# Contents

# Annex D
(informative)
# Pan-European Geographic Grid for gridded *Elevation* data

This annex explains the need to establish a Pan-European geographic grid for the provision of gridded *Elevation* spatial information (i.e. raster, coverage-based data) aimed at global purposes within the INSPIRE context and defines the characteristics of this grid.

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 geographic grid for gridded European *Elevation* data aimed at global purposes are summarized in D.1 of this annex.

## D.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. Although they are not equally relevant for every INSPIRE theme dealing with gridded data, it would be highly desirable that all the themes with similar needs makes use of the same geographical grid system in order to maintain their coherence.

Conservation of original 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 the elevation property 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 larger 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 their quality.

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

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 (Equal Area Grid). 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, because:

- The inherent properties of LAEA projection are inappropriate:

- 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 defined in 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 desirable for 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 them as possible.

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

The Zoned Geographic Grid proposed in D.2 of this annex is aimed at minimize the previous issues. It is defined in geodetic coordinates and follows a structure analogue to DTED (Digital Terrain Elevation Data), which constitutes a valid solution to mitigate the effect of convergence of meridians. Due to this effect, if a geographic grid is defined in equiangular geodetic coordinates, the grid cell dimension on the ground becomes smaller in the longitude axis while the latitude increases, causing undesirable effects in areas with high latitude. This becomes especially problematic in areas near the Polar Regions.

## D.2 Zoned Geographic Grid for gridded *Elevation* data

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*, while is a valid alternative to have continuous data regardless different levels of detail and purposes (as explained in D.1).

The amendment of this Regulation presented as a result of the INSPIRE Annex II and III process establishes the Zoned Geographic Grid, a multi-resolution geographic which may be used as a geo-referencing framework when gridded data is delivered using geodetic coordinates. The characteristics of this grid are defined below.

**IR Requirement**
*Annex II, Section 2.2.2*
**Zoned Geographic Grid**

(1) When gridded data is delivered using geodetic coordinates the multi-resolution Zoned Geographic Grid defined in this annex may be used as a geo-referencing framework.

As recommended in Section 6.2.2 of this specification, Pan-European gridded *Elevation* data in areas within the scope of ETRS89 should be at least made available using geodetic coordinates based on the Zoned Geographic Grid.

**IR Requirement**
*Annex II, Section 2.2.2*
**Zoned Geographic Grid**

(…)

(3) The grid shall be based on the ETRS89-GRS80 geodetic coordinate reference system.

**IR Requirement**
*Annex II, Section 2.2.2*
**Zoned Geographic Grid**

(…)

(4) The origin of the grid shall coincide with the intersection point of the Equator with the Greenwich Meridian (GRS80 latitude $\varphi=0$; GRS80 longitude $\lambda=0$).

**IR Requirement**
*Annex II, Section 2.2.2*
**Zoned Geographic Grid**

(…)

(5) The grid orientation shall be south-north and west-east according to the net defined by the meridians and parallels of the GRS80 ellipsoid.

The geographical grid establishes multiple levels of resolution and follows a structure analogue to DTED, dividing the world into different zones in latitude, as shown in the following table:

**Table 12– Latitudinal zones for the common Grid_ETRS89-GRS80zn**

| Zone | Latitude | Factor |
|---|---|---|
| 1 | 0°–50° | 1 |
| 2 | 50°–70° | 2 |
| 3 | 70°–75° | 3 |
| 4 | 75°–80° | 4 |
| 5 | 80°–90° | 6 |

It is recognized that a geographical grid with such structure may constitute additional efforts for Member States whose territories intersect the limit of adjoining zones. However, this is perceived as an acceptable solution to mitigate the meridian convergence. It is worth to mention here that most of territories in continental European are included in Zones 1 and 2 (Cape North in Norway is approximately at 71° latitude).

For a given level of resolution:

- The latitude spacing of cells of the geographic grid is the same in the different zones.
- Each zone has a specific longitude spacing for the cells of the geographic grid (equal or greater than the latitude spacing). Last column in the previous table shows the factor by which the latitude spacing is multiplied in each zone to obtain the longitude spacing.

When applying this factor, the cell sizes become approximately square on the ground (while they are rectangular in geodetic coordinates, i.e. 1x2, 1x3, 1x4, 1x6). Only grid cells included in Zone 1 preserve the square condition in geodetic coordinates (1x1).

**IR Requirement**
*Annex II, Section 2.2.2*
**Zoned Geographic Grid**

(…)

(2) The resolution levels are defined in Table 1.

NOTE Table 13 in this document

**IR Requirement**
*Annex II, Section 2.2.2*
**Zoned Geographic Grid**

(…)

(7) This grid shall be subdivided in zones. The south-north resolution of the grid shall have equal angular spacing. The west-east resolution of the grid shall be established as the product of angular spacing multiplied by the factor of the zone as defined in Table 1.

NOTE Table 13 in this document

The geographic grid is generically designated as Grid_ETRS89-GRS80zn. For identification of an individual resolution level the zone number (*n*) and the cell size (*res*) - in degrees (D), minutes (M), seconds (S), milliseconds (MS) or microseconds (MMS) - has to be included and appended (respectively) to this designator, resulting in the Grid_ETRS89-GRS80z*n_res*.

EXAMPLE The zoned geographical grid at a resolution level of 300 milliseconds in Zone 2 is designated as Grid_ETRS89-GRS80z*2_300MS*.

**IR Requirement**
*Annex II, Section 2.2.2*
**Zoned Geographic Grid**

(…)

(8) The grid shall be designated Grid_ETRS89-GRS80z*n_res*, where *n* represents the number of the zone and *res* the cell size in angular units, as specified in Table 1.

NOTE Table 13 in this document

**Table 13 - Common Grid_ETRS89-GRS80zn: Latitude spacing (resolution level) and longitude spacing for each zone**

| Resolution Levels | LATITUDE SPACING (Arc seconds) | LONGITUDE SPACING (Arc seconds) | | | | | Cell Size |
|---|---|---|---|---|---|---|---|
| | | Zone 1 (Lat. 0°–50°) | Zone 2 (Lat. 50°–70°) | Zone 3 (Lat. 70°–75°) | Zone 4 (Lat. 75°–80°) | Zone 5 (Lat. 80°–90°) | |
| LEVEL 0 | 3600 | 3600 | 7200 | 10800 | 14400 | 21600 | 1D |
| LEVEL 1 | 3000 | 3000 | 6000 | 9000 | 12000 | 18000 | 50M |
| LEVEL 2 | 1800 | 1800 | 3600 | 5400 | 7200 | 10800 | 30M |
| LEVEL 3 | 1200 | 1200 | 2400 | 3600 | 4800 | 7200 | 20M |
| LEVEL 4 | 600 | 600 | 1200 | 1800 | 2400 | 3600 | 10M |
| LEVEL 5 | 300 | 300 | 600 | 900 | 1200 | 1800 | 5M |
| LEVEL 6 | 120 | 120 | 240 | 360 | 480 | 720 | 2M |
| LEVEL 7 | 60 | 60 | 120 | 180 | 240 | 360 | 1M |
| LEVEL 8 | 30 | 30 | 60 | 90 | 120 | 180 | 30S |
| LEVEL 9 | 15 | 15 | 30 | 45 | 60 | 90 | 15S |
| LEVEL 10 | 5 | 5 | 10 | 15 | 20 | 30 | 5S |
| LEVEL 11 | 3 | 3 | 6 | 9 | 12 | 18 | 3S |
| LEVEL 12 | 1,5 | 1,5 | 3 | 4,5 | 6 | 9 | 1500MS |
| LEVEL 13 | 1 | 1 | 2 | 3 | 4 | 6 | 1000MS |
| LEVEL 14 | 0,75 | 0,75 | 1,5 | 2,25 | 3 | 4,5 | 750MS |
| LEVEL 15 | 0,5 | 0,5 | 1 | 1,5 | 2 | 3 | 500MS |
| LEVEL 16 | 0,3 | 0,3 | 0,6 | 0,9 | 1,2 | 1,8 | 300MS |
| LEVEL 17 | 0,15 | 0,15 | 0,3 | 0,45 | 0,6 | 0,9 | 150MS |
| LEVEL 18 | 0,1 | 0,1 | 0,2 | 0,3 | 0,4 | 0,6 | 100MS |
| LEVEL 19 | 0,075 | 0,075 | 0,15 | 0,225 | 0,3 | 0,45 | 75MS |
| LEVEL 20 | 0,03 | 0,03 | 0,06 | 0,09 | 0,12 | 0,18 | 30MS |
| LEVEL 21 | 0,015 | 0,015 | 0,03 | 0,045 | 0,06 | 0,09 | 15MS |
| LEVEL 22 | 0,01 | 0,01 | 0,02 | 0,03 | 0,04 | 0,06 | 10MS |
| LEVEL 23 | 0,0075 | 0,0075 | 0,015 | 0,0225 | 0,03 | 0,045 | 7500MMS |
| LEVEL 24 | 0,003 | 0,003 | 0,006 | 0,009 | 0,012 | 0,018 | 3000MMS |
| FACTOR | - | 1 | 2 | 3 | 4 | 6 | - |

The table above shows the latitude spacing (each resolution level), as well as the longitude spacing obtained by applying the factor parameter to each latitudinal zone.

The levels of resolution identified in Table 13 make up a hierarchical geographic grid (which constitute a pyramidal grid structure). Level 8, Level 11 and Level 13 in the previous table correspond to the levels of resolution of the Digital Terrain Elevation Data (DTED) L0, L1 and L2, respectively. Other levels in the table are derived from these taking into account the well-known scale set *GlobalCRS84Pixel* included in the WMTS v1.0.0 specification.

Table 14 illustrates the approximate geographic grid cell size on terrain in latitude at each resolution level.

**Table 14 – Approximate Grid_ETRS89-GRS80zn cell size on terrain in latitude at each resolution level**

| Resolution Levels | Cell Size in Latitude (Latitude Spacing) | Approx. Cell Size on terrain in Latitude |
|---|---|---|
| | (Arc seconds) | (Meters) |
| LEVEL 0 | 3600 | 120000 |
| LEVEL 1 | 3000 | 100000 |
| LEVEL 2 | 1800 | 60000 |
| LEVEL 3 | 1200 | 40000 |
| LEVEL 4 | 600 | 20000 |
| LEVEL 5 | 300 | 10000 |
| LEVEL 6 | 120 | 4000 |
| LEVEL 7 | 60 | 2000 |
| LEVEL 8 | 30 | 1000 |
| LEVEL 9 | 15 | 500 |
| LEVEL 10 | 5 | 166 |
| LEVEL 11 | 3 | 100 |
| LEVEL 12 | 1,5 | 50 |
| LEVEL 13 | 1 | 33.33 |
| LEVEL 14 | 0,75 | 25 |
| LEVEL 15 | 0,5 | 16 |
| LEVEL 16 | 0,3 | 10 |
| LEVEL 17 | 0,15 | 5 |
| LEVEL 18 | 0,1 | 3 |
| LEVEL 19 | 0,075 | 2.5 |
| LEVEL 20 | 0,03 | 1 |
| LEVEL 21 | 0,015 | 0.5 |
| LEVEL 22 | 0,01 | 0.33 |
| LEVEL 23 | 0,0075 | 0.25 |
| LEVEL 24 | 0,003 | 0.1 |

| | |
|---|---|
| **TG Requirement 1** | The coordinates of the top left corner of cells of the Grid_ETRS89-GRS80zn shall be used for cell identification purposes. |

The geodetic coordinates of any cell of this Zoned Geographic Grid for a specific zone will always be a multiple of the grid cell size for a given resolution level, as a consequence of establishing a common origin for the geographic grid (φ=0; λ=0).

As a consequence, problems of alignment between raster files (coverages) based on the Grid_ETRS89-GRS80z*n_res* at the same resolution level (grid coverage cell size) disappear. Remaining misalignments correspond only to the difference in absolute positioning and consistency of the data being combined. Especially in the case of very high resolution data, an inherent positional misalignment between coverages originated from two neighbour data providers may be observed, due to the different product specifications and (moreover) to the fact that the cells of the common geographic grid do not necessarily represent the same sampled features on the Earth in both datasets (e.g. because of the occlusions and/or the different angles of observation).

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 geographic grid, although it must follow the same principles as laid down for the Pan-European Grid_ETRS89-GRS80zn 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.

**IR Requirement**
*Annex II, Section 2.2.2*
**Zoned Geographic Grid**

(…)

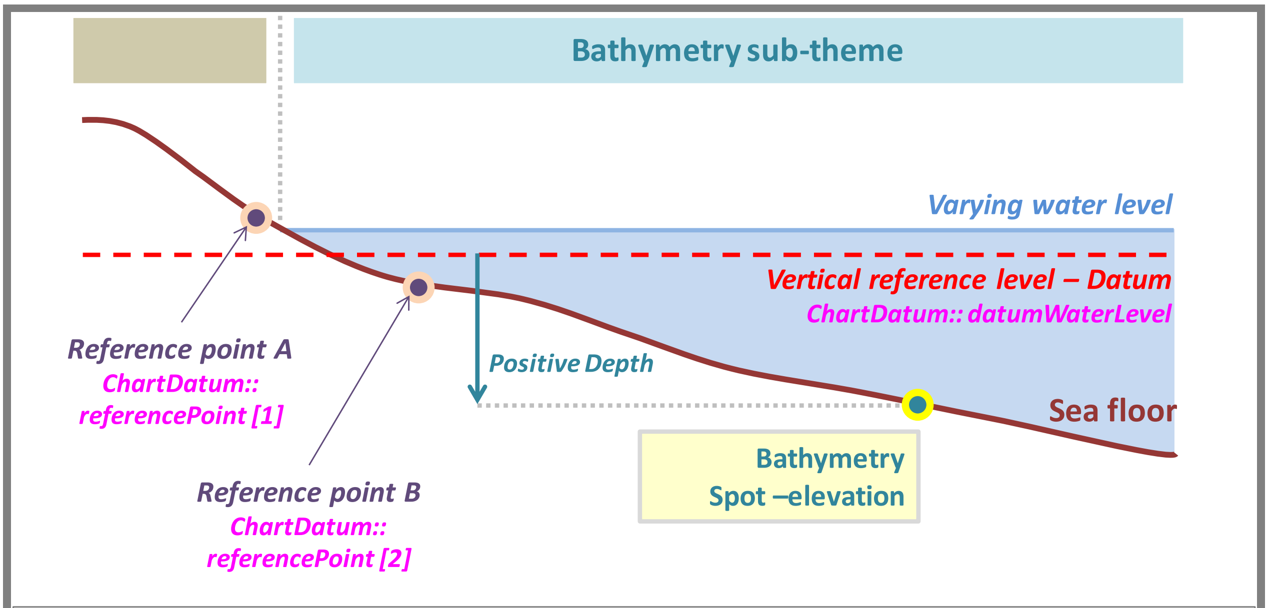
(6) For grid referencing in regions outside of continental Europe data providers may define their own grid based on a geodetic coordinate reference system compliant with ITRS, following the same principles as laid down for the Pan-European Grid_ETRS89-GRS80zn. In this case, an identifier for the CRS and the corresponding identifier for the grid shall be created.

NOTE The term continental Europe means the area within the scope of ETRS89/EVRS.

# Annex E
(informative)
# Examples on how to use *ChartDatum* data type

This annex includes example figures which help in understanding the use of the *ChartDatum* data type, defined in Section 6.2.1.4.2.

## E.1 Description of the sea floor

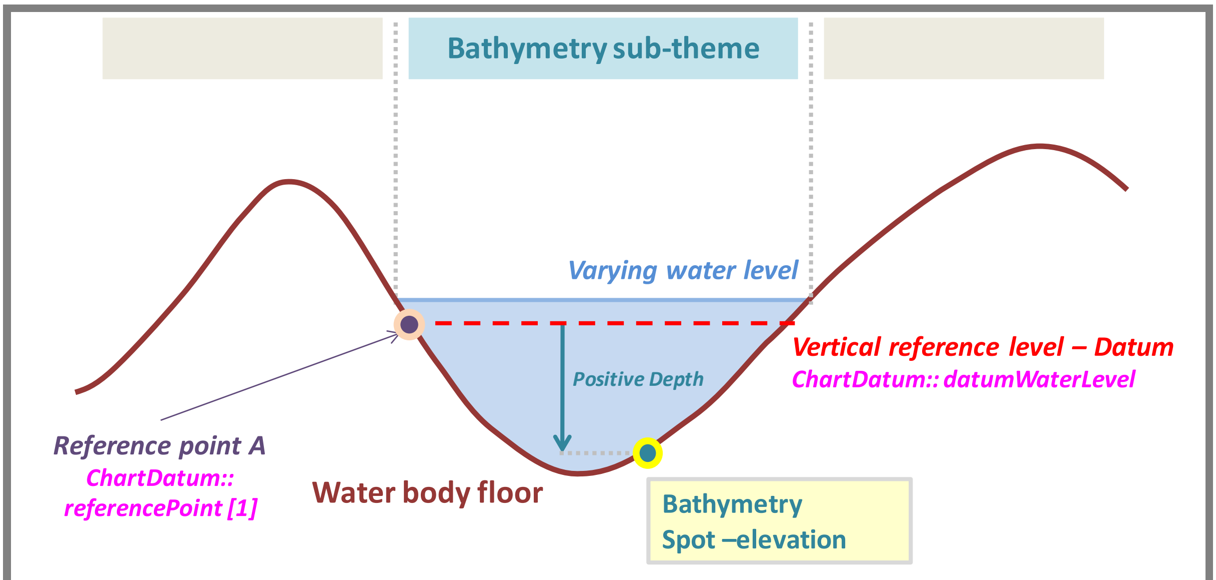



**NOTES**

1. In this example the vertical reference level is determined using two reference points ('A' and 'B') and it is informed using an instance of ChartDatum: the ***referencePoint[1]*** and ***referencePoint[2]*** attribute values determine the vertical reference level for this sea area, which is represented by the ***datumWaterLevel*** attribute.
2. Both reference points have known elevation offsets from ***datumWaterLevel***: ***offset[1]*** and ***offset[2]***, respectively (offsets are not shown in the figure).

**Figure 32 – Example: Description of the sea floor.**

## E.2 Description of the floor of an inland standing water body

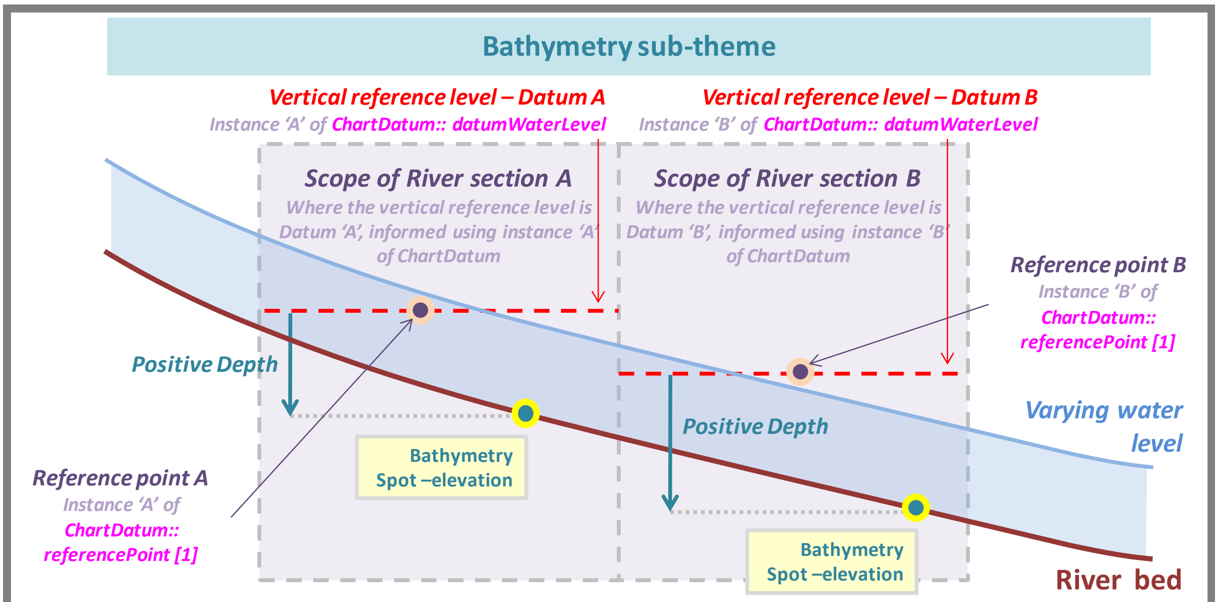



**NOTES**

1. In this example the vertical reference level is determined using one reference point ('A') and it is informed using an instance of ChartDatum: the ***referencePoint[1]*** attribute determines the vertical reference level for the inland standing water body, which is represented by the ***datumWaterLevel*** attribute.
2. The reference point have known elevation offset from ***datumWaterLevel***: ***offset[1]*** (equal to 0 in this example).

**Figure 33 – Example: Description of the floor of an inland standing water body.**

## E.3 Description of the bed of a navigable river




**NOTES**

1. In this example two sections 'A' and 'B' of a river are shown. Each of them has its own vertical reference level, which is informed using an instance of ChartDatum ('A' and 'B'): e.g. the ***referencePoint[1]*** attribute of instance 'A' of ChartDatum determines the vertical reference level for river section A , which is represented by the ***datumWaterLevel*** attribute.

**Figure 34 – Example: Description of the bed of a navigable river.**

# Annex E
(normative)
# Encoding rules for TIFF

## E.1 Introduction

This annex specifies how to use the TIFF file format for encoding the range set of grid coverages. Because pixel payload is not sufficient to construct a readable standalone image, additional descriptive information has to be packaged together in the same file, even if it is already provided somewhere else in GML. For this purpose, this part establishes schema conversion rules for all the coverage components of INSPIRE Application Schemas that have a corresponding element in the output TIFF data structures. These conversion rules play an essential role in maintaining consistency between the different representations (i.e. GML or TIFF) of the same coverage information.

On the other hand, TIFF specifications offers many options and let some variables open for encoding image data. If this flexibility allows covering most applications, it leads, in turn, to a situation where disparate implementation platforms exist while being potentially incompatible. As a result, interoperability is often unlikely. In order to fill in this gap and to enable a controlled exchange of data across Europe, this annex draws up an implementation profile of TIFF to constrain their usage within the scope of INSPIRE. It amounts to impose external format-dependent restrictions to the applicable values of the properties described in the INSPIRE application schemas.

## E.2 TIFF format

### E.2.1 Format overview

The Tagged Image File Format (TIFF) is a binary file format for storing and interchanging raster images. Originally developed by the company Aldus (Adobe Systems), it is in the public domain since 1992, the year of the latest release of the specifications (revision 6.0 [TIFF]). TIFF has become a popular “de facto standard” for high colour-depth digital images. It is widely used in image handling applications, covering various themes such as Elevation.

TIFF specifications are divided into two parts. Part 1: Baseline TIFF defines all the features that every reader must support, while Part 2: TIFF Extensions provides additional format structures designed for specialized applications, that are not necessarily taken into account by all TIFF readers (e.g. JPEG or LZW compression, tiling, CMYK images).

As highlighted in the format name, the TIFF data structure is based on the definition of tags for describing the characteristics of images. To be more precise, a TIFF file contains an image file header pointing to one or several image file directory (IFD). The image file header fixes the technical properties of the file, such as the byte order (e.g. little-endian or big-endian) or the offset of the first byte. An image file directory holds the complete description of an image by means of fields or entries. Each IFD entry consists of a tag identifying the field, the field type (e.g. byte, ASCII, short int), the number of values and the values themselves or an offset to the values. The location of the actual image data within the file is given by the combination of information elements expressed in some fields.

### E.2.2 INSPIRE TIFF profile for grid coverage data

This section lists the requirements and the constraints to be applied to the TIFF format when encoding INSPIRE Elevation data sets in this format. It should be read in conjunction with the table in section E.2.3 which provides more detailed information. Some of the rules presented here are directly inspired by the GeoTIFF Profile for Georeferenced Imagery [DGIWG-108] edited by DGIWG for the military community.

#### E.2.2.1 General rules

| | |
|---|---|
| **TG Requirement 2** | Encoding of INSPIRE Elevation data sets by using TIFF format shall conform to Baseline TIFF extended to LZW Compression. |

NOTE Baseline TIFF is described in the part 1 of the TIFF specification 6.0 [TIFF], while the TIFF extension on LZW Compression is addressed in part 2.

TIFF files must be identified as such by network services by using a predefined Internet media type or MIME type.

| | |
|---|---|
| **TG Requirement 3** | A file claiming to encode coverage elements in TIFF shall receive the *image/tiff* MIME type registered in RFC 3302. |

NOTE The absence of the optional application parameter here does not necessarily imply that the encoded TIFF image is Baseline TIFF.

#### E.2.2.2 Data structure

Even though TIFF specifications allow describing multiple related images in a single file by using more than one Image File Directory (IFD), Baseline TIFF readers are not required to decode any IFD beyond the first one. In order to ensure alignment with Baseline TIFF, all indispensable information has to be included in the first IFD.

| | |
|---|---|
| **TG Requirement 4** | A TIFF file shall not contain more than two image file directories (IFD). |

| | |
|---|---|
| **TG Requirement 5** | The first IFD shall carry the range set of the grid coverage. In the case of two IFD, the second shall be used to support a transparency mask. |

NOTE As a consequence, the different bands of a same image can not be split in separate IFDs.

The use of a second IFD is admitted for encoding an optional transparency mask, which is common for geographic raster data. This kind of ancillary information describes precisely the meaningful area of the image in the first IFD. It is useful at least for portrayal considerations. A transparency mask is a bi-level image matching pixel by pixel the image depicted in the first IFD. The pixel value 1 in the transparency mask means that the corresponding pixel in the image itself is significant. Conversely, the value 0 means that the corresponding pixel in the image holds a no data value (e.g. unknown, withheld). Typically, it must be made transparent when displaying the image.
The image file directory assigned to a transparency mask must receive the following TIFF tag values:

- BitsPerSample = 1
- Colormap: not used
- ImageDescription = 'transparency mask'
- ImageLength = ImageLength of the first IFD
- ImageWidth = ImageWidth of the first IFD
- NewSubFileType: all bits equal 0, except bit 2 = 1
- PhotometricInterpretation = 4
- SamplesPerPixel = 1

#### E.2.2.3 Grid coordinate system

Baseline TIFF supports only one type of orientation for grid coverages, that is, one type of grid coordinate system.

| | |
|---|---|
| **TG Requirement 6** | The origin of the grid coordinate system shall be the upper left corner of the grid coverage. The axis 'row' and 'column' shall be oriented downward and to the right. |

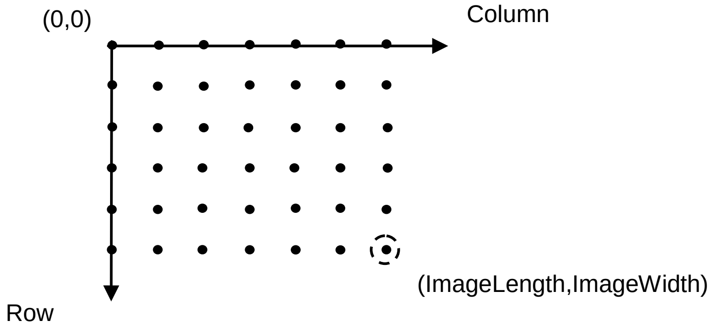



**Figure 35. referenced grid as defined by Baseline TIFF**

#### **E.2.2.4** Range values

The Baseline TIFF specifications cover four image types: bi-level, greyscale, palette-colour and full-colour images. Multi-band images are allowed but not fully addressed: baseline TIFF readers are intended to skip over the extra components gracefully, using the values of the SamplesPerPixel and BitsPerSample fields.

The image data of a TIFF file should contain either 1 (bi-level, greyscale and palette-colour), 3 (RGB) or 4 bands (RGB with associated alpha data).

NOTE 1 Alpha data, which provides opacity information, is stored as an additional component per pixel. A 4-bands RGB image must have the following TIFF tag values: SamplesPerPixel = 4, PhotometricInterpretation = 2 (RGB) and ExtraSamples = 1 (associated alpha data).

NOTE 2 Encoding multispectral images in TIFF is running the risk of losing a part of the coverage range set, since many software applications are not able to support more than three colours.

| | |
|---|---|
| **TG Requirement 7** | For gridded data (e.g. elevation data, measured data), they shall be stored as 32-bit floating points. |

NOTE If the original data do not satisfy this requirement, they will be converted in a representation using the next higher power of 2.

| | |
|---|---|
| **TG Requirement 8** | In the case of multi-band images, the number of bits per component shall be the same for all the bands. |

| | |
|---|---|
| **TG Requirement 9** | In the case of multi-band images, the planar configuration shall be *Chunky* format, i.e. the bands are interleaved. |

NOTE The range values of a same grid point in its different bands are stored contiguously. For instance, RGB data is stored as RGBRGBRGBRGB...

#### E.2.2.5 Compression

Data compression can be used within this profile to reduce the size of a file, provided that it does not distort the original range values after an encoding-decoding cycle. This condition allows, for example, ensuring the preservation of nil values.

| | |
|---|---|
| **TG Requirement 10** | The range value data shall be either uncompressed or lossless compressed with packbit or LZW compression schemes. |

NOTE As a TIFF extension, LZW compression is not supported by Baseline TIFF. However, it is included in this profile since its use is widespread, essentially for both its simplicity and its efficiency.

#### E.2.2.6 Internal tiling

The TIFF extension defined in section 15 of the specifications focuses on the way of laying out the image content into roughly square tiles. This method, as an alternative to the standard repartition of the range within separate strips, improves the access to data. However, it may cause some interoperability problems too. It is therefore better not to use it and to restrict oneself to Baseline TIFF.

### E.2.3 Mapping between TIFF and GML data structures

The following table indicates how to fill the content of TIFF tags for grid coverages in the context of INSPIRE. On the other hand, it gives the rules to be applied for ensuring the consistency of TIFF files with the Elevation GML Application(s) Schema(s). It does not address the encoding of the possible transparency mask (See E.2.2.2).

The columns *Tag name*, *Code*, *Type*, *Card.* and *Description* remind respectively the name, the code, the type, the maximum number of occurrences and the description of each Baseline TIFF tag within the meaning of the TIFF specification. The column *Obligation* informs if the tag is considered to be mandatory (M), conditional (C), optional (O) or inadequate (I). The column *Restricted values* specifies the values allowed for the tag in the context of INSPIRE. The column *Mapping to GML elements* establishes a correspondence between the tag values and the corresponding GML elements of the coverage whose type is one of those specified in the Generic Conceptual Model (e.g. RectifiedGridCoverage). N/A means not applicable.

**Table 15. Baseline TIFF implementation profile and Mapping between TIFF tags and the associated object elements from the Elevation GML Application Schema**

| Tag name | Code | Type | Card. | Description | Obligation | Restricted values | Mapping to GML elements (including restrictions) |
|---|---|---|---|---|---|---|---|
| Artist | 315 | ASCII | 1 | Person who created the image | O | - | N/A |
| BitsPerSample | 258 | Short | SamplesPerPixel | Number of bits per component | M | 1 for bi-level images<br>For imagery, constrained to **8** or **16** bits-per-pixel-per-band (e.g. 8 8 8 or 16 16 16 for RGB images).<br>For other gridded data, 8, 16 and 32 bits-per-pixel-per-band | For each band *i*, rangeType.field[*i*].constraint.interval = “0 *2^BitsPerSample[i]-1*” |
| CellLength | 265 | Short | 1 | The length of the dithering or halftoning matrix used to create a dithered or halftoned bilevel file. | I | This field should be never used | N/A |
| CellWidth | 264 | Short | 1 | The width of the dithering or halftoning matrix used to create a dithered or halftoned bilevel file. | I | This field should be never used | N/A |
| ColorMap | 320 | Short | 3*(2**BitsPerSample) | A colour map for palette colour images | C | Only for palette colour images | N/A |
| Compression | 259 | Short | 1 | Compression scheme used on the image data | M | **1** for uncompressed data<br>**5** for LZW compression<br>**32773** for PackBits compression of greyscale and palette-colour data | N/A |
| Copyright | 33432 | ASCII | 1..* | Copyright notice | O | - | N/A |
| DateTime | 306 | ASCII | 20 | Date and time of image creation | O | The Gregorian calendar should be used as a reference system for date values, and the Universal Time Coordinated (UTC) as a reference system for time values (local time is not recommended because offset from UTC can not be expressed in TIFF). | N/A<br>NOTE the field DateTime should not be confused with the properties *phenomenonTime* and *beginLifespanVersion* that report other types of temporal information. |
| ExtraSample | 338 | Short | 1..* | Description of extra components | C | Only when extra samples are present<br>**1** for 4-bands RGB images with alpha channel | N/A |

| Tag name | Code | Type | Card. | Description | Obligation | Restricted values | Mapping to GML elements (including restrictions) |
|---|---|---|---|---|---|---|---|
| FillOrder | 266 | Short | 1 | The logical order of bits within a byte. | O | **1** (default) | N/A |
| FreeByteCounts | 289 | Long | 1 | For each string of contiguous unused bytes in a TIFF file, the number of bytes in the string. | I | This field should be never used | N/A |
| FreeOffsets | 288 | Long | 1 | For each string of contiguous unused bytes in a TIFF file, the byte offset of the string. | I | This field should be never used | N/A |
| GrayResponseCurve | 291 | Short | 2**BitsPerSample | For greyscale data, the optical density of each possible pixel value. | I | This field should be never used | N/A |
| GrayResponseUnit | 290 | Short | 1 | The precision of the information contained in the GrayResponseCurve | I | This field should be never used | N/A |
| HostComputer | 316 | ASCII | 1..* | The computer and/or operating system in use at the time of image creation. | O | **-** | N/A |
| ImageDescription | 270 | ASCII | 1..* | Description of the image subject. | O | - | N/A |
| ImageLength | 257 | Short or Long | 1 | The number of rows in the image. | M | - | domainSet.extent.high.coordValues[*0*]-domainSet.extent.low.coordValues[*0*]=ImageLength |
| ImageWidth | 256 | Short or Long | 1 | The number of columns in the image, i.e. the number of pixels per row. | M | - | domainSet.extent.high.coordValues[*1*]-domainSet.extent.low.coordValues[*1*]=ImageWidth |
| Make | 271 | ASCII | 1 | The scanner manufacturer. | O | - | N/A |
| MaxSampleValue | 281 | Short | SamplesPerPixel | The maximum component value used. | O | This field should be used only for statistical purposes | N/A |
| MinSampleValue | 280 | Short | SamplesPerPixel | The minimum component value used. | O | This field should be used only for statistical purposes | N/A |
| Model | 272 | ASCII | 1 | The scanner model name or number. | O | - | N/A |
| NewSubfileType | 254 | Long | 1 | A general indication of the kind of data contained in this subfile. | O | **0** | N/A |
| Orientation | 274 | Short | 1 | The orientation of the image with respect to the rows and columns. | M | **1** (default) | domainSet.extent.low.coordValues="0 0" |

| Tag name | Code | Type | Card. | Description | Obligation | Restricted values | Mapping to GML elements (including restrictions) |
|---|---|---|---|---|---|---|---|
| PhotometricInterpretation | 262 | Short | 1 | Colour space of the image data. | M | **1** for bi-level and greyscale images (0 is black)<br>**2** for RGB images<br>**3** for palette-colour images | N/A |
| PlanarConfiguration | 284 | Short | 1 | How the components of each pixel are stored. | M | **1** which means, for RGB data, that the data is stored as RGBRGBRGB… | rangeSet.fileStructure="Record Interleaved" |
| ResolutionUnit | 296 | Short | 1 | Unit of measurement for XResolution and YResolution. | M | **2** which means dpi (dot per inch) | N/A |
| RowsPerStrip | 278 | Short or Long | 1 | Number of rows per strip. | C<br>Not used if tiling | It is recommended to choose this value such that each strip is about 8K bytes. | N/A |
| SampleFormat | 399 | Short | SamplesPerPixel | This field specifies how to interpret each data sample in a pixel. | M | **1** for imagery (unsigned integer data)<br>1, 2 or 3 for gridded data | For imagery, for each band *i*, rangeType.field[*i*].constraint.interval[0] = "0" |
| SamplesPerPixel | 277 | Short | 1 | Number of components per pixel. | M | **1** usually for bi-level, greyscale and palette-colour images<br>**3** or **4** usually for RGB images (the 4th component being used for alpha channel) | rangeType.field.size()=SamplesPerPixel |
| SmaxSampleValue | 341 | Field type that best matches the sample data | SamplesPerPixel | The maximum value for each sample. This tag is used in lieu of MaxSampleValue when the sample type is other than integer. | I | This field should be never used | N/A |
| SminSampleValue | | Field type that best matches the sample data | SamplesPerPixel | The minimum value for each sample. This tag is used in lieu of MaxSampleValue when the sample type is other than integer. | I | This field should be never used | N/A |
| Software | 305 | ASCII | 1..* | Name and version number of the software package(s) used to create the image. | O | - | N/A |
| StripByteCounts | 279 | Short or Long | StripPerImage | For each strip, number of bytes in the strip after compression. | C<br>Not used if tiling | **-** | N/A |

| Tag name | Code | Type | Card. | Description | Obligation | Restricted values | Mapping to GML elements (including restrictions) |
|---|---|---|---|---|---|---|---|
| StripOffsets | 273 | Long | StripPerImage | For each strip, the byte offset of that strip | C<br>Not used if tiling | - | N/A |
| Thresholding | 263 | Short | 1 | For black and white TIFF files that represent shades of gray, the technique used to convert gray to black and white pixels. | I | This field should be never used | N/A |
| TileWidth | 322 | Short or Long | | The tile width in pixels. This is the number of columns in each tile. | C<br>if tiling | - | N/A |
| TileLength | 323 | Short or Long | | The tile length (height) in pixels. This is the number of rows in each tile. | C<br>if tiling | - | N/A |
| TileOffsets | 324 | Long | | For each tile, the byte offset of that tile, as compressed and stored on disk. | C<br>if tiling | - | N/A |
| TileByteCount | 325 | Short or Long | | For each tile, the number of (compressed) bytes in that tile. | C<br>if tiling | - | N/A |
| Xresolution | 282 | Rational | | The number of pixels per ResolutionUnit in the ImageWidth direction. | M | - | N/A |
| Yresolution | 283 | Rational | | The number of pixels per ResolutionUnit in the ImageLength direction. | M | - | N/A |

In addition, the description of the coverage grid function must reflect the baseline ordering used by TIFF format to store the range values within a file. The following mapping must be applied:

coverageFunction.gridFunction.sequenceRule.type = “linear” AND coverageFunction.gridFunction.sequenceRule.scanDirection = “+2 +1