two points

5.9
point coverage

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

5.10
range

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

5.11
record

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

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

5.12
spatial object

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

5.13
tessellation

partitioning of a space into a set of conterminous **spatial object**, temporal object, or **spatiotemporal object** 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.

5.14
triangulated irregular network
TIN

tessellation composed of triangles [ISO 19123]

5.15
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 notations

The following symbols, abbreviations, and notations are applicable to the Elevation part. Symbols, abbreviated terms, and notations applicable to multiple parts are listed in the Base Document (Part 0).

3D – 3-dimensional

LIDAR – Light Detection and Ranging

TIN – Triangulated Irregular Network

7 Requirements

7.1 General

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.

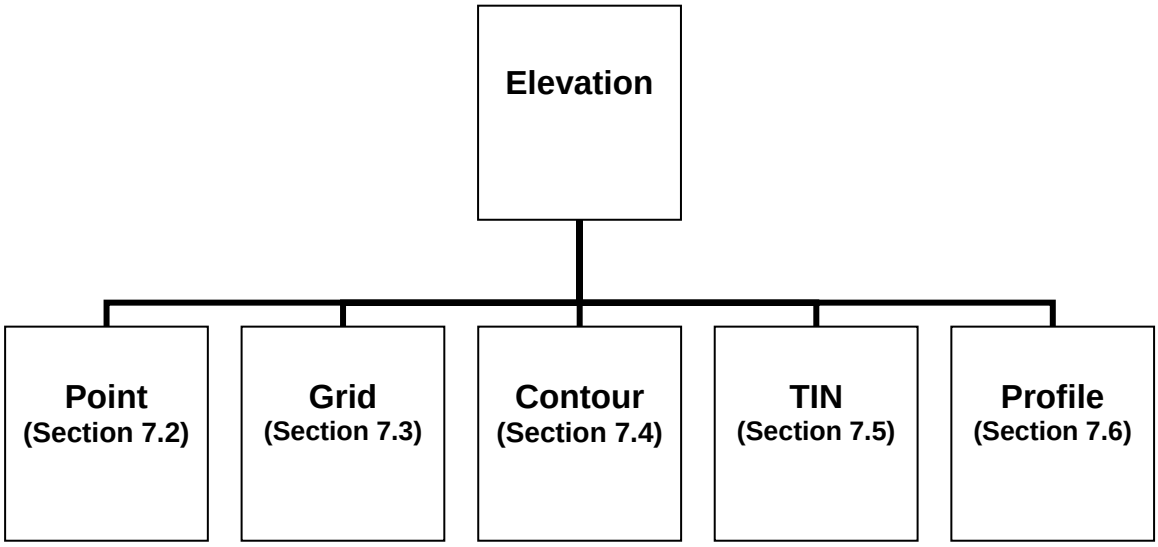

Figure 1 – Elevation

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.

7.2 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 an ElevationPointSet (see section A.12 for the ElevationPointSet UML application schema and B.7 for the ElevationPointSet UML object description) or as an attribute value to the X,Y geometry pair, known as an ElevationPointCoverage (see section A.6 for the ElevationPointCoverage UML application schema and B.4 for the ElevationPointCoverage 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.

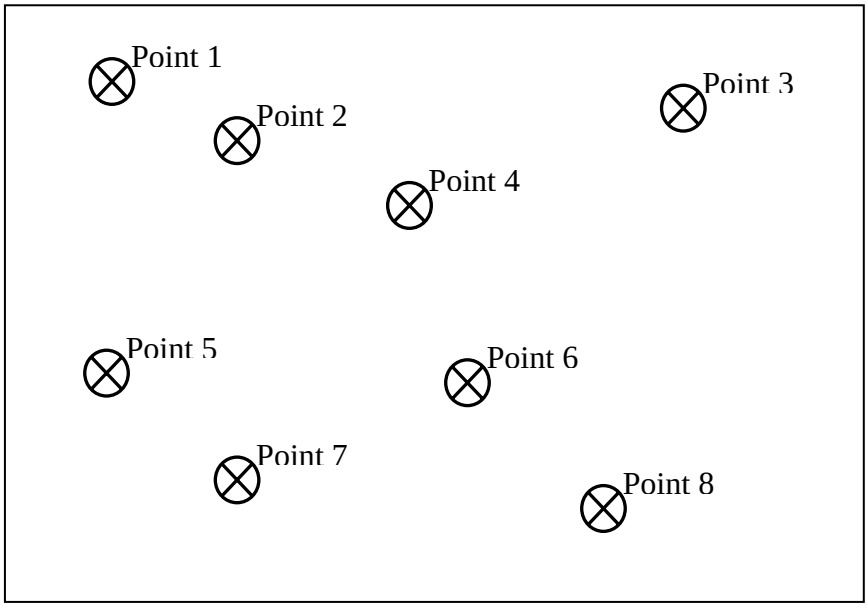

Figure 2 – Example: Point

7.3 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 A.4 for the ElevationGridCoverage UML application schema and B.3 for the ElevationGridCoverage 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 small, narrow grid spacing, while gentle relief may be adequately modeled with 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.

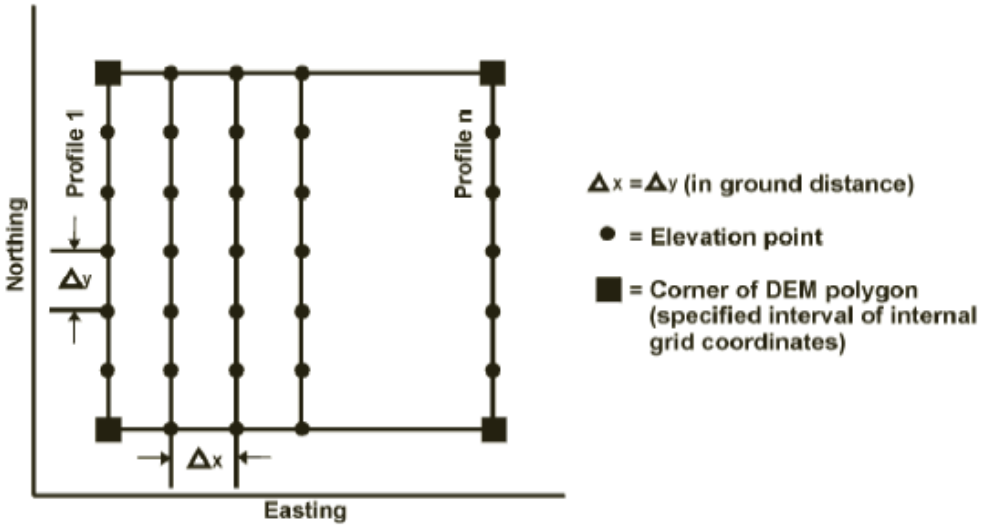

Figure 3 – Example: Grid

7.4 Contour

Three-dimensional vector modeling supports the exchange of constant-elevation features, also referred to as hypsography or contours. See section A.10 for the ElevationContourCoverage UML application schema and B.6 for the ElevationContourCoverage 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.

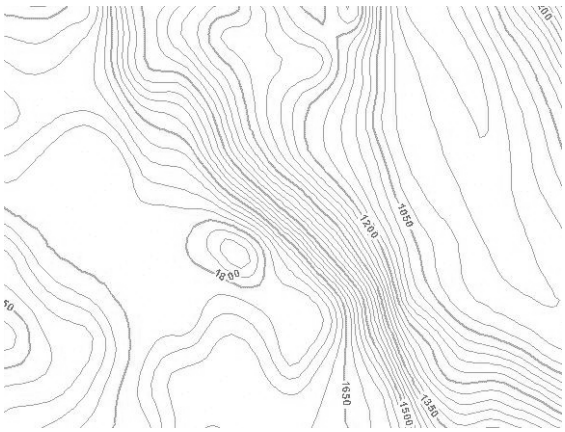

Figure 4 – Example: Contours

7.5 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, which are linked by topological structure. TIN datasets include topological relationships between points and their neighboring triangles. Each sample point has an x,y coordinate geometry pair and a surface, or z-value. These points are connected by edges to form a set of non-overlapping triangles used to represent the surface as shown in Figure 5. See section A.8 for the ElevationTINCoverage UML application schema and B.5 for the ElevationTINCoverage UML object description.

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

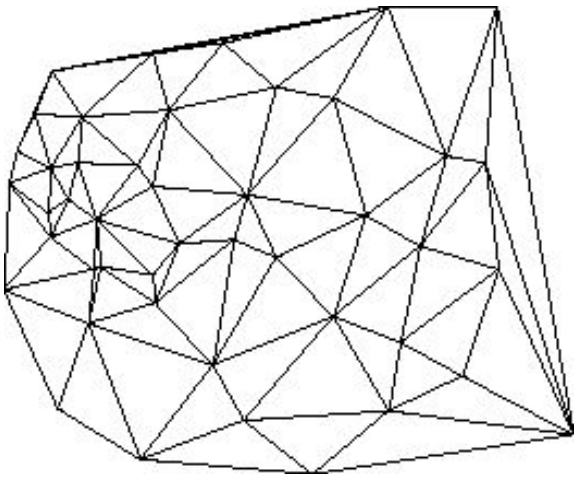

Figure 5 – Example: Triangulated irregular network

7.6 Profile

Profiles, also known as breaklines or cross sections (also referred to as transects), are lines that connect irregularly spaced points of varying elevation values as shown in Figure 6. Profiles are commonly used to model surface discontinuities such as peaks, pits, ridges, and valleys or may be used to model the elevation information of other linear features such as transportation or pipelines. See section A.15 for the ElevationProfile UML application schema and B.8 for the ElevationProfileCollection UML object description.

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

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

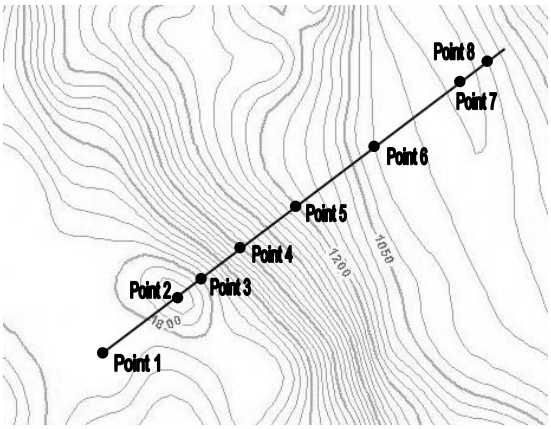

Figure 6 – Example: Profile1

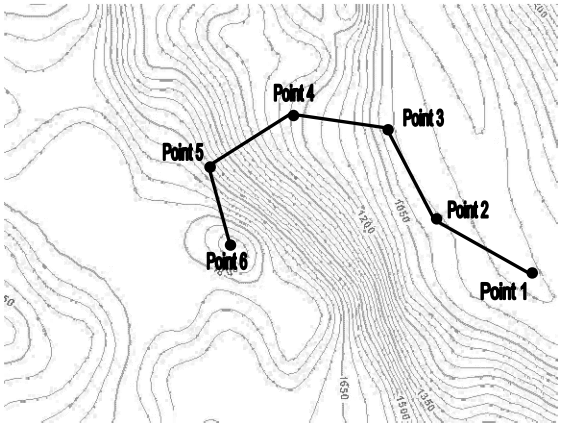

Figure 7 – Example: Profile2

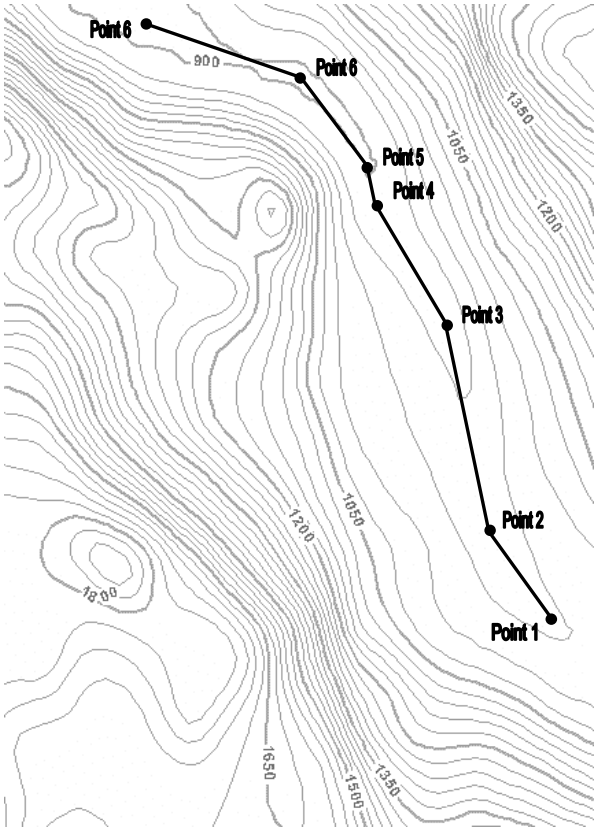

Figure 8 – Example: Profile3

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

A.1 General

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

A.2 ElevationCollection

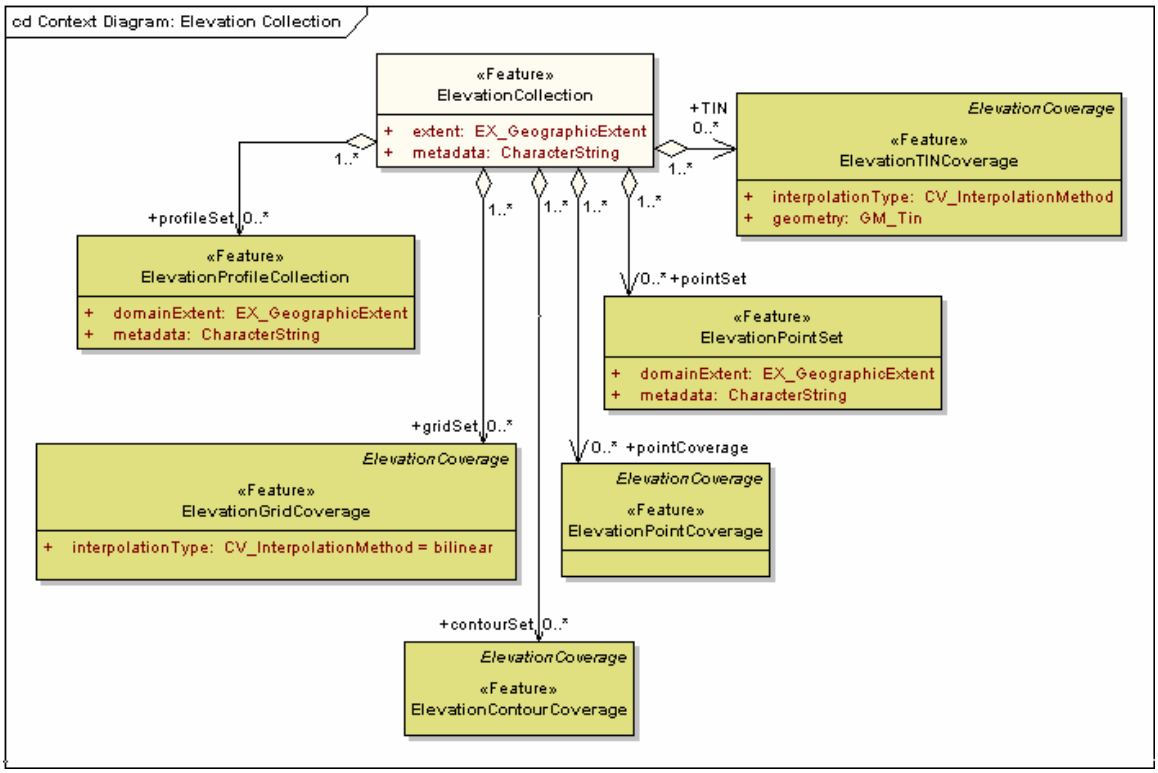

Figure A.1 – ElevationCollection

A.2.1 Semantics

The class ElevationCollection represents a collection of framework elevation data. It inherits the attribute metadata from the FeatureCollection class specified in the Base Document (Part 0).

A.2.2 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.

A.2.3 metadata

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

603 ### A.2.4 gridSet

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

606 ### A.2.5 pointSet

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

609 ### A.2.6 pointCoverage

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

612 ### A.2.7 contourSet

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

615 ### A.2.8 tin

616 The role name *tin* shall identify the set of ElevationTinCoverages contained in the
617 ElevationCollection.

618 ### A.2.9 profileSet

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

621 ## A.3 ElevationCoverage

622

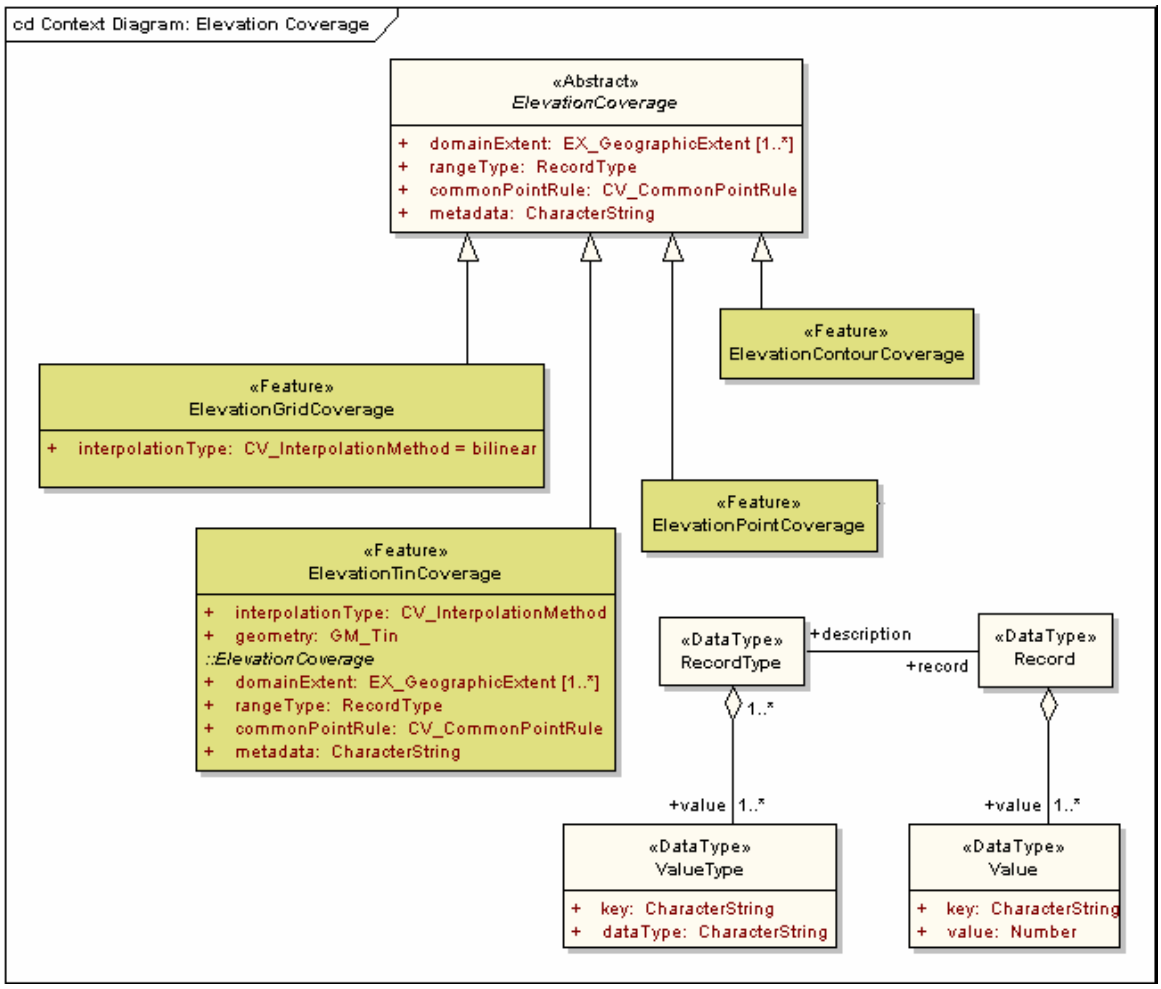

Figure A.2 – ElevationCoverage

A.3.1 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. It inherits an association to SC_CRS from CV_Coverage. SC_CRS provides a description of the coordinate reference system including horizontal and vertical datums and units of measure.

A.3.2 domainExtent

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

A.3.3 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”.

A.3.4 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”.

A.3.5 metadata

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

A.4 ElevationGridCoverage

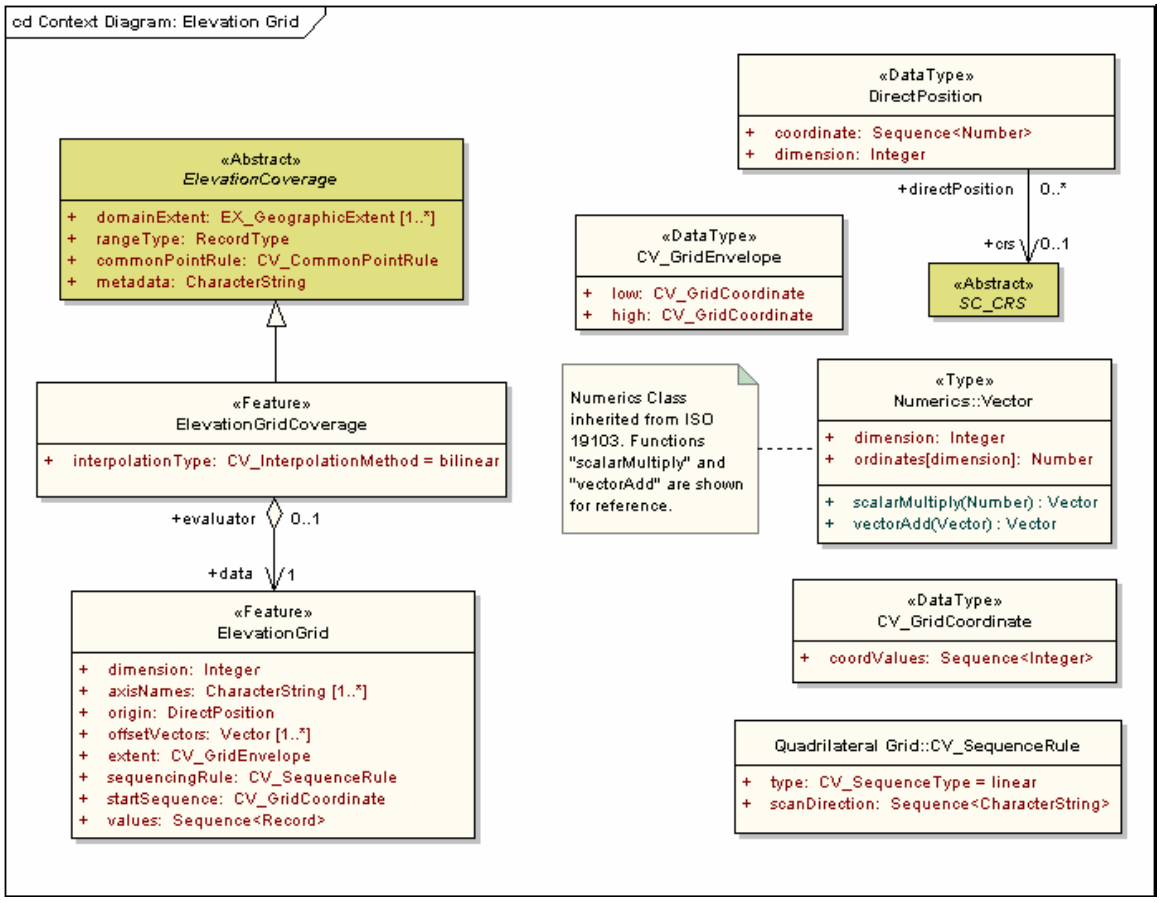

Figure A.3 – ElevationGridCoverage

A.4.1 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.

A.4.2 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”.

A.4.3 data

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

A.5 ElevationGrid

A.5.1 Semantics

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

A.5.2 dimension

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

A.5.3 axisNames

The attribute *axisNames* shall list the names of the grid axes, one of each dimension of the grid.

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

A.5.4 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. The external coordinate reference system for the ElevationGrid shall be the coordinate reference system identified by the association from ElevationCoverage to SC_CRS.

A.5.5 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.

A.5.6 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.

A.5.7 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.

A.5.8 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.

A.5.9 values

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

A.6 ElevationPointCoverage

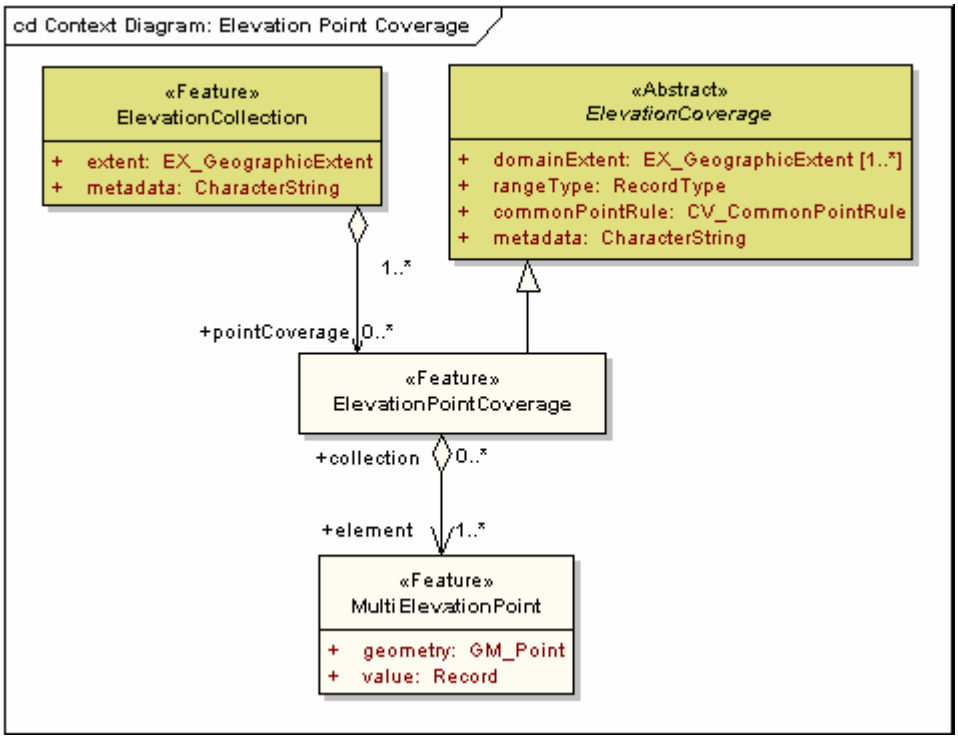

Figure A.4 – ElevationPointCoverage

A.6.1 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.

A.6.2 element

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

A.7 MultiElevationPoint

A.7.1 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.

A.7.2 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.

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

A.7.3 value

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

A.8 ElevationTinCoverage

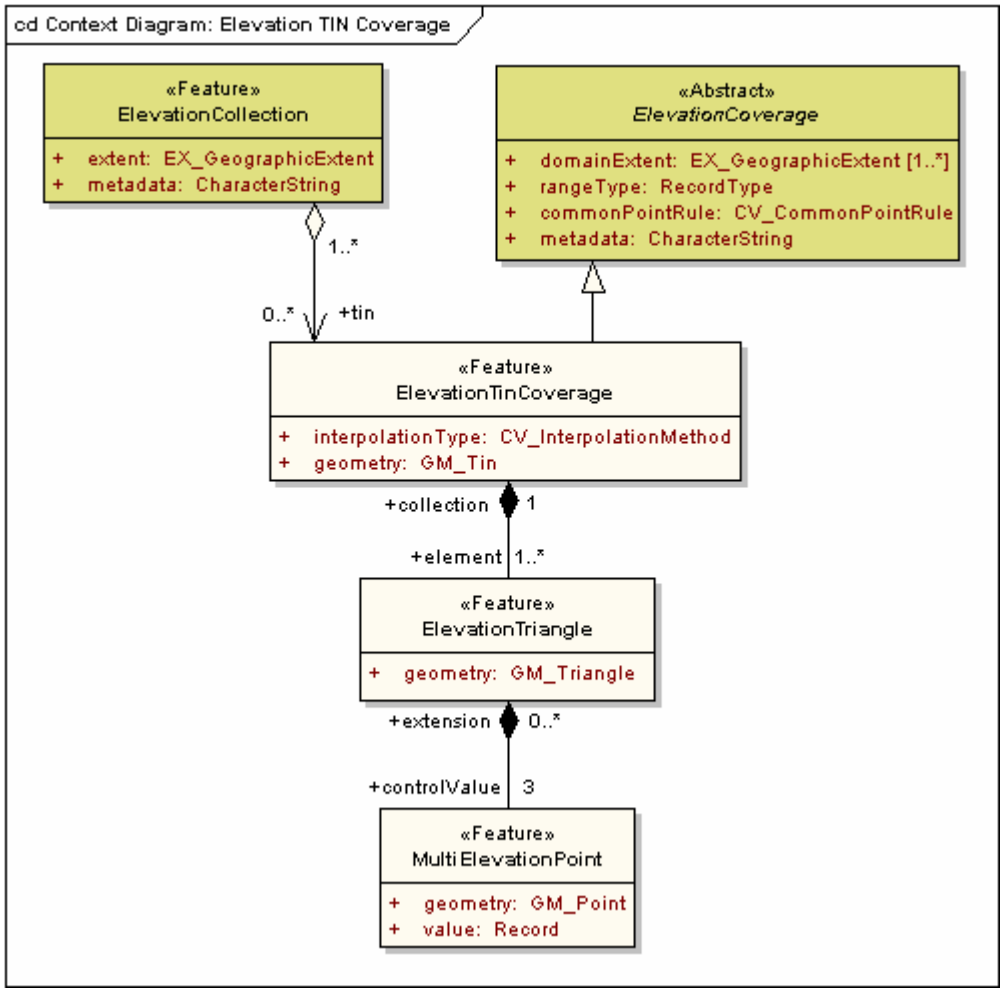

Figure A.5 – ElevationTinCoverage

A.8.1 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.

A.8.2 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 shall be “barycentric”.

A.8.3 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.

A.8.4 element

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

A.9 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.

A.9.1 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. Each instance of *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.

A.9.2 collection

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

A.9.3 control value

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

A.9.4 MultiElevationPoint

The class MultiElevationPoint is described in A.6. 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.

A.10 ElevationContourCoverage

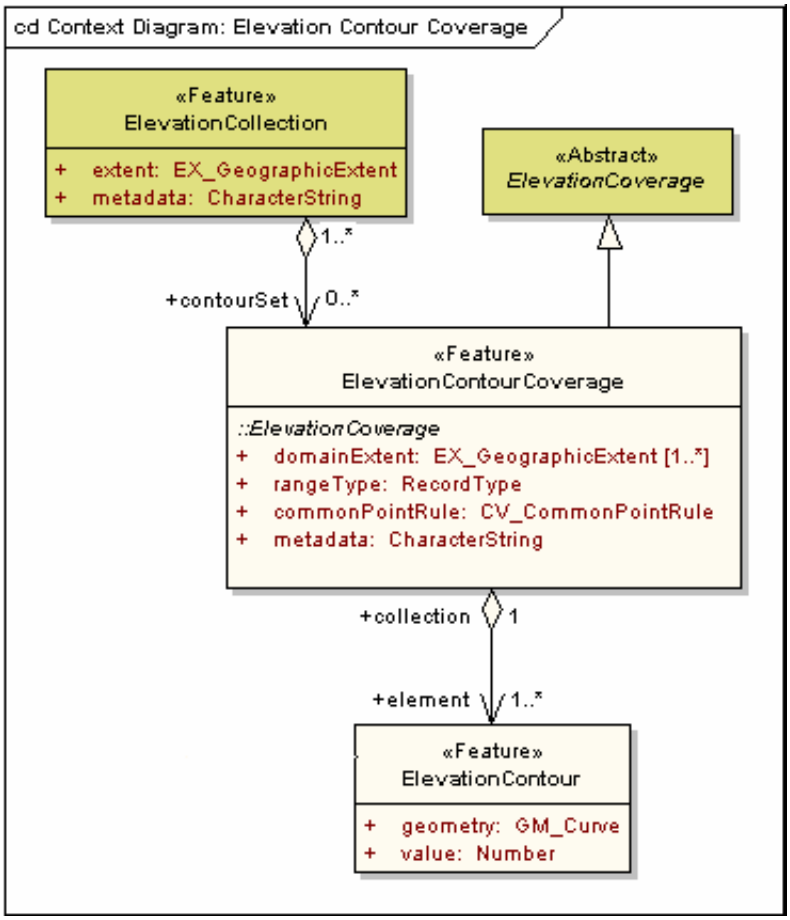

Figure A.6 – ElevationContourCoverage

A.10.1 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.

A.10.2 element

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

A.11 ElevationContour

A.11.1 Semantics

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

A.11.2 geometry

The attribute *geometry* shall contain the instance of GM_Curve that describes the shape of the contour. The position of the curve is stated with respect to a 2D coordinate reference3 system.

A.11.3 value

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

A.12 ElevationPointSet

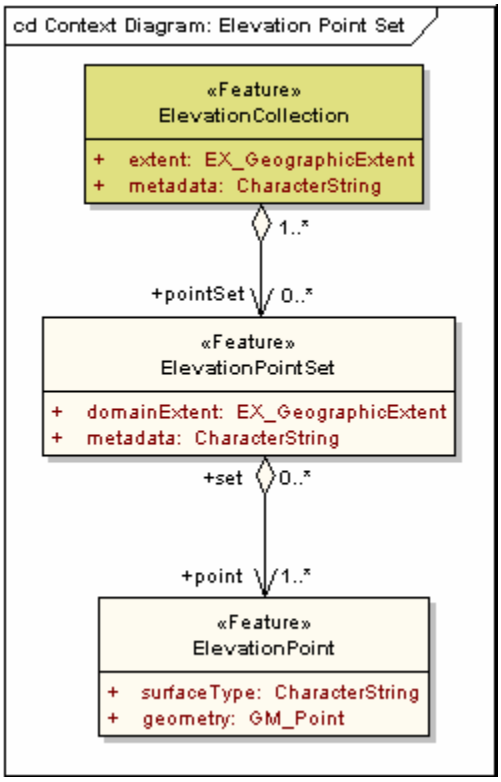

Figure A.7 – ElevationPointSet

A.12.1 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.

A.12.2 domainExtent

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

A.12.3 point

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

A.12.4 metadata

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

A.13 ElevationPoint

A.13.1 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.

A.13.2 surfaceType

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

A.13.3 geometry

The attribute *geometry* shall contain an instance of GM_Point. 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.

A.14 ElevationProfileCollection

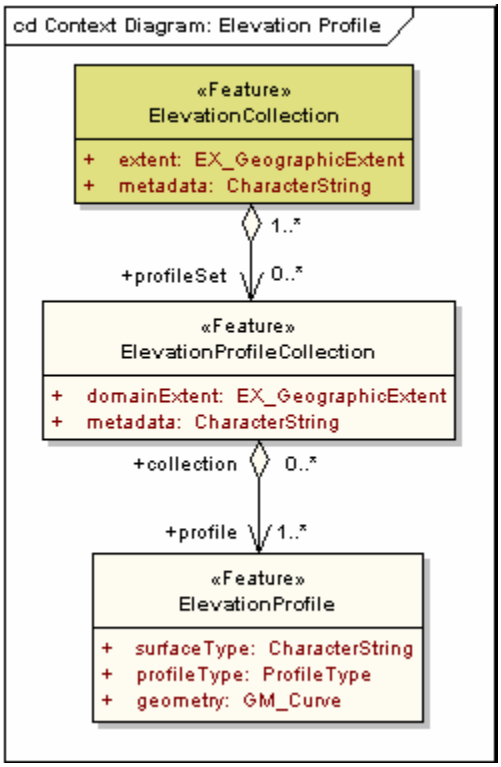

Figure A.8 – ElevationProfileCollection

A.14.1 Semantics

The class ElevationProfileCollection is an aggregation of ElevationProfiles.

A.14.2 domainExtent

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

A.14.3 metadata

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

A.14.4 profile

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

A.15 ElevationProfile

A.15.1 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.

A.15.2 surfaceType

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

A.15.3 profileType

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

A.15.4 geometry

The attribute *geometry* shall contain an instance of GM_Curve. Positions of the control points for that curve shall be described in terms of a 3D coordinate reference system. One of the coordinates shall be a value for elevation.

A.16 DirectPosition

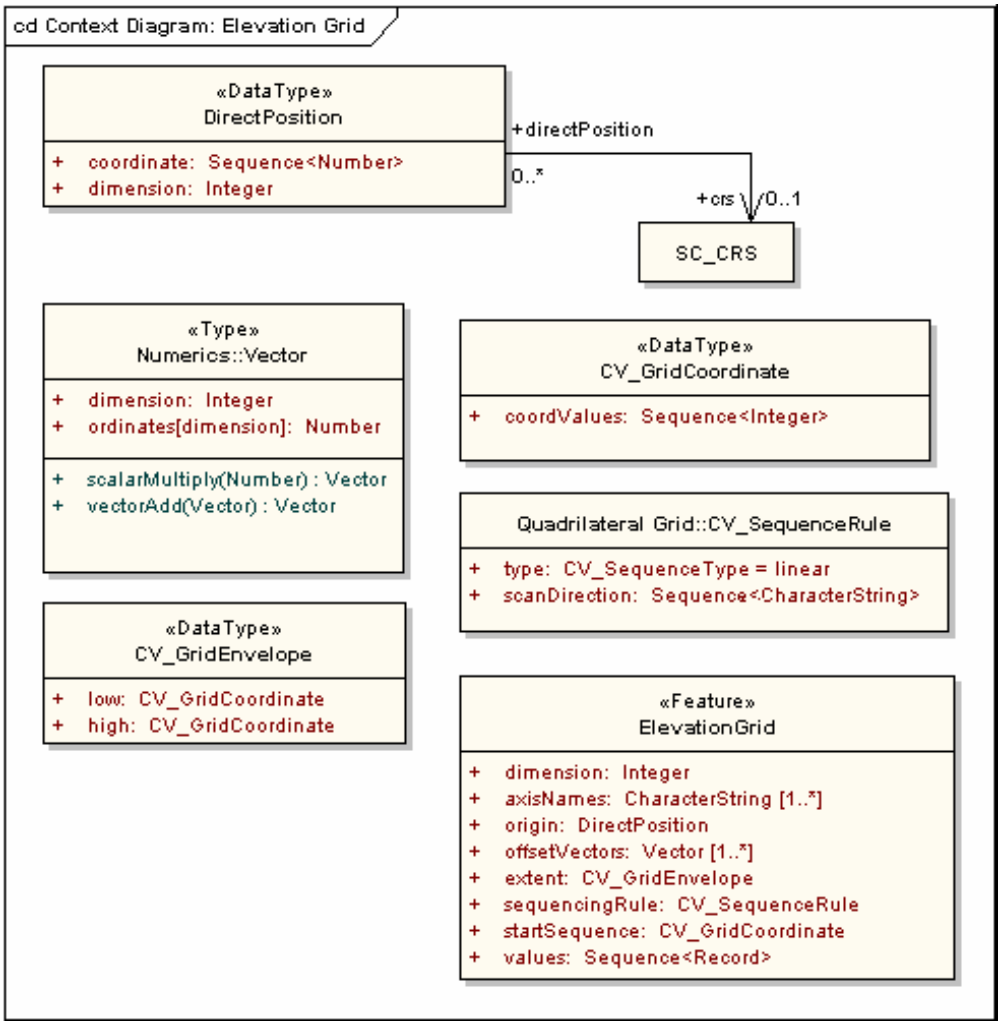

Figure A.9 – DirectPosition

A.16.1 Semantics

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

A.16.2 coordinate

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

A.16.3 dimension

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

A.16.4 coordinateReferenceSystem

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

A.17 Code lists

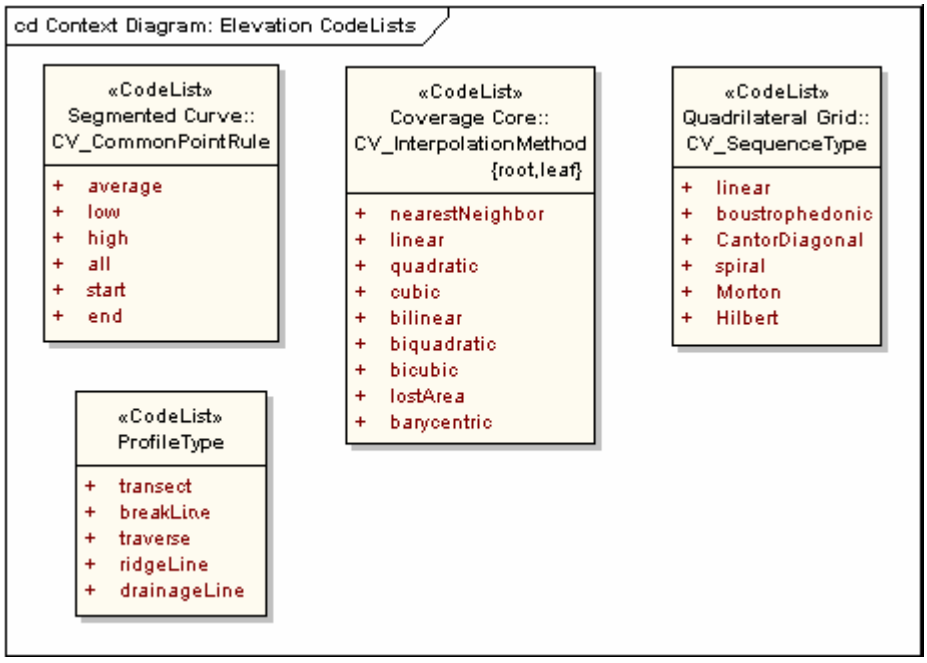

Figure A.10 – Code lists

A.17.1 CV_CommonPointRule code list

CV_CommonPointRule is a CodeList of values for the attribute commonPointRule.

881 **Table A.1 – CodeList for CV_CommonPointRule**

Name	Definition
average	
low	
high	
all	
start	
end	

882

883 ### A.17.2 CV_InterpolationMethod code list

884 CV_InterpolationMethod is a CodeList of values for the attribute interpolationType.

885

886 **Table A.2 – CodeList for CV_InterpolationMethod**

Name	Definition
nearestNeighbor	
linear	
quadratic	
cubic	
bilinear	
biquadratic	
bicubic	
lostArea	
barycentric	

887

888 ### A.17.3 CV_SequenceType code list

889 CV_SequenceType is a CodeList of values for the attribute type.

890

891 **Table A.3 – CodeList for CV_SequenceType**

Name	Definition
linear	
boustrophedonic	
CantorDiagonal	
spiral	
Morton	

Name	Definition
Hilbert	

892

893 ### A.17.4 ProfileType code list

894 ProfileType is a CodeList of values for the attribute profileType.

895

896 **Table A.4 – Codelist for ProfileType**

Name	Definition
transect	
breakLine	
traverse	
ridgeLine	
drainageLine	

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

B.1 ElevationCollection

Table B.1 – Data dictionary for ElevationCollection

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
1	ElevationCollection				<<Feature>>	Lines 2-9
2	extent	Spatial extent of the collection	M	1	EX_GeographicExtent	Unrestricted
3	metadata	Data about the ElevationCollection	M	1	CharacterString	Unrestricted
4	Role name: profileSet	Set of elevation profile sets	O	*	<<Feature>> ElevationProfileCollection	Unrestricted
5	Role name: gridSet	Set of elevation grid coverages	O	*	<<Feature>> ElevationGridCoverage	Unrestricted
6	Role name: contourSet	Set of elevation contour coverages	O	*	<<Feature>> ElevationContourCoverage	Unrestricted
7	Role name: pointCoverage	Set of elevation point coverages	O	*	<<Feature>> ElevationPointCoverage	Unrestricted
8	Role name: pointSet	Set of elevation point sets.	O	*	<<Feature>> ElevationPointSet	Unrestricted
9	Role name: tin	Set of elevation TIN coverages	O	*	<<Feature>> ElevationTinCoverage	Unrestricted
10	ElevationProfileCollection				<<Feature>>	

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
11	ElevationGridCoverage				<<Feature>>	
12	ElevationContourCoverage				<<Feature>>	
13	ElevationPointCoverage				<<Feature>>	
14	ElevationPointSet				<<Feature>>	
15	ElevationTinCoverage				<<Feature>>	

B.2 ElevationCoverage

Table B.2 – Data dictionary for ElevationCoverage

16	ElevationCoverage				<<Abstract>>	Lines 17-20
17	domainExtent	Spatial extent of the elevation coverage	M	*	EX_GeographicExtent	Unrestricted
18	rangeType	Description of the elevation values provided by the elevation coverage	M	1	RecordType	Unrestricted
19	commonPointRule	Rule to follow in interpolating a value at a point that falls on the boundary between two domain objects	M	1	<<CodeList>> CV_CommonPointRule	Average, low, high
20	metadata	Data about the ElevationCoverage	M	1	CharacterString	Unrestricted
21	ElevationGridCoverage				<<Feature>>	
22	ElevationTinCoverage				<<Feature>>	
23	ElevationPointCoverage				<<Feature>>	
24	ElevationContourCoverage				<<Feature>>	

25	RecordType				<<DataType>>	Lines 26-27
26	Role name: value		M	*	<<DataType>> ValueType	
27	Role name: record		M	1	<<DataType>> Record	
28	ValueType				<<DataType>>	Lines 29-30
29	key		M	1	CharacterString	
30	dataType		M	1	CharacterString	
31	Record				<<DataType>>	Lines 32-33
32	Role name: value		M	*	<<DataType>> Value	
33	Role name: description		M	1	<<DataType>> RecordType	
34	Value				<<DataType>>	Lines 35-36
35	key		M	1	CharacterString	
36	value		M	1	Number	

908

909 ## B.3 ElevationGridCoverage

910

911 **Table B.3 – Data dictionary for ElevationGridCoverage**

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
37	ElevationCoverage				<<Abstract>>	
38	ElevationGridCoverage				<<Feature>>	Lines 39-40

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
39	interpolationType	Recommended method for interpolating elevation values at positions between grid points	M	1	<<CodeList>> CV_InterpolationMethod = bilinear	Bilinear, bicubic
40	Role name: data	Sequence of elevation values	M	1	<<Feature>> ElevationGrid	Unrestricted
41	ElevationGrid				<<Feature>>	Lines 42-50
42	dimension	Dimension of the elevation grid	M	1	Integer	2
43	axisNames	Names of the axes of the elevation grid	M	*	CharacterString	Unrestricted
44	origin	Coordinates, in an external coordinate system, that map to grid coordinates 0, 0	M	1	<<DataType>> DirectPosition	Unrestricted
45	offsetVectors	Vectors that specify the orientation of the grid axes and the dimensions of the grid cells in directions parallel to the axes	M	*	<<Type>> Vector	Unrestricted
46	extent	Limits of the set of grid points included in the elevation grid	M	1	<<DataType>> CV_GridEnvelope	Unrestricted
47	sequencingRule	Rule for assigning values to grid points	M	1	<<DataType>> CV_SequenceRule	Unrestricted
48	startSequence	Grid point associated with the first record in the values sequence	M	1	<<DataType>> CV_GridCoordinate	Unrestricted
49	values	Recorded elevation values	M	1	Sequence<Record>	Unrestricted
50	Role name: evaluator		O	1	<<Feature>> ElevationGridCoverage	
51	CV_GridEnvelope	Grid coordinates for the diametrically opposed corners of the elevation grid			<<DataType>>	Lines 52-53

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
52	low	Minimal grid coordinate values of the part of the grid that contains elevation values	M	1	<<DataType>> CV_GridCoordinate	Unrestricted
53	high	Maximal grid coordinate values of the part of the grid that contains elevation values	M	1	<<DataType>> CV_GridCoordinate	Unrestricted
54	CV_GridCoordinate	Data type for holding the coordinates of a grid point			<<DataType>>	Line 55
55	coordValues	Number of grid cell offsets from the origin of the grid parallel to each axis	M	1	Sequence<Integer>	Unrestricted
56	Quadrilateral Grid:: CV_SequenceRule	Description of how grid points are ordered for association to the elements of the sequence values			<<DataType>>	Lines 57-58
57	type	Identifier of the type of sequencing method	M	1	<<CodeList>> CV_SequenceType = linear	Unrestricted
58	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
59	Numerics::Vector				<<Type>>	Lines 60-61
60	dimension		M	1	Integer	
61	ordinates[dimension]		M	1	Number	
62	DirectPosition				<<DataType>>	Lines 63-65
63	coordinate	Numerical description of the spatial position	M	1	Sequence<Number>	Unrestricted
64	dimension	Dimension of the coordinate space	M	1	Integer	Context dependent
65	Role name: crs	Spatial reference system to which	O	1	<<Abstract>>	Unrestricted

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
		the positions is associated			SC_CRS	
66	SC_CRS				<<Abstract>>	Line 67
67	Role name: directPosition		O	*	<<DataType>> DirectPosition	

912

913 ## B.4 ElevationPointCoverage

914

915 **Table B.4 – Data dictionary for ElevationPointCoverage**

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
68	ElevationCollection				<<Feature>>	
69	ElevationCoverage				<<Abstract>>	
70	ElevationPointCoverage				<<Feature>>	Line 71
71	Role name: element	Point included in the coverage	M	*	<<Feature>> MultiElevationPoint	Unrestricted
72	MultiElevationPoint				<<Feature>>	Lines 73-74
73	geometry	Geometric description of the elevation point	M	1	<<Type>> GM_Point	Defined in ISO 19107
74	value	Elevation at the point	M	1	Record	Unrestricted

916

B.5 ElevationTinCoverage

Table B.5 – Data dictionary for ElevationTinCoverage

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
75	ElevationCollection				<<Feature>>	
76	ElevationCoverage				<<Abstract>>	
77	ElevationTinCoverage				<<Feature>>	Lines 78-80
78	interpolationType	Recommended method for interpolating values at points within triangles	M	1	<<CodeList>> CV_InterpolationMethod	Barycentric
79	geometry		M	1	<<Type>> GM_Tin	Defined in ISO 19107
80	Role name: element		M	*	<<Feature>> ElevationTriangle	Unrestricted
81	ElevationTriangle				<<Feature>>	Lines 82-84
82	geometry	Geometric description of the elevation triangle	M	1	<<Type>> GM_Triangle	Defined in ISO 19107
83	Role name: collection		M	1	<<Feature>> ElevationTinCoverage	
84	Role name: controlValue	Elevation point at one of the vertices of the elevation triangle	M	3	<<Feature>> MultiElevationPoint	Unrestricted
85	MultiElevationPoint				<<Feature>>	Lines 86-88
86	geometry	Geometric description of the elevation point	M	1	<<Type>> GM_Point	Defined in ISO 19107
87	value	Set of elevations at the point	M	1	Record	Unrestricted

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
88	Role name: extension		O	*	<<Feature>> ElevationTriangle	

B.6 ElevationContourCoverage

Table B.6 – Data dictionary for ElevationContourCoverage

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
89	ElevationCollection				<<Feature>>	
90	ElevationCoverage				<<Abstract>>	
91	ElevationContourCoverage				<<Feature>>	Line 92
92	Role name: element	Contour included in the coverage	M	*	<<Feature>> ElevationContour	Unrestricted
93	ElevationContour				<<Feature>>	Lines 94-96
94	geometry	Geometric description of the contour	M	1	<<Type>> GM_Curve	Defined in ISO 19107
95	value	Elevation value associated with the contour	M	1	Number	Unrestricted
96	Role name: collection		M	1	<<Feature>> ElevationContourCoverage	

B.7 ElevationPointSet

Table B.7 – Data dictionary for ElevationPointSet

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
97	ElevationCollection				<<Feature>>	
98	ElevationPointSet				<<Feature>>	Lines 99-101
99	domainExtent	Spatial extent of the elevation point set	O	*	EX_GeographicExtent	Unrestricted
100	metadata	Data about the ElevationPointSet	M	1	CharacterString	Unrestricted
101	Role name: point	ElevationPoint contained in the ElevationPointSet	M	*	<<Feature>> ElevationPoint	Unrestricted
102	ElevationPoint				<<Feature>>	Lines 103-105
103	surfaceType	Type of surface with which the ElevationPoint is associated	M	1	CharacterString	Unrestricted
104	geometry	Geometric representation of the ElevationPoint	M	1	<<Type>> GM_Point	Defined in ISO 19107
105	Role name: set		O	*	<<Feature>> ElevationPointSet	

B.8 ElevationProfileCollection

Table B.8 – Data dictionary for ElevationProfileCollection

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
106	ElevationCollection				<<Feature>>	
107	ElevationProfileCollection				<<Feature>>	Lines 108-110
108	domainExtent	Extent of the elevation profile collection	M	1	EX_GeographicalExtent	Unrestricted
109	metadata	Data about the ElevationProfileCollection	M	1	CharacterString	
110	Role name: profile	Profile included in the collection	M	*	<<Feature>> ElevationProfile	Unrestricted
111	ElevationProfile				<<Feature>>	Lines 112-115
112	surfaceType	Type of surface with which the elevation profile is associated	M	1	CharacterString	Unrestricted
113	profileType	Code identifying a description of what the profile represents	M	1	ProfileType	Unrestricted
114	geometry	Geometric description of the profile	M	1	<<Type>> GM_Curve	Defined in ISO 19107
115	Role name: collection		O	*	<<Feature>> ElevationProfileCollection	

Annex C
(informative)
Bibliography

ANSI and ISO standards may be purchased through the ANSI eStandards Store at http://webstore.ansi.org/ansidocstore/default.asp, accessed October 2006.

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

National digital elevation guidelines, Version 1.0, 2004

OGC 03-065r6, Abstract specification for coverage type and its subtypes Open Geospatial Consortium, Version 1.0.0, Open GIS Consortium, Inc.