



DGIWG 116-3-3

Elevation Surface Model (ESM) Encoding Rules - Part 3: GMLJP2

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Abstract:	This document defines the ESM Encoding Rules on the basis of the DGIWG GMLJP2 profiles and the ESM UML model and metadata (DGIWG 116-1). It is to be used in conjunction with ESM Encoding Rules – Core (DGIWG 116-3-1).
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Table of Contents

1	Scope	1
2	Conformance	1
3	Normative References.....	2
4	Terms and definitions, and abbreviated terms.....	3
4.1	Terms and definitions.....	3
4.2	Abbreviated terms	3
5	Applicability and use.....	4
6	JPEG2000 ESM Coverage encoding for GMLJP2	5
7	JPEG2000 and GMLJP2 rules for ESM elevation data	5
7.1	Introduction	5
7.2	CRS	6
7.3	Units of Measure	7
7.4	Security Classification.....	7
7.5	Intellectual property rights information	7
7.6	Void Areas.....	8
7.7	ESM Data Representation	8
Annex A	ESM GMLJP2 encoding rules - Abstract test suites.....	11
A.1	ESM GMLJP2 Coverage GML instance conformance test	11
A.2	Conformance of GMLJP2 elevation data with DGIWG GMLJP2 profile.....	11
A.3	Correct encoding of CRS and UoM	11
A.4	Correct encoding of Security classification and Intellectual property rights information	11
A.5	Correct encoding of Void areas.....	11
A.6	Correct encoding of submetric unit for 4 bytes integer elevation values (for GMLJP2 v2 only)	12
A.7	Correct of the use of floating-point (Float32) elevation values (for GMLJP2 v2 only)...	12
Annex B	Requirements on consistency between JPEG2000 raster fields (JP2 format) and ESM GML elements	13
Annex C	Mapping between ESM GML elements, GMLJP2 version 1.0 data structures and ESM metadata	14
Annex D	ESM GML elements, GMLJP2 2.0 data structures and ESM metadata	17
	Bibliography.....	20

i. Submitting organizations

Nation	Parent organization
France (Lead Nation)	Institut Géographique National (IGN)
Czech Republic	Military Geographic and Hydrometeorologic Office (MGHM)
Denmark	Danish Geospatial Agency (SDFE)
Sweden	Military Geographic Service
Turkey	General Command of Mapping
United States	National Geospatial-Intelligence Agency (NGA)

ii. Revision history

Date	Release	Primary clauses modified	Description
18/10/2016	1.1 (draft)	All	Creation Review at DGIWG TP October 2016
16/05/2017	1.1		Resolution of comments in DGIWG TP, May 2017
2/10/2020	1.1.1		Update of normative references (Section 3) and throughout the document + addition of GMLCOV abbreviated term in 4.2

iii. Future work

None identified

Introduction

This document specifies how the Elevation Surface Model (ESM) shall use the GMLJP2 encoding standard to convey the elevation values assigned to regularly spaced grid points (under the Rectified Grid coverage model) or irregularly spaced grid points (under the Point coverage model) on the basis of the DGIWG standardized GMLJP2 profile for Georeferenced Imagery Version 1 (DGIWG 104), on basis of OGC GMLJP2 v1, or Version 2 (DGIWG 104-2), on basis of OGC GMLJP2 v2. It also includes the additional rules that apply to the ESM Coverage on the basis of the GMLCOV JPEG2000 extension.

It is to be used in conjunction with ESM Encoding rules – Part 1: Core (DGIWG 116-3-1) for the general encoding rules for ESM data and associated metadata, as well as associated ESM GML document (if applicable).

1 Scope

This document specifies how the Elevation Surface Model (ESM) shall use the GMLJP2 encoding standard to convey the elevation values assigned to regularly spaced grid points (under the Rectified Grid coverage model) or irregularly spaced grid points (under the Point coverage model), either on the basis of the DGIWG standardized GMLJP2 profile for Georeferenced Imagery Version 1 (DGIWG 104), based on OGC GMLJP2 v1, or on the basis of its Version 2 (DGIWG 104-2), based on OGC GMLJP2 v2. It also includes the additional rules that apply to the ESM Coverage based on the GMLCOV JPEG2000 extension.

It is to be used in conjunction with ESM Encoding rules – Part 1: Core (DGIWG 116-3-1) for the general encoding rules for ESM data and associated metadata, as well as associated ESM GML document (if applicable).

2 Conformance

Conformance to ESM Encoding Rules for GMLJP2 apply to, as detailed in Annex A, ESM Encoding Rules for GMLJP2:

- ESM Coverage schema based on GMLCOV for RectifiedGridCoverage or MultiPointCoverage with 2 options for the conformance class:
 - o in case of a message based encoding for a web service, with the GMLCOV *gml-coverage* and *multipart* conformance classes incorporating the supported format. This is the multipart data delivery conformance test for ESM Coverage data.
 - o in other cases (e.g. a physical media based encoding), with the *gml-coverage* and the *gml* conformance classes, with the exception of Clause A.1.1.17 - GML special format for the GML encoding of the RectifiedGridCoverage. In this case, the ESM GML Coverage document and the ESM data (corresponding to the rangeSet of GMLCOV), encoded in a dedicated format, are 2 distinct files. This is the multifile data encoding conformance test for ESM Coverage data.

Any ESM data claiming conformance to the DGIWG ESM Encoding Rules shall pass the applicable test specified in Annex A, ESM Encoding Rules.

Any software implementation claiming conformance to the DGIWG ESM Encoding Rules for GMLJP2 shall document its ability to import and/or export ESM compliant data in GMLJP2 encoding.

3 Normative References

The following normative documents contain provisions, which, through reference in this text, constitute provisions of these profiles.

1. DGIWG 116-1: Elevation Surface Model, Edition 1.1, 17 September 2020 [ESM]
2. DGIWG 114: DGIWG Metadata Foundation, 2.0.0, 12 July 2017 [DMF]
3. DGIWG 116-2: DGIWG ESM GML Application Schema, Edition 1.0.2, 2 October 2020 [ESM_GML_AS]
4. DGIWG 116-3-1: DGIWG ESM Encoding Rules – Part 1: Core, Edition 1.1.1, 2 October 2020 [ESM_ER_Core]
5. DGIWG 104: GMLJP2 Profile for Georeferenced Imagery – 4 February 2014, Edition 1.0.0 [DGIWG_GMLJP2v1]
6. DGIWG 104(2): GMLJP2 Profile for Georeferenced Imagery – Version 2 - 23 January 2020, Edition 2.1.1 [DGIWG_GMLJP2v2.1]
7. ISO 639-2:1998 Codes for the representation of names and languages
8. ISO 19136-1:2020 — Geographic information – Geography Markup Language (GML) – Part 1: Fundamentals
9. ISO 19136-2:2015 — Geographic information – Geography Markup Language (GML) – Part 2: Extended schemas and encoding rules
10. ISO 15444-1:2019: Information technology – JPEG 2000 image coding system – Part 1: Core Coding System
11. ISO 15444-2:2004: Information technology – JPEG 2000 image coding system – Part 2: Extensions
12. OGC® GML Application Schema – Coverages, Version: 1.0.1 (OGC 09-146r2), 11 May 2012
13. OGC® GML Application Schema – Coverages – JPEG2000 Coverage Encoding extension, Version: 1.0.0, 23 January 2015 (OGC 12-108)
14. OGC® GMLJP2 1.0 (OGC 05-047r3)
15. OGC® GMLJP2 2.1 (OGC 08-085r8)

4 Terms and definitions, and abbreviated terms

4.1 Terms and definitions

Generally, the terms and definitions of the base standard ISO 19106, ISO 19107, ISO 19123, ISO 191236-1 and ISO 19136-2 as well as DGIWG 116-1 (ESM) and DGIWG 116-3-1 (ESM Encoding Rules – Part 1: Core) apply to this profile. Some abbreviated terms are repeated in this document, for the sake of readability

4.2 Abbreviated terms

ASCII	American Standard Code for Information Interchange
CRS	Coordinate Reference System
DMF	DGIWG Metadata Foundation
ESM	Elevation Surface Model
GMLJP2	GML embedded in JPEG2000 for Geographic Imagery
GML	Geography Markup Language
GMLCOV	GML Coverage schema (associated to OGC 09-146r2)
IEEE	Institute of Electrical & Electronic Engineers
ISO	International Organization for Standardization
JPEG2000	Standard for compression and image format from Joint Photographic Experts Group (ISO 15444-1)
OGC	Open Geospatial Consortium
XML	eXtensible Markup Language

5 Applicability and use

This ESM Encoding Rules for GMLJP2 is applicable to any ESM data encoded in GMLJP2, claiming compliance to ESM. The following GML instances are optional. A web coverage service must provide this information, but these GML instances are optional depending on implementation choice:

- A single ESM GML Coverage document, together with its associated metadata, including or associated to the corresponding ESM Coverage Data (rangeSet of GMLCOV) encoded in GMLJP2. Depending on the use case, this ESM Coverage data is either a separate file or included in a multipart message.
- A collection of ESM Coverage or collection of ESM PointSet document, together with its associated metadata which, if tiling is used, is required to include the TilingScheme resource description, and associated TilingScheme geometry, according to the RectifiedGrid or MultiSurface Coverage model.
- Any elevation data file encoded in GMLJP2.

6 JPEG2000 ESM Coverage encoding for GMLJP2

The OGC specification GMLCOV JPEG2000 extension (OGC 12-108) provides additional requirements to the domain and range of a GMLCOV for JPEG2000/GMLJP2 encoded Coverages.

Requirement GMLJP2_1: An ESM coverage encoded in GMLJP2 shall conform to the tests A.1.1 to A.1.11 of GMLCOV GMLJP2 extension (OGC 12-108):

- JPEG2000 and JP2 (15444-1) and JPX conformance (15444-2 Annex M),
- Coverage type (gmlcov:RectifiedGridCoverage),
- URI to gmlcov_jpeg2000-coverages/1.0/conf/jpeg2000-coverage,
- MIME type (image/jpx (recommended) or image/jp2 if no specific capability of 15444-2 is used),
- 2 dimensions coverage,
- CRS (specified by the srsName attribute of the gml:Envelope element of the gml:boundedBy element of the ESM coverage instance, which shall be the same as the CRS used in the GMLJP2 elevation data file),
- axis order (in adherence with the axis order defined by the CRS),
- boundedBy consistency with cell geometry type / raster space Center Point,
- range order (if more than 1 elevation component)
- correct rangeType information including unit of measure, described in SWE data record (consistency with GMLJP2 elevation data file).

Requirement GMLJP2_2: The description of the coverage grid function must reflect the baseline ordering used by GMLJP2 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"
```

7 JPEG2000 and GMLJP2 rules for ESM elevation data

In general, the elevation value records for ESM data delivered in GMLJP2 format will conform to the specifications in DGIWG GMLJP2 profile (version 1 or version 2). The following clauses constrain the implementation of JPEG2000 and GMLJP2 for use with the ESM.

7.1 Introduction

Requirement GMLJP2_3: Elevation Surface Model (ESM) JPEG2000/GMLJP2 data shall be encoded on the basis of the DGIWG GMLJP2 profile for Georeferenced Imagery (version 1 or 2), according to Baseline conformance class, and pass the tests specified in their respective Annex A (Abstract Test Suite).

The individual GMLJP2 values file population strategy is defined with a means to associate each GMLJP2 file with:

- An ESM Elevation Data Set;
- An ESM Elevation Collection / Transmittal, to include tile association, when tiling is used; the TilingScheme may also be encoded in a GMLJP2 (or any other encoding) file (in case it is provided under a Rectified Grid Coverage);
- The type of data contained within the value file (i.e. rectified grid coverage);
- The surfaces represented by the data in the value file.

The general rules specified in 6.2 - General rules for ESM data (cf. [ESM_ER_Core]) apply to the JPEG2000/GMLJP2 encoding, as stated in the following paragraphs of this section.

According to Requirement 13 in [ESM_ER_Core], the GMLJP2 elevation data file parameters shall be consistent with metadata provided in ESM Metadata, and, if relevant, in ESM Coverage GML document. Annex B provides the mapping between this various information. In case of discrepancy, the information in GMLJP2 elevation data file shall prevail.

7.2 CRS

Requirement GMLJP2_4: Horizontal datum

Horizontal datum and Coordinate systems (CRS): shall be provided by the following GML attribute: *srsName* element of the *RectifiedGrid* element of the *domainSet* element, provided by following XPath:

Version 1:

```
/gml:FeatureCollection/gml:featureMember/gml:RectifiedGridCoverage/gml:rectifiedGridDomain/gml:RectifiedGrid@srsName
```

Version 2:

```
/gmljp2:GMLJP2CoverageCollection/gmljp2:featureMember/gmljp2:GMLJP2RectifiedGridCoverage/gml:domainSet/gml:RectifiedGrid/@srsName
```

Requirement GMLJP2_5: Vertical datum

Vertical datum: shall be provided by the following GMLJP2 attribute for a range of elevation values: *referenceFrame* attribute of the *swe:Quantity* element associated to the *swe:field* element in the *rangeType*, provided by following XPath:

Version 1: no capability made available

Version 2:

```
/gmljp2:GMLJP2CoverageCollection/gmljp2:featureMember/gmljp2:GMLJP2RectifiedGridCoverage/gmlcov:rangeType/swe:DataRecord/swe:field/swe:Quantity/@referenceFrame
```

Note: The vertical datum applies to the *rangeSet* parameters, which refers to the codestream with the elevation values.

Note: CRS information shall also be documented accordingly in:

- the ESM metadata,
- the ESM Coverage GML instance (if present) based on GMLCOV model.

This allows the provision of the Vertical datum in case GMLJP2 version 1 is used, as this information is not available in the data file.

7.3 Units of Measure

Requirement GMLJP2_6: Horizontal unit

Horizontal Geographic / Projected unit must be in accordance with the CRS (according to EPSG register) and need not be provided.

In addition to this, it is common practise to document the uomLabels element of the gml:RectifiedGrid, either as uomLabels="deg deg" in case of geographic, or as uomLabels="m m" in case of projected.

Requirement GMLJP2_7: Vertical unit

Vertical unit shall be provided by the following GMLJP2 attribute, in accordance with the CRS (according to EPSG register): uom element of the following element:

Version 1: no capability made available.

Version 2: Quantity element in the rangeType, provided by following XPath:

```
/gmljp2:GMLJP2CoverageCollection/gmljp2:featureMember/gmljp2:GMLJP2RectifiedGrid  
Coverage/gmlcov:rangeType/swe:DataRecord/swe:field/swe:Quantity/swe:uom
```

Note 1: Unit of measure information shall also be documented accordingly in the ESM GML instance, based on GMLCOV model.

Note 2: The capability of redefining the unit of measure for elevation values in the SWE Data Record (for GMLJP2 version 2) allows the use of submetric unit, which may be used for the provision of high resolution elevation values in cm or mm (cf. 7.7.1).

7.4 Security Classification

Requirement GMLJP2_8: When the ESM data is classified, the security marking shall be provided in the JPEG2000 IPR box, as specified in DGIWG GMLJP2 profile.

Note: This information must also be duplicated in the additional XML metadata (DMF/Resource Security Constraint).

When the ESM data is not classified, there is no requirement to declare this condition in the encoding format or the additional metadata. This information may also be explicitly set to "Unclassified" in the encoding format and the additional metadata.

7.5 Intellectual property rights information

Requirement GMLJP2_9: In case of any copyright to the data or any restriction of usage of ESM data, the JPEG2000 IPR box shall provide the information about copyright notice of the person or organization that claims the Intellectual property rights. The complete copyright statement should be listed in this box including any dates and statements of claims.

Note: This Intellectual property rights information must also be duplicated in the additional XML metadata (DMF/Resource Legal Constraint)

Otherwise, there is no requirement to declare this information in the encoding format or the additional metadata.

7.6 Void Areas

DGIWG JPEG2000/GMLJP2 profile provides 2 methods for the encoding of void values / void areas:

- Chroma-key value.
- Transparent layer.

Requirement GMLJP2_10: When an ESM data has void areas, the void area value shall be provided in chroma-key value or in a Transparent layer according to DGIWG GMLJP2 profile.

Requirement GMLJP2_11: When an ESM data has void areas, the void area value shall be provided by the following GMLJP2 attribute: *swe:nilValues* element of the Quantity element in the *rangeType*, provided by following XPath:

Version 1: no capability made available.

Version 2: Quantity element in the *rangeType*:

```
/gmljp2:GMLJP2CoverageCollection/gmljp2:featureMember/gmljp2:GMLJP2RectifiedGridCoverage/gmlcov:rangeType/swe:DataRecord/swe:field/swe:Quantity/swe:nilValues
```

Note: This void area value shall also be declared in the ESM metadata.

7.7 ESM Data Representation

JPEG2000 (15444-1) only allow to compress and encode raster data as integer numeric values. High resolution elevation data are usually stored as 4 bytes signed integers or single precision floating point values.

It is reminded that the default reference unit for elevation (vertical unit) is meter that must be documented as specified in 7.3.

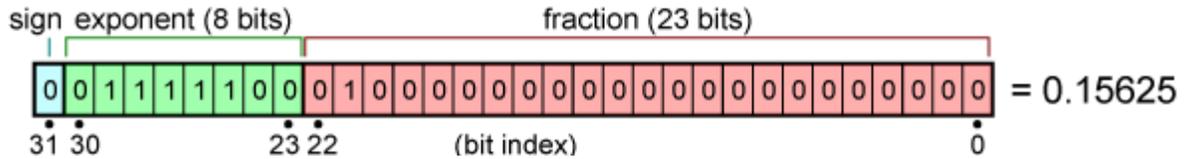
ESM data may be represented by:

- Integer values: Signed and unsigned integer, encoded in 2 bytes (signed/unsigned short) or 4 bytes (signed/unsigned long).

Requirement GMLJP2_12: When using GMLJP2 version 2 (which allows the definition of unit of elevation values by *swe:uom* element), the 4 bytes elevation values (signed/unsigned long) (equivalent to the provision of elevation values in a submetric unit - cm or mm) shall be handled by the definition of a submetric unit (cm or mm) of the unit specified by the CRS (meter) in the *swe:uom* for the elevation values.

In order to handle high resolution elevation values encoded with 4 bytes (so presumably decimal elevation values), the use of a submetric unit for elevation values, such as centimetres (cm) instead of metres (m), implies the conversion of elevation values to integer values by using a multiplier factor, such as 100 in case of cm. This method and the way it is encoded is presented below.

- Floating Point values: single precision (4-byte) IEEE formats, structured in a more complex manner than integer values, as shown below.



According to Requirement 23 in [ESM_ER_Core], the lossless mode of JPEG2000 is mandated (**the lossy compression shall not be used according to this specification**).

The parameters for JPEG2000 compression regarding the data representation are the precision (= 8, 16 or 32) and Sign (= yes or no) parameters, that are handled by BPC field in JP2 header box and Ssiz marker (precision and sign for each component) in the codestream and that must be provided to the JPEG2000 compressor tool. Once again, these parameters of the JP2 format only acknowledge and specify integer values.

Another method is to take advantage of the strictly lossless compression/decompression of JPEG2000 in order to handle 4 bytes floating-point values as 4 bytes unsigned integer values. This method is not recommended as it may result in tricky effects by software that is not aware / enabled, but may be selected if required in case application software is able to handle this mechanism.

7.7.1 Use of submetric unit and upscaled integer elevation values

The recommended way to handle decimal or floating-point values, is to upscale the elevation values so that they are converted within the integer domain before encoding in JPEG2000/GMLJP2. If elevation values have a precision expressed in centimetre or millimetre, the elevation values could be multiplied with the corresponding factor 100 (resp. 1000), thus making it possible to store all elevation values as integers.

The recommended unit for the values encoded in the JPEG2000 codestream (and GMLJP2 file) and associated factor is cm with a factor 100.

The use of such ESM JPEG2000/GMLJP2 elevation values implies multiplying the pixel values as provided by the JPEG2000 driver / software by a multiplier which is 1/factor, so 0.01 with the recommended factor 100.

This multiplier must be a decimal number. It is not stored in the GML document, but must be implicitly associated to the vertical unit which is stored in swe:uom associated to elevation coverage values according the requirement **GMLJP2_7**.

The reason for using a multiplier instead of dividing the pixel values with the factor is that some common programming languages usually returns integers when dividing integers with integers, thus defeating the key purpose to restore decimal values, which is achieved by multiplying the integer pixel values (in cm) as provided by the JPEG2000 driver by the decimal multiplier. The multiplier value should follow the rules for *xs:decimal*. That means a decimal point should be used instead of a decimal comma.

7.7.2 Use of metric unit and handling floating-point values as 4 bytes unsigned integers in JPEG2000 codestream

The way to handle Elevation floating-point values with JPEG2000 lossless compression and JP2 format is the following:

- The raster with 4 bytes-floating-point values may be compressed in lossless mode as 4 bytes-unsigned integers and encoded in JP2 format as unsigned 32 bits codestream by the JPEG driver.
- The reader (application) software has to interpret decompressed the 4 bytes values (decompressed as 4 bytes integers by the JPEG2000 driver / decompressor) as single precision floating-point values.

As JPEG2000-lossless is a *mathematically lossless* compression, this allows to compress, encode and restore the data exactly bit by bit, so the initial 4 bytes floating point values are made available to applications using such a mechanism.

Such a mechanism of an ESM GMLJP2 encoded floating-point elevation values (which are encoded as unsigned 32 bits integer codestream by JPEG driver and understood as such by JPEG2000 technology) must be duly document is the GML document of the ESM GMLJP2 file.

Requirement GMLJP2_13: ESM elevation data encoded in GMLJP2 v2 with floating-point elevation values that are compressed losslessly and encoded in a JPEG2000 codestream as unsigned 32 bits integer codestream shall document this mechanism by using the *swe:constraint* element of the *swe:Quantity* element in the *rangeType* description of the RectifiedGrid coverage, provided under the following path:

/gmljp2:GMLJP2CoverageCollection/gmljp2:featureMember/gmljp2:GMLJP2RectifiedGridCoverage/gmlcov:rangeType/swe:DataRecord/swe:field/swe:Quantity/swe:constraint

As follows: `<swe:constraint xlink:href="#FLOAT_VALUE_SPACE"/>`

In case this requirement would be violated, nothing would inform about the fact that codestream values are to be interpreted as 4 bytes floating-point. Faulty behaviour of software would then to be expected.

7.7.3 Mapping with ESM / DMF metadata

The tables provided in Annex C (for GMLJP2 1.0) or Annex D (for GMLJP2 2.0) provide the mapping between ESM GML element, corresponding element in GMLJP2 elevation data file and with ESM metadata (based on DMF).

In addition to the elements specified in these tables, the RSFMT metadata element (fileDecompressionTechnique) must indicate JPEG2000 compression.

Annex A

ESM GMLJP2 encoding rules - Abstract test suites

(normative)

This Annex provides abstract test suites for ESM GMLJP2 Encoding Rules build upon the DGIWG ESM and the DGIWG GMLJP2 profile, for data encoded in conformance with the rules specified in this document.

A.1 ESM GMLJP2 Coverage GML instance conformance test

Purpose: An ESM GMLJP2 coverage instance shall conform to the additional requirements to the domain, range and coverageFunction of a GMLCOV for JPEG2000/GMLJP2 encoded Coverages.

Method: Inspect ESM Coverage instance against the 2 requirements referenced below.

Reference: Requirements GMLJP2_1 and GMLJP2_2.

A.2 Conformance of GMLJP2 elevation data with DGIWG GMLJP2 profile

Purpose: An ESM GMLJP2 data file shall conform to DGIWG GMLJP2 profile, according to Baseline conformance class.

Method: Inspect ESM GMLJP2 data file against the requirement referenced below.

Reference: Requirement GMLJP2_3.

A.3 Correct encoding of CRS and UoM

Purpose: An ESM GMLJP2 data file shall include correct definition of Horizontal and Vertical datum, as well as UoM for elevation data.

Method: Inspect ESM GMLJP2 data file against the 4 requirements referenced below.

Reference: Requirements GMLJP2_4 to GMLJP2_7.

A.4 Correct encoding of Security classification and Intellectual property rights information

Purpose: An ESM GMLJP2 data file shall provide (when relevant) Security classification and Intellectual property rights information as specified.

Method: Inspect ESM GMLJP2 data file against the 2 requirements referenced below.

Reference: Requirements GMLJP2_8 and GMLJP2_9.

A.5 Correct encoding of Void areas

Purpose: An ESM GMLJP2 data file shall provide (when relevant) Void areas definition as specified.

Method: Inspect ESM GMLJP2 data file against the requirement referenced below.

Reference: Requirement GMLJP2_10 and GMLJP2_11 for version 2.

A.6 Correct encoding of submetric unit for 4 bytes integer elevation values (for GMLJP2 v2 only)

Purpose: An ESM GMLJP2 v2 data file using 4 bytes integer elevation values (therefore expressed in submetric unit – cm or mm) shall provide the definition of the submetric unit as specified.

Method: Inspect ESM GMLJP2 data file against the requirement referenced below.

Reference: Requirement GMLJP2_12 (version 2).

A.7 Correct of the use of floating-point (Float32) elevation values (for GMLJP2 v2 only)

Purpose: An ESM GMLJP2 v2 data file using float32 elevation values (expressed in metre) shall indicate the use of floating-point for users / readers.

Method: Inspect ESM GMLJP2 data file against the requirement referenced below.

Reference: Requirement GMLJP2_13 (version 2).

Annex B

Requirements on consistency between JPEG2000 raster fields (JP2 format) and ESM GML elements (normative)

This table provides the requirements on consistency between values of fields in JP2 format and the required ESM GML elements.

Legend for following table:

- Box Name / Field Name identifies the information in JP2 format
- Description and data type provide the description and data type (respectively) of the information
- Card column specifies cardinality of the item or specifies presence of the item (e.g. optional)
- Conditions / Values: indicates (when applicable) required values for element for this standard
- GML element/attribute: specification item of GML elements/attributes according to ESM GML Application Schema (DGIWG 116-2)

Box Name / Field name (JP2)	Description	Data type	Card	Conditions / Values	GML element/attribute (ESM GML instance)
JP2 Header box		'jp2h'	1		
Image header box		'ihdr'	1		
HEIGHT	Image area height		1		domainSet.extent.high.coordValues[0] - domainSet.extent.low.coordValues[0]
WIDTH	Image area width		1		domainSet.extent.high.coordValues[1] - domainSet.extent.low.coordValues[1]
NC	Number of components in the image		1		= rangeType.field.size()/SamplesPerPixel
BPC	Bits per component		1	components in the codestream is the same (sign and precision), equal to Ssiz JP2 marker (Precision (depth) in bits and sign of the components samples)	For each sample per post <i>i</i> , rangeType.field[i].constraint.interval = "0 2 ^{BitsPerSample[i]-1} "
Color specification box					
bpc	Bits per component (for each component)	'bpc'	Optional Required if component have different bit depth		For each sample per post <i>i</i> , rangeType.field[i].constraint.interval = "0 2 ^{BitsPerSample[i]-1} "

Annex C

Mapping between ESM GML elements, GMLJP2 version 1.0 data structures and ESM metadata (normative)

This table provides the mapping between the required ESM GML elements and values in GMLJP2 1.0 elevation data, and ESM metadata (based on DMF).

Legend for following table:

- columns GML element/attribute, Description, data type refer to corresponding specification items of GML elements/attributes according to ESM GML Application Schema (DGIWG 116-2) specification for 1st column, and DGIWG GMLJP2 profile in 7th column
- Card column specifies cardinality of the item
- Obligation column specifies presence of the item:
 - R: required (same as M, Mandatory)
 - O: optional
 - C: conditional (condition must be specified)
 - I: inadequate for profile (not applicable for georeferenced imagery conformant to this profile)
- Restricted values for the profile: indicates (when applicable) required values for element for this standard
- DMF element/attribute column provides the mapping with DMF information (when applicable).

GML element/attribute (ESM GML instance)	Description	Data type	Card	Obligation	Restricted value	GML element/attribute (GML document in GMLJP2 1.0 profile)	DMF element/attribute
limits	Envelope for the grid given in image coordinates.	gml:GridEnvelope	1	R		limits	axisDimensionsProperties of Grid Spatial Representation (GRSPREP)
origin	The images' origin coordinates given in geo-coordinates	gml:Point	1	R		origin	1 st cornerPoint of the gridLocation of the Grid Spatial Representation (GRSPREP)

GML element/attribute (ESM GML instance)	Description	Data type	Card	Obligation	Restricted value	GML element/attribute (GML document in GMLJP2 1.0 profile)	DMF element/attribute
offsetVector	The offset that each pixel contributes to in either direction	gml:offsetVector	2	R	Only required for the horizontal dimensions. Not for the vertical dimension.	offsetVector	resolution (GRSPREP)
axisLabels	Space-delimited string with axis labels.	gml:NCNameList	1	C Required when axisName elements are absent		axisName for each axis (axisLabels not used in GMLJP2 1.0 (in the gml:RectifiedGridCoverage element). axisName description is required.	dimensionName (GRSPREP)
axisName	String with axis label	string	2..*	C Required when axisLabels are absent	The GML standard requires only one axisName, but all images has at least two axis.	axisName	dimensionName (GRSPREP)
rangeParameters	Describes the values of the raster.	AssociationRoleType	1	R	This element is defined as mandatory in the OGC GMLCOV standard. If there is no adequate information about the values, this element is allowed to be empty.	rangeParameters	
fileName	GMLJP2 URI pointing at the codestream with raster data.	anyURI	1	R	The GMLJP2 URI in this element is constructed with the assumption that the codestream is located in the same file as the GML georeference.	fileName	

GML element/attribute (ESM GML instance)	Description	Data type	Card	Obligation	Restricted value	GML element/attribute (GML document in GMLJP2 1.0 profile)	DMF element/attribute
fileStructure	Required element that is irrelevant for GMLJP2	CodeType	1	R	Mandatory according to GML, but not applicable to JPEG2000. Any value is ignored.	fileStructure	
rangeType	Describes the structure of the range values, as well as their unit and reference system.	swe:DataRecordProperty Type	1	R		Not available in GMLJP2 1.0	
srsName (2D Horizontal) (srsName attribute of the gml:Envelope element of the gml:boundedBy element of a coverage encoded in JPEG2000)	Reference system used by the Coverage.	anyURI	1	R	Reference to EPSG code for CRS, as specified in DGIWG 104.	srsName of the origin gml:Point.	Resource Reference System (RSRSYS) (for HOR CRS) Note: URI or URI+ text
uomLabels (for 2D Horizontal Coordinate system) (uomLabels attribute of the gml:Envelope element of the gml:boundedBy element of a coverage encoded in JPEG2000)	Ordered units of measurement for the 2 axis of the coordinate system. When used in gml:RectifiedGrid, it applies to a horizontal measurement.	Pair of gml:NCNameList	1	O	Must be consistent with the uom specified in the CRS given by srsName.	uomLabels of the origin gml:Point.	
uom (for elevation values) (swe:uom element of the swe:Quantity in the swe:DataRecord description of the rangeType)		swe:uom	1	O	Must be consistent with the uom provided in the Vertical CRS (referenceFrame attribute of the swe:Quantity)	Not available in GMLJP2 1.0	

Annex D

ESM GML elements, GMLJP2 version 2 data structures and ESM metadata (normative)

This table provides the mapping between the required ESM GML elements and values in GMLJP2 version 2 elevation data, and ESM metadata (based on DMF). ESM GML elements and corresponding elements in GMLJP2 version 2 elevation data are based on the same GMLCOV schema and should be equal.

Legend for following table:

- columns GML element/attribute, Description, data type refer to corresponding specification items of GML elements/attributes according to GMLJP2 specifications
- Card column specifies cardinality of the item
- Obligation column specifies presence of the item:
 - R: required (same as M, Mandatory)
 - O: optional
 - C: conditional (condition must be specified)
 - I: inadequate for profile (not applicable for georeferenced imagery conformant to this profile)
- Restricted values for the profile: indicates (when applicable) required values for element for this standard.

GML element/attribute (ESM GML instance)	Description	Data type	Card	Obligation	Restricted value	GML element/attribute (GML document in GMLJP2 v 2 file)	DMF element/attribute
limits	Envelope for the grid given in image coordinates.	gml:GridEnvelope	1	R		limits	axisDimensionsProperties of Grid Spatial Representation (GRSPREP)
origin	The images' origin coordinates given in geo-coordinates	gml:Point	1	R		origin	1 st cornerPoint of the gridLocation of the Grid Spatial Representation (GRSPREP)

GML element/attribute (ESM GML instance)	Description	Data type	Card	Obligation	Restricted value	GML element/attribute (GML document in GMLJP2 v 2 file)	DMF element/attribute
offsetVector	The offset that each pixel contributes to in either direction	gml:offsetVector	2	R	Only required for the horizontal dimensions. Not for the vertical dimension.	offsetVector	resolution (GRSPREP)
axisLabels	Space-delimited string with axislabels.	gml:NCNameList	1	C Required when axisName:s are absent		axisLabels	dimensionName (GRSPREP)
axisName	String with axislabel	string	2..*	C Required when axisLabels are absent	The GML standard requires only one axisName, but all images has at least two axis. With elevation data, it is likely desired to have even a third axis.	axisName	dimensionName (GRSPREP)
rangeParameters	Describes the values of the raster.	AssociationRoleType	1	R	This element is defined as mandatory in the OGC GMLJP2 standard. If there is no adequate information about the values, this element is allowed to be empty.	rangeParameters	
fileName	GMLJP2 URI pointing at the codestream with raster data.	anyURI	1	R	The GMLJP2 URI in this element, is constructed with the assumption that the codestream is located in the same file as the GML georeference.	fileName	
fileStructure	Required element that is irrelevant for GMLJP2	CodeType	1	R	Mandatory according to GML, but not applicable to JPEG2000. Any value is ignored.	fileStructure	
rangeType	Describes the structure of the pixel values.	swe:DataRecordProperty Type	1	R		rangeType	
srsName (2D Horizontal) (srsName attribute of the gml:Envelope element of the gml:boundedBy element of a coverage encoded in JPEG2000)	Reference system used by the Coverage.	anyURI	1	R	Reference to EPSG code for CRS, as specified in DGIWG 104(2).	srsName	Resource Reference System (RSRSYS) (for HOR CRS) Note: URI or URI+ text

GML element/attribute (ESM GML instance)	Description	Data type	Card	Obligation	Restricted value	GML element/attribute (GML document in GMLJP2 v 2 file)	DMF element/attribute
uomLabels (for 2D Horizontal Coordinate system) (uomLabels attribute of the gml:Envelope element of the gml:boundedBy element of a coverage encoded in JPEG2000)	Ordered units of measurement for the 2 axis of the coordinate system. When used in gml:RectifiedGrid, it applies to a horizontal measurement.	Pair of gml:NCNameList	1	O	Must be consistent with the uom specified in the CRS given by srsName.	uomLabels	
Vertical CRS (referenceFrame attribute of the swe:Quantity in the rangeType element)		anyURI	1	M	Allowed values are: following EPSG codes: 4979 (WGS84 3D ellipsoid) 5773 (EGM96) 3855 (EGM08) 5798 (EGM84) 5714 (MSL height) 5715 (MSL depth) 32767 for other Sounding datums identified in DGIWG Geodetic registry, or user defined Vertical CRS (see §13.5 in DGIWG 104(2)).	referenceFrame attribute of the swe:quantity of the swe:DataRecord of the gml:cov:rangeType	Resource Reference System (RSRSYS) (for Vert. CRS) Note: URI or URI+ text
uom (for elevation values) (swe:uom element of the swe:Quantity in the swe:DataRecord description of the rangeType)		swe:uom	1	O	Must be consistent with the uom provided in the Vertical CRS (referenceFrame attribute of the swe:Quantity in the rangeType element)	uom	

Bibliography

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