INSPIRE
Infrastructure for Spatial Information in Europe

D2.8.II.1 Data Specification on Elevation – Draft Guidelines

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Foreword
How to read the document?

This document describes the *"INSPIRE data specification on Elevation - Guidelines"* version 2.0(.2) as developed by the Thematic Working Group (TWG) *Elevation* using both natural and a conceptual schema language. This version is now available for the public consultation. Based on the results of the consultation (received comments and the testing reports), the final version 3.0 will be prepared by the TWGs.

The data specification is based on a common template used for all data specifications and has been harmonised using the experience from the development of the Annex I data specifications.

This document provides guidelines for the implementation of the provisions laid down in the draft Implementing Rule for spatial data sets and services of the INSPIRE Directive.

This document includes two executive summaries that provide a quick overview of the INSPIRE data specification process in general, and the content of the data specification on *Elevation* in particular. We highly recommend that managers, decision makers, and all those new to the INSPIRE process and/or information modelling should read these executive summaries first.

The UML diagrams (in Chapter 5) offer a rapid way to see the main elements of the specifications and their relationships. The definition of the spatial object types, attributes, and relationships are included in the Feature Catalogue (also in Chapter 5). People having thematic expertise but not familiar with UML can fully understand the content of the data model focusing on the Feature Catalogue. Users might also find the Feature Catalogue especially useful to check if it contains the data necessary for the applications that they run. The technical details are expected to be of prime interest to those organisations that are/will be responsible for implementing INSPIRE within the field of *Elevation.*

The technical provisions and the underlying concepts are often illustrated by examples. Smaller examples are within the text of the specification, while longer explanatory examples and descriptions of selected use cases are attached in the annexes.

In order to distinguish the INSPIRE spatial data themes from the spatial object types, the INSPIRE spatial data themes are written in *italics.*

The document will be publicly available as a 'non-paper'. It does not represent an official position of the European Commission, and as such cannot be invoked in the context of legal procedures.

Interoperability of Spatial Data Sets and Services – General Executive Summary

The challenges regarding the lack of availability, quality, organisation, accessibility, and sharing of spatial information are common to a large number of policies and activities and are experienced across the various levels of public authority in Europe. In order to solve these problems it is necessary to take measures of coordination between the users and providers of spatial information. The Directive 2007/2/EC of the European Parliament and of the Council adopted on 14 March 2007 aims at establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) for environmental policies, or policies and activities that have an impact on the environment.

INSPIRE will be based on the infrastructures for spatial information that are created and maintained by the Member States. To support the establishment of a European infrastructure, Implementing Rules addressing the following components of the infrastructure are being specified: metadata, interoperability of spatial data themes (as described in Annexes I, II, III of the Directive) and spatial data services, network services and technologies, data and service sharing, and monitoring and reporting procedures.

INSPIRE does not require collection of new data. However, after the period specified in the Directive[1] Member States have to make their data available according to the Implementing Rules.

Interoperability in INSPIRE means the possibility to combine spatial data and services from different sources across the European Community in a consistent way without involving specific efforts of humans or machines. It is important to note that "interoperability" is understood as providing access to spatial data sets through network services, typically via Internet. Interoperability may be achieved by either changing (harmonising) and storing existing data sets or transforming them via services for publication in the INSPIRE infrastructure. It is expected that users will spend less time and efforts on understanding and integrating data when they build their applications based on data delivered within INSPIRE.

In order to benefit from the endeavours of international standardisation bodies and organisations established under international law their standards and technical means have been utilised and referenced, whenever possible.

To facilitate the implementation of INSPIRE, it is important that all stakeholders have the opportunity to participate in specification and development. For this reason, the Commission has put in place a consensus building process involving data users, and providers together with representatives of industry, research and government. These stakeholders, organised through Spatial Data Interest Communities (SDIC) and Legally Mandated Organisations (LMO)[2], have provided reference materials, participated in the user requirement and technical[3] surveys, proposed experts for the Data Specification Drafting Team[4] and Thematic Working Groups[5].

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[1] For all 34 Annex I,II and III data themes: within two years of the adoption of the corresponding Implementing Rules for newly collected and extensively restructured data and within 5 years for other data in electronic format still in use

[2] Number of SDICs and LMOs on 8/6/2011 was 461 and 249 respectively

[3] Surveys on unique identifiers and usage of the elements of the spatial and temporal schema,

[4] The Data Specification Drafting Team has been composed of experts from Austria, Belgium, Czech Republic, France, Germany, Greece, Italy, Netherlands, Norway, Poland, Switzerland, UK, and the European Environmental Agency

[5] The Thematic Working Groups of Annex II and III themes have been composed of experts from Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Netherlands, Norway, Poland, Romania, Slovakia, Spain, Sweden, Switzerland, Turkey, UK, the European Commission, and the European Environmental Agency

This open and participatory approach was successfully used during the development of the data specification on Annex I data themes as well as during the preparation of the Implementing Rule on Interoperability of Spatial Data Sets and Services[6] for Annex I spatial data themes.,

The development framework elaborated by the Data Specification Drafting Team aims at keeping the data specifications of the different themes coherent. It summarises the methodology to be used for the data specifications and provides a coherent set of requirements and recommendations to achieve interoperability. The pillars of the framework are four technical documents:

- The Definition of Annex Themes and Scope[7] describes in greater detail the spatial data themes defined in the Directive, and thus provides a sound starting point for the thematic aspects of the data specification development.

- The Generic Conceptual Model[8] defines the elements necessary for interoperability and data harmonisation including cross-theme issues. It specifies requirements and recommendations with regard to data specification elements of common use, like the spatial and temporal schema, unique identifier management, object referencing, a generic network model, some common code lists, etc. Those requirements of the Generic Conceptual Model that are directly implementable will be included in the Implementing Rule on Interoperability of Spatial Data Sets and Services.

- The Methodology for the Development of Data Specifications[9] defines a repeatable methodology. It describes how to arrive from user requirements to a data specification through a number of steps including use-case development, initial specification development and analysis of analogies and gaps for further specification refinement.

- The "Guidelines for the Encoding of Spatial Data"[10] defines how geographic information can be encoded to enable transfer processes between the systems of the data providers in the Member States. Even though it does not specify a mandatory encoding rule it sets GML (ISO 19136) as the default encoding for INSPIRE.

Based on these framework documents and following the successful development of the Annex I Data specifications (Technical Guidelines) and the Implementing Rules, the new Thematic Working Groups have created the INSPIRE data specification for each Annex II and III theme. These documents – at the version 2.0(.2) – are now publicly available for INSPIRE stakeholders for consultation. The consultation phase covers expert review as well as feasibility and fitness-for-purpose testing of the data specifications.

The structure of the data specifications is based on the "ISO 19131 Geographic information - Data product specifications" standard. They include the technical documentation of the application schema, the spatial object types with their properties, and other specifics of the spatial data themes using natural language as well as a formal conceptual schema language[11].

A consolidated model repository, feature concept dictionary, and glossary are being maintained to support the consistent specification development and potential further reuse of specification elements. The consolidated model consists of the harmonised models of the relevant standards from the ISO 19100 series, the INSPIRE Generic Conceptual Model, and the application schemas[12] developed for

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[6] Commission Regulation (EU) No 1089/2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services, published in the Official Journal of the European Union on 8th of December 2010.

[7] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.3_Definition_of_Annex_Themes_and_scope_v3.0.pdf*

[8] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.5_v3.3.pdf*

[9] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.6_v3.0.pdf*

[10] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.7_v3.2.pdf*

[11] UML – Unified Modelling Language

[12] Conceptual models related to specific areas (e.g. INSPIRE themes)

each spatial data theme. The multilingual INSPIRE Feature Concept Dictionary contains the definition and description of the INSPIRE themes together with the definition of the spatial object types present in the specification. The INSPIRE Glossary defines all the terms (beyond the spatial object types) necessary for understanding the INSPIRE documentation including the terminology of other components (metadata, network services, data sharing, and monitoring).

By listing a number of requirements and making the necessary recommendations, the data specifications enable full system interoperability across the Member States, within the scope of the application areas targeted by the Directive. They will be published (version 3.0) as technical guidelines and will provide the basis for the content of the Amendment of the Implementing Rule on Interoperability of Spatial Data Sets and Services for data themes included in Annex II and III of the Directive. The Implementing Rule Amendment will be extracted from the data specifications keeping in mind short and medium term feasibility as well as cost-benefit considerations. The Implementing Rule will be legally binding for the Member States.

In addition to providing a basis for the interoperability of spatial data in INSPIRE, the data specification development framework and the thematic data specifications can be reused in other environments at local, regional, national and global level contributing to improvements in the coherence and interoperability of data in spatial data infrastructures.

Elevation – Executive Summary

The *Elevation* of a terrain surface, whether bathymetric or land based in nature, is one of the most important descriptors of the Earth's morphology. Recognising the specific role that elevation may play in engineering and spatial analysis the related data theme has been included in Annex II of INSPIRE. The *Elevation* data theme includes digital elevation models for land, ice and ocean surfaces both for terrestrial elevation and bathymetry, as well as shorelines.

The INSPIRE data specification for *Elevation* has been prepared following the participative principle of a consensus building process. The stakeholders, based on their registration as a Spatial Data Interest Community (SDIC) or a Legally Mandated Organisation (LMO) have the opportunity to bring forward user requirements and reference materials, propose experts for the specification's development, and to participate in reviewing and testing the data specifications. The Thematic Working Group responsible for the specification development was composed of experts from Finland, France, Germany, Hungary, Poland, Spain, The Netherlands, UK, and USA. The specification process took place according to the methodology elaborated for INSPIRE with respect to the requirements and the recommendation of the INSPIRE Generic Conceptual Model.

Elevation data is being used in a wide range of applications like civil engineering, Earth science applications (especially flood mapping), planning and resource management, surveying and photogrammetry (in particular orthoimagery) and defence, which is reflected in the use-cases governing the data specification process.

The main purpose of a Digital Elevation Model is to provide an elevation property with reference to a specified origin (datum). This property may be height (when the value is measured opposite to the gravity field of the Earth) or depth (when the value is measured in the direction of the gravity field). Therefore they share the basic modelling concepts. When an elevation property describes the bare surface of the land or sea floor the related model is called Digital Terrain Model (DTM). When an elevation property includes the heights of the objects present on the surface (vegetation, man-made objects) the related model is referred as Digital Surface Model (DSM). The INSPIRE data model permits the description of both options. In all cases, only one elevation value is included for each planimetric position.

The INSPIRE *Elevation* data specification allows the use of 2D or 3D geometries. In the first case the vertical component of the coordinates are given as an attribute of a two dimensional spatial object, while in the second all the points in the elevation data set are expressed by true 3D coordinates, where the elevation value is assigned to the Z coordinate.

In line with existing technologies three spatial representation methods have been offered: vector, grid and triangulated irregular network (TIN). Each of them is described in a separate package. In addition, generic modelling elements, such as unique identifiers, dataset level metadata and code lists of generic utilities are included in the base application schema.

The vector model consists of land elevation and bathymetry (depth) contour lines, spot heights and depths, as well as break lines. These elements are well known from topographical maps or nautical charts. The model supports the provision of all attributes and classifications that are required by the selected use-cases. It should be noted that the shoreline spatial object has been specified in the *Sea Regions* data specification and not in the *Elevation* as it was foreseen by the Directive.

The *Elevation* data specification includes the widely used grid representation, which is based on a coverage geometry, indicating elevation values at the points of a rectified grid. For Pan-European and cross-border purposes the data specification recommends the provision of elevation data using a theme-specific common grid based on ETRS89 geodetic coordinates (shared with the *Orthoimagery* data specifications), while using real time re-projection for display through view services.

The other alternative spatial representation form specified in INSPIRE is the TIN, where the geometry of points representing the terrain follows the rules of a 2D-Delaunay triangulation.

As stated in the Commission Regulation (EU) No 1089/2010, on interoperability of spatial data sets and services, the European Vertical Reference System (EVRS) shall be used to express gravity-related heights for the vertical component on land, within its geographical scope (continental Europe). Outside the geographical scope of EVRS (e.g. overseas territories), other vertical reference systems related to the Earth gravity field shall be used, which shall be defined and documented according to EN ISO 19111 and ISO 19127 by the Member State concerned. The Earth Gravitational Model (EGM Version 2008) is recommended in that cases.

Interoperability is further supported by harmonised metadata elements, recommendations for data quality, and agreed encoding to facilitate data exchange. The default encoding is GML. Gridded land and bathymetry elevation data is encoded using a GML Coverage. For the former, (land) the elevation values may alternatively be provided using external files like GeoTIFF, TIFF or JPEG2000. For the latter, (bathymetry) the BAG standard of the International Hydrographic Organisation may be used optionally as an external file to provide the values. Only those compression methods are valid that do not lead to data loss. TIN data shall be encoded using CityGML of the OPenGIS consortium. For supporting INSPIRE view services, default and alternative portrayal styles have been defined.

The main value of the INSPIRE *Elevation data* specification stands in the conceptually homogenous approaches to land elevation and bathymetry, as well as in the integrated presentation of different spatial representation forms. This is expected to underpin the exchange of all datasets in use in an interoperable way.

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The Thematic Working Group *Elevation* (TWG-EL) included:
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The Drafting Team Data Specifications included:
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The Consolidated UML repository has been set up by Michael Lutz, Anders Friis-Christensen, and Clemens Portele. The INSPIRE Registry has been developed by Angelo Quaglia and Michael Lutz. The INSPIRE Feature Concept Dictionary and Glossary has been consolidated by Darja Lihteneger. The data specification testing has been coordinated by Martin Tuchyna. The Testing communication tools have been set up by Loizos Bailas, Karen Fullerton and Nicole Ostländer. Web communication and tools for the consultations have been developed by Karen Fullerton and Hildegard Gerlach.

The stakeholders participated, as Spatial Data Interested Communities (SDIC) or Legally Mandated Organisations (LMO), in different steps of the development of the data specification development framework documents and the technical guidelines, providing information on questionnaires and user surveys, participating in the consultation process and workshops, testing the draft data specifications and supporting the work of their members in the Thematic Working Groups and Drafting Team Data Specifications.

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Table of contents

1 Scope

This document specifies a harmonised data specification for the spatial data theme *Elevation* as defined in Annex II of the INSPIRE Directive.

This data specification provides the basis for the drafting of Implementing Rules according to Article 7 (1) of the INSPIRE Directive [Directive 2007/2/EC]. The entire data specification will be published as implementation guidelines accompanying these Implementing Rules.

2 Overview

2.1 Name

INSPIRE data specification for the theme Elevation.

2.2 Informal description

Definition:

The Elevation theme is defined within the INSPIRE Directive as:

"Digital elevation models for land, ice and ocean surface. Includes terrestrial elevation, bathymetry and shoreline." [Directive 2007/2/EC]

Description:

Data content

The theme *Elevation* describes digital models for describing land, ice and ocean surfaces in terms of absolute gravity-related terrestrial elevation information (heights) and bathymetry data (depths).

It is further described as follows, based on the preliminary content from the INSPIRE Feature Concept Dictionary which has been adapted by the TWG:

"The theme includes:

- *Terrestrial elevation (namely land-elevation), represented as:*
  - *Digital Terrain Models (DTM) describing the three-dimensional shape of the Earth's surface (ground surface topography).*
  - *Digital Surface Models (DSM) specifying the three dimensional geometry of every feature on the ground, for example vegetation, buildings and bridges.*
- *Bathymetry data, e.g. a gridded sea floor model*

[Adapted from INSPIRE Feature Concept Dictionary]

Scope

The data model incorporated in this specification supports the description of an *Elevation* property (height or depth) as Digital Elevation Models (Digital Terrain Models and Digital Surface Models) in terms of Grid coverages, TIN models and vector format spatial objects, which may all form part of an *Elevation* data set. Vector objects include spot heights, depth spots, contour lines and break lines describing the morphology of the terrain.

Land-elevation and bathymetry of sea and inland (standing) water bodies are included in the scope of this specification as end-product data sets, regardless of the processes and measurements from which this information had been captured.

Only modelling of surfaces (DTM and DSM) in 2.5-D is supported, i.e. a single elevation property value can be stored for each planimetric position in the surface. As illustration, this means that a visor or tafoni (whose shape hides part of the morphology of terrain) can not be modelled using this specification; and for the cantilever formed by the roof of a building only one elevation value can be stored, the top one.

The shoreline feature (included as part of the *Elevation* theme as stated in the INSPIRE Directive) is not considered as an *Elevation* object, but as a feature which may be sometimes a useful reference for *Elevation* data mapping. Hence, the shoreline feature is defined in the INSPIRE Data Specification on Sea Regions (as the CoastLine spatial object) attending to physical properties and it is not included in this specification.

Open issue 1: Bathymetry of river courses
Bathymetry within river courses is not included in the scope of this specification. The necessity of supporting this type of measures within the *Elevation* model needs to be revised in the next version of this specification taken into account existing user needs. It may be a key aspect for relevant use cases like e.g. safety of inland navigation.

Spatial extent

This INSPIRE data specification covers spatial data sets which relate to an area where a Member State has and/or exercises jurisdictional rights.

Purpose

INSPIRE *Elevation* data specification consists of a set of conceptually homogenous approaches to land elevation and bathymetry, as well as of an integrated presentation of different spatial representation forms which are relevant to this kind of information. This all is mainly expected to underpin exchanging all existing European data sets in an interoperable way.

Applications

Digital Elevation Models are used in a number of applications in the earth, environmental and engineering sciences, constituting an important method for modelling and analysis of spatial topographic information in five main application domains:

- Civil engineering

  Dealing with problems involved with road design, site planning, volumetric calculations in building dams, reservoirs, excavating and trucking earthworks etc.

- Earth sciences

  Earth or geo-scientific applications mainly focused on specific functions for modelling, analysis and interpretation of the unique terrain morphology, including: drainage basin network development and delineation, hydrological run-off modelling, geomorphological simulation and classification, geological mapping, generation of slope and aspect maps and slope profiles for creating shaded relief maps.

- Planning and resource management

  Group of diverse fields whose central focus is the management of natural resources, including: re-mote sensing, agriculture, soil science, meteorology, climatology, environmental and urban planning and forestry.

  Applications best characterising this domain include site location, support of image classification in remote sensing, geometric and radiometric correction of remote sensing images, soil erosion

potential models, crop suitability studies, wind flow and pollution dispersion models, modelling of flooding events and emergency response management.

This group covers a wide range of concerns and requires using software tools covering procedures for data capture, editing, verification, managing data models and structures in both Grid and TIN (Triangulated Irregular Networks) formats, robust analytical calculation, modelling, and visualisation tools.

- Surveying and Photogrammetry

  One of the main objectives of employing surveying and photogrammetry is in building reliable DTMs (Digital Terrain Models) to be used in a number of production-related applications: survey or photogrammetric data capture and subsequent editing, orthophoto production, data quality as-assessment and topographic mapping.

- Military applications

  Almost every aspect of the military environment depends on a reliable and accurate understanding of the terrain, elevation and slope of the land surface. The military usage combines facets and methods mentioned for the previous application domains, with the peculiarity of having very specialised and demanding objectives – including e.g. inter-visibility analysis for battlefield management, 3-D display for weapons guidance systems and flight simulation and radar line-of-sight analyses.

Use cases

A selection of use cases relevant for the *Elevation* products are detailed in Annex B of this document.

Spatial representation type

The spatial representation types for this theme are: Vector, Grid and TIN.

- Vector data:

  The spatial schema considered in this specification allows 2-D and/or 3-D geometries for vector objects.

  In case of using 2-D geometries, the vertical component (third dimension) shall be provided as *Elevation* property values (as an attribute).

  In case of using 3-D geometries, the *Elevation* values shall be included within the third coordinate (Z) of the geometries.

- Gridded data:

  A model of this kind shall be provided as a rectified Grid coverage, where the *Elevation* values are included within the range set of the coverage.

- TIN data:

  A model of this kind is composed of a collection of vector geometries (control points, break lines and stop lines) and parameters according the type *GM_Tin* defined in ISO 19107. It allows calculating for example a 2D-Delaunay triangulation in a subsequent process.

Spatial resolution

No specific restrictions on spatial resolution are established in this specification for the *Elevation* theme information, given the heterogeneity of data sources from which existing data across Europe is derived as well as the wide range of relevant use cases to be served.

All levels of resolution are therefore affected: the European level, the National level, the Regional level and the Local level.

2.3 Normative References

[Directive 2007/2/EC] Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)

[ISO 19107] EN ISO 19107:2005, Geographic Information – Spatial Schema

[ISO 19108] EN ISO 19108:2005, Geographic Information – Temporal Schema

[ISO 19108-c] ISO 19108:2002/Cor 1:2006, Geographic Information – Temporal Schema, Technical Corrigendum 1

[ISO 19111] EN ISO 19111:2007 Geographic information - Spatial referencing by coordinates (ISO 19111:2007)

[ISO 19113] EN ISO 19113:2005, Geographic Information – Quality principles

[ISO 19115] EN ISO 19115:2005, Geographic information – Metadata (ISO 19115:2003)

[ISO 19118] EN ISO 19118:2006, Geographic information – Encoding (ISO 19118:2005)

[ISO 19123] EN ISO 19123:2007, Geographic Information – Schema for coverage geometry and functions

[ISO 19135] EN ISO 19135:2007 Geographic information – Procedures for item registration (ISO 19135:2005)

[ISO 19138] ISO/TS 19138:2006, Geographic Information – Data quality measures

[ISO 19139] ISO/TS 19139:2007, Geographic information – Metadata – XML schema implementation

[OGC 06-103r3] Implementation Specification for Geographic Information - Simple feature access – Part 1: Common Architecture v1.2.0

NOTE This is an updated version of "EN ISO 19125-1:2006, Geographic information – Simple feature access – Part 1: Common architecture". A revision of the EN ISO standard has been proposed.

[Regulation 1205/2008/EC] Regulation 1205/2008/EC implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata

2.4 Terms and definitions

General terms and definitions helpful for understanding the INSPIRE data specification documents are defined in the INSPIRE Glossary[13].

Specifically, for the theme Elevation, the following terms are defined:

(1) Coverage
Spatial object that acts as a function to return values from its range for any direct position within its spatial, temporal or spatiotemporal domain [INSPIRE glossary].

NOTE In other words, a coverage is a feature that has multiple values for each attribute type, where each direct position within the geometric representation of the feature has a single value for each attribute type. An elevation property may be one of these attribute types.

(2) Depth
Elevation property measured in a direction coincident to Earth's gravity field (downwards).

NOTE This definition intentionally avoids making reference to complex geodetic terms. It is only intended to specify the direction in which the elevation property has been measured.

(3) Digital Elevation Model
Three dimensional surface describing the shape of a part of the Earth's or sea floor surfaces, which may include in some cases other features placed on them (such as buildings, bridges or vegetation).

EXAMPLE Digital Terrain Model, Digital Surface Model

(4) Digital Surface Model
Three dimensional surface describing the shape of a part of the Earth's or sea floor surfaces, including every feature placed on them (such as buildings, bridges or vegetation).

NOTE 1 It provides information about the highest elevation at a specific location, which may correspond to a point on ground surface (emerged or submerged) or on any feature above it.

NOTE 2 When describing depths of a part of submerged land (e.g. the sea floor), water bodies are obviously excluded from the surface. Hence it provides information about the depth of points located on the water body floor with respect to a well-defined datum.

(5) Digital Terrain Model
Three dimensional surface describing the shape of a part of the Earth's or sea floor bare surfaces, excluding any possible features placed on them (such as buildings, bridges or vegetation).

NOTE When describing heights of a part of emerged land, all features placed on its surface are excluded except water bodies. Hence it provides information about the height of points located on ground surface or any body of water placed on it with respect to a well-defined datum.

(6) Domain
Well-defined set [ISO/TS 19103]

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[13] The INSPIRE Glossary is available from http://inspire-registry.jrc.ec.europa.eu/registers/GLOSSARY

(7) Elevation
Vertically-constrained dimensional property of an element consisting of an absolute measure referenced to a well-defined surface which is commonly taken as origin (geoid, water level, etc.).

EXAMPLE Height, depth.

NOTE It does not include relative elevations of the element referenced to other spatial objects.

(8) Height
Elevation property measured along a plumb line in a direction opposite to Earth's gravity field (upwards).

NOTE This definition intentionally avoids making reference to complex geodetic terms. It is only intended to specify the direction in which the elevation property has been measured.

(9) Range
(Coverage) Set of feature attribute values associated by a function with the elements of the domain of a coverage [ISO 19123].

2.5 Symbols and abbreviations

CRS Coordinate Reference System.

DEM Digital Elevation Model.

DSM Digital Surface Model.

DTM Digital Terrain Model.

EL Elevation.

GCM Generic Conceptual Model

IHO International Hydrographic Organization.

LAT Lowest Astronomical Tide.

RMS Root Mean Square Error.

RMS_v Vertical Root Mean Square Error.

TIN Triangulated Irregular Network.

TWG Thematic Working Group.

2.6 Notation of requirements and recommendations

To make it easier to identify the mandatory requirements and the recommendations for spatial data sets in the text, they are highlighted and numbered.

IR Requirement X	Requirements that are reflected in the Implementing Rule on interoperability of spatial data sets and services are shown using this style.

DS Requirement X	Requirements that are not reflected in the Implementing Rule on interoperability of spatial data sets and services are shown using this style.

Recommendation 1 Recommendations are shown using this style.

2.7 Conformance

DS Requirement 1	Any dataset claiming conformance with this INSPIRE data specification shall pass the requirements described in the abstract test suite presented in Annex A.

3 Specification scopes

This data specification does not distinguish different specification scopes, but just considers one general scope.

NOTE For more information on specification scopes, see [ISO 19131:2007], clause 8 and Annex D.

4 Identification information

NOTE Since the content of this chapter was redundant with the overview description (section 2) and executive summary, it has been decided that this chapter will be removed in v3.0.

5 Data content and structure

IR Requirement 1 Spatial data sets related to the theme **Elevation** shall be provided using the spatial object types and data types specified in the application schemas in this section.

IR Requirement 2 Each spatial object shall comply with all constraints specified for its spatial object type or data types used in values of its properties, respectively.

Recommendation 1 The reason for a void value should be provided where possible using a listed value from the VoidValueReason code list to indicate the reason for the missing value.

NOTEThe application schema specifies requirements on the properties of each spatial object including its multiplicity, domain of valid values, constraints, etc. All properties have to be reported, if the relevant information is part of the data set. Most properties may be reported as “void”, if the data set does not include relevant information. See the Generic Conceptual Model [INSPIRE DS-D2.5] for more details.

5.1 Basic notions

This section explains some of the basic notions used in the INSPIRE application schemas. These explanations are based on the GCM [DS-D2.5].

5.1.1 Placeholder and candidate types

INSPIRE data specifications may refer to types that thematically belong and might be fully specified in future (i.e. Annex II or III) spatial data themes. Two kinds of such types are distinguished:

- A *placeholder type* is a type that acts as a placeholder for a type (typically a spatial object type) that will be specified as part of a future spatial data theme, but is already used as a value type of an attribute or association role in this data specification.

  Placeholder types receive the stereotype «placeholder» and are placed in the application schema package of the future spatial data theme where they thematically belong. A definition for the placeholder type is specified based on the requirements of the Annex I theme. This definition shall be taken into account when the type is specified in the future spatial data theme, and the attributes or association roles in this data specification that have the placeholder as a value type shall be updated if necessary.

- A *candidate type* is a type (typically a spatial object type) for which already a preliminary specification is given. Candidate types do not receive a specific stereotype and is placed in the application schema package of the future spatial data theme where they thematically belong. A definition for the type and its attributes and association roles are specified based on the requirements of the Annex I theme.

  This specification shall be taken into account in the specification work of the Annex II or III theme. If the type cannot be incorporated in the Annex II or III data specification according to its preliminary specification, it shall be moved into the application schema of the Annex I theme where it has first been specified. In this case, the attributes or association roles in this data specification that have the type as a value type shall be updated if necessary.

Placeholders and candidate types are listed in a separate subsection of the Feature Catalogue.

5.1.2 Voidable characteristics

If a characteristic of a spatial object is not present in the spatial data set, but may be present or applicable in the real world, the property shall receive this stereotype.

If and only if a property receives this stereotype, the value of *void* may be used as a value of the property. A *void* value shall imply that no corresponding value is contained in the spatial data set maintained by the data provider or no corresponding value can be derived from existing values at reasonable costs, even though the characteristic may be present or applicable in the real world.

It is possible to qualify a value of void in the data with a reason using the VoidValueReason type. The VoidValueReason type is a code list, which includes the following pre-defined values:

- *Unpopulated*: The characteristic is not part of the dataset maintained by the data provider. However, the characteristic may exist in the real world. For example when the “elevation of the water body above the sea level” has not been included in a dataset containing lake spatial objects, then the reason for a void value of this property would be ‘Unpopulated’. The characteristic receives this value for all objects in the spatial data set.
- *Unknown*: The correct value for the specific spatial object is not known to, and not computable by the data provider. However, a correct value may exist. For example when the “elevation of the water body above the sea level” *of a certain lake* has not been measured, then the reason for a void value of this property would be ‘Unknown’. This value is applied on an object-by-object basis in a spatial data set.

NOTEIt is expected that additional reasons will be identified in the future, in particular to support reasons / special values in coverage ranges.

The «voidable» stereotype does not give any information on whether or not a characteristic exists in the real world. This is expressed using the multiplicity:

- If a characteristic may or may not exist in the real world, its minimum cardinality shall be defined as 0. For example, an if an Address may or may not have a house number, the multiplicity of the corresponding property shall be 0..1.
- If at least one value for a certain characteristic exists in the real world, the minimum cardinality shall be defined as 1. For example, if an Administrative Unit always has at least one name, the multiplicity of the corresponding property shall be 1..*.

In both cases, the «voidable» stereotype can be applied. A value (the real value or void) only needs to be made available for properties that have a minimum cardinality of 1.

5.1.3 Code lists and Enumerations

5.1.3.1. Style

All code lists and enumerations use the following modelling style:

- No initial value, but only the attribute name part, is used.
- The attribute name conforms to the rules for attributes names, i.e. is a lowerCamelCase name. Exceptions are words that consist of all uppercase letters (acronyms).

5.1.3.2. Governance

Two types of code lists can be distinguished:

- code lists that shall be managed centrally in the INSPIRE code list register and only values from that register may be used, and
- code lists that may be extended by data providers.

In the UML model, all code lists that are centrally managed have the tagged value "codeList" with the preliminary value "urn:x-inspire:def:codeList:INSPIRE:<name of the class>".

5.1.4 Stereotypes

In the application schemas in this sections several stereotypes are used that have been defined as part of a UML profile for use in INSPIRE [INSPIRE DS-D2.5]. These are explained in Table 1 below.

Table 1 – Stereotypes (adapted from [INSPIRE DS-D2.5])

Stereotype	Model element	Description
applicationSchema	Package	An INSPIRE application schema according to ISO 19109 and the Generic Conceptual Model.
featureType	Class	A spatial object type.
type	Class	A conceptual, abstract type that is not a spatial object type.
dataType	Class	A structured data type without identity.
union	Class	A structured data type without identity where exactly one of the properties of the type is present in any instance.
enumeration	Class	A fixed list of valid identifiers of named literal values. Attributes of an enumerated type may only take values from this list.
codeList	Class	A flexible enumeration that uses string values for expressing a list of potential values.
placeholder	Class	A placeholder class (see definition in section 5.1.1).
voidable	Attribute, association role	A voidable attribute or association role (see definition in section 5.1.2).
lifeCycleInfo	Attribute, association role	If in an application schema a property is considered to be part of the life-cycle information of a spatial object type, the property shall receive this stereotype.
version	Association role	If in an application schema an association role ends at a spatial object type, this stereotype denotes that the value of the property is meant to be a specific version of the spatial object, not the spatial object in general.

5.2 Application schemas of Elevation

5.2.1 Overview

In this section it is provided a brief overview of the structure of the **Elevation** model, which is based on four application schema packages.

5.2.1.1. Narrative description

The **Elevation** model is structured in four different application schemas: *Elevation – Base*, *Elevation – Vector Elements, Elevation – Coverages* and *Elevation - TIN*, as illustrated in Figure 1, Section 5.2.1.2.

Elevation – Vector Elements, *Elevation – Coverages* and *Elevation – TIN* application schemas, depend on the *Elevation – Base* application schema, which provides the basis for the theme model (possible elements composing INSPIRE elevation data sets) and also defines those common elements and characteristics which are used in the previous application schemas.

The *Elevation – Vector Elements* application schema defines the spatial objects (feature types) that form part of an INSPIRE vector format elevation data set, together with their attributes and relationships.

The *Elevation – Coverages* application schema defines the basis for the provision of elevation models as coverages based on a Grid structure. These types of coverages may also form part of an INSPIRE elevation data set. The coverages defined in this application schema are based on the common model for coverages included in the Generic Conceptual Model, which provides the framework for the definition of coverage types. This common model has been established according current draft of WCS2.0 and ISO 19123 – *Coverage geometry and functions*.

The *Elevation – TIN* application schema defines the basis for the provision of elevation models as a TIN structure. The basic component in this application schema is defined according the type *GM_Tin* defined in ISO 19107 and it consists on a collection of vector geometries like control points, break lines and stop lines, in addition to the necessary parameters which allow calculating for example a Delaunay triangulation in a subsequent process.

Figure 2, Section 5.2.1.3 shows the dependencies between the four **Elevation** packages and those external packages from where they import classes (Generic Conceptual Model, ISO standards, application schemas defined by other INSPIRE themes).

5.2.1.2. UML Overview

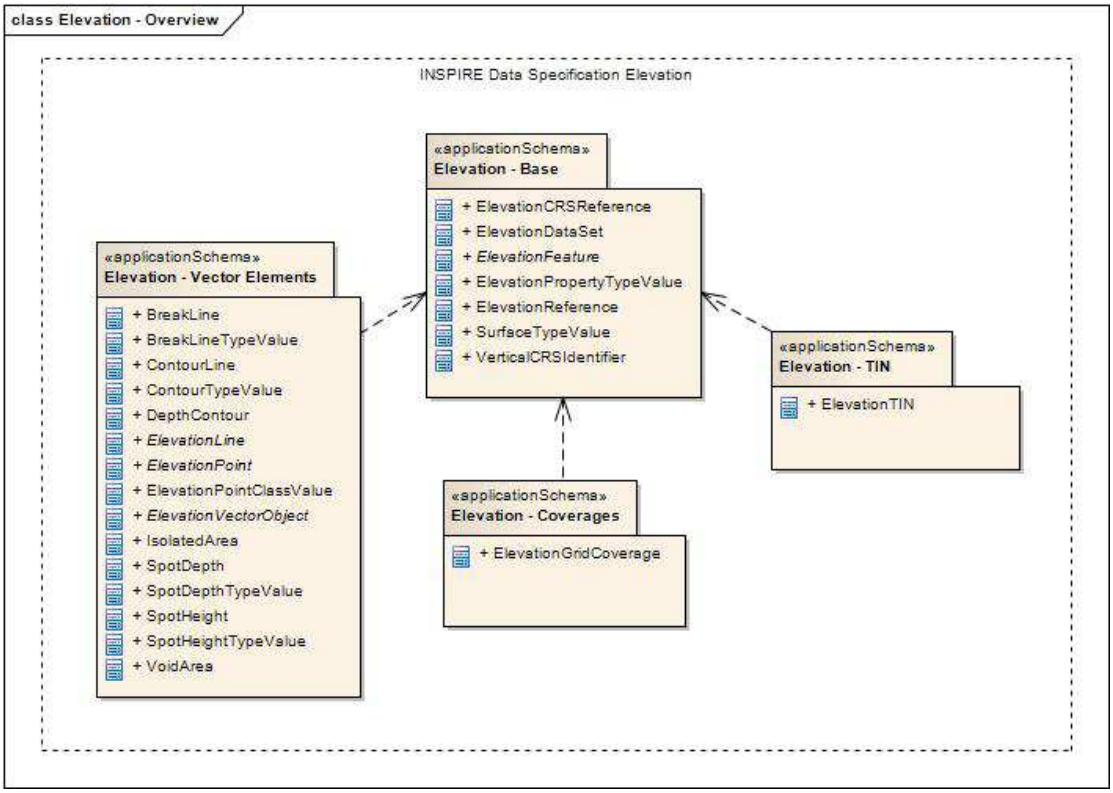


Figure 1 – UML class diagram: Overview of the application schemas of Elevation

5.2.1.3. Package dependencies

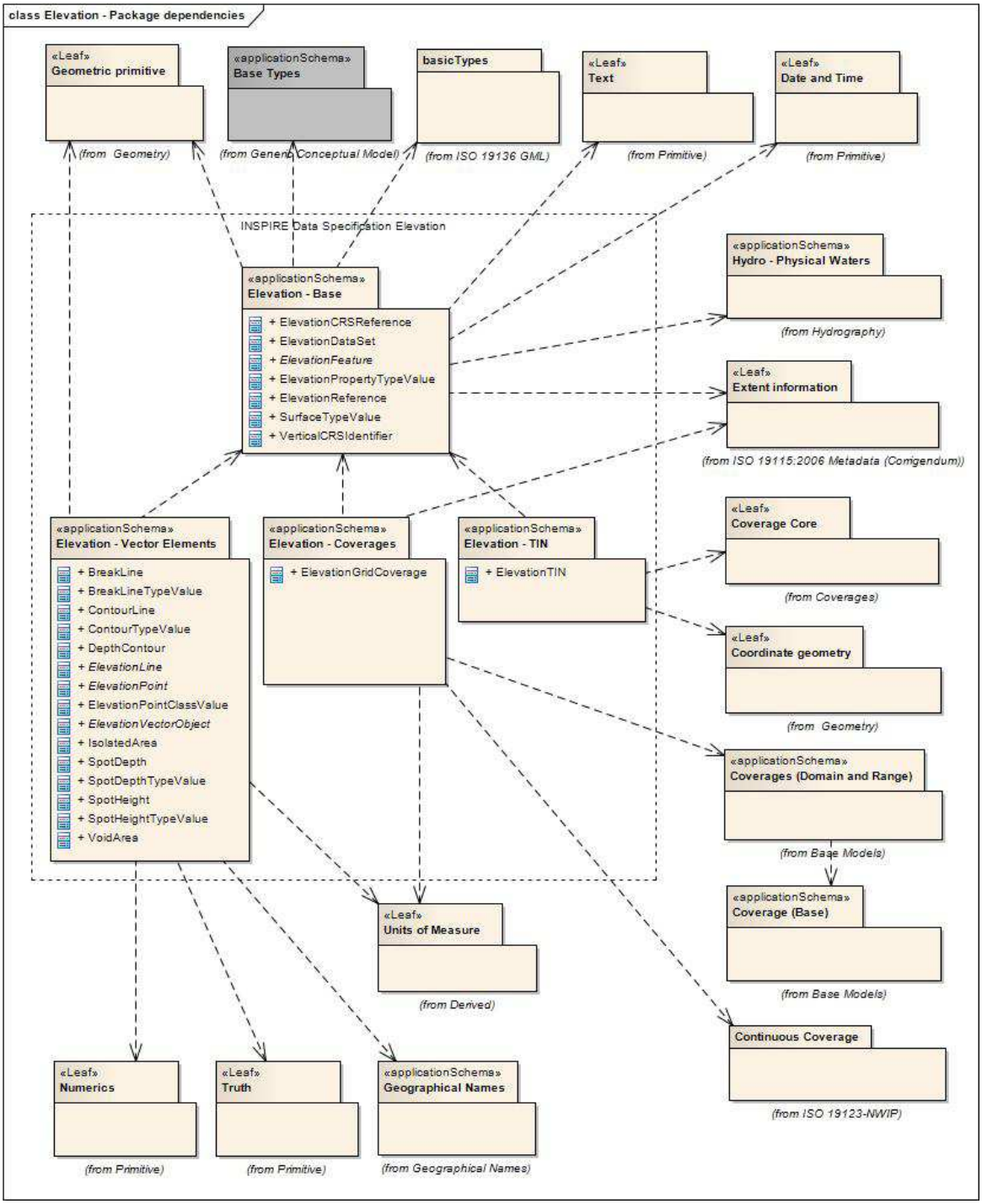


Figure 2 – Package dependencies: Application schemas of Elevation

5.3 Application schema *Elevation - Base*

5.3.1 Description

5.3.1.1. Narrative description

The *Elevation - Base* application schema provides the basis for the **Elevation** model.

It describes the possible elements composing INSPIRE elevation data sets and also defines those common classes and characteristics which are used in the other application schemas of the model (*Elevation – Vector Elements, Elevation – Coverages* and *Elevation – TIN* application schemas).

5.3.1.2. UML Overview

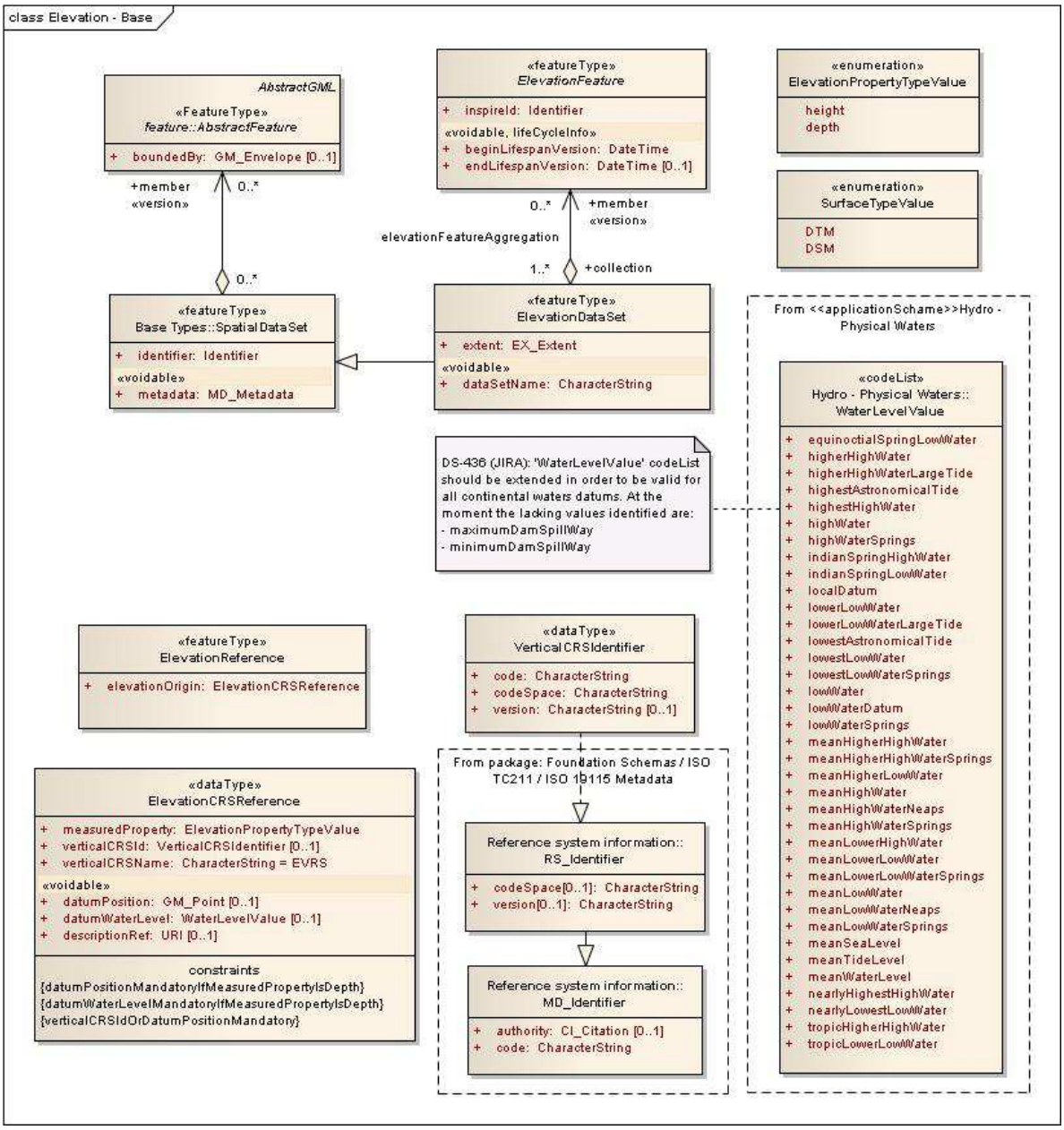


Figure 3 – UML class diagram: Overview of the *Elevation – Base* application schema

The *Elevation – Base* application schema outlines how an INSPIRE **Elevation** data set may be considered as an aggregation of generic components: these may be either a set of vector elements, grid coverages or TIN models. Hence, vector and gridded data representations may be potentially combined in the same **Elevation** data set.

Therefore, the main diagram is focused on the class *ElevationDataSet* (Section 5.3.2.1.1), which defines the common properties of an **Elevation** data set, such as: spatiotemporal extent, name identifying the data set or dataset-level metadata.

The abstract class *ElevationFeature* (Section 5.3.2.1.2) represents here a generic component which may form part of an **Elevation** data set. It defines the properties which are common to all possible components, such as inspire identifier and lifecycle information attributes.

The different spatial objects types allowed within **Elevation** data sets (e.g. vector elements, grid coverages and TIN structures) are defined in the *Elevation – Vector Elements*, *Elevation – Coverages* and *Elevation – TIN* application schema packages, respectively.

Regardless of the data representation type used, the *Elevation – Base* application schema also establishes the different **Elevation** *properties types* allowed in the model.

As stated in this specification, an **Elevation** property is a vertically-constrained dimensional property of an element consisting of an absolute measure referenced to a well-defined surface which is commonly taken as origin (geoid, water level, etc.). The possible types of **Elevation** properties are defined with regard to Earth's gravity field direction: *height* (opposite direction to Earth's gravity field, or upwards direction) and *depth* (same direction of Earth's gravity field, or downwards direction).

Therefore, the meaning of term **Elevation** in this specification shall be understood as integrating all absolute measures of dimensions constrained to the vertical component, either having upward (*height*) or downward direction (*depth*). As a result, other existing interpretations of the term **Elevation** shared by specific communities shall be avoided.

5.3.1.3. Consistency between spatial data sets

As described in D2.6 A.18 there are three topic areas regarding consistency between spatial data sets, these are:

a. Coherence between spatial objects of the same theme at different levels of detail.

b. Coherence between different spatial objects within a same area.

c. Coherence at state boundaries.

Different **Elevation** features and spatial object types considered in this specification should maintain integrity and positional consistency in order to use them together as a common layer (to serve different purposes) and allow making any type of calculations with reliable input **Elevation** data.

Recommendation 2	The different object types in the **Elevation** theme should be positionally consistent in order to use them together as a common reliable input data layer.

Elevation data is often combined with other spatial data themes in a wide variety of applications with several purposes (**Elevation** mapping, flood modelling or other spatial analysis). Data integrity demands that these should be positionally consistent to ensure both a faithful representation of the real world and a professional appearance that will fill the user with confidence. For example, rivers, water bodies and man-made constructions combined together with **Elevation** data.

Recommendation 3	The spatial objects provided within the **Elevation** data sets should be positionally consistent with the spatial objects from other themes (e.g. with rivers, water bodies, man-made constructions.

Open issue 2: Cross-theme data consistency
The way to achieve the desired positional and logical consistency between data from different themes in INSPIRE (as stated by the previous recommendation) is a cross-theme issue, which is not only in the scope of this specification.

Open issue 3: Cross-border data consistency
Coherence of **Elevation** data at state boundaries must be further investigated by the TWG for vector data and TIN models, two of the different representations considered in this specification.

The common European grid specified in Annex C of this document is recommended in the case of Gridded Pan-European **Elevation** data sets aimed at global purposes, to avoid cross-border problems caused by aggregation of this data from different data providers or Member States.

5.3.1.4. Identifier management

As is required by the GCM, all spatial objects must have a unique identifier. This must be persistent and will usually be supported by a defined lifecycle to ensure that users understand the conditions that the identifier may be created, modified (in terms of its relationship with the spatial object) and deleted.

IR Requirement 3	Each **Elevation** spatial object (*ElevationFeature*) shall receive a unique external identifier as specified in the Generic Conceptual Model [INSPIRE DS-D2.5]. This identifier is carried by the attribute *inspireId*.

The unique object identifier will be modelled on the form described in D2.5 Sections 9.7, 9.8.2 and Chapter 14, where a country code and namespace is applied as a prefix to the existing local identifier used by the authority responsible for the data. This will both ensure that the identifier is:

- Unique in the European spatial data infrastructure.
- The object is traceable in that infrastructure.

All spatial objects in the **Elevation** will have a unique object identifier – this includes:

- Those spatial objects that contain classical geometries (vector objects).
- Grid coverages, whose domain points (control points) are included in a common spatially referenced structure.
- And TIN structures with all their components: vertices (control points), break lines, stop lines.

5.3.1.5. Modelling of object references

This data specification does not provide specific rules for modelling object references between different levels of detail.

Gridded Pan-European **Elevation** data sets aimed at cross-border purposes constitute an exception to the previous statement, as specified in Section 5.5.1.5.

5.3.1.6. Geometry representation

The spatial schema used in this specification allows using 2-D or 3-D geometries. In order to represent the vertical component (third dimension) **Elevation** spatial objects shall be provided fulfilling at least one of these two cases:

- To have 2-D geometries, where the vertical component (third dimension) shall be provided as **Elevation** property values within an attribute designed for such purpose.
- To have 3-D geometries, where the third coordinate (Z) shall include the corresponding **Elevation** property values.

IR Requirement 4	In case of providing **Elevation** data sets using 2-D geometries, the vertical component (third dimension) shall be provided as **Elevation** property values within: the attribute *propertyValue* for vector objects (also those included within a TIN structure); the corresponding element from the range set for Grid coverages.

IR Requirement 5	In case of providing **Elevation** data sets using 3-D geometries, the **Elevation** property values shall be only included within the third coordinate (Z) of those geometries.

The **Elevation** data provided through INSPIRE should have the best spatial, temporal and thematic accuracy available. Relevant use-cases like modelling and control of floods especially pose strict spatial accuracy requirements to measures in the vertical dimension, which are often fulfilled by using accurate data capture methods (e.g. LIDAR data).

Recommendation 4	All spatial objects should be provided at the best spatial, temporal and thematic accuracy available, in order to serve relevant use-cases, like modelling of flooding events and emergency response.

More specific requirements and recommendations for **Elevation** vector data, Grid coverages and TINs are provided in the *Elevation – Vector Elements*, *Elevation – Coverages* and *Elevation – TIN* application schema packages, respectively.

5.3.1.7. Temporality representation

The application schema(s) use(s) the derived attributes "beginLifespanObject" and "endLifespanObject" to record the lifespan of a spatial object.

The attributes "beginLifespanVersion" specifies the date and time at which this version of the spatial object was inserted or changed in the spatial data set. The attribute "endLifespanVersion" specifies the date and time at which this version of the spatial object was superseded or retired in the spatial data set.

NOTE 1 The attributes specify the beginning of the lifespan of the version in the spatial data set itself, which is different from the temporal characteristics of the real-world phenomenon described by the spatial object. This lifespan information, if available, supports mainly two requirements: First, knowledge about the spatial data set content at a specific time; second, knowledge about changes to a data set in a specific time frame. The lifespan information should be as detailed as in the data set (i.e., if the lifespan information in the data set includes seconds, the seconds should be represented in data published in INSPIRE) and include time zone information.

NOTE 2 Changes to the attribute "endLifespanVersion" does not trigger a change in the attribute "beginLifespanVersion".

Recommendation 5	If life-cycle information is not maintained as part of the spatial data set, all spatial objects belonging to this data set should provide a void value with a reason of "unpopulated".

5.3.2 Feature catalogue

Table 3 - Feature catalogue metadata

Feature catalogue name	INSPIRE feature catalogue Elevation - Base
Scope	Elevation - Base
Version number	2.0
Version date	2011-06-10
Definition source	INSPIRE data specification Elevation - Base

Table 4 - Types defined in the feature catalogue

Type	Package	Stereotypes	Section
ElevationCRSReference	Elevation - Base	«dataType»	5.3.2.2.1
ElevationDataSet	Elevation - Base	«featureType»	5.3.2.1.1
ElevationFeature	Elevation - Base	«featureType»	5.3.2.1.2
ElevationPropertyTypeValue	Elevation - Base	«enumeration»	5.3.2.3.1
ElevationReference	Elevation - Base	«featureType»	5.3.2.1.3
SurfaceTypeValue	Elevation - Base	«enumeration»	5.3.2.3.2
VerticalCRSIdentifier	Elevation - Base	«dataType»	5.3.2.2.2

5.3.2.1. Spatial object types

5.3.2.1.1. ElevationDataSet

ElevationDataSet

Subtype of: SpatialDataSet
Definition: Spatial data set representing the surface of land, ice and/or ocean of a specified geographic extent in terms of distribution of a dimensional property linked to the vertical component (height, depth).
Status: Proposed
Stereotypes: «featureType»
URI: null

Attribute: dataSetName

Value type: CharacterString
Definition: The name which is used to identify the data set.
Multiplicity: 1
Stereotypes: «voidable»

Attribute: extent

Value type: EX_Extent
Definition: Extent of the spatial data set.
Multiplicity: 1

Association role: member

Value type: ElevationFeature
Definition: Feature included as a member of an elevation data set.
Multiplicity: 0..*
Stereotypes: «version»

5.3.2.1.2. ElevationFeature

ElevationFeature (abstract)

Definition: Element included within an elevation data set which takes part in the description of a land, ice and/or ocean surface in terms of a dimensional property linked to the vertical component (height, depth).
Status: Proposed

ElevationFeature (abstract)	
Stereotypes:	«featureType»
URI:	null

Attribute: beginLifespanVersion

Value type:	DateTime
Definition:	Date and time at which this version of the spatial object was inserted or changed in the spatial data set.
Multiplicity:	1
Stereotypes:	«voidable,lifeCycleInfo»

Attribute: endLifespanVersion

Value type:	DateTime
Definition:	Date and time at which this version of the spatial object was superseded or retired in the spatial data set.
Multiplicity:	0..1
Stereotypes:	«voidable,lifeCycleInfo»

Attribute: inspireId

Value type:	Identifier
Definition:	External object identifier of the spatial object.
Description:	NOTE An external object identifier is a unique object identifier published by the responsible body, which may be used by external applications to reference the spatial object. The identifier is an identifier of the spatial object, not an identifier of the real-world phenomenon.
Multiplicity:	1

5.3.2.1.3. ElevationReference

ElevationReference	
Definition:	Reference to the origin used to refer the elevation values associated to an object.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null

Attribute: elevationOrigin

Value type:	ElevationCRSReference
Definition:	Vertical coordinate reference system taken as origin to refer the elevation values associated to the object.
Multiplicity:	1

5.3.2.2. Data types

5.3.2.2.1. ElevationCRSReference

ElevationCRSReference	
Definition:	Reference used to identify the vertical coordinate reference system used to refer elevation values of spatial objects.

ElevationCRSReference

Description: NOTE 1 The elevation coordinate reference system (CRS) reference identifies the vertical CRS used to refer the elevation values of spatial objects belonging to any INSPIRE theme. This includes spatial objects and coverages which may compose an elevation data set.
The European Vertical Reference System (EVRS) shall be used to express gravity-related heights for the vertical component on land, within its geographical scope (continental Europe). Outside the geographical scope of EVRS (e.g. overseas territories), other vertical reference systems related to the Earth gravity field shall be used. The geodetic codes and parameters for these vertical reference systems shall be documented and an identifier shall be created, according to EN ISO 19111 and ISO 19127.
In both cases the vertical CRS used shall be properly identified using the elevation CRS reference, which links to a resource where its full definition can be found.

NOTE 2 The elevation CRS reference is not intended to be a full definition / description of a vertical CRS. It is just a link to an existing resource which includes this information.
The reference consists of the name and the identifier of the vertical CRS, where the identifier is the code with which the CRS is registered in an external CRS registry (e.g. like EPSG).
Exceptions to this are local bathymetric CRSs used to refer depths in lakes. In that cases, there is no point in obliging to register these CRSs. Therefore, the reference consists of the origin point to which depths are referred (attribute 'datumPosition') and the water level corresponding to it (attribute 'datumWaterLevel').

NOTE 3 The attribute 'descriptionRef' may be optionally used to include a reference to an additional resource in which the vertical coordinate reference system is described.

NOTE 4 Two types of vertical CRSs are distinguished in this specification: height and depth CRS. This distinction has to be informed by means of the attribute measuredProperty.

NOTE 5 If the elevation CRS is defined for the measurement of depth values, it should only be used in a region of limited extent, as the related datum is often referred to a local tide level.

NOTE 6 The planimetric position of the point used as datum or origin of depth values in an elevation CRS for depths can be considered as unique identifier for this local datum. A unique identifier is needed to distinguish depth datums corresponding to the same (tidal) water level in different locations (e.g. the level of Lowest Astronomical Tide determines different depth datums in different locations).

Status: Proposed

Stereotypes: «dataType»

URI: null

Attribute: datumPosition

Value type: GM_Point

ElevationCRSReference

Definition: Geographical position of the point used as origin of depth values in a vertical coordinate reference system for depth measurement. -- Description – NOTE 1 This attribute identifies the location of the datum point associated to a coordinate reference system for depth measurement. NOTE 2 The planimetric position of the datum point may be used as unique identifier for a local coordinate reference system for depth measurement. NOTE 3 The altimetric position must be the height of the datum point referred to EVRS. This parameter can be utilised at local level to calculate EVRS heights for those objects whose depth values are referred to the coordinate reference system for depth measurement. NOTE 4 The level taken as origin of depths changes locally from one chart to another. In order to distinguish between coordinate reference systems for depth measurement corresponding to the same (tidal) water level in different locations (e.g. the level of Lowest Astronomical Tide determines different depth datums in different locations) a unique identifier is needed.

Multiplicity: 0..1

Stereotypes: «voidable»

Attribute: datumWaterLevel

Value type: WaterLevelValue

Definition: Water-level used to define the datum of a vertical coordinate reference system for depth measurement.

Description: EXAMPLE High water, low water, etc.

NOTE 1 Values in the code list are applicable either for sea or inland waters.

NOTE 2 When defining a depth datum for inland waters, it is recommended the use of "highWater", "lowWater" or "meanWaterLevel" - as applicable. All the other levels in the code list are well defined but usually just locally and do not serve for cross border purposes.

Multiplicity: 0..1

Stereotypes: «voidable»

Attribute: descriptionRef

Value type: URI

Definition: External reference to an information resource providing the specification and definition of the vertical coordinate reference system.

Multiplicity: 0..1

Stereotypes: «voidable»

Attribute: measuredProperty

Value type: ElevationPropertyTypeValue

Definition: Indication of the type of property for whose measurement the vertical coordinate reference system has been designed.

Multiplicity: 1

Attribute: verticalCRSId

Value type: VerticalCRSIdentifier

Definition: Unique identifier of the vertical coordinate reference system within a given namespace.

Description: NOTE 1If a vertical CRS is used to provide elevation data to INSPIRE, it is recommended to have this vertical CRS registered within a CRS registry (e.g. like EPSG).

NOTE 2 When identifying a local datum for referring depths in a specific lake, there is no point in obliging to register this local vertical CRSs in a registry. This is the reason why the cardinality of this attribute may be 0.

ElevationCRSReference	
Multiplicity:	0..1
Attribute: verticalCRSName	
Value type:	CharacterString
Definition:	Character string used as text identifier of the vertical coordinate reference system.
Multiplicity:	1
Constraint: verticalCRSIdOrDatumPositionMandatory	
Natural language:	All elevation CRS references must have either a vertical CRS identifier or datum position.
OCL:	inv: verticalCRSId->notEmpty() or datumPosition->notEmpty()
Constraint: datumPositionMandatoryIfMeasuredPropertyIsDepth	
Natural language:	If the measuredProperty attribute is 'depth', the datumPosition attribute has to be provided.
OCL:	inv: (measuredProperty='depth') implies (datumPosition->notEmpty())
Constraint: datumWaterLevelMandatoryIfMeasuredPropertyIsDepth	
Natural language:	If the measuredProperty attribute is 'depth', the datumWaterLevel attribute has to be provided.
OCL:	inv: (measuredProperty = 'depth') implies (datumWaterLevel -> notEmpty())

5.3.2.2.2. VerticalCRSIdentifier

VerticalCRSIdentifier	
Definition:	Identifier of the vertical reference system.
Status:	Proposed
Stereotypes:	«dataType»
URI:	null
Attribute: code	
Value type:	CharacterString
Definition:	Alphanumeric value identifying an instance in the namespace.
Multiplicity:	1
Attribute: codeSpace	
Value type:	CharacterString
Definition:	Name or identifier of the person or organization responsible for the namespace.
Description:	NOTE 1 Ideally the namespace would a registry where it is possible to register the vertical CRS and identify it using the code. NOTE 2 EPSG is an example of CRS registry, but other registries may be used (e.g. a future INSPIRE CRS registry, in case it is created).
Multiplicity:	1
Attribute: version	
Value type:	CharacterString
Definition:	Version identifier for the namespace.
Multiplicity:	0..1
Association role:	
Value type:	RS_Identifier
Multiplicity:	

5.3.2.3. Enumerations

5.3.2.3.1. ElevationPropertyTypeValue

ElevationPropertyTypeValue	
Definition:	Enumeration types which determine the elevation property which have been measured or calculated.
Description:	NOTE 1 An elevation property is a vertically-constrained dimensional property of an element consisting of an absolute measure referenced to a well-defined surface which is commonly taken as origin (geoid, water level, etc.). NOTE 2 It does not include relative elevations of the element referenced to other spatial objects. EXAMPLE Height, depth.
Status:	Proposed
Stereotypes:	«enumeration»
URI:	null
Value: depth	
Definition:	Elevation property measured along a plumb line in a direction coincident to Earth's gravity field (downwards).
Description:	NOTE This definition intentionally avoids making reference to complex geodetic terms. It is only intended to specify the direction in which the elevation property has been measured.
Value: height	
Definition:	Elevation property measured along a plumb line in a direction opposite to Earth's gravity field (upwards).
Description:	NOTE This definition intentionally avoids making reference to complex geodetic terms. It is only intended to specify the direction in which the elevation property has been measured.

5.3.2.3.2. SurfaceTypeValue

SurfaceTypeValue	
Definition:	Enumeration types specifying the surface for which elevation property values are provided, with regard to its relative position from the terrain (Earth's surface).
Status:	Proposed
Stereotypes:	«enumeration»
URI:	null
Value: DSM	
Definition:	Three dimensional surface describing the shape of a part of the Earth's or sea floor surface, including every feature placed on them (such us buildings, bridges or vegetation).
Description:	NOTE 1 It provides information about the highest elevation at a specific location, which may correspond to a point on the ground surface (emerged or submerged) or on any feature above it. NOTE 2 When describing depths of a part of submerged land (e.g. the sea floor), water bodies are obviously excluded from the surface. Hence it provides information about the depth of points located on the water body floor with respect to a well-defined datum.
Value: DTM	
Definition:	Three dimensional surface describing the shape of a part of the Earth's or sea floor bare surfaces, excluding any possible features placed on them (such us buildings, bridges or vegetation).

SurfaceTypeValue	
Description:	NOTE When describing heights of a part of emerged land, all features placed on its surface are excluded except water bodies. Hence it provides information about the height of points located on ground surface or any body of water placed on it with respect to a well-defined datum.

5.3.2.4. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

5.3.2.4.1. CharacterString

CharacterString	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103 Conceptual Schema Language::ISO 19103:2005 Schema Language::Basic Types::Primitive::Text [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.3.2.4.2. DateTime

DateTime	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103 Conceptual Schema Language::ISO 19103:2005 Schema Language::Basic Types::Primitive::Date and Time [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.3.2.4.3. EX_Extent

EX_Extent	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2006 Metadata (Corrigendum)::Extent information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.3.2.4.4. GM_Point

GM_Point	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107 Spatial Schema::ISO 19107:2003 Spatial Schema:: Geometry::Geometric primitive [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.3.2.4.5. Identifier

Identifier	
Package:	INSPIRE Consolidated UML Model::Generic Conceptual Model::Base Types [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	External unique object identifier published by the responsible body, which may be used by external applications to reference the spatial object.
Description:	NOTE1 External object identifiers are distinct from thematic object identifiers. NOTE 2 The voidable version identifier attribute is not part of the unique identifier of a spatial object and may be used to distinguish two versions of the same spatial object. NOTE 3 The unique identifier will not change during the life-time of a spatial object.

5.3.2.4.6. SpatialDataSet

SpatialDataSet	
Package:	INSPIRE Consolidated UML Model::Generic Conceptual Model::Base Types [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Identifiable collection of spatial data.
Description:	NOTE The type SpatialDataSet is offered as a pre-defined type for spatial data sets. INSPIRE application schemas may specify their own spatial data set types. It specifies three properties: an external object identifier, a container for metadata (may be void), and an association to zero or more spatial objects.

5.3.2.4.7. URI

URI	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19136 GML::basicTypes [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.3.2.4.8. WaterLevelValue

WaterLevelValue	
Package:	INSPIRE Consolidated UML Model::Themes::Hydrography::Hydro - Physical Waters [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	The tidal datum / waterlevel to which depths and heights are referenced.
Description:	SOURCE [Codelist values based on DFDD].

5.4 Application schema *Elevation – Vector Elements*

5.4.1 Description

5.4.1.1. Narrative description

The *Elevation – Vector Elements* application schema defines the spatial objects (feature types) that form part of an INSPIRE vector format elevation data set, together with their attributes and relationships.

5.4.1.2. UML Overview

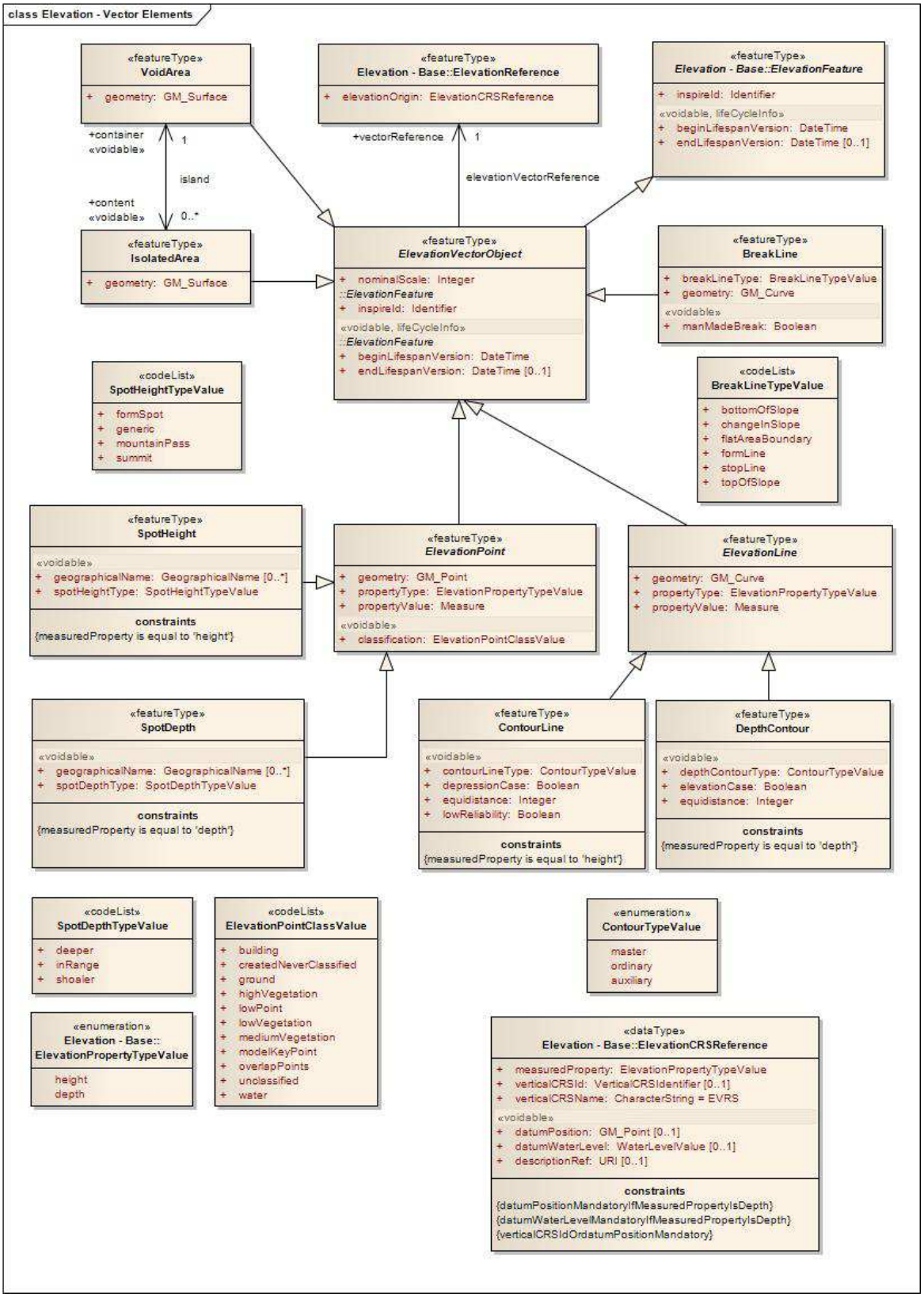


Figure 4 – UML class diagram: Overview of the *Elevation – Vector elements* application schema

The *Elevation – Vector elements* application schema defines the different vector spatial objects which may form part of an INSPIRE **Elevation** data set.

Recommendation 1 The provision of vector-format data for the **Elevation** theme is well recommended.

The previous diagram is focused on the abstract class *ElevationVectorObject* (Section 5.4.2.1.6), which establishes common properties shared by all vector object types defined in this specification, such as: inspire identifier, attributes describing the temporality representation or nominal scale.

The abstract class *ElevationVectorObject* is child of the abstract class *ElevationFeature* (Section 5.3.2.1.2) defined in the *Elevation – Base* application schema, from which it inherits common properties such as inspire identifier and lifecycle information attributes. *ElevationVectorObject* is further specialized into two new abstract classes, each having different roles and added meaning: *ElevationPoint* (Section 5.4.2.1.5) and *ElevationLine* (Section 5.4.2.1.4).

These two classes (*ElevationPoint* and *ElevationLine*) constitute the main types of **Elevation** spatial objects in vector data sets. These are points and lines having a specific elevation property value, respectively. It is worth highlighting that this elevation property may either represent *height* or *depth* values, as stated in the description of the *Elevation – Base* application schema (Section 5.3.1.2). For example, vector spatial objects inherited from these two classes are spot heights, depth spots, contour lines, depth contours (e.g. elements describing heights or bathymetry).

Apart from the mentioned two abstract classes, the *ElevationVectorObject* is additionally specialized into three non-abstract classes: *BreakLine* (Section 5.4.2.1.1 - lines representing breaks in slope within the elevation surface represented), *VoidArea* (Section 5.4.2.1.10 - areas without elevation data) and *IsolatedArea* (Section 5.4.2.1.7 - areas with elevation data inside void areas). All these objects represent different types of vector spatial objects which can be useful as input data for the generation of a more appropriate or accurate digital elevation model. These objects are not strictly considered as elevation data, but auxiliary data that may be used to derive proper elevation data through interpolation processes.

5.4.1.3. Consistency between spatial data sets

All requirements and recommendations on **Elevation** defined in the *Elevation – Base* application schema (see Section 5.3.1.3) also apply to the elements/classes defined in this application schema.

5.4.1.4. Identifier management

All requirements and recommendations on **Elevation** defined in the *Elevation – Base* application schema (see Section 5.3.1.4) also apply to the elements/classes defined in this application schema.

5.4.1.5. Modelling of object references

Modelling of internal object references between **Elevation** vector objects is not necessary.

5.4.1.6. Geometry representation

All requirements and recommendations on **Elevation** defined in the *Elevation – Base* application schema (see Section 5.3.1.6) also apply to the elements/classes defined in this application schema.

This section specifies concrete requirements and recommendations for **Elevation** vector-format data.

In particular, curve line spatial objects defined in this application schema (e.g. contour lines, depth contours, break lines) for which the type *GM_Curve* is used shall only implement linear interpolation methods. The main reason for stating this constraint is that curve geometric types make use of interpolation parameters which are frequently implemented in different ways in software systems.
Additionally, some of these systems may not able to work with complex curve interpolation methods to manage these geometries (software systems for generation of DEMs as well).

IR Requirement 6	All geometries of type *GM_Curve* defined in this spatial schema only allow use of linear interpolations for curves.

Recommendation 2	Provision of break line features stored using 3-D geometries is totally recommended in order to describe the singularities of terrain surface in detail.

If this recommendation is not accomplished, break line objects are stored using 2-D geometries, without elevation information. In this case their usefulness is very limited when users take them as input data to calculate derived **Elevation** models through interpolation procedures.

5.4.1.7. Temporality representation

All requirements and recommendations on **Elevation** defined in the *Elevation – Base* application schema (see Section 5.3.1.7) also apply to the elements/classes defined in this application schema.

5.4.2 Feature catalogue

Table 3 - Feature catalogue metadata

Feature catalogue name	INSPIRE feature catalogue Elevation - Vector Elements
Scope	Elevation - Vector Elements
Version number	2.0
Version date	2011-06-10
Definition source	INSPIRE data specification Elevation - Vector Elements

Table 4 - Types defined in the feature catalogue

Type	Package	Stereotypes	Section
BreakLine	Elevation - Vector Elements	«featureType»	5.4.2.1.1
BreakLineTypeValue	Elevation - Vector Elements	«codeList»	5.4.2.3.1
ContourLine	Elevation - Vector Elements	«featureType»	5.4.2.1.2
ContourTypeValue	Elevation - Vector Elements	«enumeration»	5.4.2.2.1
DepthContour	Elevation - Vector Elements	«featureType»	5.4.2.1.3
ElevationLine	Elevation - Vector Elements	«featureType»	5.4.2.1.4
ElevationPoint	Elevation - Vector Elements	«featureType»	5.4.2.1.5
ElevationPointClassValue	Elevation - Vector Elements	«codeList»	5.4.2.3.2
ElevationVectorObject	Elevation - Vector Elements	«featureType»	5.4.2.1.6
IsolatedArea	Elevation - Vector Elements	«featureType»	5.4.2.1.7
SpotDepth	Elevation - Vector Elements	«featureType»	5.4.2.1.8
SpotDepthTypeValue	Elevation - Vector Elements	«codeList»	5.4.2.3.3
SpotHeight	Elevation - Vector Elements	«featureType»	5.4.2.1.9
SpotHeightTypeValue	Elevation - Vector Elements	«codeList»	5.4.2.3.4
VoidArea	Elevation - Vector Elements	«featureType»	5.4.2.1.10

5.4.2.1. Spatial object types

5.4.2.1.1. BreakLine

BreakLine	
Subtype of:	ElevationVectorObject

BreakLine	
Definition:	A line of a critical nature to describe the shape of an elevation surface which indicates a distinct interruption or discontinuity in this surface (i.e. an abrupt change in gradient), where differently sloped adjoining terrain surfaces intersects.
Description:	SOURCE Adapted from [ISO 19107:2003]. EXAMPLE Breaklines represent local ridges or depressions (streams or drainage lines) in the surface, man-made structures (e.g. roads), etc. NOTE 1 A breakline connects points with different elevation and therefore its description using 3-D coordinates (using the 'geometry' attribute) is fully recommended. NOTE 2 No triangle in a TIN may cross a breakline (in other words, breakline segments are enforced as triangle edges), even if doing so violates the Delaunay criterion. NOTE 3 All breaklines are located on the ground surface or any of the artificial structures built on it. Any breaks present in a Digital Surface Model can not be described within this specification. NOTE 4 Breaklines act as auxiliary objects, which can be useful as input data for the generation of a more appropriate or accurate digital elevation model - in order to serve specific user needs - by using interpolation methods.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null

Attribute: breakLineType	
Value type:	BreakLineTypeValue
Definition:	The type of break line with regard the natural or man-made real world characteristic it represents, or the specific function it has in calculating a Digital Elevation Model (DEM).
Multiplicity:	1

Attribute: geometry	
Value type:	GM_Curve
Definition:	Represents the geometric properties of the break line, elevation auxiliary spatial object.
Multiplicity:	1

Attribute: manMadeBreak	
Value type:	Boolean
Definition:	Line which represents an elevation break due to an artificial or man-made construction present on the terrain.
Multiplicity:	1
Stereotypes:	«voidable»

5.4.2.1.2. ContourLine

ContourLine	
Subtype of:	ElevationLine
Definition:	A contour line is a line that connects points that have the same altitude value with respect to a specific vertical reference system. It describes the morphology of the land surface.

ContourLine

Description: SOURCE [GIS4EU D3.5]

NOTE The relief of the land surface is often represented in vector elevation datasets as a set of contourlines, where the subsequent ones are separated in the vertical component a distance equal to the equidistance parameter (normal contour vertical interval vertical).

Status: Proposed

Stereotypes: «featureType»

URI: null

Attribute: contourLineType

Value type: ContourTypeValue

Definition: The type of contourline.

Multiplicity: 1

Stereotypes: «voidable»

Attribute: depressionCase

Value type: Boolean

Definition: Property indicating that the contourline surrounds an area with an altitude lower than itself (the area represents a depression of the ground surface).

Description: NOTE This case (depression) is contrary to the more frequent case in cartographic representation, where a contourline surrounds an area with an altitude higher than itself (the area represents an elevation of the ground surface).

Multiplicity: 1

Stereotypes: «voidable»

Attribute: equidistance

Value type: Integer

Definition: Property indicating the normal contour vertical interval between two subsequent contours expressed in meters.

Multiplicity: 1

Stereotypes: «voidable»

Attribute: lowReliability

Value type: Boolean

Definition: Property indicating the existence of quality problems in the contour line section, due to the own limitations of the data capture process.

Description: NOTE 1 It is a qualitative indicator of the accuracy of this spatial object.

NOTE 2 Reliability of a contour line often depends on the grade of visibility of the ground surface during the data capture process (e.g. in forest areas when contours are obtained by stereoplotting). Such problems could have an impact on the elevation surface which is being mesured (e.g. the surface represented by data may differ from that of the real terrain in some areas).

Multiplicity: 1

Stereotypes: «voidable»

Constraint: measuredProperty is equal to 'height'

Natural language: The attribute measuredProperty is equal to 'height'.

OCL: inv: measuredProperty = MeasuredPropertyValue::height

5.4.2.1.3. DepthContour

DepthContour	
Subtype of:	ElevationLine
Definition:	A depth contour is a line that connects points that have the same depth value with respect to a specific vertical reference system. It describes the morphology of a surface coincident with the sea floor or the bottom of a lake. NOTE The sea floor surface is often represented in vector elevation datasets as a set of depth contour lines, where the distance separating subsequent ones can not be a constant parameter for the whole set. In case this distance is constant for the whole set of depth contour lines, the equidistance parameter (normal contour vertical interval) can be used to specify it.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Attribute: depthContourType	
Value type:	ContourTypeValue
Definition:	The type of depth contour line.
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: elevationCase	
Value type:	Boolean
Definition:	Property indicating that the depth contour line surrounds an area with a depth lower than itself (the area represents an elevation of the sea-bottom surface).
Description:	NOTE This case (elevation) is contrary to the more frequent case in cartographic representation, where a depth contour line surrounds an area with a depth higher than itself (the area represents a depression of the sea-bottom surface).
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: equidistance	
Value type:	Integer
Definition:	Property indicating the normal contour vertical interval between two subsequent contours expressed in meters.
Multiplicity:	1
Stereotypes:	«voidable»
Constraint: measuredProperty is equal to 'depth'	
Natural language:	The attribute measuredProperty is equal to 'depth'.
OCL:	inv: measuredProperty = MeasuredPropertyValue::depth

5.4.2.1.4. ElevationLine

ElevationLine (abstract)	
Subtype of:	ElevationVectorObject
Definition:	A linear spatial object that provides a single value of an elevation property. It describes the elevation of a real world surface for a set of aligned adjoining locations characterized by having the same elevation.
Description:	NOTE A set of elevation lines, each of them having a different value of the elevation property, is often used in topographic datasets to represent the global morphology of the surface.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null

ElevationLine (abstract)	
Attribute: geometry	
Value type:	GM_Curve
Definition:	Represents the geometric properties of the elevation line spatial object.
Multiplicity:	1
Attribute: propertyType	
Value type:	ElevationPropertyTypeValue
Definition:	An elevation property which has been measured or calculated.
Description:	NOTE 1 An elevation property is a vertically-constrained dimensional property of an element consisting of an absolute measure referenced to a well-defined surface which is commonly taken as origin (geoid, water level, etc.). It does not include relative elevations of the element referenced to other spatial objects. EXAMPLE Height, depth.
Multiplicity:	1
Attribute: propertyValue	
Value type:	Measure
Definition:	Value of the elevation property which has been measured or calculated.
Description:	NOTE 1 An elevation property is a vertically-constrained dimensional property of an element consisting of an absolute measure referenced to a well-defined surface which is commonly taken as origin (geoid, water level, etc.). It does not include relative elevations of the element referenced to other spatial objects.
Multiplicity:	1

5.4.2.1.5. ElevationPoint

ElevationPoint (abstract)	
Subtype of:	ElevationVectorObject
Definition:	A point spatial object that provides a single value of an elevation property. It describes the elevation of a real world surface at a specific location.
Description:	NOTE It includes the elevation property value of the surface at a specific location, which often represents a singular point in the morphology of the surface.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Attribute: classification	
Value type:	ElevationPointClassValue
Definition:	Class of elevation point according the LAS specification v1.3 - R10, of the American Society for Photogrammetry & Remote Sensing.
Description:	NOTE The classification proposed for every elevation point regardless of their adquisition method corresponds to the ASPRS Standard LIDAR Point Classes.
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: geometry	
Value type:	GM_Point
Definition:	Represents the geometric properties of the elevation point spatial object.
Multiplicity:	1
Attribute: propertyType	
Value type:	ElevationPropertyTypeValue
Definition:	An elevation property which has been measured or calculated.

ElevationPoint (abstract)	
Description:	NOTE 1 An elevation property is a vertically-constrained dimensional property of an element consisting of an absolute measure referenced to a well-defined surface which is commonly taken as origin (geoid, water level, etc.). It does not include relative elevations of the element referenced to other spatial objects. EXAMPLE Height, depth.
Multiplicity:	1

Attribute: propertyValue	
Value type:	Measure
Definition:	Value of the elevation property which has been measured or calculated.
Description:	NOTE 1 An elevation property is a vertically-constrained dimensional property of an element consisting of an absolute measure referenced to a well-defined surface which is commonly taken as origin (geoid, water level, etc.). It does not include relative elevations of the element referenced to other spatial objects.
Multiplicity:	1

5.4.2.1.6. ElevationVectorObject

ElevationVectorObject (abstract)	
Subtype of:	ElevationFeature
Definition:	A spatial object forming part of a vector-format data set, which participates in the description of the elevation property of a real world surface. It consists of an identity base for all vector objects which can be included as part of an elevation data set.
Description:	It is an abstract feature type which generically describes every possible type of elevation vector object. It includes common attributes, properties and constraints for such spatial objects.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null

Attribute: nominalScale	
Value type:	Integer
Definition:	Number indicating the denominator of the nominal scale at which the vector object was captured or from which it was calculated or derived.
Multiplicity:	1

Association role: vectorReference	
Value type:	ElevationReference
Definition:	The elevation reference to which the measured property value (height or depth) of the vector object is referenced to.
Multiplicity:	1

5.4.2.1.7. IsolatedArea

IsolatedArea	
Subtype of:	ElevationVectorObject
Definition:	Area that delimits an isolated part of the territory where the elevation model exists.
Description:	SOURCE Adapted from "IslandArea" [GIS4EU D3.5]. NOTE 1 It includes an isolated part into the elevation model. NOTE 2 Isolated areas act as auxiliary objects, which can be useful as input data (mask) for a more appropriate or accurate digital elevation model - in order to serve specific user needs.

IsolatedArea	
Status:	Proposed
Stereotypes:	«featureType»
URI:	null

Attribute: geometry

Value type:	GM_Surface
Definition:	Represents the geometric properties of the isolated area spatial object.
Multiplicity:	1

Association role: container

Value type:	VoidArea
Definition:	Void area including zero or more isolated areas.
Multiplicity:	1
Stereotypes:	«voidable»

5.4.2.1.8. SpotDepth

SpotDepth	
Subtype of:	ElevationPoint
Definition:	Permanent elevation point which describes the morphology of a surface coincident with the sea floor or the bottom of a lake by indicating its depth with respect a specific vertical reference system.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null

Attribute: geographicalName

Value type:	GeographicalName
Definition:	A geographical name that is used to identify a named sea-bottom location in the real world, represented by a spot depth object in the elevation model. It provides a 'key' for implicitly associating different representations of the object.
Multiplicity:	0..*
Stereotypes:	«voidable»

Attribute: spotDepthType

Value type:	SpotDepthTypeValue
Definition:	The type of spot depth.
Multiplicity:	1
Stereotypes:	«voidable»

Constraint: measuredProperty is equal to 'depth'

Natural language:	The attribute measuredProperty is equal to 'depth'.
OCL:	inv: measuredProperty = MeasuredPropertyValue::depth

5.4.2.1.9. SpotHeight

SpotHeight	
Subtype of:	ElevationPoint
Definition:	Permanent elevation point which describes the morphology of the land suface by indicating its altitude with respect a specific vertical reference system.
Description:	SOURCE Adapted from [GIS4EU D3.5].
Status:	Proposed
Stereotypes:	«featureType»
URI:	null

SpotHeight	
Attribute: geographicalName	
Value type:	GeographicalName
Definition:	A geographical name that is used to identify a named location in the real world, represented by a spot height object in the elevation model. It provides a 'key' for implicitly associating different representations of the object.
Multiplicity:	0..*
Stereotypes:	«voidable»
Attribute: spotHeightType	
Value type:	SpotHeightTypeValue
Definition:	The type of spot height.
Multiplicity:	1
Stereotypes:	«voidable»
Constraint: measuredProperty is equal to 'height'	
Natural language:	The attribute measuredProperty is equal to 'height'.
OCL:	inv: measuredProperty = MeasuredPropertyValue::height

5.4.2.1.10. VoidArea

VoidArea	
Subtype of:	ElevationVectorObject
Definition:	Area that delimits a part of the territory where the elevation model is unknown because of missing input data.
Description:	SOURCE "ObscureArea" [GIS4EU D3.5]. NOTE 1 The portion of territory covered by the void area is excluded from an elevation model, except for the cases stated in note 2. NOTE 2 A void area may contain a number of isolated areas with elevation data. These areas are considered valid exceptions according note 1. NOTE 3 Void areas act as auxiliary objects, which can be useful as input data (mask) for a more appropriate or accurate digital elevation model - in order to serve specific user needs.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Attribute: geometry	
Value type:	GM_Surface
Definition:	Represents the geometric properties of the void area, elevation auxiliary spatial object.
Multiplicity:	1
Association role: content	
Value type:	IsolatedArea
Definition:	Isolated area included in a void area.
Multiplicity:	0..*
Stereotypes:	«voidable»

5.4.2.2. Enumerations

5.4.2.2.1. ContourTypeValue

ContourTypeValue

ContourTypeValue	
Definition:	List of possible type values for contour lines with regard the equidistance parameter.
Description:	NOTE This list of values applies to both, contourlines (where the measured property is altitude) and depth contours (where the measured property is depth).
Status:	Proposed
Stereotypes:	«enumeration»
URI:	null
Value: auxiliary	
Definition:	A supplementary contour – not corresponding to the normal contour vertical interval – estimated or interpolated from surrounding contours, used in areas where there is insufficient height information for elevation mapping purposes or to control the creation of a digital elevation model.
Description:	NOTE This term is equivalent to the value 'intermediate' used in some Member States.
Value: master	
Definition:	Contour at a vertical distance which is multiple to the equidistance parameter (corresponding to a certain multiple of the normal contour vertical interval) associated with the nominal scale.
Value: ordinary	
Definition:	Contour at the equidistance parameter (corresponding to the normal contour vertical interval) associated with the nominal scale, and which is not a master contour.

5.4.2.3. Code lists

5.4.2.3.1. BreakLineTypeValue

BreakLineTypeValue	
Definition:	List of possible type values for breakline auxiliary objects, with regard to real objects they represent.
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	http://inspire-registry.jrc.ec.europa.eu/registers/CLR/BreakLineTypeValue
Value: bottomOfSlope	
Definition:	Line representing the lower boundary of an area having a constant slope in the terrain surface, typically varying approximately between 2° and 40°.
Value: changeInSlope	
Definition:	Line representing a collection of adjoining points where the terrain has an abrupt change in slope.
Value: flatAreaBoundary	
Definition:	Line that delimits an isolated part of the territory where the elevation model has to be constrained at the same elevation value.
Description:	NOTE The boundary of a flat area shall be closed. EXAMPLE Boundary of a land water body (e.g. lake).
Value: formLine	
Definition:	Breakline representing a local direction in which the elevation surface being described takes the greatest slope.

BreakLineTypeValue	
Description:	NOTE 1 Form lines are always perpendicular to contour lines describing the same elevation surface. NOTE 2 This special case of break line is often used to describe troughs and ridges of the terrain surface. EXAMPLE Ridge line, thalweg.
Value: stopLine	
Definition:	Stop lines are lines where the local continuity or regularity of the elevation surface is questionable. In the area of these morphologies, triangles intersecting a stop line shall be removed from a TIN surface, leaving holes in the surface. If coincidence occurs on surface boundary triangles, the result shall be a change of the surface boundary.
Description:	SOURCE Adapted from [ISO 19107:2003].
Value: topOfSlope	
Definition:	Line representing the upper boundary of an area having a constant slope in the terrain surface, typically varying approximately between 2° and 40°.

5.4.2.3.2. ElevationPointClassValue

ElevationPointClassValue	
Definition:	List of possible classification values for elavation points according the LAS specification v1.3 - R10, of the American Society for Photogrammetry & Remote Sensing.
Description:	NOTE The classes proposed for every elevation point regardless of their adquisition method corresponds to the ASPRS Standard LIDAR Point Classes.
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	http://inspire-registry.jrc.ec.europa.eu/registers/CLR/ElevationPointClassValue
Value: building	
Definition:	ASPRS Standard LIDAR Point Classes - Classification value 6.
Description:	SOURCE [LAS specification v1.3 - R10].
Value: createdNeverClassified	
Definition:	ASPRS Standard LIDAR Point Classes - Classification value 0.
Description:	SOURCE [LAS specification v1.3 - R10].
Value: ground	
Definition:	ASPRS Standard LIDAR Point Classes - Classification value 2.
Description:	SOURCE [LAS specification v1.3 - R10].
Value: highVegetation	
Definition:	ASPRS Standard LIDAR Point Classes - Classification value 5.
Description:	SOURCE [LAS specification v1.3 - R10].
Value: lowPoint	
Definition:	ASPRS Standard LIDAR Point Classes - Classification value 7.
Description:	SOURCE [LAS specification v1.3 - R10].
Value: lowVegetation	
Definition:	ASPRS Standard LIDAR Point Classes - Classification value 3.
Description:	SOURCE [LAS specification v1.3 - R10].

ElevationPointClassValue	
Value: mediumVegetation	
Definition:	ASPRS Standard LIDAR Point Classes - Classification value 4.
Description:	SOURCE [LAS specification v1.3 - R10].
Value: modelKeyPoint	
Definition:	ASPRS Standard LIDAR Point Classes - Classification value 8.
Description:	SOURCE [LAS specification v1.3 - R10].
Value: overlapPoints	
Definition:	ASPRS Standard LIDAR Point Classes - Classification value 12.
Description:	SOURCE [LAS specification v1.3 - R10]. NOTE Overlap Points are those points that were immediately culled during the merging of overlapping flight lines.
Value: unclassified	
Definition:	ASPRS Standard LIDAR Point Classes - Classification value 1.
Description:	SOURCE [LAS specification v1.3 - R10].
Value: water	
Definition:	ASPRS Standard LIDAR Point Classes - Classification value 9.
Description:	SOURCE [LAS specification v1.3 - R10].

5.4.2.3.3. SpotDepthTypeValue

SpotDepthTypeValue	
Definition:	Property indicating the relation between the 'value of sounding' of the object and the depth of the submerged surrounding area.
Description:	SOURCE Adapted from [IHO S-57]. NOTE 1 This classification is useful to distinguish singular locations on the floor of a water body. NOTE 2 Shallow locations could be a potential danger for navigation.
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	http://inspire-registry.jrc.ec.europa.eu/registers/CLR/SpotDepthTypeValue
Value: deeper	
Definition:	The depth spot is deeper than the maximum depth of the surrounding depth area.
Description:	SOURCE [IHO S-57]. NOTE 'Deeper' is a hydrographic term used in IHO S-57. It means that the spot depth is deeper than the surrounding area.
Value: inRange	
Definition:	The depth spot corresponds to the depth range of the surrounding depth area.
Description:	SOURCE [IHO S-57] NOTE Bathymetric point within the range of depth of the surrounding depth area, i.e. the depth is not shoaler than the minimum depth of the surrounding depth area or deeper than the maximum depth of the surrounding depth area.
Value: shoaler	

SpotDepthTypeValue	
Definition:	The depth spot is shoaler than the minimum depth of the surrounding depth area.
Description:	SOURCE [IHO S-57]. NOTE 'Shoaler' is a hydrographic term used in IHO S-57. It means that the spot depth is shallower than the surrounding area.

5.4.2.3.4. SpotHeightTypeValue

SpotHeightTypeValue	
Definition:	List of possible type values for spot heights points with regard to its sigular location in the terrain.
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	http://inspire-registry.jrc.ec.europa.eu/registers/CLR/SpotHeightTypeValue
Value: formSpot	
Definition:	A supplementary spot height, estimated or interpolated from surrounding heights, in areas where few contourlines or other height information exist.
Description:	NOTE Used to control the creation of digital elevation models.
Value: generic	
Definition:	Spot height feature not fulfilling the description of any of the other values in the current code list.
Value: mountainPass	
Definition:	Lower point of a depression within a mountain alineation, generally opened in the crest line, which allow passing from one slope to another.
Description:	NOTE A mountain pass is a point of double curvature, one in the direction of the crest line and another in the direction of the thalwegs born in this point (i.e. with two maximum curvatures - concave and convex, respectively).
Value: summit	
Definition:	Highest point of a mountain or any other orographic elevation sorrounded by points with lower elevation values.

5.4.2.4. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

5.4.2.4.1. Boolean

Boolean	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103 Conceptual Schema Language::ISO 19103:2005 Schema Language::Basic Types::Primitive::Truth [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.4.2.4.2. ElevationFeature

ElevationFeature (abstract)	
Package:	ANNEX II + III::Themes::Annex II::Elevation::Elevation - Base [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

ElevationFeature (abstract)	
Definition:	Element included within an elevation data set which takes part in the description of a land, ice and/or ocean surface in terms of a dimensional property linked to the vertical component (height, depth).

5.4.2.4.3. ElevationPropertyTypeValue

ElevationPropertyTypeValue	
Package:	ANNEX II + III::Themes::Annex II::Elevation::Elevation - Base [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Enumeration types which determine the elevation property which have been measured or calculated.
Description:	NOTE 1 An elevation property is a vertically-constrained dimensional property of an element consisting of an absolute measure referenced to a well-defined surface which is commonly taken as origin (geoid, water level, etc.). NOTE 2 It does not include relative elevations of the element referenced to other spatial objects. EXAMPLE Height, depth.

5.4.2.4.4. ElevationReference

ElevationReference	
Package:	ANNEX II + III::Themes::Annex II::Elevation::Elevation - Base [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Reference to the origin used to refer the elevation values associated to an object.

5.4.2.4.5. GM_Curve

GM_Curve	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107 Spatial Schema::ISO 19107:2003 Spatial Schema:: Geometry::Geometric primitive [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.4.2.4.6. GM_Point

GM_Point	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107 Spatial Schema::ISO 19107:2003 Spatial Schema:: Geometry::Geometric primitive [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.4.2.4.7. GM_Surface

GM_Surface	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107 Spatial Schema::ISO 19107:2003 Spatial Schema:: Geometry::Geometric primitive [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.4.2.4.8. GeographicalName

GeographicalName	
Package:	INSPIRE Consolidated UML Model::Themes::Geographical Names::Geographical Names [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Proper noun applied to a real world entity.

5.4.2.4.9. Integer

Integer	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103 Conceptual Schema Language::ISO 19103:2005 Schema Language::Basic Types::Primitive::Numerics [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.4.2.4.10. Measure

Measure	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103 Conceptual Schema Language::ISO 19103:2005 Schema Language::Basic Types::Derived::Units of Measure [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.5 Application schema *Elevation - Coverages*

5.5.1 Description

5.5.1.1. Narrative description

The *Elevation – Coverages* application schema defines the basis for the provision of elevation models as coverages based on a Grid. These types of coverages may also form part of an INSPIRE **Elevation** data set. Additionally, the *Elevation – Coverages* application schema depends on the common model for coverages included in the Generic Conceptual Model (GCM). This common model has been defined according WCS 2.0 draft and ISO 19123 – *Coverage geometry and functions*, which provide the framework for the definition of coverage data types.

Open issue 4: Grid coverage data aggregation
The basis for grid coverage data aggregation needs to be included in the **Elevation** model and this data specification.
This should be addressed in INSPIRE Data Specification **Elevation** v3.0, hopefully integrating a harmonised cross-theme approach common to those themes dealing with coverages (e.g. orthoimagery).

5.5.1.2. UML Overview

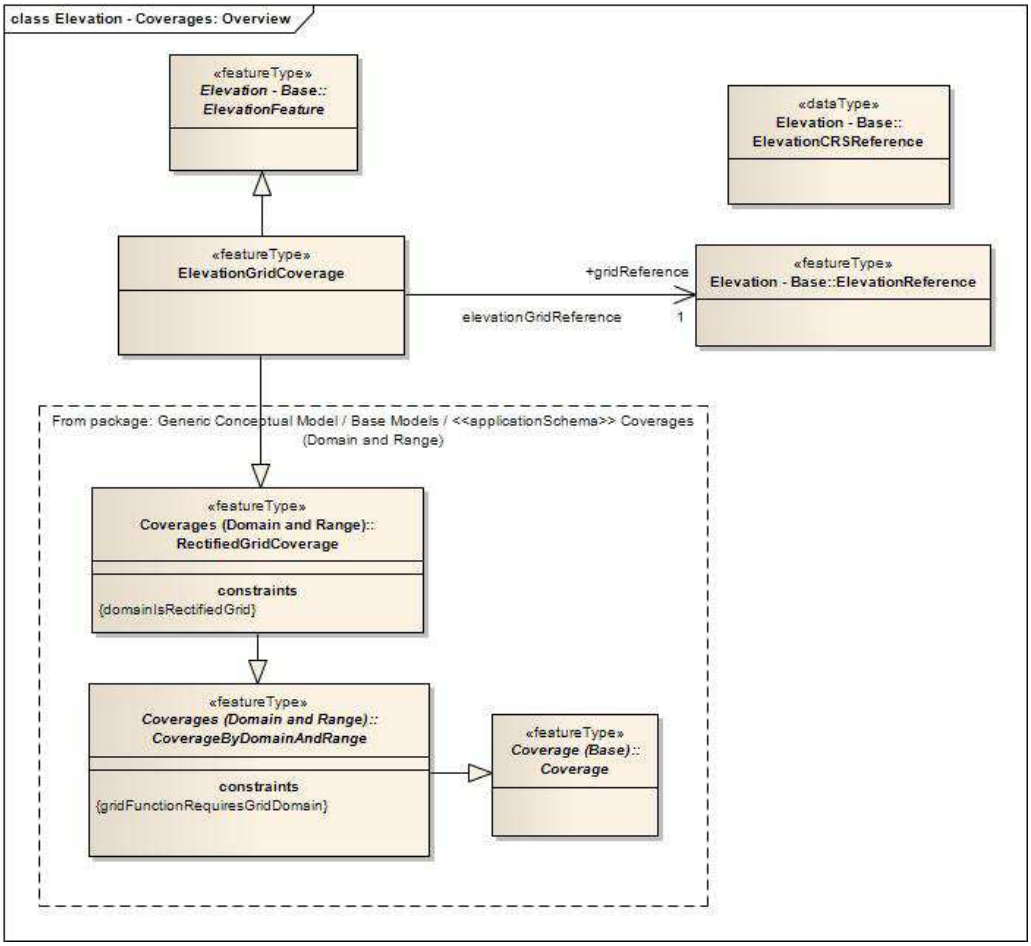


Figure 5 – UML class diagram: Overview of the *Elevation – Coverages* application schema

The *Elevation – Coverages* application schema defines an ISO 19123 compliant structure for gridded continuous coverage types which may form part of an INSPIRE **Elevation** data set.

Some of the properties identified in this specification for Grid **Elevation** models are inherited from those which are realized within the common model for coverages (in the GCM) and correspond to the basic properties of coverages as defined in ISO 19123 (for the corresponding grid structure).

The previous diagram is focused on the basic class (feature type) *ElevationGridCoverage* (Section 5.5.2.1.1), representing a rectified coverage with a regular grid structure. This feature type is derived through inheritance relationships from classes defined in the common model for coverages included in the GCM: *Coverage (Base)* and *Coverages (Domain and Range)* application schemas. The second one is presented in the next figure.

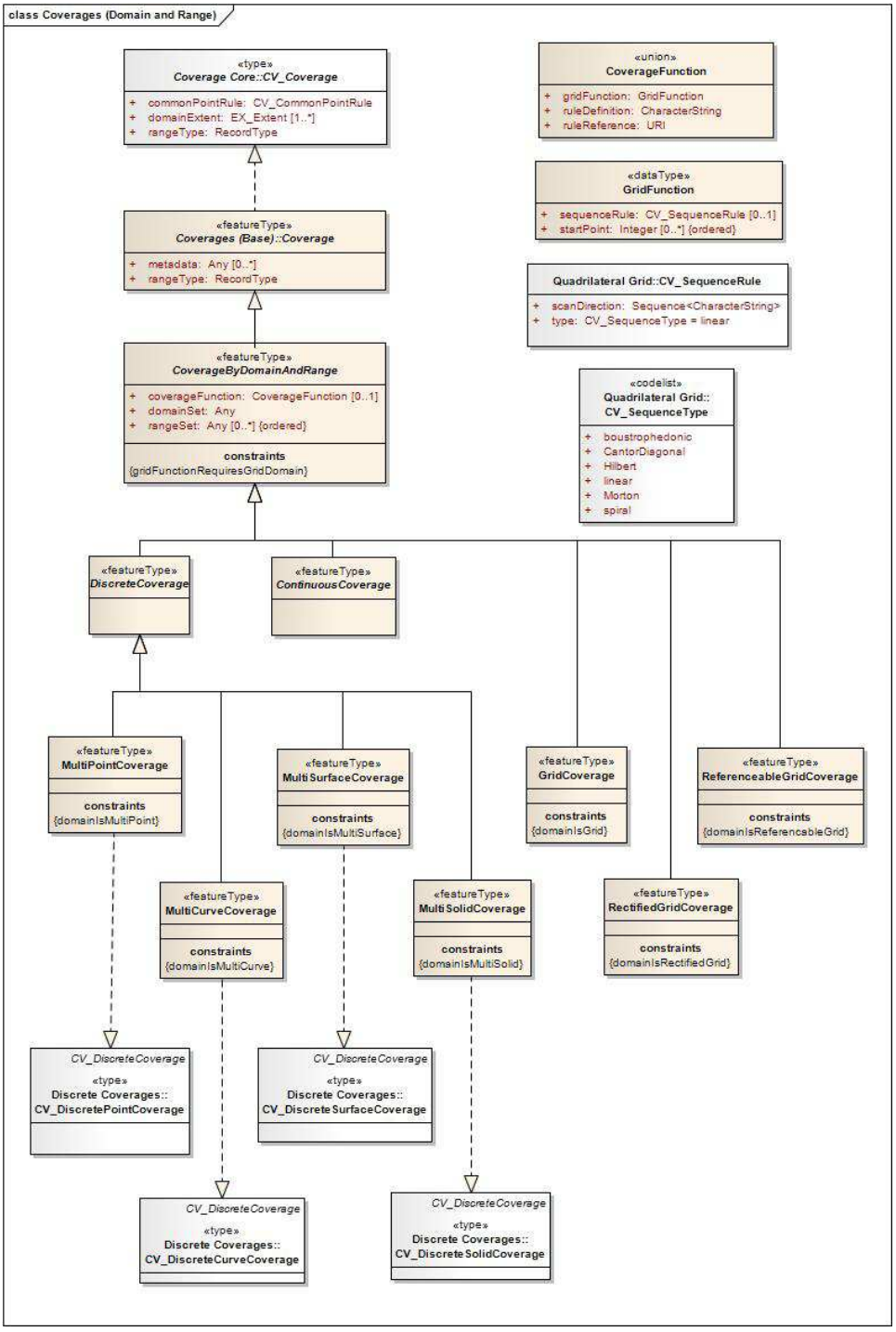


Figure 6 – GCM: *Coverages (Domain and Range)* application schema

Therefore, *ElevationGridCoverage* has properties which are inherited from the coverage types from which it derives: coverage-level metadata and range type. It also has properties defined in this specification, such as: inspire identifier, spatiotemporal extent, attributes describing the temporality representation, identification of the elevation property and the type of real surface represented by the coverage (DTM or DSM), interpolation type and unit of measure in which the elevation property is provided.

ElevationGridCoverage feature type is defined as continuous coverage (i.e. having a continuous domain with a discrete set of control points with known values of the properties represented by the coverage) with these characteristics:

- Domain: well-defined set composed of objects representing a set of direct positions in space and time, for which a value of the elevation property can be derived from the range of the coverage.

- Range: set of feature elevation values associated by a function with the elements of the domain of the coverage.

- Interpolation method: identification of the calculation method which is recommended for use in order to evaluate the continuous coverage, i.e. determine the values of the coverage at any direct position within the domain of the coverage, by using the values known for the corresponding set of control points.

- Sequence rule: method provided to establish an unambiguous correspondence between each point in the domain of the coverage and the associated value from the range of the coverage.
  Implementation of sequence rules demands modelling the domain and the range of the coverage (both composed of sets of elements) as ordered structures.

For the purpose of this specification, only one property (an elevation property, as stated in Section 5.3.1.2 for the *Elevation – Base* application schema) is represented by a coverage type.

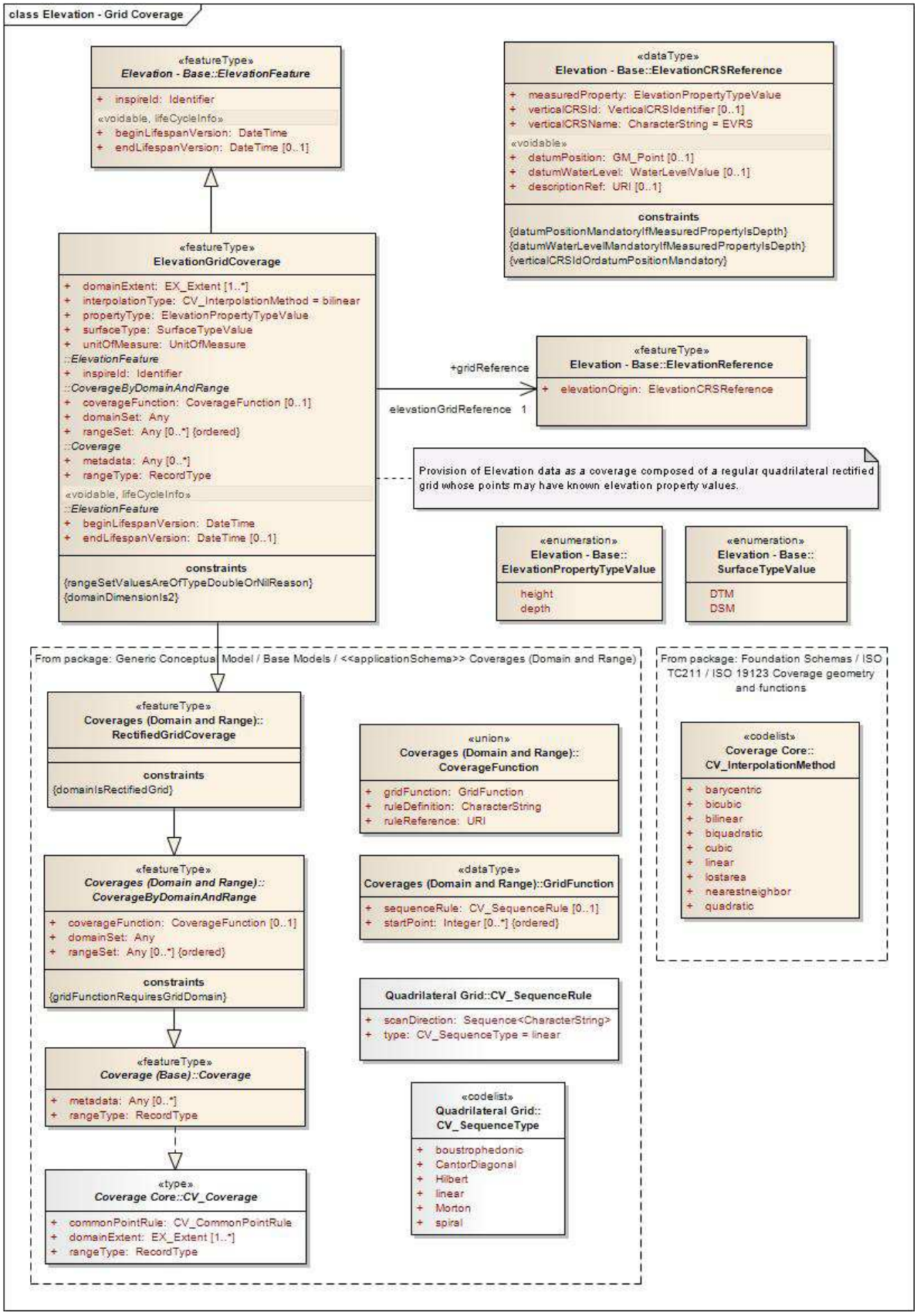


Figure 7 – UML class diagram: *Elevation* – *Coverages* application schema – Grid Coverage

The previous diagram shows the structure defined in this specification for the provision of Gridded **Elevation** data.

The regular grid is one of the most extended formats for **Elevation** models, which is also widely accepted for data exchange and use between users of different technical levels. This is a common situation for most territories of Europe, as shown in Pan-European projects like *EuroDEM (EuroGeographics)*.

IR Requirement 1	The provision of Grid-based coverage data is mandatory for the **Elevation** theme for the geographic areas where this type of data is available.

The abstract **Elevation** Grid coverage *(ElevationGridCoverage)* feature type is child of the abstract class *ElevationFeature* (Section 5.3.2.1.2) defined in the *Elevation – Base* application schema, from which it inherits common properties such as inspire identifier and lifecycle information attributes.

Additionally, the *ElevationGridCoverage* feature type is directly inherited from the *RectifiedGridCoverage* class (from the *Coverages (Domain and Range)* application schema, in the GCM), which provides this coverage type with a specific domain. This domain is of type *CV_RectifiedGrid* (defined in ISO 19123), which means it can be spatially referenced through a coordinate reference system.

RectifiedGridCoverage is itself an implementation of *continuous quadrilateral grid coverage*, as defined in ISO 19123. It inherits the properties which are necessary to process the coverage: *domainSet* and *rangeType* respectively describe the structures of the domain (i.e. geometry) and the range values of the coverage, *rangeSet* contains the feature attribute values whereas *coverageFunction* details how to assign the records to the points of the grid.

The range set of the **Elevation** Grid coverage is composed of a finite number of values which are of type *doubleOrNilReason*. This means that **Elevation** values are stored as float numbers but can be left void in the cases where the values are unknown (e.g. grid points inside void areas). It is worth mention here that these cases are not considered as data quality omission errors in the context of this specification.

Default interpolation method proposed for the **Elevation** Grid coverage is bilinear.

The sequence rule for **Elevation** Grid coverages is implicitly established by the coverage function, which is one of the properties inherited from the *RectifiedGridCoverage* GCM coverage class. This function includes the *startPoint* and *sequenceRule* properties. The former identifies the first cell of the Grid corresponding to the first value provided within the range set of the coverage; whereas the latter identifies the method followed to go through the Grid cells, which corresponds to the order followed to provide the elevation values in the range of the coverage – starting from the value associated to the start point cell.

5.5.1.3. Consistency between spatial data sets

All requirements and recommendations on **Elevation** defined in the *Elevation – Base* application schema (see Section 5.3.1.3) also apply to the elements/classes defined in this application schema.

5.5.1.4. Identifier management

All requirements and recommendations on **Elevation** defined in the *Elevation – Base* application schema (see Section 5.3.1.4) also apply to the elements/classes defined in this application schema.

5.5.1.5. Modelling of object references

Gridded Pan-European **Elevation** data sets aimed at cross-border purposes should use a common European grid, as introduced in Section 6.4. This common grid is specified in Annex C. It is defined in ETRS89 geodetic coordinates and based on different levels of resolution. Modelling of object references may be implicitly established between corresponding DEM cells from each of these levels (pyramids).

5.5.1.6. Geometry representation

The geometry representation for **Elevation** coverages is identified by the data structures defined for Grids in this specification.

5.5.1.7. Temporality representation

All requirements and recommendations on **Elevation** defined in the *Elevation – Base* application schema (see Section 5.3.1.7) also apply to the elements/classes defined in this application schema.

5.5.2 Feature catalogue

Table 3 - Feature catalogue metadata

Feature catalogue name	INSPIRE feature catalogue Elevation - Coverages
Scope	Elevation - Coverages
Version number	2.0
Version date	2011-06-10
Definition source	INSPIRE data specification Elevation - Coverages

Table 4 - Types defined in the feature catalogue

Type	Package	Stereotypes	Section
ElevationGridCoverage	Elevation - Coverages	«featureType»	5.5.2.1.1

5.5.2.1. Spatial object types

5.5.2.1.1. ElevationGridCoverage

ElevationGridCoverage	
Subtype of:	RectifiedGridCoverage, ElevationFeature
Definition:	Continuous coverage which uses a systematic tessellation based on a regular rectified quadrilateral grid to cover its domain, where the elevation property value is usually known for each of the grid points forming this domain.
Description:	SOURCE Adapted from [ISO 19123:2005]. NOTE 1 A coverage is a feature type that acts as a function to return an elevation property value from its range for any direct position within its spatial, temporal or spatiotemporal domain (Adapted from "Coverage" [ISO 19123:2005]). Hence, an elevation coverage is a feature type which assigns elevation property values (range) to the geometric elements forming part of the coverage domain. NOTE 2 A rectified grid is a grid for which there is an affine transformation between the grid coordinates and the coordinates of an external coordinate reference system. NOTE 3 Grid coverages employ a systematic tessellation of the domain. The principal advantage of such tessellations is that they support a sequential enumeration of the elements of the domain, which makes data storage and access more efficient. NOTE 4 An elevation grid coverage is a continuous coverage. It provides a mathematical method to interpolate elevation values for any direct position within its domain extent from the elevation values known for the grid points (domain elements).
Status:	Proposed

ElevationGridCoverage

Stereotypes: «featureType»
URI: null

Attribute: domainExtent

Value type: EX_Extent
Definition: The attribute domainExtent shall contain the extent of the spatiotemporal domain of the coverage. The data type EX_Extent, is defined in ISO 19103. Extents may be specified in both space and time.
Description: SOURCE [ISO 19123:2005].

NOTE The domain extent shall be specified at least in space by using EX_BoundingPolygon, EX_GeographicBoundingBox or EX_GeographicDescription. The whole geographic extent of the elevation coverage is affected, including areas where grid points hold nil reason values.
Multiplicity: 1..*

Attribute: interpolationType

Value type: CV_InterpolationMethod
Definition: Mathematical method which shall be used to evaluate a continuous coverage, i.e. determine the values of the coverage at any direct position within the domain of the coverage.
Description: EXAMPLE Evaluation of a rectified quadrilateral grid coverage in a certain location involves interpolation of values within a quadrilateral cell (which contains this location) composed of four neighbouring point value pairs (grid cell corners); and possibly involve additional grid points outside the cell.

NOTE The list of possible values for interpolation methods is defined in ISO 19123:2005 - Annex C (Interpolation methods). Default value provided in this specification is "bilinear".
Multiplicity: 1

Attribute: propertyType

Value type: ElevationPropertyTypeValue
Definition: An elevation property which has been measured or calculated.
Description: NOTE 1 An elevation property is a vertically-constrained dimensional property of an element consisting of an absolute measure referenced to a well-defined surface which is commonly taken as origin (geoid, water level, etc.). It does not include relative elevations of the element referenced to other spatial objects.

EXAMPLE Height, depth.

NOTE 2 It describes the type of property of the values provided within the elevation coverage.
Multiplicity: 1

Attribute: surfaceType

Value type: SurfaceTypeValue
Definition: Attribute indicating the type of elevation surface that the coverage describes in relation to the terrain.
Multiplicity: 1

Attribute: unitOfMeasure

Value type: UnitOfMeasure
Definition: Unit of measure used to provide the elevation property values within the range set.

ElevationGridCoverage	
Multiplicity:	1
Association role: gridReference	
Value type:	ElevationReference
Definition:	The elevation reference to which the measured property values (heights or depths) of the elevation grid coverage are referenced to.
Multiplicity:	1
Constraint: domainDimensionIs2	
Natural language:	The grid dimension is always 2 in a Elevation Grid Coverage
OCL:	inv: domainSet.dimension=2
Constraint: rangeSetValuesAreOfTypeDoubleOrNilReason	
Natural language:	rangeSet values are of type doubleOrNilReason
OCL:	inv: rangeSet.forAll(oclIsKindOf(doubleOrNilReason))

5.5.2.2. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

5.5.2.2.1. CV_InterpolationMethod

CV_InterpolationMethod	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19123 Coverage geometry and functions::ISO 19123-NWIP::Continuous Coverage [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.5.2.2.2. EX_Extent

EX_Extent	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2006 Metadata (Corrigendum)::Extent information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.5.2.2.3. ElevationFeature

ElevationFeature (abstract)	
Package:	ANNEX II + III::Themes::Annex II::Elevation::Elevation - Base [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Element included within an elevation data set which takes part in the description of a land, ice and/or ocean surface in terms of a dimensional property linked to the vertical component (height, depth).

5.5.2.2.4. ElevationPropertyTypeValue

ElevationPropertyTypeValue	
Package:	ANNEX II + III::Themes::Annex II::Elevation::Elevation - Base [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Enumeration types which determine the elevation property which have been measured or calculated.

ElevationPropertyTypeValue	
Description:	NOTE 1 An elevation property is a vertically-constrained dimensional property of an element consisting of an absolute measure referenced to a well-defined surface which is commonly taken as origin (geoid, water level, etc.). NOTE 2 It does not include relative elevations of the element referenced to other spatial objects. EXAMPLE Height, depth.

5.5.2.2.5. ElevationReference

ElevationReference	
Package:	ANNEX II + III::Themes::Annex II::Elevation::Elevation - Base [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Reference to the origin used to refer the elevation values associated to an object.

5.5.2.2.6. RectifiedGridCoverage

RectifiedGridCoverage	
Package:	INSPIRE Consolidated UML Model::Generic Conceptual Model::Base Models::Coverages (Domain and Range) [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	coverage whose domain consists of a rectified grid
Description:	A rectified grid is a grid for which there is an affine transformation between the grid coordinates and the coordinates of a coordinate reference system. NOTE This type can be used for both discrete and continuous coverages.

5.5.2.2.7. SurfaceTypeValue

SurfaceTypeValue	
Package:	ANNEX II + III::Themes::Annex II::Elevation::Elevation - Base [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Enumeration types specifying the surface for which elevation property values are provided, with regard to its relative position from the terrain (Earth's surface).

5.5.2.2.8. UnitOfMeasure

UnitOfMeasure (abstract)	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103 Conceptual Schema Language::ISO 19103:2005 Schema Language::Basic Types::Derived::Units of Measure [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.6 Application schema *Elevation - TIN*

5.6.1 Description

5.6.1.1. Narrative description

The *Elevation – TIN* application schema defines the basis for the provision of elevation models based on a Triangulated Irregular Network (TIN) structure.

5.6.1.2. UML Overview

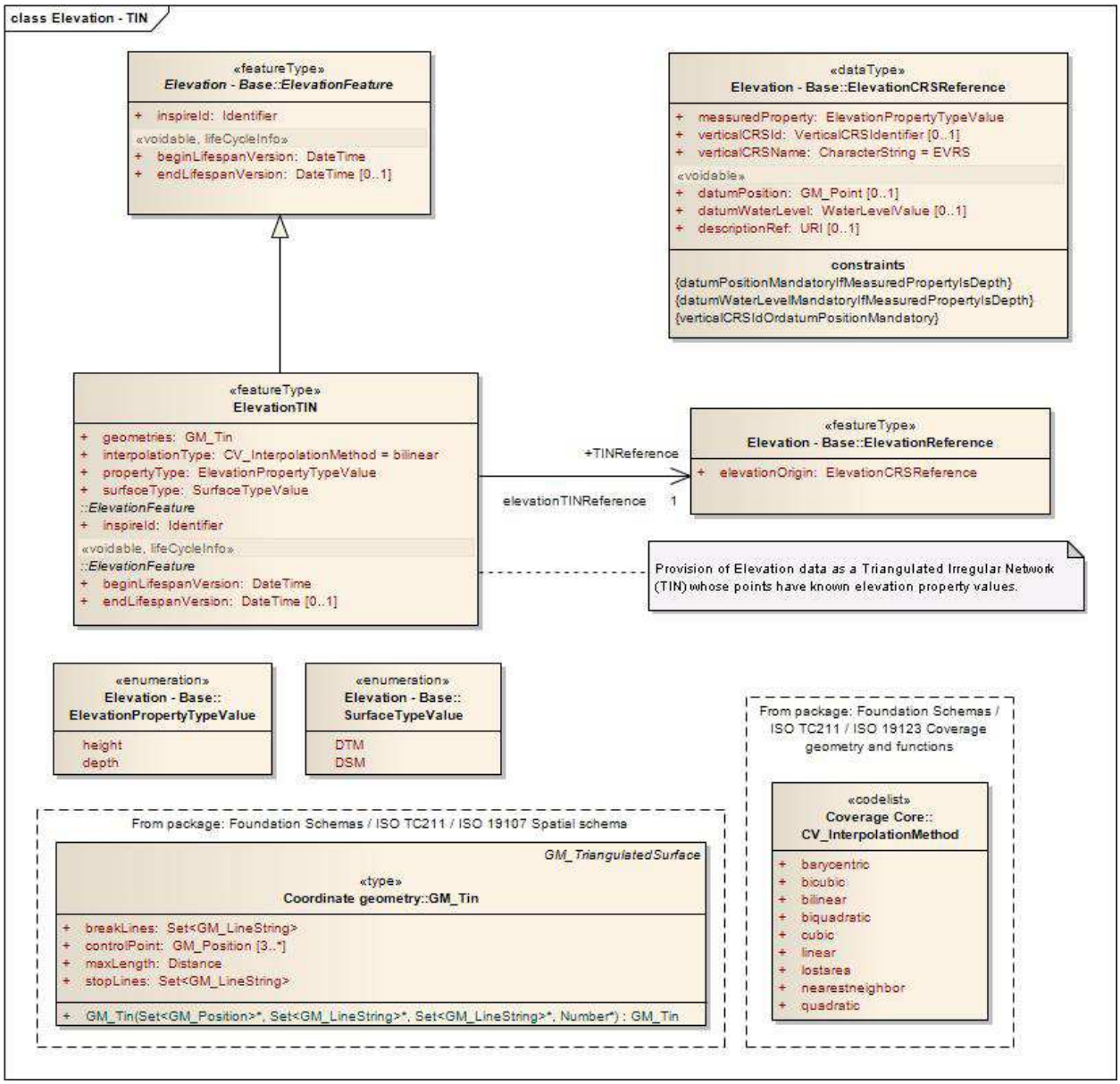


Figure 8 – UML class diagram: *Elevation – TIN* application schema – TIN structure

The previous diagram shows the structure defined in this specification for the provision of TIN **Elevation** data.

Access and use of TIN **Elevation** data is often limited to advanced technical users and is not as widespread as grid-base **Elevation** data does.

The basic component in this application schema, the **Elevation** TIN *(ElevationTIN)* feature type, is child of the abstract class *ElevationFeature* (Section 5.3.2.1.2) defined in the *Elevation – Base* application schema, from which it inherits common properties such as inspire identifier and lifecycle information attributes.

The *ElevationTIN* feature type defines a particular tessellation of the space based on a Triangulated Irregular Network according the complex type *GM_Tin* defined in ISO 19107:2003. It consists of a collection of vector geometries like control points (whose elevation property values are known), break lines and stop lines, in addition to the necessary parameters which allow calculating for example a Delaunay triangulation of a surface in a subsequent process. A Delaunay triangulation has triangles that are optimally equiangular in shape, and are generated in such a manner that the circumscribing circle containing each triangle contains no vertex points other than those at the vertices of the triangle.

An *ElevationTIN* is at least composed of 3 vertices (1 triangle). Modelling of void areas inside a TIN structure is possible by using an appropriate se of stop lines, preventing the generation of the triangles corresponding to that area.

At conceptual level, an *ElevationTIN* implicitly defines a coverage, i.e. a feature type which assigns elevation property values (coverage range) to the geometric elements forming part of the set of control points (coverage domain).

Moreover, this coverage may be considered as a continuous coverage, since this class also provides a mathematical method to interpolate elevation values for any direct position within its domain extent. The interpolation is calculated using the elevation values known for the vertices forming the TIN network (domain elements). The interpolation method recommended for the TIN is informed within the attribute *interpolationType*. Default interpolation method proposed for the **Elevation** TIN is bilinear.

5.6.1.3. Consistency between spatial data sets

All requirements and recommendations on **Elevation** defined in the *Elevation – Base* application schema (see Section 5.3.1.3) also apply to the elements/classes defined in this application schema.

5.6.1.4. Identifier management

All requirements and recommendations on **Elevation** defined in the *Elevation – Base* application schema (see Section 5.3.1.4) also apply to the elements/classes defined in this application schema.

5.6.1.5. Modelling of object references

This data specification does not provide specific rules for modelling object references between TIN models corresponding to different levels of detail.

5.6.1.6. Geometry representation

The geometry representation for **Elevation** coverages is identified by the data structures defined for vector objects in this specification (see Section 5.4.1.6).

5.6.1.7. Temporality representation

All requirements and recommendations on **Elevation** defined in the *Elevation – Base* application schema (see Section 5.3.1.7) also apply to the elements/classes defined in this application schema.

5.6.2 Feature catalogue

Table 3 - Feature catalogue metadata

Feature catalogue name	INSPIRE feature catalogue Elevation - TIN
Scope	Elevation - TIN
Version number	2.0
Version date	2011-06-10
Definition source	INSPIRE data specification Elevation - TIN

Table 4 - Types defined in the feature catalogue

Type	Package	Stereotypes	Section
ElevationTIN	Elevation - TIN	«featureType»	5.6.2.1.1

5.6.2.1. Spatial object types

5.6.2.1.1. ElevationTIN

ElevationTIN	
Subtype of:	ElevationFeature
Definition:	Elevation feature using a particular tessellation of the space based on a Triangulated Irregular Network according the type GM_Tin (from ISO 19107:2003) which describes a Delaunay triangulation, mainly composed of a set of control points whose elevation property values are known.
Description:	NOTE 1 A coverage is a feature type that acts as a function to return an elevation property value from its range for any direct position within its spatial, temporal or spatiotemporal domain (adapted from "Coverage" [ISO 19123:2005]). At conceptual level, an elevation TIN implicitly defines a coverage: a feature type which assigns elevation property values (coverage range) to the geometric elements forming part of the set of control points (coverage domain). Moreover, this coverage may be considered as a continuous coverage, since the elevation TIN provides a mathematical method to interpolate elevation values for any direct position within its domain extent from the elevation values known for the vertices forming the TIN network (domain elements). NOTE 2 The basic idea of a TIN is to partition the convex hull of the points in the domain of a discrete point coverage into a computationally unique set of non-overlapping triangles. Each triangle is formed by three of the points in the domain of the discrete point coverage. The Delaunay triangulation method is commonly used to produce TIN tessellations with triangles that are optimally equiangular in shape, and are generated in such a manner that the circumscribing circle containing each triangle contains no point of the discrete point coverage other than those at the vertices of the triangle [ISO 19123:2005].
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Attribute: geometries	
Value type:	GM_Tin
Definition:	Represents the collection of geometric properties of the elevation TIN feature.
Multiplicity:	1
Attribute: interpolationType	
Value type:	CV_InterpolationMethod
Definition:	Mathematical method which shall be used to evaluate a continuous coverage, i.e. determine the values of the coverage at any direct position within the domain of the coverage.

ElevationTIN	
Description:	EXAMPLE Evaluation of a triangulated irregular network in a certain location involves interpolation of values within a triangle (which contains this location) composed of three neighbouring point value pairs (triangle vertices). NOTE The list of possible values for interpolation methods is defined in ISO 19123:2005 - Annex C (Interpolation methods). Default value provided in this specification is "bilinear".
Multiplicity:	1

Attribute: propertyType	
Value type:	ElevationPropertyTypeValue
Definition:	An elevation property which has been measured or calculated.
Description:	NOTE 1 An elevation property is a vertically-constrained dimensional property of an element consisting of an absolute measure referenced to a well-defined surface which is commonly taken as origin (geoid, water level, etc.). It does not include relative elevations of the element referenced to other spatial objects. EXAMPLE Height, depth. NOTE 2 It describes the type of property of the values provided within the elevation coverage.
Multiplicity:	1

Attribute: surfaceType	
Value type:	SurfaceTypeValue
Definition:	Attribute indicating the type of elevation surface that the coverage describes in relation to the terrain.
Multiplicity:	1

Association role: TINReference	
Value type:	ElevationReference
Definition:	The elevation reference to which the measured property values (heights or depths) of the elevation TIN are referenced to.
Multiplicity:	1

5.6.2.2. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

5.6.2.2.1. CV_InterpolationMethod

CV_InterpolationMethod	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19123 Coverage geometry and functions::ISO 19123:2005 Coverages::Coverages::Coverage Core [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.6.2.2.2. ElevationFeature

ElevationFeature (abstract)	
Package:	ANNEX II + III::Themes::Annex II::Elevation::Elevation - Base [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

ElevationFeature (abstract)	
Definition:	Element included within an elevation data set which takes part in the description of a land, ice and/or ocean surface in terms of a dimensional property linked to the vertical component (height, depth).

5.6.2.2.3. ElevationPropertyTypeValue

ElevationPropertyTypeValue	
Package:	ANNEX II + III::Themes::Annex II::Elevation::Elevation - Base [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Enumeration types which determine the elevation property which have been measured or calculated.
Description:	NOTE 1 An elevation property is a vertically-constrained dimensional property of an element consisting of an absolute measure referenced to a well-defined surface which is commonly taken as origin (geoid, water level, etc.). NOTE 2 It does not include relative elevations of the element referenced to other spatial objects. EXAMPLE Height, depth.

5.6.2.2.4. ElevationReference

ElevationReference	
Package:	ANNEX II + III::Themes::Annex II::Elevation::Elevation - Base [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Reference to the origin used to refer the elevation values associated to an object.

5.6.2.2.5. GM_Tin

GM_Tin	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107 Spatial Schema::ISO 19107:2003 Spatial Schema:: Geometry::Coordinate geometry [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.6.2.2.6. SurfaceTypeValue

SurfaceTypeValue	
Package:	ANNEX II + III::Themes::Annex II::Elevation::Elevation - Base [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Enumeration types specifying the surface for which elevation property values are provided, with regard to its relative position from the terrain (Earth's surface).

6 Reference systems

6.1 Coordinate reference systems

6.1.1 Datum

IR Requirement 2 For the coordinate reference systems used for making available the INSPIRE spatial data sets, the datum shall be the datum of the European Terrestrial Reference System 1989 (ETRS89) in areas within its geographical scope, and the datum of the International Terrestrial Reference System (ITRS) or other geodetic coordinate reference systems compliant with ITRS in areas that are outside the geographical scope of ETRS89. Compliant with the ITRS means that the system definition is based on the definition of the ITRS and there is a well established and described relationship between both systems, according to EN ISO 19111.

6.1.2 Coordinate reference systems

IR Requirement 3 INSPIRE spatial data sets shall be made available using one of the three-dimensional, two-dimensional or compound coordinate reference systems specified in the list below.

Other coordinate reference systems than those listed below may only be used for regions outside of continental Europe. The geodetic codes and parameters for these coordinate reference systems shall be documented, and an identifier shall be created, according to EN ISO 19111 and ISO 19127.

1. Three-dimensional Coordinate Reference Systems
   - Three-dimensional Cartesian coordinates
   - Three-dimensional geodetic coordinates (latitude, longitude and ellipsoidal height), using the parameters of the GRS80 ellipsoid

2. Two-dimensional Coordinate Reference Systems
   - Two-dimensional geodetic coordinates, using the parameters of the GRS80 ellipsoid
   - Plane coordinates using the Lambert Azimuthal Equal Area projection and the parameters of the GRS80 ellipsoid
   - Plane coordinates using the Lambert Conformal Conic projection and the parameters of the GRS80 ellipsoid
   - Plane coordinates using the Transverse Mercator projection and the parameters of the GRS80 ellipsoid

3. Compound Coordinate Reference Systems
   - For the horizontal component of the compound coordinate reference system, one of the two-dimensional coordinate reference systems specified above shall be used
   - For the vertical component on land, the European Vertical Reference System (EVRS) shall be used to express gravity-related heights within its geographical scope
   - Other vertical reference systems related to the Earth gravity field shall be used to express gravity-related heights in areas that are outside the geographical scope of EVRS. The geodetic codes and parameters for these vertical reference systems shall be documented and an identifier shall be created, according to EN ISO 19111 and ISO 19127
   - For the vertical component measuring the depth of the sea floor, where there is an appreciable tidal range, the Lowest Astronomical Tide shall be used as reference surface. In marine areas

without an appreciable tidal range, in open oceans and effectively in waters that are deeper than 200 m, the depth of the sea floor shall be referenced to the Mean Sea Level
- For the vertical component measuring depths above the sea floor in the free ocean, barometric pressure shall be used
- For the vertical component in the free atmosphere, barometric pressure, converted to height using ISO 2533:1975 International Standard Atmosphere shall be used

6.1.3 Display

IR Requirement 4 For the display of the INSPIRE spatial data sets with the View Service specified in D003152/02 Draft Commission Regulation implementing Directive 2007/2/EC of the European Parliament and of the Council as regards Network Services, at least the two dimensional geodetic coordinate system shall be made available.

6.1.4 Identifiers for coordinate reference systems

IR Requirement 5 For referring to the non-compound coordinate reference systems listed in this Section, the identifiers listed below shall be used.

For referring to a compound coordinate reference system, an identifier composed of the identifier of the horizontal component, followed by a slash (/), followed by the identifier of the vertical component, shall be used.

- ETRS89-XYZ for Cartesian coordinates in ETRS89
- ETRS89-GRS80h for three-dimensional geodetic coordinates in ETRS89 on the GRS80 ellipsoid
- ETRS89-GRS80 for two-dimensional geodetic coordinates in ETRS89 on the GRS80
- EVRS for height in EVRS
- LAT for depth of the sea floor, where there is an appreciable tidal range
- MSL for depth of the sea floor, in marine areas without an appreciable tidal range, in open oceans and effectively in waters that are deeper than 200m
- ISA for pressure coordinate in the free atmosphere
- PFO for Pressure coordinate in the free ocean
- ETRS89-LAEA for ETRS89 coordinates projected into plane coordinates by the Lambert Azimuthal Equal Area projection
- ETRS89-LCC for ETRS89 coordinates projected into plane coordinates by the Lambert Conformal Conic projection
- ETRS89-TMzn for ETRS89 coordinates projected into plane coordinates by the Transverse Mercator projection

6.2 Temporal reference system

IR Requirement 6 The Gregorian Calendar shall be used for as a reference system for date values, and the Universal Time Coordinated (UTC) or the local time including the time zone as an offset from UTC shall be used as a reference system for time values.

6.3 Theme-specific requirements and recommendations on reference systems

INSPIRE Data specification on Coordinate reference systems v3.1 states the following requirements on geodetic reference systems which shall be taken into account for every INSPIRE data set:

- *Requirement 1* - For the three-dimensional and two-dimensional (horizontal component) coordinate reference systems, the European Terrestrial Reference System 1989 (ETRS89) shall be used for the areas within the geographical scope of ETRS89.

- *Requirement 2* - The International Terrestrial Reference System (ITRS) or other geodetic coordinate reference systems compliant with ITRS shall be used in areas that are outside the geographical scope of ETRS89

These statements on geodetic reference systems apply to both, INSPIRE Land-Elevation and Bathymetry data sets.

6.3.1 Land-Elevation

As regards land elevation, the mentioned data specification document also establishes the following requirements:

- *Requirement 8* - For the vertical component on land, the European Vertical Reference System (EVRS) shall be used to express gravity-related heights for the areas within the geographical scope of EVRS.

- *Requirement 9* - Other vertical reference systems related to the Earth gravity field shall be used to express gravity-related heights in areas that are outside the geographical scope of EVRS.

In the light of these statements and those requirements and recommendations stated in *Section 5.2.2 (Map projections)* of the same document, this data specification formulates the following recommendations:

Recommendation 3	For pan-European global *Elevation* datasets the compound CRS ETRS89-GRS80/EVRS is recommended, for areas that are in the geographical scope of ETRS89.

Recommendation 4	For regional European *Elevation* datasets, covering specific parts of countries, the compound CRS ETRS89-TMzn/EVRS is recommended, for areas that are in the geographical scope of ETRS89.

ETRS89- GRS80/EVRS means two-dimensional ETRS89 geodetic coordinates on the GRS80 ellipsoid to describe the position in planimetry, and a value in metres to specify the EVRS height to describe the position in altimetry.

ETRS89-TMzn/EVRS means two-dimensional ETRS89 coordinates projected by the Tranverse Mercator Projection (N, E) to describe the position in planimetry, and a value in metres to specify the EVRS height to describe the position in altimetry.

Recommendation 5	The Earth Gravitational Model (EGM Version 2008) is recommended as height datum for areas that are outside the geographical scope of ETRS89.

6.3.2 Bathymetry

Section 6.1.2 point 3 (*Compound Coordinate Reference Systems*) includes two statements concerning bathymetry datums as requirements. The statements are:

- *For the vertical component measuring the depth of the sea floor, where there is an appreciable tidal range, the Lowest Astronomical Tide shall be used as reference surface. In marine areas without an appreciable tidal range, in open oceans and effectively in waters that are deeper than 200 m, the depth of the sea floor shall be referenced to the Mean Sea Level*.
- *For the vertical component measuring depths above the sea floor in the free ocean, barometric pressure shall be used*.

Open issue 5: Requirements on depth measurement
These two statements are neither established as requirements in the Implementing rule on interoperability of spatial data sets and services nor in the INSPIRE Data specification on Coordinate reference systems v3.1. In fact, in the last document these statements are suggested as a starting point for discussion during INSPIRE Annex II and III TWG work.
Therefore this issue should be clarified and these statements discussed between TWG EL and other TWGs involved, and the template for INSPIRE data specifications updated consequently.

Recommendation 6 The *Lowest Astronomical Tide (LAT)* reference surface is recommended for bathymetry data sets in areas where this surface is determined.

6.3.3 Identification of the coordinate reference system used to refer *Elevation* spatial objects

The mentioned distinctions between areas inside and outside the scope of ETRS89 and EVRS make the identification of the coordinate reference system used necessary.

As regards compound coordinate reference systems used for the INSPIRE data sets, *INSPIRE Data specification on Coordinate reference systems v3.1 Requirement 11* states that Member States shall make available information as to which system they use, and that the geodetic codes and parameters they used shall be documented according to ISO 19111:2007 and ISO 19127:2005.

A full definition and description of the vertical coordinate reference system used to provide *Elevation* data is outside the scope of this specification. In the case where a Member State uses a vertical reference system different from EVRS, it shall provide this information using the appropriate mechanisms according the ISO standards, as stated before.

In the absence of an official INSPIRE European registry for coordinate reference systems, this specification provides a simple mechanism to identify the vertical CRS used for each *Elevation* vector spatial object, Grid coverage or TIN structure. Despite this kind of information usually being included as data set level metadata, it is relatively frequent to find elevation data sets combining land elevations and bathymetry data, or combining data from different sources. When this kind of combination is found, there is a need to provide information about the vertical reference for heights/depths for each spatial object or set of spatial objects.

The next figure illustrates the basic classes composing this mechanism, which are included and defined within the *Elevation – Base* application schema: the *ElevationReference* feature type and the *ElevationCRSReference* data type (described in Sections 5.3.2.1.3 and 5.3.2.2.1, respectively).

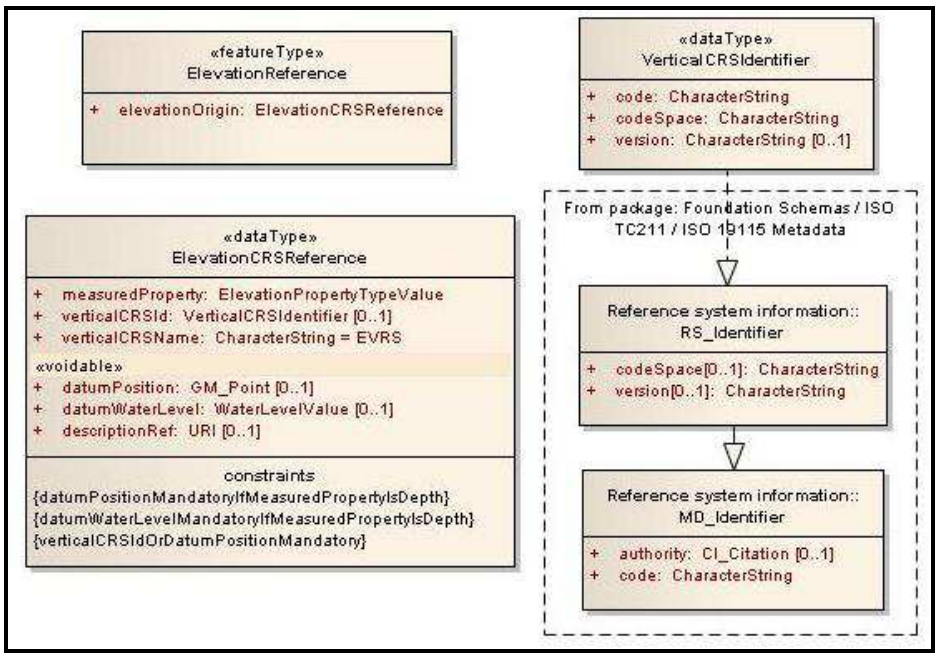


Figure 9 – Identification of vertical CRS used: *ElevationReference* and *ElevationCRSReference* classes

There are two alternative methods available within this mechanism in order to identify the vertical CRS used to refer elevation values:

1. Using an attribute of type *ElevationCRSReference* data type to identify the vertical CRS. The elevation values provided for the spatial object are referenced to the vertical CRS identified by the former attribute.
2. Linking the feature type having the elevation value to the *ElevationReference* feature type, by means of an association (see the *elevationVectorReference*, *elevationGridReference* and *elevationTINReference* associations in diagrams in Sections 5.4.1.2, 5.5.1.2 and 5.6.1.2 Section 5.3.1.7). The *ElevationReference* feature type contains the attribute *elevationOrigin*, which identifies the vertical CRS by using the mechanism 1.

   This is the method particularly used in the *Elevation* model, where e.g. in the case of 2-D vector objects the *propertyValue* attribute contains the elevation value. The feature types (representing these vector objects) having this attribute are associated to *ElevationReference* through the *elevationVectorReference* association (diagram in Section 5.4.1.2).

When using the first method the information about the vertical CRS is included as an attribute, contained by each spatial object having an elevation value. Therefore the information about the vertical reference is repeated for each instance having this specific CRS.

When the second method is used, each vertical CRS used in the data set is stored only once. Every spatial object having its elevation value referenced to a specific elevation CRS is linked to the corresponding CRS by means of an association (e.g. the *elevationVectorReference* association, in the case of the *Elevation* - *Vector elements* application schema).

Both methods are available for other INSPIRE themes to introduce elevation values in their models and provide information about the vertical CRS to which those values are referenced.

The information about the vertical CRS is included within the *ElevationCRSReference* data type, which has these main items:

- Attribute *measuredProperty* - Two types of vertical CRSs are distinguished in this specification: height and depth CRS. This attribute is intended to inform this distinction for a specific vertical CRS.

- Attribute *verticalCRSId*, of type *VerticalCRSIdentifier*, which is a profile of *RS_Identifier* (defined in ISO 19115) defined in this specification as a simplification - To introduce the CRS identifier associated to an existing namespace or registry (e.g. like the EPSG code or any other available in the MS).
- Attribute *verticalCRSName*, of type *CharacterString* - To introduce a text identifying the vertical CRS. The default value of this attribute is 'EVRS', since the CRS will be often EVRS.
- Attribute *descriptionRef*, of type *URI* - To introduce optionally a link to an external reference to an information resource where the vertical CRS is described.

The following items shall be additionally provided in the case of datums establishing a CRS for depths (chart datums):

- Attribute *datumPosition*, of type *GM_Point* - Containing the ETRS89 X Y coordinates together with the EVRS height of the datum point. It is introduced to determine approximately the shift between depth values referenced to a specific depth datum and the EVRS datum. Note this shift is approximate and applicable only at local level, like the functional extent of a chart datum.
- Attribute *datumWaterLevel* - To introduce the water level taken as reference for bathymetry values referred to the depth datum. The possible values of this attribute are controlled by the *WaterLevelValue* code list, which is defined by TWG Hydrography and mainly based on well-defined tide levels.

A constraint is defined regarding the attributes *verticalCRSId* and *datumPosition*: All elevation CRS references must have either a vertical CRS identifier or a datum position.

IR Requirement 7	The identifier of the vertical CRS, a code with which the CRS is registered in an external namespace or registry (e.g. like EPSG), is mandatory and shall be included within the attribute *verticalCRSId*. Exceptions to this are local bathymetric CRSs used to refer depths in lakes.

The *verticalCRSId* attribute is of type *VerticalCRSIdentifier*; for simplicity reasons, this data type is a profile (subset) of the data type *RS_Identifie*r defined in ISO 19115.

This data type is composed of 3 attributes:
- *code*: identifier of the vertical CRS in the namespace or registry.
- *codeSpace*: identification of the namespace or registry.
- *version*: version of the vertical CRS, if any.

As stated before, the *ElevationCRSReference* allows the possibility to reference the vertical CRS in any existing registry. It may be a national registry or the future INSPIRE registry of Coordinate Reference Systems. However, by the time being, the registry used more often is the EPSG (European Petroleum Survey Group) registry. This registry may be accessed on *www.epsg-registry.org*

EXAMPLE

A data producer provides a spatial object with an elevation measure in EVRF 2007 (that is a realisation of EVRS, the vertical CRS mandated by INSPIRE to refer gravity-related absolute heights within the continental Europe) and indicates the vertical CRS by using a reference to the EPSG registry.

☐	EVRF2007 height	EPSG::5621	VerticalCRS	Valid	Europe: Andorra; Austria; Belgium; Bosnia and Herzegovina; Bulgaria; Croatia; Czech Republic; Denmark; Estonia; Finland; France - mainland; Germany; Hungary; Italy - mainland and Sicily; Latvia; Liech...

Figure 10 – Extract from an EPSG register (EPSG registry)

The data type *VerticalCRSReference* may be informed as follows:

- *measuredProperty*: Height
- *verticalCRSId*
  - *code*: EPSG::5621
  - *nameSpace*: EPSG
  - *version*:
- *verticalCRSName*: EVRS
- *datumPosition*: <EMPTY>
- *datumWaterLevel:* <EMPTY>
- *descriptionRef:* <EMPTY>

6.4 Theme-specific requirements and recommendations on geographical grids

As a referencing framework for Pan-European <*Theme Name*> theme data sets aimed at cross-border purposes, the Grid_ETRS89-GRS80 based on ETRS89 geodetic coordinates as defined in Annex C is recommended for data provision in order to obtain continuous-seamless data. Real time re-projection is recommended for display through the view services serving these data sets.

Annex C also explains the need to establish such a common grid.

7 Data quality

This chapter includes a description of data quality elements and sub-elements as well as the associated data quality measures (section 7.1). The selected data quality measures should be used to evaluate quality of data sets for a specific data quality element / sub-element. The evaluation can be performed at the level of spatial object, spatial object type, dataset or dataset series.

The results of the evaluation are then reported at the spatial object type or dataset level in metadata utilising the same data quality elements and measures (see chapter 8).

NOTE The selection of appropriate data quality measures represents the first step towards the harmonisation of documenting data quality.

In addition, for some of the data quality elements described in section 7.1, minimum data quality requirements or recommendations may be defined. These are described in the section 1.2.

Recommendation 7 If data quality information is required at spatial object level then it should be modelled in the data model as an attribute of a relevant spatial object type.

7.1 Data quality elements and measures

Recommendation 8 To evaluate and report the data quality of data sets related to the spatial data theme **Elevation**, the elements and measures listed in Table 1 should be used.

Table 2 – Data quality elements for evaluating and reporting the data quality of data sets related to the spatial data theme Elevation

Section	Data quality element and sub-element	Applicable to Data formats		
		Vector	Grid	TIN
7.1.1	Completeness – Commission	■		■
7.1.2	Completeness – Omission	■	■	■
7.1.3	Logical Consistency – Topological consistency	■		■
7.1.4	Positional accuracy – Absolute or external accuracy	Planimetry ■	Planimetry ■	Planimetry ■
		Altimetry ■		Altimetry ■
7.1.5	Positional accuracy – Gridded data position accuracy		Altimetry ■	
7.1.6	Logical consistency – Domain consistency	■		■
7.1.7	Logical consistency – Format consistency	■	■	■
7.1.8	Thematic accuracy – Classification correctness	■	■	■

7.1.1 Completeness – Commission

Commission should be documented using the rate of excess items.

Name	**Rate of excess items**
Alternative name	–
Data quality element	Completeness
Data quality sub-element	Commission
Data quality basic measure	Error rate
Definition	Number of excess items in the dataset in relation to the number of items that should have been present.
Description	–
Evaluation scope	data set data set series
Reporting scope	data set data set series
Parameter	–
Data quality value type	Real, percentage, ratio (example: 0,0189 ; 98,11% ; 11:582)
Data quality value structure	–
Source reference	–
Example	-
Measure identifier	3 (ISO 19138)

7.1.2 Completeness – Omission

Omission should be documented using the rate of missing items.

Name	**Rate of missing items**
Alternative name	–
Data quality element	Completeness
Data quality sub-element	Omission
Data quality basic measure	Error rate
Definition	Number of missing items in the dataset in relation to the number of items that should have been present.
Description	-
Evaluation scope	spatial object type: ContourLine data set data set series
Reporting scope	spatial object type: ContourLine data set data set series
Parameter	–
Data quality value type	Real, percentage, ratio (example: 0,0189 ; 98,11% ; 11:582)
Data quality value structure	–
Source reference	–
Example	-
Measure identifier	7 (ISO 19138)

7.1.3 Logical Consistency – Topological consistency

This specification uses the topological consistency data quality sub-element to evaluate the quality and connectivity of linear spatial objects (linear vector objects within vector format or TIN structures).

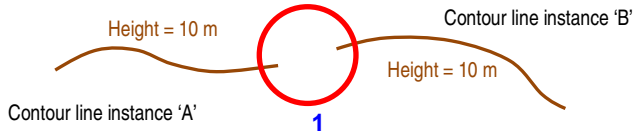
Topological consistency should be documented using the following measures: Rate of missing connections due to undershoots; Rate of missing connections due to overshoots; Rate of invalid self-intersect errors; Rate of invalid self-overlap errors. They should be evaluated at spatial data set level.

7.1.3.1. Rate of missing connections due to undershoots

This measure is applicable to linear spatial objects which shall be connected (e.g. connected contour line instances corresponding to the same elevation).

It is explicitly defined in this data specification and directly derived from a data quality measure identified in ISO 19138:2006.

Name	**Rate of missing connections due to undershoots**
Alternative name	Undershoots rate
Data quality element	Logical consistency
Data quality sub-element	Topological consistency
Data quality basic measure	Error rate
Definition	Count of items in the dataset, within the parameter tolerance, that are mismatched due to undershoots divided by the total number of elements in the data set.
Description	Missing connections exceeding the parameter tolerance are considered as errors (undershoots) if the real linear elevation features have to be connected.
Evaluation scope	data set data set series
Reporting scope	data set data set series
Parameter	Name *Connectivity tolerance* Definition Search distance from the end of a dangling line. Description This parameter is specific for each data provider's dataset and must be reported as metadata in order to evaluate this data quality measure. The tolerance must be specified by the data provider using the following elements of the DQ_TopologicalConsistency metadata element for the current measure: - 102. measureDescription (type: free text): Defined as "*Description of the measure*". - 107. Result (type DQ_Result): Defined as "*Value (or set of values) obtained from applying a data quality measure or the outcome of evaluating the obtained value (or set of values) against a specified acceptable conformance quality level*". Specifically, the tolerance must be informed within the two elements, together with the result of the data quality measure:

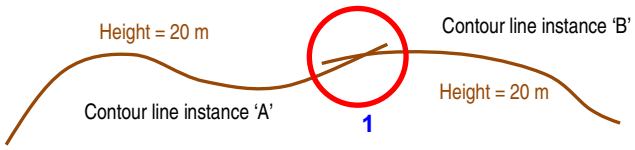
	- 130. specification - 131. explanation from DQ_Result class. Note: Metadata elements defined in ISO 19115.
Data quality value type	Real, percentage, ratio
Data quality value structure	-
Source reference	-
Example	Example – Connectivity between two consecutive contour line instances with the same height which have to be connected.  **Key** **1** Search tolerance is 3 m
Measure identifier	This measure is explicitly defined in this data specification. It is derived from data quality measure 23 from ISO 19138:2006.

7.1.3.2. Rate of missing connections due to overshoots

This measure is applicable to linear spatial objects which shall be connected (e.g. connected contour line instances corresponding to the same elevation).

It is explicitly defined in this data specification and directly derived from a data quality measure identified in ISO 19138:2006.

Name	**Rate of missing connections due to overshoots**
Alternative name	Overshoots rate
Data quality element	Logical consistency
Data quality sub-element	Topological consistency
Data quality basic measure	Error rate
Definition	Count of items in the dataset, within the parameter tolerance, that are mismatched due to overshoots divided by the total number of elements in the data set.
Description	Missing connections exceeding the parameter tolerance are considered as errors (overshoots) if the real linear elevation features have to be connected.
Evaluation scope	data set data set series
Reporting scope	data set data set series
Parameter	Name *Connectivity tolerance* Definition Search distance from the end of a dangling line. Description This parameter is specific for each data provider's dataset and must be reported as metadata in order to evaluate this data quality measure. The tolerance must be specified by the data provider using the following elements of the DQ_TopologicalConsistency metadata element for the current measure:

	- 102. measureDescription (type: free text): Defined as "*Description of the measure*". - 107. Result (type DQ_Result): Defined as "*Value (or set of values) obtained from applying a data quality measure or the outcome of evaluating the obtained value (or set of values) against a specified acceptable conformance quality level*". Specifically, the tolerance must be informed within the two elements, together with the result of the data quality measure: - 130. specification - 131. explanation from DQ_Result class. Note: Metadata elements defined in ISO 19115.
Data quality value type	Real, percentage, ratio
Data quality value structure	-
Source reference	-
Example	Example – Connectivity between two consecutive contour line instances with the same height which have to be connected.  **Key** **1** Search tolerance is 3 m
Measure identifier	This measure is explicitly defined in this data specification. It is derived from data quality measure 24 from ISO 19138:2006.

7.1.3.3. Rate of invalid self-intersect errors

This measure is applicable to all linear spatial objects and is used to evaluate the rate of illegal loops for these objects.

It is explicitly defined in this data specification and directly derived from a data quality measure identified in ISO 19138:2006.

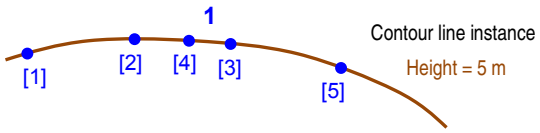
Name	**Rate of invalid self-intersect errors**
Alternative name	Loops rate
Data quality element	Logical consistency
Data quality sub-element	Topological consistency
Data quality basic measure	Error rate
Definition	Count of all items in the data that illegally intersect with themselves divided by the total number of elements in the data set.
Description	-
Evaluation scope	data set data set series
Reporting scope	data set data set series
Parameter	-
Data quality value type	Real, percentage, ratio
Data quality value structure	-
Source reference	-

Example	Example – Self-intersection of a contour line instance.  **Key** **1** Illegal intersection (loop)
Measure identifier	This measure is explicitly defined in this data specification. It is derived from data quality measure 26 from ISO 19138:2006.

7.1.3.4. Rate of invalid self-overlap errors

This measure is applicable to all linear spatial objects and is used to evaluate the rate of kickbacks for these objects.

It is explicitly defined in this data specification and directly derived from a data quality measure identified in ISO 19138:2006.

Name	**Rate of invalid self-overlap errors**
Alternative name	Kickbacks rate
Data quality element	Logical consistency
Data quality sub-element	Topological consistency
Data quality basic measure	Error rate
Definition	Count of all items in the data that illegally self overlap divided by the total number of elements in the data set.
Description	-
Evaluation scope	data set data set series
Reporting scope	data set data set series
Parameter	-
Data quality value type	Real, percentage, ratio
Data quality value structure	-
Source reference	-
Example	Example – Self-overlap of a contour line instance.  **Key** • Vertices [digitized order] **1** Illegal overlap (kickback)
Measure identifier	This measure is explicitly defined in this data specification. It is derived from data quality measure 27 from ISO 19138:2006.

7.1.4 Positional accuracy – Absolute or external accuracy

This specification uses the Absolute or external accuracy data quality sub-element (Root mean square error of planimetry measure) to evaluate the closeness of planimetric position of: vector objects within vector format data sets; vector objects within TIN structures; and geometric objects composing the domain (direct positions) of Grid coverages.

Absolute or external accuracy of planimetry should be documented using Root mean square error of planimetry.

Name	**Root mean square error of planimetry**
Alternative name	RMSEP
Data quality element	Positional accuracy
Data quality sub-element	Absolute or external accuracy
Data quality basic measure	Not applicable
Definition	Radius of a circle around the given point, in which the true value lies with probability P
Description	The true values of the observed coordinates *X* and *Y* are known as x_t and y_t. From this the estimator $\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left[(x_{mi}-x_t)^2+(y_{mi}-y_t)^2\right]}$ yields to the linear root mean square error of planimetry RMSEP = σ
Evaluation scope	spatial object: SpotHeight, SpotDepth, ContourLine, DepthContour, BreakLine spatial object type: SpotHeight, SpotDepth, ContourLine, DepthContour, BreakLine, ElevationGridCoverage data set data set series
Reporting scope	spatial object type: SpotHeight, SpotDepth, ContourLine, DepthContour, BreakLine, ElevationGridCoverage data set data set series
Parameter	-
Data quality value type	Measure
Data quality value structure	-
Source reference	-
Example	-
Measure identifier	47 (ISO 19138:2006)

This specification uses the Absolute or external accuracy data quality sub-element (Root mean square error measure) to evaluate the closeness of altimetric position (or elevation values) of: vector objects within vector format data sets; and vector objects within TIN structures.

Absolute or external accuracy of altimetry should be documented using Root mean square error.

Name	**Root mean square error**
Alternative name	RMSE
Data quality element	Positional accuracy
Data quality sub-element	Absolute or external accuracy
Data quality basic measure	Not applicable
Definition	Standard deviation, where the true value is not estimated from the observations but known *a priori*
Description	The true value of an observable Z is known as z_t. From this, the estimator: $\sigma_z = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(Z_{mi} - z_t)^2}$ yields to the linear root mean square error RMSE = σ_z.
Evaluation scope	spatial object: SpotHeight, SpotDepth, ContourLine, DepthContour, BreakLine spatial object type: SpotHeight, SpotDepth, ContourLine, DepthContour, BreakLine data set data set series
Reporting scope	spatial object type: SpotHeight, SpotDepth, ContourLine, DepthContour, BreakLine data set data set series
Parameter	-
Data quality value type	Measure
Data quality value structure	-
Source reference	-
Example	-
Measure identifier	39 (ISO 19138:2006)

7.1.5 Positional accuracy – Gridded data position accuracy

This specification uses the Gridded data position accuracy data quality sub-element (Root mean square error measure) to evaluate the closeness of altimetry position (or elevation values) of the values composing the range (grid values) of Grid coverages.

Gridded data position accuracy of altimetry should be documented using Root mean square error.

Name	**Root mean square error**
Alternative name	RMSE
Data quality element	Positional accuracy
Data quality sub-element	Gridded data position accuracy
Data quality basic measure	Not applicable
Definition	Standard deviation, where the true value is not estimated from the observations but known *a priori*
Description	The true value of an observable Z is known as z_t. From this, the estimator: $\sigma_z = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(Z_{mi} - z_t)^2}$ yields to the linear root mean square error RMSE = σ_z.
Evaluation scope	spatial object: ElevationGridCoverage spatial object type: ElevationGridCoverage data set data set series
Reporting scope	spatial object type: ElevationGridCoverage data set data set series
Parameter	-
Data quality value type	Measure
Data quality value structure	-
Source reference	-
Example	-
Measure identifier	39 (ISO 19138:2006)

7.1.6 Logical consistency – Domain consistency

Domain consistency should be documented using Value domain nonconformance rate.

Name	**Value domain nonconformance rate**
Alternative name	-
Data quality element	Logical consistency
Data quality subelement	Domain consistency
Data quality basic measure	Error rate
Definition	Number of items in the dataset that are not in conformance with their value domain in relation to the total number of items.
Description	-
Evaluation scope	data set data set series
Reporting scope	data set data set series
Parameter	-
Data quality value type	Real, percentage, ratio
Data quality value structure	-
Source reference	-
Example	-
Measure identifier	18 (ISO 19138:2006)

7.1.7 Logical consistency – Format consistency

Format consistency should be documented using Physical structure conflict rate.

Name	**Physical structure conflict rate**
Alternative name	-
Data quality element	Logical consistency
Data quality subelement	Format consistency
Data quality basic measure	Error rate
Definition	Number of items in the dataset that are stored in conflict with the physical structure of the dataset divided by the total number of items.
Description	-
Evaluation scope	data set data set series
Reporting scope	data set data set series
Parameter	-
Data quality value type	Real, percentage, ratio
Data quality value structure	-
Source reference	-
Example	-
Measure identifier	20 (ISO 19138:2006)

7.1.8 Thematic accuracy – Classification correctness

Classification correctness should be documented using Misclassification rate.

Name	**Misclassification rate**
Alternative name	-
Data quality element	Thematic accuracy
Data quality subelement	Classification correctness
Data quality basic measure	Error rate
Definition	Number of incorrectly classified features in relation to the number of features that are supposed to be there.
Description	-
Evaluation scope	data set data set series
Reporting scope	data set data set series
Parameter	-
Data quality value type	Real, percentage, ratio
Data quality value structure	-
Source reference	-
Example	-
Measure identifier	61 (ISO 19138:2006)

7.2 Minimum data quality requirements and recommendations

7.2.1 Data quality targets

IR Requirement 8 For the data quality elements listed in Table 3, all data sets related to the spatial data theme **Elevation** shall meet the specified target results.

Table 3 – Data quality elements and measures for which minimum data quality requirements are defined for the spatial data theme Elevation

Section	Data quality element and sub-element	Measure name(s)	Target result(s)	Condition
7.1.1	Completeness – Commission	Rate of excess items	Under discussion	Under discussion
7.1.2	Completeness – Omission	Rate of missing items	Under discussion	Under discussion
7.1.3	Logical Consistency – Topological consistency	Rate of missing connections due to undershoots	Under discussion	Under discussion
		Rate of missing connections due to overshoots	Under discussion	Under discussion
		Rate of invalid self-intersect errors	Under discussion	Under discussion
		Rate of invalid self-overlap errors	Under discussion	Under discussion
7.1.4	Positional accuracy – Absolute or external accuracy	Root mean square error of planimetry	Under discussion	Under discussion
		Root mean square error	Under discussion	Under discussion
7.1.6	Positional accuracy – Gridded data position accuracy	Root mean square error	Under discussion	Under discussion

Recommendation 9 For the data quality elements listed in Table 4, all data sets related to the spatial data theme **Elevation** should meet the specified target results.

Table 4 – Data quality elements and measures for which minimum data quality recommendations are defined for the spatial data theme Elevation

Section	Data quality element and sub-element	Measure name(s)	Target result(s)	Condition
7.1.6	Logical consistency - Domain consistency	Value domain nonconformance rate	Under discussion	Under discussion
7.1.7	Logical consistency - Format consistency	Physical structure conflict rate	Under discussion	Under discussion
7.1.8	Thematic accuracy - Classification correctness	Misclassification rate	Under discussion	Under discussion

7.2.2 Additional minimum data quality recommendations

7.2.2.1. Elevation Vector elements (Land elevations)

7.2.2.1.1. Density of elevation information

Relations regarding the contour line equidistance (vertical interval) and quality (scale of mapping) can be specified between:

- Contour distance and scale of mapping, taking into consideration different types of terrain (flat, undulating, hilly, mountainous).

Table 5 – Vertical interval of contour lines for different levels of detail (map scales)

Topographic map 1:10 000 (1:5 000)	
1.25 m	terrain: flat (with slopes < 2 degrees) und undulating (with slopes 2 - 6 degrees)
2.5 m	terrain: hilly (with slopes 6 – 12 degrees)
5 m	terrain: mountainous (with slopes > 12 degrees)
Topographic map 1:25 000	
1.25 m	terrain: flat (with slopes < 2 degrees)
2.5 m	terrain: undulating (with slopes 2 - 6 degrees)
5 m	terrain: hilly (with slopes 6 – 12 degrees)
10 m	terrain: mountainous (with slopes > 12 degrees)
Topographic map 1:50 000	
2.5 m	terrain: flat (with slopes < 2 degrees)
5 m	terrain: undulating (with slopes 2 - 6 degrees)
10 m	terrain: hilly (with slopes 6 – 12 degrees)
20 m	terrain: mountainous (with slopes > 12 degrees)

Recommendation 10 **Elevation** theme data sets describing the land surface should have a vertical interval consistent with the level of detail (scale of mapping) of the data set and the type of terrain - as proposed in Table 5.

- Contour distance and vertical accuracy, taking into consideration the slope of terrain surface.

  Elevation interpolated from a contour map should have at least a vertical accuracy (RMS_v) of:

Table 6 – Consistency between vertical accuracy and contour line vertical interval

Vertical accuracy (RMS_v) *	***Type of terrain***
1/3 of contour equidistance	Flat terrain (slope < 2 degrees)
2/3 of contour equidistance	Undulating terrain (slope 2-6 degrees)
1 contour equidistance	Hilly terrain (slope 6-12 degrees) and mountainous terrain (slope > 12 degrees)

***** In wooded areas these figures can be increased by 50%.

Recommendation 11 **Elevation** theme data sets describing the land surface should have a vertical accuracy (RMS_v) consistent with the contour line vertical interval and the type of terrain - as proposed in Table 6.

7.2.2.2. Elevation Coverages (Grids)

7.2.2.2.1. Grid spacing

The linear grid spacing of a DTM having a GRID structure should be consistent with its vertical accuracy, expressed as RMS_v (vertical Root Mean Square).

The recommended relation between grid spacing of the DTM and its related RMS_v should be as following:

- Grid spacing not longer than (approximately) 20 times RMS_v and not smaller than 3 times RMS_v - for flat and undulating terrain.
- Grid spacing not longer than (approximately) 10 times RMS_v and not smaller than 3 times RMS_v - for hilly and mountainous terrain.

Table 7 – Recommended grid spacing in relation to vertical accuracy (RMSv)

Recommended Grid spacing	***Type of terrain***
3 times RMS_v ≤ Grid spacing ≤ 20 times RMS_v	Flat and undulating terrain
3 times RMS_v ≤ Grid spacing ≤ 10 times RMS_v	Hilly and mountainous terrain

Recommendation 12 **Elevation** theme grid DTM models should have a grid spacing consistent with its vertical accuracy (RMS_v) and the type of terrain - as proposed in Table 7.

7.2.2.3. Elevation TIN structures

No recommendations on minimum data quality are defined in this data specification for TIN structures.

7.2.2.4. Bathymetry-specific objects

Bathymetry grid quality is divided into four different classes, named as Orders:

Table 8 – Different orders for bathymetry and corresponding quality requirements

Order	Description of areas	RMS_v
Special	Areas where under keel clearance is critical.	a = 0.25 m b = 0.0075
1a	Areas shallower than 100 m where under keel clearance is less critical but features of concern to surface shipping may exist.	a = 0.5 m b = 0.013
1b	Areas shallower than 100 m where under- keel clearance is not considered to be an issue for the type of surface shipping expected to transit the area.	a = 0.5 m b = 0.013 m
2	Areas generally deeper than 100 metres where a general description of the sea floor is considered adequate.	a = 1.0 m b = 0.023

RMS_v is computed as: $\frac{\sqrt{a^2 + (b \cdot d)^2}}{2}$ with d = depth in meters.

Recommendation 13 **Elevation** theme data sets describing the sea floor should have a vertical accuracy (RMS_v) consistent with the computed values relative to depth - as proposed in Table 13.

This quality recommendation is generic for both, vector and gridded bathymetric data, however:

- For Orders *Special* and *1A*, a full seafloor search is required, i.e. a gridded representation of the sea floor is therefore needed by users.
- For Orders *1b* and *2*, line spacing for a singular remote sensing trace is required. From there contour lines and spot soundings can be generated using interpolation of singular elevation points.

8 Dataset-level metadata

Metadata can be reported for each individual spatial object (spatial object-level metadata) or once for a complete dataset or dataset series (dataset-level metadata). Spatial object-level metadata is fully described in the application schema (section **5**). If data quality elements are used at spatial object level, the documentation shall refer to the appropriate definition in section 7. This section only specifies dataset-level metadata elements.

For some dataset-level metadata elements, in particular on data quality and maintenance, a more specific scope can be specified. This allows the definition of metadata at sub-dataset level, e.g. separately for each spatial object type. When using ISO 19115/19139 to encode the metadata, the following rules should be followed:

- The scope element (of type DQ_Scope) of the DQ_DataQuality subtype should be used to encode the scope.
- Only the following values should be used for the level element of DQ_Scope: Series, Dataset, featureType.
- If the level is featureType the levelDescription/MDScopeDescription/features element (of type Set< GF_FeatureType>) shall be used to list the feature type names.

NOTEThe value featureType is used to denote spatial object type.

Mandatory or conditional metadata elements are specified in Section 8.1. Optional metadata elements are specified in Section 8. The tables describing the metadata elements contain the following information:

- The first column provides a reference to a more detailed description.
- The second column specifies the name of the metadata element.
- The third column specifies the multiplicity.
- The fourth column specifies the condition, under which the given element becomes mandatory (only for Table 9 and Table 10).

8.1 Common metadata elements

IR Requirement 9	The metadata describing a spatial data set or a spatial data set series related to the theme **Elevation** shall comprise the metadata elements required by Regulation 1205/2008/EC (implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata) for spatial datasets and spatial dataset series (Table 9) as well as the metadata elements specified in Table 10.

Table 9 – Metadata for spatial datasets and spatial dataset series specified in Regulation 1205/2008/EC (implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata)

Metadata Regulation Section	Metadata element	Multiplicity	Condition
1.1	Resource title	1	
1.2	Resource abstract	1	

1.3	Resource type	1	
1.4	Resource locator	0..*	Mandatory if a URL is available to obtain more information on the resource, and/or access related services.
1.5	Unique resource identifier	1..*	
1.7	Resource language	0..*	Mandatory if the resource includes textual information.
2.1	Topic category	1..*	
3	Keyword	1..*	
4.1	Geographic bounding box	1..*	
5	Temporal reference	1..*	
6.1	Lineage	1	
6.2	Spatial resolution	0..*	Mandatory for data sets and data set series if an equivalent scale or a resolution distance can be specified.
7	Conformity	1..*	
8.1	Conditions for access and use	1..*	
8.2	Limitations on public access	1..*	
9	Responsible organisation	1..*	
10.1	Metadata point of contact	1..*	
10.2	Metadata date	1	
10.3	Metadata language	1	

Table 10 – Mandatory and conditional common metadata elements

INSPIRE Data Specification Elevation **Section**	**Metadata element**	**Multiplicity**	**Condition**
8.1.1	Coordinate Reference System	1	
8.1.2	Temporal Reference System	0..*	Mandatory, if the spatial data set or one of its feature types contains temporal information that does not refer to the Gregorian Calendar or the Coordinated Universal Time.
8.1.3	Encoding	1..*	
8.1.4	Character Encoding	0..*	Mandatory, if an encoding is used that is not based on UTF-8.

8.1.5	Data Quality – Logical Consistency – Topological Consistency	0..*	Mandatory, if the data set includes types from the Generic Network Model and does not assure centreline topology (connectivity of centrelines) for the network.

8.1.1 Coordinate Reference System

Metadata element name	**Coordinate Reference System**
Definition	Description of the coordinate reference system used in the dataset.
ISO 19115 number and name	13. referenceSystemInfo
ISO/TS 19139 path	referenceSystemInfo
INSPIRE obligation / condition	mandatory
INSPIRE multiplicity	1
Data type(and ISO 19115 no.)	189. MD_CRS
Domain	Either the referenceSystemIdentifier (RS_Identifier) or the projection (RS_Identifier), ellipsoid (RS_Identifier) and datum (RS_Identifier) properties shall be provided. NOTE More specific instructions, in particular on pre-defined values for filling the referenceSystemIdentifier attribute should be agreed among Member States during the implementation phase to support interoperability.
Implementing instructions	
Example	referenceSystemIdentifier: code: ETRS_89 codeSpace: INSPIRE RS registry
Example XML encoding	
Comments	

8.1.2 Temporal Reference System

Metadata element name	**Temporal Reference System**
Definition	Description of the temporal reference systems used in the dataset.
ISO 19115 number and name	13. referenceSystemInfo
ISO/TS 19139 path	referenceSystemInfo
INSPIRE obligation / condition	Mandatory, if the spatial data set or one of its feature types contains temporal information that does not refer to the Gregorian Calendar or the Coordinated Universal Time.
INSPIRE multiplicity	0..*
Data type(and ISO 19115 no.)	186. MD_ReferenceSystem
Domain	No specific type is defined in ISO 19115 for temporal reference systems. Thus, the generic MD_ReferenceSystem element and its reference SystemIdentifier (RS_Identifier) property shall be provided. NOTEMore specific instructions, in particular on pre-defined values for filling the referenceSystemIdentifier attribute should be agreed among Member States during the implementation phase to support interoperability.
Implementing instructions	
Example	referenceSystemIdentifier: code: GregorianCalendar codeSpace: INSPIRE RS registry
Example XML encoding	

Comments	

8.1.3 Encoding

Metadata element name	**Encoding**
Definition	Description of the computer language construct that specifies the representation of data objects in a record, file, message, storage device or transmission channel
ISO 19115 number and name	271. distributionFormat
ISO/TS 19139 path	distributionInfo/MD_Distribution/distributionFormat
INSPIRE obligation / condition	mandatory
INSPIRE multiplicity	1
Data type (and ISO 19115 no.)	284. MD_Format
Domain	See B.2.10.4. The property values (name, version, specification) specified in section 9 shall be used to document the default and alternative encodings.
Implementing instructions	
Example	name: **Elevation** GML application schema version: version **2.0(.3)**, GML, version 3.2.1 specification: D2.8.**II**.**1** Data Specification on **Elevation** – Draft Guidelines
Example XML encoding	
Comments	

8.1.4 Character Encoding

Metadata element name	**Character Encoding**
Definition	The character encoding used in the data set.
ISO 19115 number and name	
ISO/TS 19139 path	
INSPIRE obligation / condition	Mandatory, if an encoding is used that is not based on UTF-8.
INSPIRE multiplicity	0..*
Data type (and ISO 19115 no.)	
Domain	
Implementing instructions	
Example	-
Example XML encoding	-
Comments	

8.1.5 Data Quality – Logical Consistency – Topological Consistency

Metadata element name	**Data Quality – Logical Consistency – Topological Consistency**
Definition	Correctness of the explicitly encoded topological characteristics of the dataset as described by the scope
ISO 19115 number and name	18. dataQualityInfo
ISO/TS 19139 path	dataQualityInfo
INSPIRE obligation / condition	Mandatory, if the data set includes types from the Generic Network Model and does not assure centreline topology (connectivity of centrelines) for the network.
INSPIRE multiplicity	0..*
Data type (and ISO 19115 no.)	115. DQ_TopologicalConsistency
Domain	Lines 100-107 from ISO 19115

Implementing instructions	This metadata should be filled, at least, with these elements: - valueUnit: UnitOfMeasure - value: Record
Example	
Example XML encoding	
Comments	See clauses on topological consistency in section 7 for detailed information. This metadata element is mandatory if connectivity is not assured for network centrelines in the dataset. In this case the *Connectivity tolerance* parameter – as described in section 7 – must be provided in order to ensure automatic and unambiguous creation of centreline topology in post-process.

8.2 Metadata elements for reporting data quality

Recommendation 14 For reporting the results of the data quality evaluation quantitatively, the data quality elements and measures defined in Chapter 7 should be used.

NOTE For reporting compliance with minimum data quality requirements and recommendations, see the Open issue 2 mentioned below the table.

The scope for reporting may be different from the scope for evaluating data quality (see section 7). If data quality is reported at the data set or spatial object type level, the results are usually derived or aggregated.

Recommendation 15 If the reported data quality results are derived or aggregated (i.e. the scope levels for evaluation and reporting are different), the derivation or aggregation should also be specified in the metadata using the 104. *evaluationMethodDescription* element.

Metadata element name	**See chapter 7**
Definition	<see chapter 7)
ISO 19115 number and name	80. report
ISO/TS 19139 path	dataQualityInfo/*/report
INSPIRE obligation / condition	optional
INSPIRE multiplicity	0..*
Data type (and ISO 19115 no.)	Corresponding DQ_xxx element from ISO 19115, e.g. 109. DQ_CompletenessCommission
Domain	Lines 100-107 from ISO 19115 100. nameOfMeasure (O) 101. measureIdentification (O) 102. measureDescription (O) 103. evaluationMethodType (O) 104. evaluationMethodDescription (O) 105. evaluationProcedure (O) 106. dateTime (O) 107. result : DQ_Result (M)

Implementing instructions	Recommendation: For each DQ result included in the metadata, at least the following properties should be provided: 100, 103, 104, 106, 107 100 should be the name as defined in Chapter 7 103 should be selected from the DQ_EvaluationMethodTypeCode 104 should be used also for describing a method used for aggregation of the DQ results 106 should be data or range of dates on which the DQ measure was applied 107 should be of type DQ_QuantitativeResult.
Example	Add example
Example XML encoding	
Comments	See Chapter 7 for detailed information on the individual data quality elements and measures to be used.

Open issue 6: In the ongoing revision of ISO 19115 and development of new ISO 19157 standard (Geographic Information – Data quality) a new element is introduced (DQ_DescriptiveResult). This element enables to describe and report qualitative results of the data quality evaluation and can be used instead of DQ_QuantitativeResult. Once the standards are approved these guidelines should be updated if necessary.

Open issue 7: Documentation of conformance with target results specified in section 7.

Should be done using DQ_ConformanceResults. However, this issue is part of the larger discussion on the ATS and defining conformance classes for the data specification. This will be dealt with for v3.0.

8.3 Theme-specific metadata elements

Open issue 8: Mandatory theme-specific metadata elements
Mandatory theme-specific metadata elements are under discussion for this theme.

IR Requirement 10 The metadata describing a spatial data set or a spatial data set series related to the theme **Elevation** shall also comprise the theme-specific metadata elements specified in Table 11.

Table 11 – Mandatory and conditional theme-specific metadata elements for the theme Elevation

INSPIRE Data Specification Elevation **Section**	**Metadata element**	**Multiplicity**	**Condition**
	Still under discussion		

Open issue 9: Optional theme-specific metadata elements
Optional theme-specific metadata elements are under discussion for this theme.

Recommendation 16 The metadata describing a spatial data set or a spatial data set series related to the theme **Elevation** should comprise the theme-specific metadata elements specified in Table 12.

Table 12 – Optional theme-specific metadata elements for the theme Elevation

INSPIRE Data Specification Elevation **Section**	**Metadata element**	**Multiplicity**
8.3.1	Maintenance Information	0..1
	Still under discussion	

8.3.1 Maintenance Information

Metadata element name	**Maintenance information**
Definition	Information about the scope and frequency of updating
ISO 19115 number and name	30. resourceMaintenance
ISO/TS 19139 path	identificationInfo/MD_Identification/resourceMaintenance
INSPIRE obligation / condition	optional
INSPIRE multiplicity	0..1
Data type(and ISO 19115 no.)	142. MD_MaintenanceInformation
Domain	This is a complex type (lines 143-148 from ISO 19115). At least the following elements should be used (the multiplicity according to ISO 19115 is shown in parentheses): – maintenanceAndUpdateFrequency [1]: frequency with which changes and additions are made to the resource after the initial resource is completed / domain value: MD_MaintenanceFrequencyCode: – updateScope [0..*]: scope of data to which maintenance is applied / domain value: MD_ScopeCode – maintenanceNote [0..*]: information regarding specific requirements for maintaining the resource / domain value: free text
Implementing instructions	
Example	
Example XML encoding	
Comments	

8.4 Guidelines on using metadata elements defined in Regulation 1205/2008/EC

8.4.1 Conformity

The *Conformity* metadata element defined in Regulation 1205/2008/EC allows to report the conformance with the Implementing Rule for interoperability of spatial data sets and services or

another specification. The degree of conformity of the dataset can be *Conformant* (if the dataset is fully conformant with the cited specification), *Not Conformant* (if the dataset does not conform to the cited specification) or *Not evaluated* (if the conformance has not been evaluated).

Recommendation 17 The Conformity metadata element should be used to report conceptual consistency with this INSPIRE data specification. The value of Conformant should be used for the Degree element only if the dataset passes all the requirements described in the abstract test suite presented in Annex A. The Specification element should be given as follows:
- title: "INSPIRE Data Specification on <Theme Name> – Draft Guidelines"
- date:
  - dateType: publication
  - date: 2011-06-15

Open issue 10: Conformance testing is still an open issue under discussion.

Instructions on conformance testing and a common abstract test suite (including detailed instructions on how to test specific requirements) will be added at a later stage.

This may also lead to an update of the recommendations on how to fill the conformity metadata element.

8.4.2 Lineage

Recommendation 18 Following the ISO 19113 Quality principles, if a data provider has a procedure for quality validation of their spatial data sets then the data quality elements listed in the Chapters 7 and 8 should be used. If not, the *Lineage* metadata element (defined in Regulation 1205/2008/EC) should be used to describe the overall quality of a spatial data set.

According to Regulation 1205/2008/EC, lineage "is a statement on process history and/or overall quality of the spatial data set. Where appropriate it may include a statement whether the data set has been validated or quality assured, whether it is the official version (if multiple versions exist), and whether it has legal validity. The value domain of this metadata element is free text".

The Metadata Technical Guidelines based on EN ISO 19115 and EN ISO 19119 specify that the statement sub-element of LI_Lineage (EN ISO 19115) should be used to implement the lineage metadata element.

Recommendation 19 To describe the transformation steps and related source data, it is recommended to use the following sub-elements of LI_Lineage:
- For the description of the transformation process of the local to the common INSPIRE data structures, the LI_ProcessStep sub-element should be used.
- For the description of the source data the LI_Source sub-element should be used.

NOTE 1 This recommendation is based on the conclusions of the INSPIRE Data Quality Working Group to avoid overloading of the overall lineage statement element with information on the transformation steps and related source data.

NOTE 2 In order to improve the interoperability, domain templates and instructions for filling these free text elements (descriptions) may be specified in an Annex of this data specification.

Open issue 11: The suggested use of the LI_Lineage sub-elements needs to be discussed as part of the maintenance of the INSPIRE metadata Technical Guidelines.

8.4.3 Temporal reference

According to Regulation 1205/2008/EC, at least one of the following temporal reference metadata elements shall be provided: temporal extent, date of publication, date of last revision, date of creation. If feasible, the date of the last revision of a spatial data set should be reported using the *Date of last revision* metadata element.

9 Delivery

9.1 Delivery medium

DS Requirement 2	Data conformant to this INSPIRE data specification shall be made available through an INSPIRE network service.

DS Requirement 3	All information that is required by a calling application to be able to retrieve the data through the used network service shall be made available in accordance with the requirements defined in the Implementing Rules on Network Services.

EXAMPLE 1 Through the Get Spatial Objects function, a download service can either download a pre-defined data set or pre-defined part of a data set (non-direct access download service), or give direct access to the spatial objects contained in the data set, and download selections of spatial objects based upon a query (direct access download service). To execute such a request, some of the following information might be required:

- the list of spatial object types and/or predefined data sets that are offered by the download service (to be provided through the Get Download Service Metadata operation),
- and the query capabilities section advertising the types of predicates that may be used to form a query expression (to be provided through the Get Download Service Metadata operation, where applicable),
- a description of spatial object types offered by a download service instance (to be proviced through the Describe Spatial Object Types operation).

EXAMPLE 2 Through the Transform function, a transformation service carries out data content transformations from native data forms to the INSPIRE-compliant form and vice versa. If this operation is directly called by an application to transform source data (e.g. obtained through a download service) that is not yet conformant with this data specification, the following parameters are required:
Input data (mandatory). The data set to be transformed.

- Source model (mandatory, if cannot be determined from the input data). The model in which the input data is provided.
- Target model (mandatory). The model in which the results are expected.
- Model mapping (mandatory, unless a default exists). Detailed description of how the transformation is to be carried out.

9.2 Encodings

9.2.1 Default Encoding(s)

DS Requirement 4	Data conformant to the application schema(s) defined in section 5 shall be encoded using the encoding(s) specified in this section.

9.2.1.1. Default encoding for application schema *Elevation – Vector elements*

Format name: Elevation – Vector elements GML Application Schema
Version of the format: 1.9, GML, version 3.2.1
Reference to the specification of the format: ISO 19136:2007
Character set: UTF-8

The GML Application Schema is distributed in a zip-file separately from the data specification document.

9.2.1.2. Default encodings for application schema *Elevation – Coverages*

9.2.1.2.1. Land GRID/DTM

Format name: Elevation Land GRID/DTM GML Coverage, GML Application Schema
Version of the format: 1.9, GML, version 3.2.1
Reference to the specification of the format: GML Application Schema for Coverages [OGC 09-146] based on ISO 19136:2007
Character set: UTF-8

The GML Application Schema is distributed in a zip-file separately from the data specification document.

Note that GML allows the encoding of the value side of the coverage (i.e. the range set) either internally to the GML Coverage or in external files by using references. Either option is permitted. For the external file formats used it is suggested that either GeoTiff, Tiff or JPEG2000 (without lossy compression) could be used.

Recommendation 20	When using the external file format version for the range set in GML coverages, these should be encoded by means of binary file formats that are commonly used within the geographic community. For example GeoTiff, Tiff or JPEG2000 (without lossy compression).

9.2.1.2.2. Water GRID/DTM

Format name: Elevation Water GRID/DTM GML Coverage, GML Application Schema
Version of the format: 1.9, GML, version 3.2.1
Reference to the specification of the format: GML Application Schema for Coverages [OGC 09-146] based on ISO 19136:2007
Character set: UTF-8

The GML Application Schema is distributed in a zip-file separately from the data specification document.

Note that GML allows the encoding of the value side of the coverage (i.e. the range set) either internally to the GML Coverage or in external files by using references. Either option is permitted. For the external file formats used there is no restriction on the formats used. The International Hydrographic Organization (IHO) Geospatial Standard for hydrographic data S-102, Bathymetric Attributed Grid Object (BAG), version 1.0 could be one such format referenced externally. But any 'well-known' format could be used.

Recommendation 21 When using the external file format version for the range set in GML coverages, these should be encoded by means of binary file formats that are commonly used within the hydrographic community. For example Bathymetric Attributed Grid Object (BAG).

9.2.1.3. Default encoding for application schema *Elevation – TIN* (Triangulated Irregular Network)

Format name: CityGML Application Schema
Version of the format: 1.0
Reference to the specification of the format: OpenGIS City Geography Markup Language (CityGML) Encoding Standard
Character set: UTF-8

The cityGML Application Schema is distributed in a zip-file separately from the data specification document.

9.2.2 Alternative Encoding(s)

Recommendation 22 It is recommended that also the encodings specified in this section be provided for the relevant application schemas.

9.2.2.1. Alternative encoding for application schemas of *Elevation*

No alternative encodings are specified for the *Elevation* application schemas.

10 Data Capture

This chapter highlights cases which require specific attention as regards collecting and assembling different data components and information of the Elevation data sets.

According to the Elevation model included in this specification, guidance is focused on vector elements, grid coverages and TIN structures.

10.1 Elevation - Vector elements

10.1.1 Generic consistency rules

Generic consistency rules set requirements / recommendations mainly aimed to control topological relationships established between vector spatial objects of the Elevation theme.

IR Requirement 11	Connected *contour line* features shall have the same elevation value.

IR Requirement 12	Connected *depth contour* features shall have the same elevation value.

Recommendation 23	Provision the *break line* features is recommended in 3D in order to better describe the singularities of the terrain. If this is not accomplished, these features can be stored in 2D without elevation information, since 2D spatial objects are allowed in the Elevation theme model.

IR Requirement 13	When two break line features intersect each other, the intersection point shall have the same elevation value (if break line spatial objects are stored in 3D).

IR Requirement 14	When a contour line (or a depth contour) feature and a break line feature intersect each other, the intersection point must have the same elevation value (if break line spatial objects are stored in 3D).

Recommendation 24	Contour line (or depth contour) features should not self-intersect.

IR Requirement 15	Contour line (or depth contour) features/spatial objects having different elevation value can neither intersect nor touch each other.

IR Requirement 16	The boundary of an isolated area feature/spatial object must not touch the boundary of a void area spatial object.

10.1.2 Density of Elevation data

Relations regarding the contour line equidistance (vertical interval) and quality (scale of mapping) can be specified between:

- Contour distance and scale of mapping, taking into consideration different types of terrain (flat, hilly, mountainous).
- Contour distance and vertical accuracy, taking into consideration the slope of terrain surface.

These aspects are strongly related to data quality and related recommendations are therefore included in Section 7.2.2.

10.2 Elevation - Coverages (Grids)

10.2.1 Grid spacing

This aspect is strongly related to data quality and a grid spacing recommendation is therefore included in Section 7.2.2.

10.3 Elevation - TIN

No specific guidance is provided regarding data capture for TIN structures.

Those vector objects provided as components within a TIN structure shall fulfil the generic consistency rules provided for vector objects.

10.4 Bathymetry-specific objects

Bathymetry data is divided into four different classes. These are named Orders. The different Orders are applicable to areas of interest in shipping. Each Order has specific requirements for safety of navigation, including detection of features present on the sea floor, as stated in the following table.

Table 13 – Different orders for bathymetry and corresponding quality requirements

Order	Description of areas	Feature detection
Special	Areas where under keel clearance is critical.	Cubic features > 1 m
1a	Areas shallower than 100 m where under keel clearance is less critical but features of concern to surface shipping may exist.	Cubic features > 2 m in depths up to 40 m.
		Cubic features = 10% of depth in depths beyond 40 m.
1b	Areas shallower than 100 m where under- keel clearance is not considered to be an issue for the type of surface shipping expected to transit the area.	Not required.
2	Areas generally deeper than 100 metres where a general description of the sea floor is considered adequate.	Not required.

Additionally, special attention should be paid to the following error sources in bathymetric surveys:

- vertical datum errors
- vertical positioning system errors
- tidal measurement errors
- instrument errors
- sound speed errors
- ellipsoidal / vertical datum separation model errors
- vessel motion errors
- vessel draught
- vessel settlement and squat
- sea floor slope
- time synchronisation / latency

Further recommendations strongly related to bathymetry data quality are included in Section 7.2.2.

11 Portrayal

This clause defines the rules for layers and styles to be used for portrayal of the spatial object types defined for this theme.

In section 11.1, the *types* of layers are defined that are to be used for the portrayal of the spatial object types defined in this specification. A view service may offer several layers of the same type, one for each dataset that it offers on a specific topic.

Section 11.2 specifies the styles that shall be supported by INSPIRE view services for each of these layer types.

In section 11.3, further styles can be specified that represent examples of styles typically used in a thematic domain. It is recommended that also these styles should be supported by INSPIRE view services, where applicable.

Where XML fragments are used in these sections, the following namespace prefixes apply:

- sld="http://www.opengis.net/sld" (WMS/SLD 1.1)
- se="http://www.opengis.net/se" (SE 1.1)
- ogc="http://www.opengis.net/ogc" (FE 1.1)

IR Requirement 17 If an INSPIRE view services supports the portrayal of data related to the theme **Elevation**, it shall provide layers of the types specified in this section.

DS Requirement 5 If an INSPIRE view network service supports the portrayal of spatial data sets corresponding to the spatial data theme **Elevation**, it shall support the styles specified in section 11.2.

If no user-defined style is specified in a portrayal request for a specific layer to an INSPIRE view service, the default style specified in section 11.2 for that layer shall be used.

Recommendation 25 In addition to the styles defined in section 11.2, it is recommended that, where applicable, INSPIRE view services also support the styles defined in section 11.3.

11.1 Layers to be provided by INSPIRE view services

Layer Name	Layer Title	Spatial object type(s)	Keywords
EL.BreakLine	Break Line	BreakLine	break line
EL.ContourLine	Contour Line	ContourLine	contour line
EL.DepthContour	Depth Contour	DepthContour	depth contour
EL.DepthElevationReference	Depth Elevation Reference	ElevationReference	Depth Elevation Reference
EL.IsolatedArea	Isolated Area	IsolatedArea	isolated area
EL.SpotDepth	Spot Depth	SpotDepth	spot depth
EL.SpotHeight	Spot Height	SpotHeight	spot height
EL.VoidArea	Void Area	VoidArea	void, obscure area
EL.GridCoverage	Grid coverage	ElevationGridCoverage	grid, coverage

11.1.1 Layers organisation

None.

11.2 Styles to be supported by INSPIRE view services

11.2.1 Styles for the layer EL.BreakLine

Style Name	**EL.BreakLine.Default**
Default Style	yes
Style Title	Break Line Default Style
Style Abstract	Break Line is a light brown (#CF7916) line with 2 pixels width
Symbology	<sld:NamedLayer> <se:Name>EL.BreakLine</se:Name> <sld:UserStyle> <se:Name>EL.BreakLine.Default</se:Name> <sld:IsDefault>1</sld:IsDefault> <se:FeatureTypeStyle version="1.1.0"> <se:Description> <se:Title>Break Line Default Style/se:Title> <se:Abstract> Break Line (#CF7916) line 2 pixel. </se:Abstract> </se:Description> <se:FeatureTypeName>BreakLine</se:FeatureTypeName> <se:Rule> <se:MinScaleDenominator>1</se:MinScaleDenominator> <se:MaxScaleDenominator>100000</se:MaxScaleDenominator> <se:LineSymbolizer> <se:Geometry> <ogc:PropertyName>geometry</ogc:PropertyName> </se:Geometry> <se:Stroke> <se:SvgParameter name="stroke">#CF7916</se:SvgParameter> <se:SvgParameter name="stroke-width">2</se:SvgParameter> </se:Stroke> </se:LineSymbolizer> </se:Rule> </se:FeatureTypeStyle> </sld:UserStyle> </sld:NamedLayer>
Minimum & maximum scales	1: 1 - 1: 100 000

11.2.2 Styles for the layer EL.ContourLine

Style Name	**EL.ContourLine.Default**
Default Style	yes
Style Title	Contour Line Default Style
Style Abstract	Contour Line is a brown (#A47916) line with 1 pixels width
Symbology	<sld:NamedLayer> <se:Name>EL.ContourLine</se:Name> <sld:UserStyle> <se:Name>EL.ContourLine.Default</se:Name> <sld:IsDefault>1</sld:IsDefault> <se:FeatureTypeStyle version="1.1.0"> <se:Description> <se:Title>Contour Line Default Style/se:Title> <se:Abstract> Contour Line (#A47916) line 1 pixel. </se:Abstract> </se:Description> <se:FeatureTypeName>ContourLine</se:FeatureTypeName> <se:Rule> <se:MinScaleDenominator>1</se:MinScaleDenominator> <se:MaxScaleDenominator>1000000</se:MaxScaleDenominator> <se:LineSymbolizer> <se:Geometry> <ogc:PropertyName>geometry</ogc:PropertyName> </se:Geometry> <se:Stroke> <se:SvgParameter name="stroke">#A47916</se:SvgParameter> <se:SvgParameter name="stroke-width">1</se:SvgParameter> </se:Stroke> </se:LineSymbolizer> </se:Rule> </se:FeatureTypeStyle> </sld:UserStyle> </sld:NamedLayer>
Minimum & maximum scales	1: 1 - 1: 1 000 000

11.2.3 Styles for the layer EL.DepthContour

Style Name	**EL.DepthContour.Default**
Default Style	yes
Style Title	Depth Contour Default Style
Style Abstract	Depth Contour is a blue (#0A93FC) line with 1 pixels width
Symbology	<sld:NamedLayer> <se:Name>EL.DepthContour</se:Name> <sld:UserStyle> <se:Name>EL.DepthContour.Default</se:Name> <sld:IsDefault>1</sld:IsDefault> <se:FeatureTypeStyle version="1.1.0"> <se:Description> <se:Title>Depth Contour Default Style/se:Title> <se:Abstract> Depth Contour (#0A93FC) line 1 pixel. </se:Abstract> </se:Description> <se:FeatureTypeName>DepthContour</se:FeatureTypeName> <se:Rule> <se:MinScaleDenominator>1</se:MinScaleDenominator> <se:MaxScaleDenominator>500000</se:MaxScaleDenominator> <se:LineSymbolizer> <se:Geometry> <ogc:PropertyName>geometry</ogc:PropertyName> </se:Geometry> <se:Stroke> <se:SvgParameter name="stroke">#0A93FC</se:SvgParameter> <se:SvgParameter name="stroke-width">1</se:SvgParameter> </se:Stroke> </se:LineSymbolizer> </se:Rule> </se:FeatureTypeStyle> </sld:UserStyle> </sld:NamedLayer>
Minimum & maximum scales	1: 1 - 1: 500 000

11.2.4 Styles for the layer EL.DepthElevationReference

Style Name	**EL.DepthElevationReference.Default**
Default Style	yes
Style Title	Depth Elevation Reference Default Style
Style Abstract	Only Elevation References representing the planimetric position of a chart datum for depths are represented using this style. Depth Elevation Reference is a blue (#0000FF) star size 10 with 2 pixels width, ElevationReference.elevationOrigin.verticalCRSName is Arial 10 black (#000000)
Symbology	<sld:NamedLayer> <se:Name>EL.DepthElevationReference</se:Name> <sld:UserStyle> <se:Name>EL.DepthElevationReference </se:Name> <sld:IsDefault>1</sld:IsDefault> <se:FeatureTypeStyle version="1.1.0"> <se:Description> <se:Title> Depth Elevation Reference Default Style/se:Title> <se:Abstract> Depth Elevation Reference is a blue(#0000FF) star size 10 2 pixel. </se:Abstract> </se:Description> <se:FeatureTypeName>ElevationReference</se:FeatureTypeName> <se:Rule> <se:MinScaleDenominator>1</se:MinScaleDenominator> <se:MaxScaleDenominator>100000</se:MaxScaleDenominator> <se:PointSymbolizer> <se:Geometry> <ogc:PropertyName>DepthElevationReference</ogc:PropertyName> </se:Geometry> <se:Graphic> <se:Mark> <se:WellKnownName>star</se:WellKnownName> <se:Stroke> <se:SvgParameter name="stroke">#0000FF</se:SvgParameter> <se:SvgParameter name="stroke-width">2</se:SvgParameter> </se:Stroke> </se:Mark> <se:Size> <se:SvgParameter name=”size”>10</se:SvgParameter> </se:Size> </se:Graphic> </se:PointSymbolizer> </se:Rule> <se:Rule> <se:MinScaleDenominator>1</se:MinScaleDenominator> <se:MaxScaleDenominator>100000</se:MaxScaleDenominator> <se:TextSymbolizer> <se:Label> <ogc:PropertyName>verticalCRSName</ogc:PropertyName> </se:Label> <se:Font> <se:SvgParameter name="font-family">Arial</se:SvgParameter> <se:SvgParameter name="font-size">10</se:SvgParameter> </se:Font> <se:Fill> <se:SvgParameter name="fill">#000000</se:SvgParameter> </se:Fill> </se:TextSymbolizer>

	</se:Rule> </se:FeatureTypeStyle> </sld:UserStyle> </sld:NamedLayer>
Minimum & maximum scales	1: 1 - 1: 100 000

11.2.5 Styles for the layer EL.IsolatedArea

Style Name	**EL.IsolatedArea.Default**
Default Style	yes
Style Title	Isolated Area Default Style
Style Abstract	Isolated Area is a light pink (#FFE6FF) filled polygon with 1 pixel width outline
Symbology	<sld:NamedLayer> <se:Name>EL.IsolatedArea</se:Name> <sld:UserStyle> <se:Name>EL.IsolatedArea.Default</se:Name> <sld:IsDefault>1</sld:IsDefault> <se:FeatureTypeStyle version="1.1.0"> <se:Description> <se:Title>Isolated Area Default Style/se:Title> <se:Abstract> Isolated Area is a light pink (#FFE6FF) filled polygon with 1 pixel width outline </se:Abstract> </se:Description> <se:FeatureTypeName>IsolatedArea</se:FeatureTypeName> <se:Rule> <se:MinScaleDenominator>1</se:MinScaleDenominator> <se:MaxScaleDenominator>500000</se:MaxScaleDenominator> <se:PolygonSymbolizer> <se:Geometry> <ogc:PropertyName>geometry</ogc:PropertyName> </se:Geometry> <se:Stroke> <se:SvgParameter name="stroke">#000000</se:SvgParameter> <se:SvgParameter name="stroke-width">1</se:SvgParameter> <se:SvgParameter name="fill">#FFE6FF</se:SvgParameter> </se:Stroke> </se:PolygonSymbolizer> </se:Rule> </se:FeatureTypeStyle> </sld:UserStyle> </sld:NamedLayer>
Minimum & maximum scales	1: 1 - 1: 500 000

11.2.6 Styles for the layer EL.SpotDepth

Style Name	**EL.SpotDepth.Default**
Default Style	yes
Style Title	Spot Depth Default Style
Style Abstract	Depth Datum is a blue (#0000FF) circle size 10 with 1 pixel width
Symbology	<sld:NamedLayer> <se:Name>EL.SpotDepth</se:Name> <sld:UserStyle> <se:Name>EL.SpotDepth.Default</se:Name> <sld:IsDefault>1</sld:IsDefault> <se:FeatureTypeStyle version="1.1.0"> <se:Description> <se:Title>Spot Depth Default Style/se:Title> <se:Abstract> Depth Datum is a blue(#0000FF) circle size 10 1 pixel. Depth Values as labels: in Arial 10 blue (#0000FF) </se:Abstract> </se:Description> <se:FeatureTypeName>DepthDatum</se:FeatureTypeName> <se:Rule> <se:MinScaleDenominator>1</se:MinScaleDenominator> <se:MaxScaleDenominator>100000</se:MaxScaleDenominator> <se:PointSymbolizer> <se:Geometry> <ogc:PropertyName>SpotDepth</ogc:PropertyName> </se:Geometry> <se:Graphic> <se:Mark> <se:WellKnownName>circle</se:WellKnownName> <se:Stroke> <se:SvgParameter name="stroke">#0000FF</se:SvgParameter> <se:SvgParameter name="stroke-width">1</se:SvgParameter> </se:Stroke> </se:Mark> <se:Size> <se:SvgParameter name=”size”>10</se:SvgParameter> </se:Size> </se:Graphic> </se:PointSymbolizer> </se:Rule> <se:Rule> <se:MinScaleDenominator>1</se:MinScaleDenominator> <se:MaxScaleDenominator>100000</se:MaxScaleDenominator> <se:TextSymbolizer> <se:Label> <ogc:PropertyName>measuredProperty</ogc:PropertyName> </se:Label> <se:Font> <se:SvgParameter name="font-family">Arial</se:SvgParameter> <se:SvgParameter name="font-size">10</se:SvgParameter> </se:Font> <se:Fill> <se:SvgParameter name="fill">#0000FF</se:SvgParameter> </se:Fill> </se:TextSymbolizer> </se:Rule> </se:FeatureTypeStyle> </sld:UserStyle> </sld:NamedLayer>

Minimum & maximum scales	1: 1 - 1: 100 000

11.2.7 Styles for the layer EL.SpotHeight

Style Name	**EL.SpotHeight.Default**
Default Style	yes
Style Title	Spot Height Default Style
Style Abstract	Spot Height is a black (#000000) circle size 10 with 1 pixels width Height Values as labels: in Arial 10 black (#000000)
Symbology	

```
   <sld:NamedLayer>
       <se:Name>EL.SpotHeight</se:Name>
       <sld:UserStyle>
         <se:Name>EL.SpotHeight.Default</se:Name>
         <sld:IsDefault>1</sld:IsDefault>
         <se:FeatureTypeStyle version="1.1.0">
           <se:Description>
           <se:Title>Spot Height Default Style/se:Title>
            <se:Abstract> Spot Height is a black(#000000) circle size 10 1
pixel. Height Values as labels: in Arial 10 black (#000000)

   </se:Abstract>
   </se:Description>



        <se:FeatureTypeName>SpotHeight</se:FeatureTypeName>
        <se:Rule>
            <se:MinScaleDenominator>1</se:MinScaleDenominator>
            <se:MaxScaleDenominator>100000</se:MaxScaleDenominator>
            <se:PointSymbolizer>
              <se:Geometry>
               <ogc:PropertyName>SpotHeight</ogc:PropertyName>
              </se:Geometry>
              <se:Graphic>
              <se:Mark>
                <se:WellKnownName>circle</se:WellKnownName>
                <se:Stroke>
             <se:SvgParameter name="stroke">#000000</se:SvgParameter>
           <se:SvgParameter name="stroke-width">1</se:SvgParameter>
          </se:Stroke>
          </se:Mark>
          <se:Size>
          <se:SvgParameter name=”size”>10</se:SvgParameter>
          </se:Size>
          </se:Graphic>
        </se:PointSymbolizer>
       </se:Rule>

          <se:Rule>
          <se:MinScaleDenominator>1</se:MinScaleDenominator>
        <se:MaxScaleDenominator>100000</se:MaxScaleDenominator>
         <se:TextSymbolizer>
           <se:Label>
              <ogc:PropertyName>measuredProperty</ogc:PropertyName>
           </se:Label>
              <se:Font>
        <se:SvgParameter name="font-family">Arial</se:SvgParameter>
       <se:SvgParameter name="font-size">10</se:SvgParameter>
          </se:Font>
             <se:Fill>
```

	<se:SvgParameter name="fill">#000000</se:SvgParameter> </se:Fill> </se:TextSymbolizer> </se:Rule> </se:FeatureTypeStyle> </sld:UserStyle> </sld:NamedLayer>
Minimum & maximum scales	1: 1 - 1: 100 000

11.2.8 Styles for the layer EL.VoidArea

Style Name	**EL.VoidArea.Default**
Default Style	yes
Style Title	Void Area Default Style
Style Abstract	Void Area outline is black (#000000) with 1 pixel width outline, no fill
Symbology	<sld:NamedLayer> <se:Name>EL.VoidArea</se:Name> <sld:UserStyle> <se:Name>EL.VoidArea.Default</se:Name> <sld:IsDefault>1</sld:IsDefault> <se:FeatureTypeStyle version="1.1.0"> <se:Description> <se:Title>Void Area Default Style/se:Title> <se:Abstract> Void Area outline is black (#000000) with 1 pixel width outline, no fill </se:Abstract> </se:Description> <se:FeatureTypeName>VoidArea</se:FeatureTypeName> <se:Rule> <se:MinScaleDenominator>1</se:MinScaleDenominator> <se:MaxScaleDenominator>500000</se:MaxScaleDenominator> <se:PolygonSymbolizer> <se:Geometry> <ogc:PropertyName>geometry</ogc:PropertyName> </se:Geometry> <se:Stroke> <se:SvgParameter name="stroke">#000000</se:SvgParameter> <se:SvgParameter name="stroke-width">1</se:SvgParameter> </se:Stroke> </se:PolygonSymbolizer> </se:Rule> </se:FeatureTypeStyle> </sld:UserStyle> </sld:NamedLayer>
Minimum & maximum scales	1: 1 - 1: 500 000

11.2.9 Styles for the layer EL.GridCoverage

Style Name	**EL.GridCoverage.Default**
Default Style	yes
Style Title	**Grid Coverage Default Style**
Style Abstract	Grid Coverage is symbolized by a colored raster symbolizer (values in meter)

Symbology	<sld:NamedLayer>
	`<se:Name>EL.GridCoverage</se:Name>`
	`<sld:UserStyle>`
	`<se:Name>EL.GridCoverage.Default</se:Name>`
	`<sld:IsDefault>1</sld:IsDefault>`
	`<se:Raster Symbolizer version="1.1.0">`
	`<se:Description>`
	`<se:Title>GridCoverage Default Style/se:Title>`
	`<se:Abstract> Grid Coverage is symbolized by a colored raster symbolizer (Values in meter)`
	`</se:Abstract>`
	`</se:Description>`
	
	`<se:Opacity>1.0</se:Opacity>`
	`<se:OverlapBehavior>AVERAGE</se:OverlapBehavior>`
	`<se:ColorMap>`
	`<se:Categorize fallbackValue="#78c818">`
	`<se:LookupValue>Rasterdata</se:LookupValue>`
	`<se:Value>#005CE6</se:Value>`
	`<se:Threshold>-100</se:Threshold>`
	`<se:Value>#28EDD6</se:Value>`
	`<se:Threshold>0</se:Threshold>`
	`<se:Value>#54F76D</se:Value>`
	`<se:Threshold>50</se:Threshold>`
	`<se:Value>#9AFA66</se:Value>`
	`<se:Threshold>100</se:Threshold>`
	`<se:Value>#7BF23A</se:Value>`
	`<se:Threshold>150</se:Threshold>`
	`<se:Value>#5DE813</se:Value>`
	`<se:Threshold>200</se:Threshold>`
	`<se:Value>#70E02B</se:Value>`
	`<se:Threshold>250</se:Threshold>`
	`<se:Value>#A4D453</se:Value>`
	`<se:Threshold>300</se:Threshold>`
	`<se:Value>#D4C574</se:Value>`
	`<se:Threshold>400</se:Threshold>`
	`<se:Value>#BFA15C</se:Value>`
	`<se:Threshold>500</se:Threshold>`
	`<se:Value>#A17C3D</se:Value>`
	`<se:Threshold>600</se:Threshold>`
	`<se:Value>#8A622B</se:Value>`
	`<se:Threshold>700</se:Threshold>`
	`<se:Value>#94765C</se:Value>`
	`<se:Threshold>800</se:Threshold>`
	`<se:Value>#968992</se:Value>`
	`<se:Threshold>900</se:Threshold>`
	`<se:Value>#9B96B5</se:Value>`
	`<se:Threshold>1000</se:Threshold>`
	`<se:Value>#A696B5</se:Value>`
	`<se:Threshold>1500</se:Threshold>`
	`<se:Value>#B196B5</se:Value>`
	`<se:Threshold>2000</se:Threshold>`
	`<se:Value>#C7AFC7</se:Value>`
	`<se:Threshold>3000</se:Threshold>`
	`<se:Value>#E3D5E3</se:Value>`
	`<se:Threshold>5000</se:Threshold>`
	`<se:Value>#FFFFFF</se:Value>`
	`</se:Categorize>`
	`</se:ColorMap>`
	`<se:ShadedRelief>`

	</se:RasterSymbolizer> </sld:UserStyle> </sld:NamedLayer>
Minimum & maximum scales	1: 1 - 1: 3 000 000

11.2.10 Examples

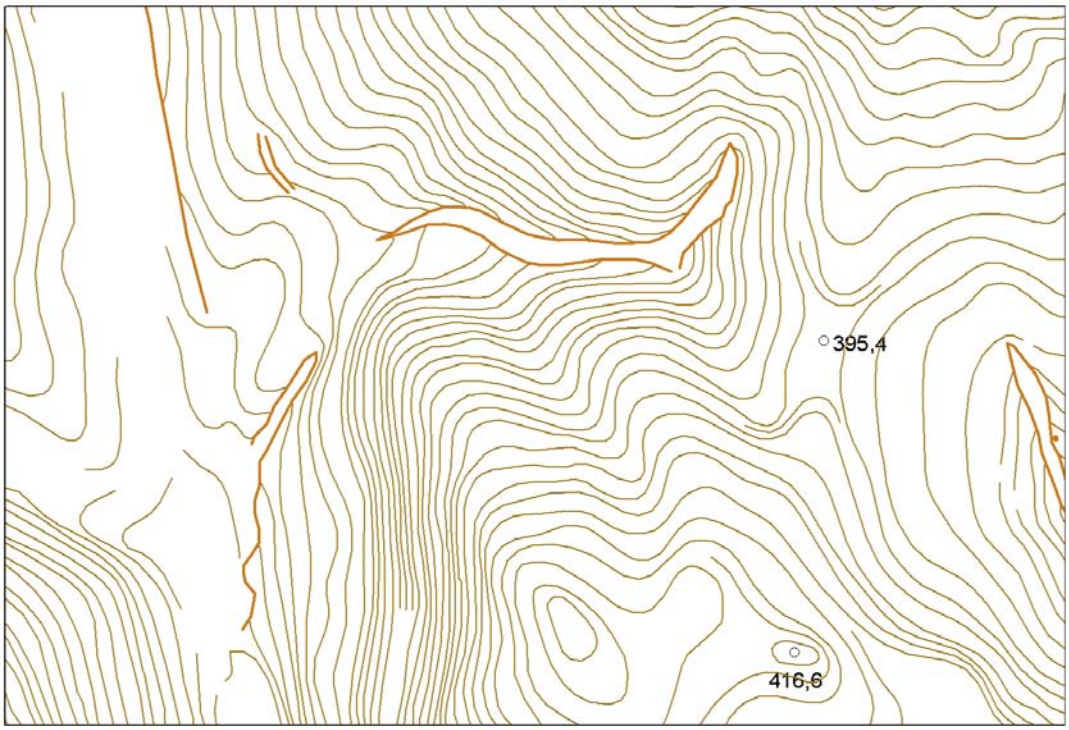


Figure 11 – Default Styles for Contour Line, Break Line and Spot Height (Scale: 1:3 000)

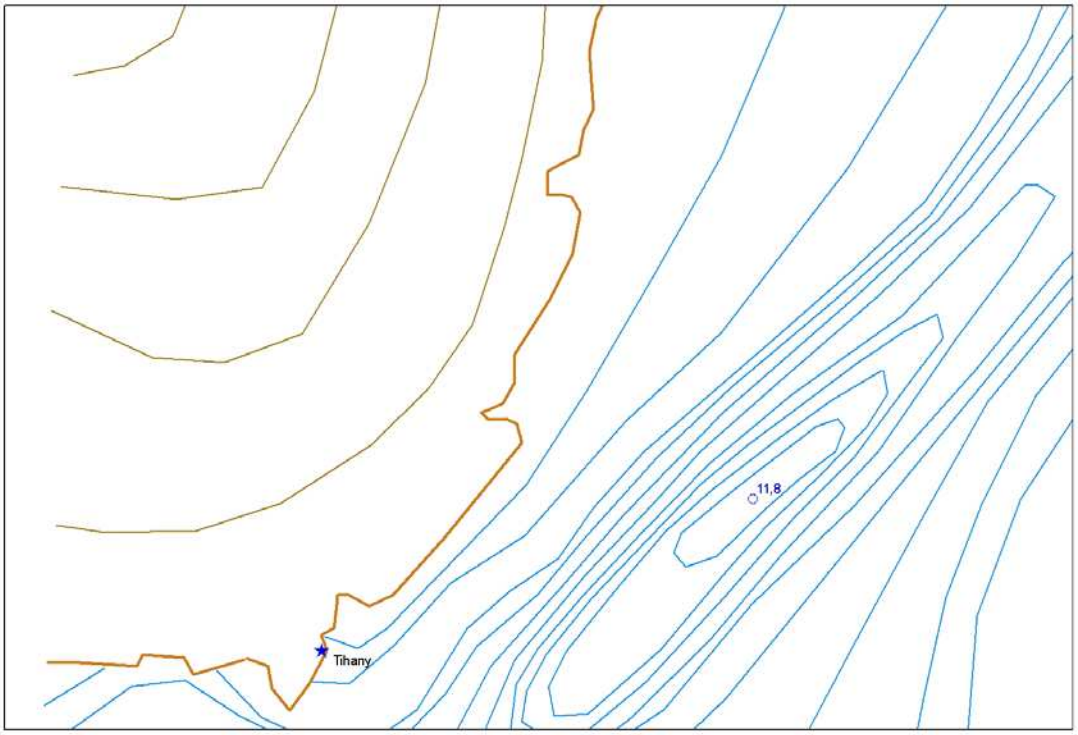


Figure 12 – Default Styles for Depth Elevation Reference, Depth Contour, Spot Depth (Scale: 1:3 000)

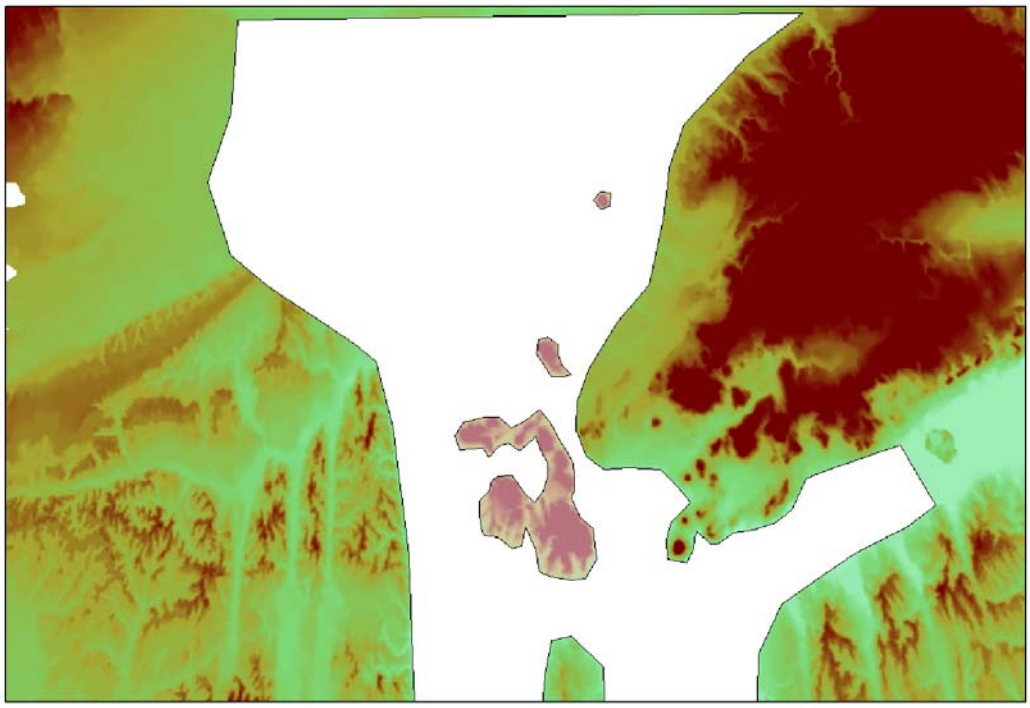


Figure 13 – Default Styles for Void Area and Isolated Area with GRID (Scale: 1:300 000)

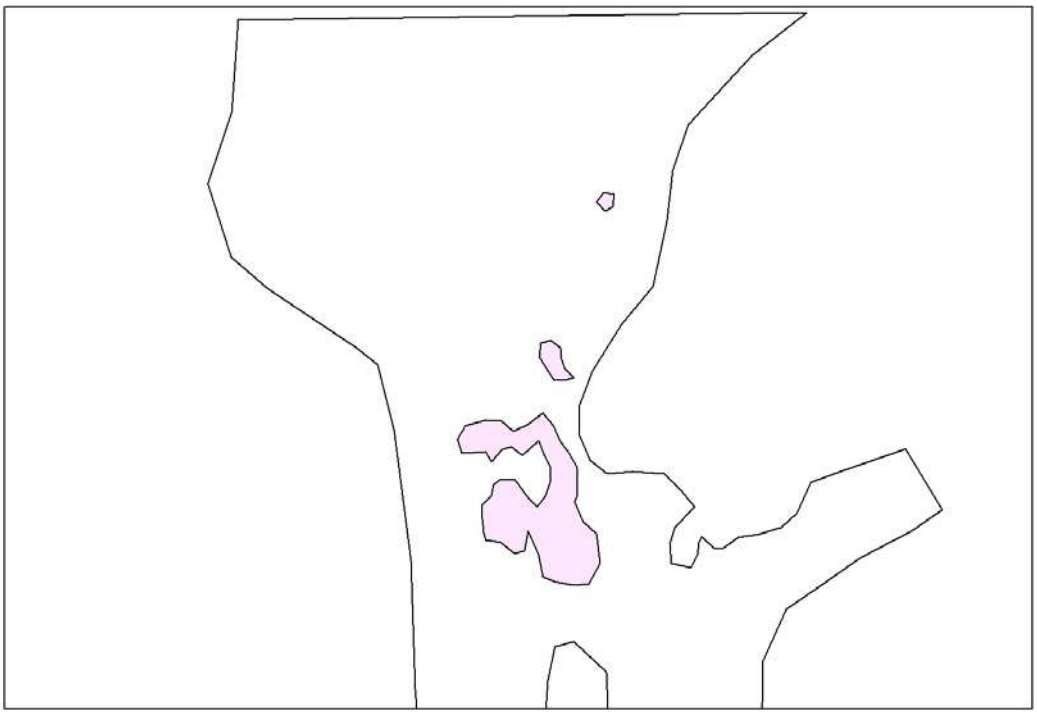


Figure 14 – Default Styles for Void Area and Isolated Area without GRID (Scale: 1:300 000)

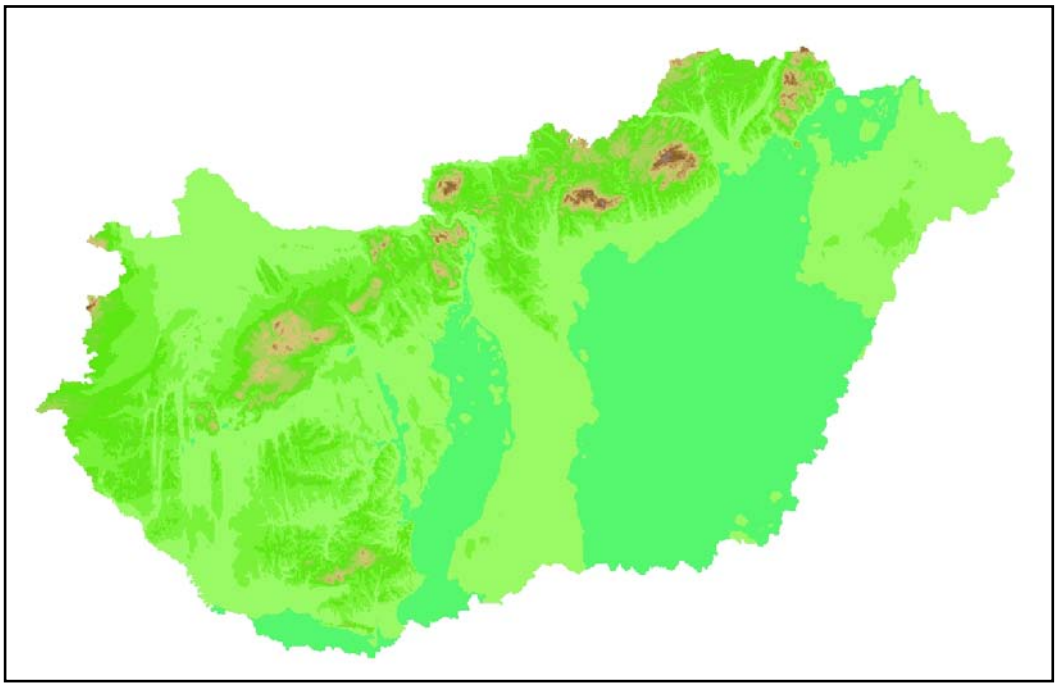


Figure 15 – Default Style for GRID Coverage (Hungary) (Scale: 1:2 000 000)

11.2.11 Default Style for ElevationTINCoverage

No additional Style definition is needed for ElevationTINCoverage. Since ElevationTINCoverage is a GM_Tin class, the default styles for members are:

- stopLines – the same as EL.ContourLine
- breakLines – the same as EL.BreakLine
- controlPoint – the same as EL. SpotHeight

In the case of ElevationTINCoverage related to depth, EL.DepthContour and EL.SpotDepth should be used instead of EL.ContourLine and EL.SpotHeight.

NOTE 1 The default styles described in 11.2 are considered as convenient for displaying elevation and related information as background data.

NOTE 2 These default styles can always be overridden by a user-defined symbology, e.g. in order to use an existing national or thematic style or to avoid conflicts when visualising several themes together.

11.3 Other recommended styles

11.3.1 Styles for the layer EL.ContourLine

11.3.1.1. Major contours

Style Name	**EL.ContourLine.Major**
Style Title	Contour Line - for major contours
Style Abstract	Major Contour Line is a brown (#A47916) line with 2 pixels width
Symbology	<sld:NamedLayer> <se:Name>EL.ContourLine</se:Name> <sld:UserStyle> <se:Name>EL.ContourLine.Major</se:Name> <sld:IsDefault>1</sld:IsDefault> <se:FeatureTypeStyle version="1.1.0"> <se:Description> <se:Title>Major Contour Line Style</se:Title> <se:Abstract> Major Contour Line (#A47916) line 2 pixel. </se:Abstract> </se:Description> <se:FeatureTypeName>ContourLine</se:FeatureTypeName> <se:Rule> <se:MinScaleDenominator>1</se:MinScaleDenominator> <se:MaxScaleDenominator>1000000</se:MaxScaleDenominator> <se:LineSymbolizer> <se:Geometry> <ogc:PropertyName>geometry</ogc:PropertyName> </se:Geometry> <se:Stroke> <se:SvgParameter name="stroke">#A47916</se:SvgParameter> <se:SvgParameter name="stroke-width">2</se:SvgParameter> </se:Stroke> </se:LineSymbolizer> </se:Rule> </se:FeatureTypeStyle> </sld:UserStyle> </sld:NamedLayer>
Minimum & maximum scales	1: 1 - 1: 1 000 000

11.3.1.2. Minor contours

Style Name	**EL.ContourLine.Minor**
Style Title	Contour Line – for minor contours
Style Abstract	Minor Contour Line is a brown (#734C00) line with 1 pixels width
Symbology	<sld:NamedLayer> <se:Name>EL.ContourLine</se:Name> <sld:UserStyle> <se:Name>EL.ContourLine.Minor</se:Name> <sld:IsDefault>1</sld:IsDefault> <se:FeatureTypeStyle version="1.1.0"> <se:Description> <se:Title>Minor Contour Line Style</se:Title> <se:Abstract> Minor Contour Line (#734C00) line 1 pixel. </se:Abstract> </se:Description> <se:FeatureTypeName>ContourLine</se:FeatureTypeName> <se:Rule> <se:MinScaleDenominator>1</se:MinScaleDenominator> <se:MaxScaleDenominator>1000000</se:MaxScaleDenominator> <se:LineSymbolizer> <se:Geometry> <ogc:PropertyName>geometry</ogc:PropertyName> </se:Geometry> <se:Stroke> <se:SvgParameter name="stroke">#734C00</se:SvgParameter> <se:SvgParameter name="stroke-width">1</se:SvgParameter> </se:Stroke> </se:LineSymbolizer> </se:Rule> </se:FeatureTypeStyle> </sld:UserStyle> </sld:NamedLayer>
Minimum & maximum scales	1: 1 - 1: 1 000 000

11.3.1.3. Auxiliary contours

Style Name	**EL.ContourLine.Auxiliary**
Style Title	Contour Line – for auxiliary contours
Style Abstract	Auxiliary Contour Line is a brown (#734C00) dashed line with 1 pixels width
Symbology	<sld:NamedLayer> <se:Name>EL.ContourLine</se:Name> <sld:UserStyle> <se:Name>EL.ContourLine.Auxiliary</se:Name> <sld:IsDefault>1</sld:IsDefault> <se:FeatureTypeStyle version="1.1.0"> <se:Description> <se:Title>Auxiliary Contour Line Style</se:Title> <se:Abstract> Auxiliary Contour Line (#734C00) dashed line 1 pixel. </se:Abstract> </se:Description> <se:FeatureTypeName>ContourLine</se:FeatureTypeName> <se:Rule> <se:MinScaleDenominator>1</se:MinScaleDenominator> <se:MaxScaleDenominator>1000000</se:MaxScaleDenominator> <se:LineSymbolizer> <se:Geometry> <ogc:PropertyName>geometry</ogc:PropertyName> </se:Geometry> <se:Stroke> <se:SvgParameter name="stroke">#734C00</se:SvgParameter> <se:SvgParameter name="stroke-width">1</se:SvgParameter> <se:SvgParameter name="stroke-dasharray">6 2</se:SvgParameter> </se:Stroke> </se:LineSymbolizer> </se:Rule> </se:FeatureTypeStyle> </sld:UserStyle> </sld:NamedLayer>
Minimum & maximum scales	1: 1 - 1: 1 000 000

11.3.2 Examples

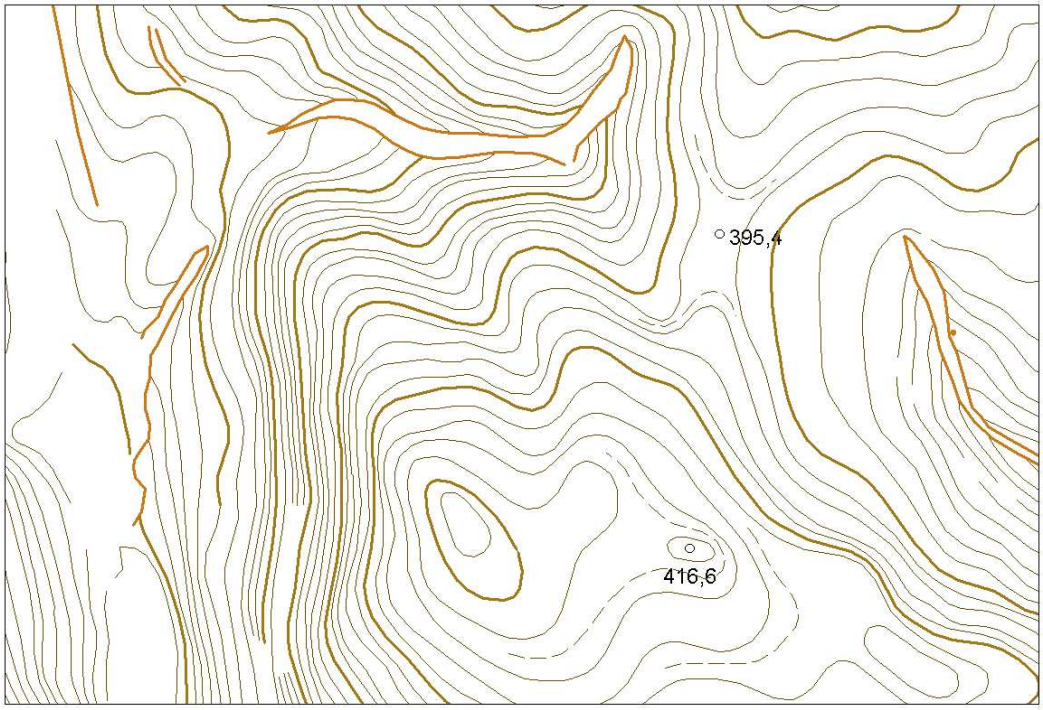


Figure 16 – Usage of Other Well-Defined Styles on Contour Lines (Scale: 1:3 000)

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Annex A
(normative)

Abstract Test Suite

Any dataset conforming to this INSPIRE data specification shall meet all requirements specified in this document.

Open issue 12: Conformance testing is still an open issue under discussion.

Instructions on conformance testing and a common abstract test suite (including detailed instructions on how to test specific requirements) will be added at a later stage.

Annex B
(informative)
Use-Cases

B.1 *Documented high-level use cases*

Four high-level real use cases have been documented in the development of this specification, as examples of user needs regarding *Elevation* data.

B.1.1 Flood mapping

Use Case Description	
Name	Generic Flood mapping for any actor from the citizen to the European Commission. It could be required for reporting purposes or for general information.
Priority	High / Medium
Description	A data provider or modeler will present flood-related information in a spatial context to the user.
Pre-condition	The representation of all main flood related elements, as well as facilities and constructions related to the water network is needed to provide a map background for orientation and to understand spatial relationships. Feature classification may be required as reference data or defined rules to choose reference elements (features, dimensions). Portrayal: Generalisation and symbol assignment rules for reference data and flood related information Alternatively a set of pre-defined raster data.reference maps could be specified as context.
Flow of Events – Basic Path	
Step 1.	The data provider defines the purpose of a flood map (Flood Event Map, Flood Hazard Map, Flood Risk Map, Map for Land Use Planning, Urban and Regional Planning etc.)
Step 2	The map creator asks for a reference map (SDI/ view service …) and for flood-related information such as modeling results, locations of flood events etc
Step 3	Several objects or coverages are requested by the map creator for reference data at specific resolutions (DEM, Name and position of the hydrographic element, GIS-layer with topographic elements etc.) and flood-related information
Step 4	Generalisation and symbol assignment rules should be applied, suitability of flood-related information for each purpose should be checked by a competent authority to avoid false statements with respect to conclusions.

Use Case Description	
Step 5	Data provider delivers requested layer
Step 6	When thematic layers containing the same information from different providers are provided there may be a requirement to manipulate data before merging, analyzing etc. (e.g. recalculation of values, classes)
Flow of Events – Alternative Paths	
Step 3	Request, concurrent with delivery, a pre-defined target data model (e.g. features, values) to support merging, harmonization etc.
Step 4.	Pre-defined reference map selection
Step 5	Delivery of seamless and as far as possible harmonised requested layer
Post-condition	Layers coming from different thematic databases must be merged to produce the reference map: e. g. flood risk level information and verified by a competent authority.
Data source: Topographic Reference Data	
Description	Topographic reference data including hydrographic data There are two roles for which topographic data are required: Topographic data as a visual background. The aim here is to help locate a flood risk zone in its surroundings. The scale of data ranges from 1:500 000 to 1:25 000. The data can be modeled in 2D geometry. There are no specific topological constraints on these data. Topographic data as a tool for modeling the flood hazard. Data here are used for the modeling of a flood hazard map. The scale of data here ranges from 1: 25 000 up to what is deemed necessary by the modeller. The geographical extent of these data is limited to the areas that are likely to be investigated as prospective flood hazard area, (whose decision to investigate is up to the modeller). Data can be modeled in 2D, 2.5D or 3D Item for topographic constraints.
Data provider	Mapping agency; Eurogeographics, OpenStreetMap, Google earth, EEA (WISE-reference datasets like ECRINS)
Geographic scope	Various (Pan-European, cross-border, national, regional, local)
Thematic scope	Spatial information supporting orientation on maps and understanding of spatial relationships. The aim of topographic data is to help locate a flood risk zone in its surrounding.
Scale, resolution	Various (depends on the purpose) For Topographic reference data, scale ranges from 1:500 000 to 1:25 000
Delivery	GIS-Raster files, GIS-Vector-files
Documentation	Metadata

Use Case Description	
Data source: Thematic information for example relating to elements at risk	
Description	For example building use information
Data provider	Topographic data providers. Data harmonized with cadastral information.
Geographic scope	Various (Pan-European, cross-border, national, regional, local)
Thematic scope	That useful to answer initial flood question.
Scale, resolution	Various (depends on the purpose)
Delivery	GIS-Raster files, GIS-Vector-files, GML-files, WFS
Documentation	Metadata, Model description

B.1.2 Orthoimagery production

A. Orthorectification of satellite images - Regione Liguria, Italy

Use Case Description	
Name	Orthorectification of satellite images
Priority	High
Description	The orthorectification of a satellite image consists in the correction of the image according to DTM and with satellite orbital parameters. We dispose of several orthorectification methods. RLIG use the RPC (Rational Polynomial Coefficients)one. It uses the RPC that are contained in an auxiliary file of the image. This use case is real and already implemented.
Pre-condition	It is necessary to have DTM, ground control points, RPC files and the CTR (technical topographic base map) 1:5000. All the input data must overlay the satellite image-bounding block.
Flow of Events: Basic Path	
Step 1	To orthorectify satellite images it is necessary to give to the software the corresponding DTM and Rational Polynomial Coefficients files.
Step 2	After that it is necessary to collect at least 15-20 ground control points within the image and the CTR 1:5000 (technical topographic base map) until you get at least a standard error smaller than a satellite image's pixel (1 m).
Step 3	At this step it is possible to start orthorectification process that can take several hours.
Step 4	The last step is the control quality check that is performed using ground control points that were not used before.
Flow of Events: Alternative Path in case we don't have the RPC file.	
Step 1	In this case, in order to orthorectify satellite images, it is necessary to give to the software only the corresponding DTM.
Step 2	After that, it is necessary to collect ground control points between the image and the CTR 1:5000 (technical topographic base map) until you get at least a standard error smaller than a satellite image's pixel (1 m). In this case the method used is called RPF model (Rational Polynomial Function). Here the number of ground control points necessary is much higher than with the RPC method.
Step 3	At this step it is possible to start orthorectification process that can take several hours.
Step 4	The last step is the control quality check that is performed using ground control points not used before.

Use Case Description	
Post-Condition	Orthorectified image in geotiff formats. At this step we get all the multispectral bands orthorectified.
Data Source: Input image in the row format	
Description	The satellite image is in a row format only with the system corrections. It is in geotiff 16-bit format. The image file is together with the ancillary files and with the RPC files.
Data Provider(s)	Digital Globe-Telespazio
Geographic Scope(s)	Regione Liguria
Thematic Scope	Remote sensing applications
Scale, resolution	From 1:7000 to 1:100000, form 0.6x0,6 m to 30x30 m
Delivery	Geotiff 16 bit unsigned uncompressed
Documentation	http://www.cartografia.regione.liguria.it/repertorio cartografico/immagini satellitari e aeree/mmagini satellitari ad alta risoluzione
Data Source: DEM	
Description	The RLIG DEM was carried out using DBPrior10K's morphology data: contour lines and elevation points. A TTN file was carried out from the vector base map at scale 1:5000 using a Delaunay Interpolation with bilinear algorithm. The TTN file was converted into GRID file (16 bit) with cell of 5mx5m. The prior model was mosaicated with SRTM data (90 m grid size) and Spot-5 data for areas on Liguria's boundary in order to obtain the DTM of the Region.
Data Provider(s)	Regione Liguria
Geographic Scope(s)	Regione Liguria
Thematic Scope	Elevation data
Scale, resolution	Form 5x5 m to 20x20 m grid
Delivery	Geotiff 16 bit, Grid ASCII Esri, XYZ ASCII on CD
Documentation	http://www.cartografia.regione.liguria.it/repertorio/carte di base/quote e prodotti derivati
Data source: SRTM Digital Elevation Data	
Description Elevation Data	SRTM 90m Digital
Data Provider(s)	CGIAR-CSI SRTM

Use Case Description	
Geographic Scope(s)	World
Thematic Scope	Elevation data
Scale, resolution	90x90 m grid
Delivery	Download from http://csi.cgiar.org/
Documentation	http://srtm.csi.cgiar.org/

B. Orthophoto rectification – Catalunya, Spain

Use Case Description	
Name	Orthophoto rectification
Priority	High
Description	Correction of the image according to the DEM. The software for orthophoto rectification was developed by the ICC. In the orthophoto of Catalonia at scale 1:5000, the process is based on a triangulation derived from the extraction of the data of the BT-5M that covers the area to rectify.
Pre-condition	DEM data is available.
Flow of Events: Basic Path	
Step 1	Extraction of the surface data of the Topographic Database of Catalonia at 1:5000 that covers the area to rectify
Step 2	Processing of the input data to avoid the generation of vertical triangles
Step 3	Generation of a triangulation
Step 4	Rectification process
Post-Condition	The orthophotos are rectified
Data Source: DTM of Catalonia	
Description	DTM and DEM compiled at the same time that the compilation of the Topographic Database of Catalonia at 1:5000 scale. Following DTM elements are available: scan lines, break lines, spots height and flat areas. DEM elements are buildings and bridges
Data Provider(s)	Institute Cartogràfic de Catalunya
Geographic Scope(s)	Catalonia
Thematic Scope	Elevation data
Scale, resolution	1:5000
Delivery	DGN from MicroStation (Bentley)
Documentation	Not available

C. Orthorectification of MADOP aerial photographs - Hungary

Use Case Description	
Name	Orthorectification of MADOP aerial photographs
Priority	High
Description	In MADOP programs 1:30 000 scale analogue aerial photos had been taken, which are the base of Digital Orthophoto Database of Hungary. These photos have been scanned by 21 microns resolution and HUNDEM-5 was used as height reference data for orthorectification of photographs.
Pre-condition	It is necessary to have DEM for orthorectification of photographs
Flow of Events: Basic Path	
Step 1	Aerial triangulation of photographs by bundle block adjustment to determine the exterior orientation parameters of photographs
Step 2	Inner orientation of photographs to reconstruct the bundle of rays at the time of exposition
Step 3	Orthorectification of photographs by orientation parameters and HUNDEM-5
Step 4	Quality check of orthophotos
Step 5	Mosaicing of orthophotos
Step 6	Cutting of mosaics and resembling of orthophoto to 1:10 000 scale topomaps sheets and 0,5 resolution
Post-Condition	No
Data Source	
Description	HUNDEM-5 see above
Data Provider(s)	FÖMI and Private Companies which carried out aerial photography and aerial triangulation
Geographic Scope(s)	Hungary
Thematic Scope	orthophoto
Scale, resolution	0,5m
Delivery	ESRI ASCII GRID
Documentation	Each unit

B.1.3 Maritime and hydrographic navigation

Use Case Description	
Name	Maritime and hydrographic navigation
Priority	Medium
Description	A data provider or modeler will present maritime and hydrographic information in a spatial context to the user. Collection, management, processing and dissemination of Nautical Information by the means of nautical charts and other publications continuously updated.
Pre-condition	
Flow of Events – Basic Path	
Step 1.	Collection of nautical information
Step 2	Data management
Step 3	Data selection and compilation
Step 4	Production
Flow of Events – Alternative Paths	
Step 1.	
Post-condition	
Data source: Reference Data	
Description	Reference Data relevant for Maritime and hydrographic navigation
Data provider	Public authorities in the field of hydrography
Geographic scope	Various (Pan-European, cross-border, national, regional, local)
Thematic scope	
Scale, resolution	Various (depends on the purpose) For Topographic reference data, scale ranges from 1:1 000 000 to 1:1 000
Delivery	GIS-Raster files, GIS-Vector files
Documentation	Metadata

B.1.4 Elevation mapping

A. DTM production using airborne laser scanning - NLS Finland

Use Case Description	
Name	DTM production using airborne laser scanning
Priority	High
Description	National Land Survey of Finland started 2008 production of accurate homogenous DTM using laser scanning.
Pre-condition	It is necessary to have stereo models, ground control points and digital topographic data (water areas, rivers, bridges and buildings)
Flow of Events	
Step 1.	Identifying areas requiring precise elevation data
Step 2.	Planning of flights
Step 3.	Measurements of control points
Step 4.	Laser scanning
Step 5.	Project calibrations
Step 6.	Quality control
Step 7.	Automatic classification of point data
Step 8.	Interactive classification of point data
Step 9.	Calculation of DTM
Step 10.	Provide different outputs to users
Post-condition	Classified elevation point data, DTM 2 m grid, metadata
Data source: Elevation point data	
Description	Elevation point data refers to an entire point cloud, since all points (for instance those hitting the ground or the trees) have a known elevation and the entire point mass is stored for various purposes.
Data provider	NLS of Finland
Geographic scope	Finland
Thematic scope	Elevation data

Use Case Description	
Scale, resolution	Elevation accuracy (RMSE at the most) is 15 cm on unambiguous surfaces.
Delivery	Files in LAS-format
Documentation	
Data source: DTM 2 m grid	
Description	The national elevation model is a grid model with a grid size of 2 metres.
Data provider	NLS of Finland
Geographic scope	Finland
Thematic scope	Elevation data
Scale, resolution	The accuracy (RMSE at the most) is 30 cm.
Delivery	ASCII grid, ASCII xyz
Documentation	

B.2 *Additional use cases*

As additional information, in the development of this specification the following use cases has been also taken into account as further input for user requirements:

- Environmental impact assessment.
- Air traffic management.
- Support to cartographic processing tasks, as stated in document D3.5 of GIS4EU project:
  - DEM interpolation, DEM merging, DEM analysis.
  - Generation of shaded-relief, hypsometric-areas and slope maps, natural basins, viewsheds and vector elevation features.
  - Generalization of DEM and spot heights.

Annex C
(normative)
Pan-European Grid for raster *Elevation* data at global level

This annex explains the need to establish a common European grid to provide raster-based spatial information for the *Elevation* theme aimed at Pan-European global purposes within the INSPIRE context and establishes the characteristics of this grid.

This grid is harmonised with other themes with similar needs.

C.1 *Introduction*

The amount of information made available to users will be enormous when INSPIRE services become operative. In order to combine all these data sets or make cross-reference analyses aimed at satisfying pan-European cross-border needs, it would be highly desirable to make data available in the same coordinate reference system (with its associated datum) to obtain consistent data. This is supported by key use-cases like flood modelling and emergency response.

Conservation of original radiometric values is important when working with raster files, since interpolations directly affect the accuracy of those variables computed from them. As an example, in the case of elevations resampling diminishes height values associated to points on the Earth surface.

The different projections allowed by the *INSPIRE Data Specification on Coordinate Reference Systems v3.1* for representation in plane coordinates are recommended in association to a certain range of scales and/or purposes, but problems arise when combining the data using these map projections (due to their inherent characteristics). As an example, ETRS-LAEA is suitable for spatial analysis and reporting, ETRS89-LCC is recommended for mapping at scales smaller than 1:500,000 and ETRS89-TMzn at scales greater than 1:500,000, with the additional inconvenience of using different zones for the whole Europe.

Hence, it would be recommendable to minimise coordinate reference system transformations of the data sets as possible, in order to preserve quality.

Furthermore, even in the case where data is made available in the same coordinate reference system, when combining raster georeferenced data from different sources, limits of grid cells or pixels usually do not match in x, y coordinates (i.e. may be they are not aligned due to the fact they were generated by independent production chains). In order to get the proper alignment of grid cells or pixels it is necessary to establish additional rules, such as the origin of the common grid and the reference point of a grid cell.

Section 2.2.1 of the *Commission Regulation (EU) No 1089/2010, on interoperability of spatial data sets and services*, establishes a common grid for pan-European spatial analysis and reporting. This geographical grid (identified as Grid_ETRS89-LAEA) is based on the ETRS89 Lambert Azimuthal Equal Area coordinate reference system (ETRS89-LAEA) and is proposed as the multipurpose Pan-European standard. However, the Grid_ETRS89-LAEA is not suited for *Elevation* data:

- LAEA projection is inappropriate for the *Elevation* theme data due to its inherent properties:
  - The direction of the Geographic North varies as geographical longitude does;
  - The scale gradually decreases from the centre of the projection;
  - Directions are only true directions from this point;
  - Shape distortions increases while moving away from this point.
  - It makes difficult the use of hierarchical levels of grid cell sizes, since resolution varies depending on the position;

- The Grid_ETRS89-LAEA is an equal area projection suited for thematic spatial analysis and reporting, whereas for *Elevation* data the geometric aspects are important (e.g. conservation of angles, shapes and directions), as it is reference data.

In prevision of this type of issues, Section 2.2.2 of the mentioned regulation, states that other grids than the Grid_ETRS89-LAEA may be specified for specific spatial data themes of the INSPIRE Annexes. Therefore there is the possibility to solve these issues or minimize it as possible.

As a consequence of all the aspects above, this specification recommends the use of a specific common European grid in order to achieve convergence of raster *Elevation* data sets in terms of datum (already fixed by the *Commission Regulation (EU) No 1089/2010*), coordinate reference system and data sets organization for the different levels of detail (levels of the common grid) for data provision.

C.2 *Definition of the pan-European grid for raster* Elevation *data*

C.2.1 Legal framework

Section 2.2.1 of the *Commission Regulation (EU) No 1089/2010, of 23 November 2010, implementing Directive 2007/2/CE of the European Parliament and of the Council as regards interoperability of spatial data sets and services*, establishes a common grid for pan-European spatial analysis and reporting.

As stated in Section 2.2.2 of the mentioned regulation, other grids may be specified for specific spatial data themes of the INSPIRE Annexes.

The reasons justifying the recommendation to use a specific grid for raster European *Elevation* data aimed at global purposes are summarized in C.1 of this annex.

C.2.2 Definition of the grid

Provision of data in ETRS89-GRS80 geodetic coordinates is aligned with the *Commission Regulation (EU) No 1089/2010, of 23 November 2010, on interoperability of spatial data sets and services* and with the *INSPIRE Data Specification on Coordinate Reference Systems v3.1*, while is a valid alternative to have continuous data regardless different levels of detail and purposes.

A grid typically uses a matrix of n x m cells spanned by 2 axes. As a result, a grid cell can be referenced by a sequence of integer values (one for each axis) that represent the position of the reference cell along each of the axes of the grid. See CV_GridCoordinate as specified in ISO 19123.

The grid defined in this annex – proposed as the raster data Pan-European standard at global level – is based on the ETRS89-GRS80 geodetic coordinate reference system (CRS identifier in INSPIRE: ETRS89-GRS80).

The grid is designated as Grid_ETRS89-GRS80. For identification of an individual resolution level the cell size in degrees (D), minutes (M), seconds (S), milliseconds (MS) or microseconds (MMS) is appended to this name.

EXAMPLE The grid at a resolution level of 300 milliseconds is designated as Grid_ETRS89-GRS80_*300MS*.

The origin of Grid_ ETRS89-GRS80 coincides with the point where the Equator intersects with the Greenwich Meridian (GRS80 latitude φ=0; GRS80 longitude λ=0).

The grid is defined as a hierarchical one with the resolutions established in the following table, based on a modification of the well-known scale set *GlobalCRS84Pixel* included in the WMTS v1.0.0

specification. The levels defined in this table constitute a pyramidal grid structure. Most of its levels can be obtained as an aggregation of certain lower one/s.

Table 1 – Levels of resolution for the common Grid_ETRS89-GRS80

Cell Size (degrees)	Cell Size ID	Approx. Cell Size in a Meridian (m)
2	2 D	240000
1	1 D	120000
0.8333333333333333 (50')	50 M	100000
0.5 (30')	30 M	60000
0.333333333333333 (20')	20 M	40000
0.166666666666667 (10')	10 M	20000
$8.333333333333333\ 10^{-2}$ (5')	5 M	10000
$3.333333333333333\ 10^{-2}$ (2')	2 M	4000
$1.666666666666667\ 10^{-2}$ (1')	1 M	2000
$8.333333333333333\ 10^{-3}$ (30")	30 S	1000
$4.166666666666667\ 10^{-3}$ (15")	15 S	500
$8.333333333333333\ 10^{-4}$ (3")	3 S	100
$4.166666666666666\ 10^{-4}$ (1.5")	1500 MS	50
$2.777777777777777\ 10^{-4}$ (1")	1000 MS	33.33
$2.083333333333333\ 10^{-4}$ (0.75")	750 MS	25
$8.333333333333333\ 10^{-5}$ (0.3")	300 MS	10
$4.166666666666666\ 10^{-5}$ (0.15")	150 MS	5
$2.083333333333333\ 10^{-5}$ (0.075")	75 MS	2.5
$8.333333333333333\ 10^{-6}$ (0.03")	30 MS	1
$4.166666666666666\ 10^{-6}$ (0.015")	15 MS	0.5
$2.083333333333333\ 10^{-6}$ (0.0075")	7500 MMS	0.25
$8.333333333333333\ 10^{-7}$ (0.003")	3000 MMS	0.1

The previous table is proposed as a starting point in the current version of this data specification. It may be modified or extended if justified during the subsequent development of the data specification.

The grid orientation is south-north, west-east – according the net defined by the meridians and parallels of the GRS80 ellipsoid.

The reference point of a grid cell shall be the top left corner of the grid cell.

The coordinates of any grid cell will always be a multiple of the grid cell size for a specific grid level, as a consequence of establishing a common origin for the grid (φ=0; λ=0).

As a consequence, problems of alignment between raster files with the same grid cell size disappear.

Recommendation 26 The Grid_ETRS89-GRS80 as defined in this annex should be used as a geo-referencing framework for the *Elevation* theme data sets in order to support cross-border use-cases and purposes.

IR Requirement 18 The grid shall be designated as Grid_ETRS89-GRS80. For identification of an individual resolution level the cell size in angular units shall be appended, according to the "*Cell size ID*" column in Table 1 (e.g. Grid_ETRS89-GRS80_*300MS*).

IR Requirement 19 The reference point of a grid cell for grids based on ETRS89-GRS80 shall be the top left corner of the grid cell.

The origin cell of a raster file shall be the grid cell located at the top left corner.

IR Requirement 20 The origin cell of any raster file based on the Grid_ETRS89-GRS80 shall be the grid cell located at the top left corner of the raster file.

A coding system for the unambiguous referencing and identification of a grid cell is under discussion. Guidance on this will be included in the next version of this specification.

It is recognised that there is a need to enable grid referencing for regions outside of continental Europe, for example for overseas Member States (MS) territories. For these regions, MS are able to define their own grid, although it must follow the same principles as laid down for the Pan-European Grid_ETRS89-GRS80 and be documented according to ISO 19100 standards.

Such MS defined grids will be based on the International Terrestrial Reference System (ITRS), or other geodetic coordinate reference systems compliant with ITRS in areas that are outside the geographical scope of ETRS89. This follows the Requirement 2 of the Implementing Rule on Coordinate reference systems [INSPIRE-DS-CRS], i.e. compliant with the ITRS means that the system definition is based on the definition of the ITRS and there is a well established and described relationship between both systems, according to ISO 19111:2007 Geographic Information – Spatial referencing by coordinates. An identifier shall be created according to the rules established in the "*Cell size ID*" column in Table 1.

IR Requirement 21 For grid referencing in regions outside of continental Europe MS may define their own grid based on a geodetic coordinate reference system compliant with ITRS, following the same principles as laid down for the Pan-European Grid_ETRS89-GRS80. In this case, an identifier for the CRS and the corresponding identifier for the grid shall be created.

EXAMPLE Example of a correctly constructed grid identifier: 'Grid_ETRS89-GRS80'.

C.3 *Use of the pan-European grid for raster* Elevation *data*

Whereas most *Elevation* applications may be solved using national datasets (based on existing national grids in the MS), there is a need to properly combine raster data in order to serve cross-border use-cases (e.g. flooding management and emergency response). This implies the utilization of a common grid which avoids the problems caused by the fact of using different map projections and introduces cell alignment rules. Making available this kind of data using ETRS89-GRS80 geodetic coordinates according a common grid is a solution to the problem.

The grid defined in C.2.2 is designed for this specific purpose. It is applicable for delivering raster spatial data sets of the *Elevation* theme and its geographical scope is the continental part of Europe.

Recommendation 27 INSPIRE raster *Elevation* data sets within the continental Europe should be at least made available using geodetic coordinates based on the Grid_ETRS89-GRS80 in order to avoid interoperability problems in cross-border areas.

Obviously, the use of map projections is needed in order to properly visualize the data in a specific geographical area. However, this can be performed in a subsequent process whereas data is geometrically continuous and provided in geodetic coordinates at pan-European level. Therefore it will be necessary to perform on-the-fly re-projections to transform from the source coordinate reference

system (in which data is stored) to the one chosen for display. This implies unavoidable degradation of source data on the screen, as any additional geometric transformation involves resampling processes.

It is worthy to mention here that the most direct way to provide raster data sets through a download service according the previous recommendation would be to store them at data sources using geodetic coordinates based on the Grid_ETRS89-GRS80. This would make possible downloading the original harmonised data free of any additional transformation.

In the future, production of *Elevation* data sets should be based on the common Grid_ETRS89-GRS80 instead of national grids, since the unavoidable transformation between the grids has an inherent loss of quality.

The planar representation of geodetic coordinates introduces unusual distortions as the latitude parameter increases, as a result of the convergence of meridians. This may cause undesirable effects in areas located at high latitudes, which become especially important in areas near the Polar Regions. Particularly, the longitude axe is rescaled causing a stretching of the grid in the WE direction when it is represented in geodetic coordinates (visually this is perceived as if the grid is flattened in the NS direction).

As a consequence of this convergence, the volume of data needed to store raster information in geodetic coordinates increases as the latitude does, since the number of grid cells per area unit becomes greater.

EXAMPLE While 1 arcsecond in longitude corresponds approximately to 31 meters at the Equator, it corresponds to 25 meters in Gibraltar (southern part of Spain - latitude 35 degrees) and only to 10 meters in North Cape (North Scandinavia - latitude 71 degrees).

Therefore, for the visualization of such data sets it is recommended the use of any map projection which is suitable to the specific geographical area to be rendered as well as it is allowed by the *Regulation (EU) No 1089/2010, of 23 November 2010, on interoperability of spatial data sets and services*.

Consequently, *on-the-fly* projection transformations are needed for view services serving these data sets.

Recommendation 28 Real time re-projection is recommended for the view services serving INSPIRE raster *Elevation* data sets aimed at serving global purposes.