DGIWG 116-3

Elevation Surface Model (ESM) Encoding rules

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Abstract:	This document defines the ESM GML application schema and documents the process used to derive this application schema from the ESM UML model, associated to STD-116-1
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i. Submitting organizations

France, Sweden, Czech Republic, United Kingdom, and the USA

ii. Revision history

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19/05/2014	0.3		Final adjustments after comments in Prague TP (D32, T05)
26/06/2014	1.0 (draft r1)		Final draft after D32 telecon (June 2014)
2/10/2014	1.0		Standard for publication (after resolution of comments)

iii. Future work

- Incorporation of additional encoding annexes for NSIF, GMLJP2, DTED
- Incorporation of the TIN encoding into the ESM Encoding rules once it has been included into the ESM GML Application Schema.

Introduction

The Elevation Surface Model Standardized Profile (DGIWG STD-116-1) provides the conceptual schema for describing and manipulating the information content required for the exchange of surface elevation information for a variety of surfaces such as bare earth, vegetation canopy, or bathymetric depth, under different data models, such as coverages (Rectified Grids, Point Coverages or TIN Coverages) or Point Sets, together with the associated metadata.

This document defines the ESM GML Encodings Rules that are recommended for the encoding of ESM data. It contains the relevant conformance clauses and conformance classes associated to the various use cases.

Limitation: As the GML coverage application schema, in its present version, does not handle the TIN coverage model, the TIN component is currently excluded from this ESM Encoding Rules.

The aim of this ESM GML Encodings Rules is to comply with:

- GMLCOV (for its Coverage components only), in order to facilitate ESM data access via WCS service.
- GML (and more particularly DGIWG GML profile L1.3D.0d for its PointSet components only), in order to facilitate ESM data access via WFS service.
- DMF for ESM metadata, in order to be consistent with other DGIWG standards for topographic and imagery metadata.

1 Scope

This document defines the Elevation Surface Model (ESM) GML Encoding Rules that are recommended for ESM data based on DGIWG ESM standard (STD-116-1), including their associated ESM GML coverage or point set documents and ESM DMF/XML metadata.

As stated in STD-116-1, ESM model includes Gridded and Point coverage model, as well as TIN coverage (not retained in the present version of ESM encoding rules), and Point set model. It should be noticed that it does not include Elevation Contour Lines, which are usually part of a dedicated theme / layer of topographic data.

2 Conformance

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

- General encoding rules for ESM collection or single ESM dataset
- ESM metadata, applicable to the dataset or collection of datasets, or TilingScheme resources. The TilingScheme description is associated to ESM Collection metadata, in case a tiling scheme applies to the collection.
- ESM Coverage schema based on GMLCOV for RectifiedGridCoverage or MultiPointCoverage with 2 options for the conformance class:
    - 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.
    - 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.
- ESM PointSet schema based on GML profile L1.3D.0d for PointSet
- Any encoding of ESM Coverage Elevation data, in one of the format supported in the annexes, with conformance rules specified in corresponding annexes, in either a separate file, or as part of the multipart message.

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 shall document its ability to import and/or export ESM compliant data.

3 Normative References

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

ISO and OGC Standards

ISO 639-2:1998 Codes for the representation of names and languages

ISO 19136:2007 — Geographic information – Geography Markup Language (GML)

ISO 19139:2006 Geographic information – Metadata – XML schema implementation

OGC® GML Application Schema – Coverages, Version: 1.0.1, 11 May 2012 (OGC 09-146r2)

DGIWG Standards

[ESM] DGIWG STD–116-1: Elevation Surface Model, Edition 1.0, 18 June 2013

[DMF] DGIWG STD-114: DGIWG Metadata Foundation, Edition 1.0, 26 November 2013

[ESM_GMLAS] DGIWG STD–113-2: DGIWG ESM GML Application Schema, Edition 1.0, 2 October 2014

[DGIWG_GTIFF] DGIWG STD–108: GeoTIFF Profile for Georeferenced Imagery – 13 March 2014, Edition 2.0.3

4 Terms and definitions, and abbreviated terms

4.1 Terms and definitions

Generally, the terms and definitions of the base standard ISO 19106:2004, ISO 19107:2003 and ISO 19136:2007 apply to this profile. To facilitate understanding, the main terms and definitions are repeated in this document.

4.2 Abbreviated terms

ASCII	American Standard Code for Information Interchange
BIIF	Basic Imagery Interchange Format (ISO 12087-5)
CRS	Coordinate Reference System
DMF	DGIWG Metadata Foundation
DTED	Digital Terrain Elevation Data (US MIL and NATO standard)
ESM	Elevation Surface Model
GeoTIFF	Geographic TIFF
GML	Geography Markup Language
GMLJP2	GML (embedded) in JPEG2000
ISO	International Organisation for Standardization
NSIF	NATO Secondary Imagery Format (STANAG 4545)
OGC	Open Geospatial Consortium
TIFF	Tagged Image File Format
XML	eXtensible Markup Language

5 Applicability and use

This ESM Encoding Rules is applicable to any ESM data, claiming compliance to ESM. The following GML instances are optional. A web coverage service must provide this information, but these GML instances are optional (except for the GML PointSet document) 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 one standardized format addressed in Annexes B to E. Depending on the use case, this ESM Coverage data is either a separate file or included in a multipart message.
- A single ESM GML PointSet document, together with its associated metadata and including the PointSet Data.
- A collection of ESM Coverage or collection of ESM PointSet document, together with its associated metadata which, if tiling is used, this metadata is required to include the TilingScheme resource description, and associated TilingScheme geometry, according to the RectifiedGrid or MultiSurface Coverage model.

These documents provide the full set of encoding requirements on ESM model information encoded in GML instances (based on ESM GML schema), ESM metadata encoded in XML (based on DMF schema), associated to any ESM data (in any available “legacy” format – such as GeoTIFF, JPEG2000 or BIIF).

As a result, such ESM encoded data can be produced, discovered (via a catalog web service) and delivered to the users via Web Coverage Service (for the Coverage compliant data) or Web Feature Service (for the PointSet compliant data), in addition to the basic transmittal on a physical media.

This ESM Encoding Rules is intended to result in a higher degree of interoperability between elevation (including bathymetric) data based on GML and GML Coverage application schemas, the DGIWG Metadata Foundation (DMF), and other DGIWG imagery or topographic data standards.

6 ESM Encoding Rules

6.1 Introduction

This section contains information and requirements that is applicable to both producers and users of ESM data. An ESM data may be a single dataset or a collection of datasets.

These requirements apply to:

- the ESM collection GML instance (optional), and its associated ESM Collection metadata set (based on the DS_Aggregate element of 19139) in accordance with DMF for collection resource, with RSTYPE set to ‘series’.
- the ESM dataset GML instance (optional in the coverage case), based either on the GMLCOV or the PointSet model, and its associated ESM dataset metadata set (based on DS_Dataset element of 19139) in accordance with DMF for dataset resource, with RSTYPE set to ‘dataset’. In the case of the PointSet model, this document includes the GML Point set data.

  Note: Depending on implementation choice, ESM collection and datasets in the collection may be organized according to 2 schemes:

  - separate files under a collection directory structure: ESM dataset GML instances for all the coverages in a collection in separate files / subdirectories under the ESM collection directory; in this case, either the GML collection document or the metadata associated to the collection / series must refer to the ESM datasets resources;
  - one single integrated GML instance describing collection and all dataset components of the collection.
- the ESM data file (in the coverage case), in a standardized encoding format, which is in a separate file, or may be part of a multipart message as a response to a delivery request.

The specific information and requirements on the encoding of the ESM data file in standardized formats are addressed by the encoding annexes of this document.

Note: The metadata resource and the elevation data file are usually both constrained by specific requirements in terms of metadata or information on the data. Consequently, some information items are redundant in the two components of an “ESM dataset”. In order to avoid redundant information, the ESM GML instance information is specified with the minimum level of information required by the GMLCOV or PointSet model. However, the constraints of ESM GML model will provide some information (e.g. CRS, UoM) three times, as explained further in this document.

The metadata property of the feature or coverage specified in the ESM GML instance (if any) should reference the metadata set resource.

The applicable use cases that this ESM encoding rules is intend to support are presented in [ESM] and [ESM_GML_AS] documents in their Use cases section.

6.2 General ESM encoding rules for ESM collection or single ESM dataset

An ESM dataset contains the ESM data file encoded in a standardized format and the associated ESM metadata set; it may also contain the associated ESM GML instance, conformant to its applicable ESM schema (ESMCoverage or ESMPointSet). This application schema facilitates web service capability, on the basis of GML (for PointSet) and GML coverage schemas.

An ESM collection contains the packaging ESM Collection GML instance, associated ESM Collection metadata set and ESM datasets.

A transmittal may contain an ESM dataset or an ESM collection and associated metadata.

Access to metadata may be provided by a dedicated web service. In a WCS2.0 context, a message in reply to a describeCoverage will provide the ESM metadata associated to the coverage.

This encoding rules document places no requirement on the implementer to give precedence to the data file, or the metadata resource or the GML coverage document as an entry point into the associated set of artifacts.

Requirement 1: An ESM dataset (or collection of datasets) shall contain the following components:

- An ESM GML instance (optional), for the ESM collection corresponding to an ESM Transmittal / exchange, and its associated ESM collection metadata.

For each Coverage or PointSet dataset in the ESM collection

- o an ESM GML instance (optional in the coverage case), according to ESM Coverage schema and ESM_COV conformance class (for a Coverage dataset), or to ESM PointSet schema and ESM_PTS conformance class (for a PointSet dataset)
- o its associated ESM metadata set based on DMF-all schema and the ESM metadata rules.
- o (for coverage elevation data) the Elevation data in a standardized encoding format as specified in one of the annexes B to E.

Requirement 2: An ESM collection instance shall be based on ESM GML Application Schema

- for a collection of Coverage data, according to ESM coverage schema and ESM_COV conformance class ;
- for a collection of PointSet data, according to ESM PointSet schema and ESM_PTS conformance class.

Requirement 3: The ESM datasets resources shall be referred to by either the GML collection document (if any) or the metadata associated to the collection / series (or both mechanisms).

6.3 ESM Coverage GML instance

6.3.1 ESM GML coverage instance

Requirement 4: The GML instance for ESM Coverage shall be based on ESM Coverage Application Schema, according to the ESM_COV conformance class, either for ESM_GridCoverage or ESM_PointCoverage.

Requirement 5: The coverage domain information in the GML instance for ESM Coverage shall be consistent with the corresponding information specified by the internal encoding format for the ESM data. In case of discrepancy, the internal encoding format information shall prevail.

6.3.2 Modes for encoding / packaging ESM coverage data

For coverages, different encodings may be used for the domain and the range of the coverage. Two modes are allowed for packaging the domain and range encoding when producing or delivering coverage data on a physical media, or delivering it through a download service, as discussed below:

Mode 1: Multipart representation: for download service delivery

For performance reasons, binary file formats are usually preferred to text-based formats such as XML for storing large amounts of coverage data. However, they cannot directly constitute an alternative to pure GML, since their own data structure might often not support all the ISO 19123 elements used to describe coverages in the conceptual model.

The OGC standard GML Application Schema for coverages [OGC 09-146r2] offers a format encoding which combines these two approaches. The first part consists of a GML document representing all coverage components except the range set, which is contained in the second part in some other encoding format such as ‘well known’ binary formats’ (for example TIFF or GeoTIFF, according to the dedicated GMLCOV encoding extension). Some information in the second part may be redundant with the GML content of the first part. In this case, consistency must be ensured through a mapping of the additional encoding format structure to GML

The advantage of this multipart representation is that coverage constituents are not handled individually (as in Mode 2 below)

Requirement 6: Coverage data encoded as multipart document shall comply with the *multipart* representation conformance class defined in GML Application Schema for Coverages [OGC 09 146r2]. This mode shall be used when delivering coverage data through a web coverage service. Note: The GML Application Schema for Coverages establishes a one-to-one relationship between coverages and multipart document instances.

Mode 2: Reference to an external file: for encoding on a physical media

The range set can be encoded as an external binary file and referenced within the XML structure using the gml:File element. This has the benefit of efficiently storing the range set

data within an external file that is of a well-known format type, for example TIFF / GeoTIFF. This method of encoding is of most use for the storage of large files.

Requirement 7: The reference to an external binary file using the gml:File element shall be used when encoding or delivering coverage data via a physical media, according to the GML special format requirement class specified by GMLCOV.

6.4 ESM PointSet GML instance

Requirement 8: The GML instance for ESM PointSet shall be based on ESM GML PointSet Application Schema, for the ESM_PTS conformance class.

This ESM GML PointSet instance shall include the ESM PointSet data, according to the DGIWG GML profile L1.3D.0d.

6.5 ESM metadata encoding

ESM metadata are associated with each ESM data resource (collection, dataset). An ESM metadata set is a XML resource conformant to DMF schema, and following the rules specified in [ESM] for ESM metadata and hereafter.

Requirement 9: An ESM metadata set shall be associated with each ESM data resource (ESM collection, ESM dataset,), based on the relevant metadata elements as specified in ESM metadata (ESM] and [DMF], with the RSTYPE element as follows:

- for collection RSTYPE = series
- for dataset : RSTYPE = dataset.

Requirement 10: The association between the ESM metadata resource and the ESM data file should be bi-directional:

- the ESM metadata resource shall provide the reference to the ESM data file, according to the ESM metadata dictionary (Dataset identifier, DMF – RSID element)
- the data file should (if format allows this) provide a link to the ESM metadata resource. The location of the link will be defined in the relevant encoding annex.

Requirement 11: Each ESM metadata set associated to each ESM resource shall conform to the DMF/Data+ conformance class applicable to metadata set, on the basis of the DMF-All schema and to the ESM metadata test suite specified in [ESM].

Requirement 12: In case of ESM collection with external tiling, the ESM TilingScheme shall be documented as metadata elements (Collection Tiling scheme and Tile Identifier) of the ESM collection metadata on the basis of DMF and to the ESM metadata test suite specified in [ESM] (TilingScheme test case).

Requirement 13: ESM metadata shall be consistent with the corresponding information specified by the ESM GML instance (if any) and the internal encoding format. In case of discrepancy, the internal encoding format information shall prevail.

6.6 General rules for ESM data encodings

6.6.1 CRS

Horizontal datum: This document recommends the use of World Geodetic System 1984 (WGS84) as the horizontal datum for Elevation data in Defense Elevation data.

Vertical datum: This document recommends the use of any of the following vertical datums (Vertical CRS) for elevation data[1]:

- WGS84 ellipsoid (EPSG code 4979)
- the geoids defined by the following WGS 84 Earth Gravity Field Models (EGM):
- EGM96 (EPSG code 5773), used by DTED data,
- EGM08 (EPSG code 3855), the emergent updated geoid included in EPSG registry,
- EGM84 (EPSG code 5798), in order to support legacy systems that may not be able to accommodate the increased level of detail of EGM96
- a global Sounding Datum or Hydrographic Datum, based on a selected tide level related to Mean Sea Level (MSL): MSL height (EPSG code 5714) and MSL depth (EPSG code 5715),
- or any other user-defined vertical datum; for specific local vertical reference systems.

Requirement 14: The identification of the Horizontal and Vertical CRS shall be based on EPSG code (as in EPSG active registry), or the reference of the sounding datum for the Vertical CRS in the DGIWG Geodetic Codes and Parameters registry (http://www.dgiwg.org/DGIWG_Geodetic_Codes) for the other hydrographic datum, or by description of user-defined vertical CRS.

Coordinate systems: This document limits expression of coordinate references to longitude and latitude (geographic coordinate system) or the UTM Grid System Easting and Northing (projected / cartographic coordinate system).

Requirement 15: CRS information shall be documented consistently in the following two (or three) locations:

- the ESM GML instance, if any,
  - either based on GMLCOV model for the coverage case; the encoding of Horizontal shall be based on a CRS on the basis of OGC-11.135r1 - Name Type Specification for CRSs. The Vertical CRS shall be documented in the SWE common Data Record of the RangeType.
  - or based on DGIWG GML L1.3D.0d profile for the PointSet case with a compound CRS Horizontal+Vertical on the basis of OGC-11.135r1.

[1] Future evolutions of the gravity model (EGM) should be added to this list as necessary.

- the ESM metadata: DMF/ RSRSYS element.
- the CRS information as in the internal encoding format, for example dedicated tags in GeoTIFF.

NB: In some encoding formats, an ASCII identification of the CRS, may be provided in addition to the EPSG (or DGIWG) registry code.

6.6.2 Units of Measure

This document recommends the use of the following units of measures:

- decimal degrees for longitude and latitude (geographic coordinate system)
- meters for UTM Grid System Easting and Northing (projected / cartographic coordinate system)
- meters for elevation values (or submetric units for high resolution elevation when encoded by signed integers).

Requirement 16: Horizontal and vertical units of measure information shall be both documented in:

- the ESM Coverage GML instance (if any) or ESM PointSet instance, respectively based on GMLCOV or DGIWG GML L1.3D.0d profile
- the units of measure information as in the internal encoding format, for example dedicated tags in GeoTIFF or in the GML coverage document in GMLJP2.

Note: [ESM] states that the unit of measure is associated to the CRS (as in EPSG registry) and therefore need not to be documented in metadata.

6.6.3 Security Classification

ESM metadata set should be used to associate security markers and dissemination controls for content of ESM data. However, in the case of classified ESM data, inclusion of the security constraint information within the encoding format structure is also required so that the data file will always include security marking information.

Consequently:

Requirement 17: When the data is classified, the security marking shall be present in both the encoding format and in the XML metadata (DMF/Resource Security Constraint).

When the data is not classified, the security system (DMF/Resource Security System) determines whether the dataset must be marked ‘unclassified’. When required, this marking must appear in both the encoding format and the additional XML metadata.

6.6.4 Intellectual property rights information encoding

ESM metadata set should be used to declare Intellectual property rights information on ESM data. However, when the data is subject to Intellectual property rights restriction, this restriction must also be reflected within the encoding format structure. Consequently:

Requirement 18 When the use of data is restricted by Intellectual property rights, the Intellectual property rights information must be present in both the encoding format and in the additional XML metadata (DMF/Resource Legal Constraint).

6.6.5 Void Areas

Identification of void or missing data areas is a requirement that only applies to grids (cf. ESM 1.0 § 7.4.5). The gridded data formats that are used to carry elevation data generally have some provision to declare a value for void areas, by use of a designated "out-of-range" value, typically the most negative value available for the data type selected (or the non-number value designated for the selected data type) to represent the elevation values. Since the ESM supports bathymetric surfaces, due care must be taken when using a negative "out-of-range' value to avoid confusion with actual data values.

Requirement 19: For gridded elevation data, void area value shall be both documented in:

- the NULL value definition of the encoding format for void areas
- in the ESM Coverage instance (if any), in the quantity element of the rangeType (cf. ESM Grid coverages requirements in [ESM_GMLAS]).
- in the ESM metadata, by using the Content Information of the Coverage Metadata element : GRCINF.specialCell.

Note: Some encoding formats may also use transparency mask or alpha channel for coding void areas.

NB: Suspect areas have associated elevation values that are obviously outside of the logical range for the surface described. Suspect areas can be adequately addressed using the data quality section of the metadata and are not addressed by the encoding rules.

6.6.6 ESM data quality

Requirement 20: ESM dataset quality metadata (according to ESM specification for Metadata) shall include at least;

- Absolute horizontal and vertical accuracy reports
- A report of 'completeness' (percentage of the direct positions within the dataset extents where the range values are not void or suspect values).

6.6.7 ESM data encoding

ESM elevation data (Point Sets or optionally for Coverages) are encoded in GML and included in the ESM GML instance.

For the coverage data that are encoded in formats other than GML, encoding rules to map the ESM GML AS to the format data structure are required. They are provided in the encoding annexes.

Requirement 21: The encoding of coverage components in one of the file formats specified in the annexes B to E shall conform to the requirements and mapping rules specified in the corresponding annex.

Requirement 22: Depending on encoding format, elevation values in an ESM coverage data shall be represented by:

- signed integer, encoded on 2 bytes (signed short) or 4 bytes (signed long)
- floating point values: single precision (4-byte) IEEE formats

High resolution Elevation data are usually stored as 4 bytes signed integers or single precision point values.

6.6.8 ESM data compression

Requirement 23: In case of compression of ESM data, lossless compression methods shall be used.

For example, JPEG2000 lossless provides a minimum compression ratio of 2 to 2.5.

6.6.9 ESM TilingScheme

ESM allows for value records within an elevation collection or a fundamental dataset to be organized into tiles, as stated in § 10.3 of [ESM]. The three primary motivations for organizing value records into a tiling scheme are:

1) The nature and description of the value records within the collection is different, thus requiring different metadata descriptions;
2) The sampling density varies within the coverage of the gridded dataset;
3) The physical size of the value data is so large that it warrants subdivision for ease of data management.

Note: The data encoding formats usually support an internal tiling structure that facilitates indexed addressing to internal tiles data, within the same data file, thus optimizing data access. The term 'ESM_TilingScheme' does not refer to this internal tiling associated to an encoding format. It refers to what may also be called 'external tiling', with the tiles being composed of separate data files.

As stated in [ESM], the Tiling Scheme normally consists of a simple rectangular grid with tiles of equal density. A grid coverage may also be defined with tiles of variable density (quad tree). A more complex tiling scheme may also be defined as a discrete polygon coverage. An example polygon tiling scheme is a data collection consisting of elevation cut along political boundaries. A tiling scheme may be defined for an elevation collection of any type. For gridded data, the tiling scheme is usually a second grid that is superimposed on the first (simple) grid.

The data encoding formats do not contain a place to address the ESM TilingScheme, consequently it is addressed by the following requirement; the ESM TilingScheme is not addressed by the encoding annexes.

Requirement 24: The ESM TilingScheme shall be documented in the dedicated ESM metadata elements associated to the ESM Collection resource (according to requirement 12) for the purpose of exchange, data discovery and handling.

The usual Tiling Scheme options are:

- *Simple Grid Tiling:* one ESM data file per ESM-defined tile
- *Quadtree Tiling:* one ESM data file is used to contain the value records for each quadtree tile

In both cases, each ESM Tile data should correspond to a single ESM data file in its encoding format: the entire data file constitutes the ESM Tile.

A more complex tiling scheme may be defined as a set of polygons, as presented in § 10.3 in [ESM]. This method may be useful when it is necessary to separate areas within the dataset according to unique surface types (e.g. land vs. water, or political boundaries). Each polygon shall be assigned an identifier unique within the dataset. The polygon boundaries shall be defined in the metadata as ordered lists of vertices. While the simple grid and quadtree tiling approaches are rectangular in nature and use numeric indices to identify each tile, polygonal tiling defines tiles using a set of geographic points. Except for the specific case where the polygonal vertices are selected to be coincidental with the rectangular data file, the ESM polygonal tiling has no direct relationship with the data files. When polygonal tiling is used to associate different metadata attributes to elevation values, the position of the elevation value must be evaluated to determine which polygon-defined tile it is associated with.

Annex A
ESM Encoding Rules Abstract test suites

(normative)

This Annex provides abstract test suites for ESM Encoding Rules build upon the DGIWG ESM 1.0 specification, ESM GML application schema and encoded in conformance with the rules specified in this document.

A.1 ESM Coverage GML instance conformance test

A.1.1 Abstract test for ESM Coverage GML instance (collection or dataset) as valid ESM Coverage GML implementation for the relevant resource (ESM data Coverage structure + schema validation test)

Purpose: Verify that the ESM Coverage GML instance (if present) is a valid implementation of ESM GML schema for the corresponding resource (ESM Coverage Collection, ESM Coverage).

Method: Inspect ESM data + Validation against ESM schema according to the required conformance class (ESM_COV).

Reference: DGIWG ESM GML AS: Annex B Abstract test suites for ESM Coverage GML data + this document, requirements 1, 2, 4.

A.1.2 Abstract test for ESM Coverage GML instance consistency with ESM Coverage data file

Purpose: Verify that ESM Coverage GML instance (if present) satisfy requirement 5 in section 6.3 of this document.

Method: Inspection of ESM Coverage GML instance and ESM Coverage data file.

Reference: This document, requirement 5 + Mapping table for the relevant format in Annexes B to E

A.1.3 Abstract test for ESM Coverage type

Purpose: An ESM coverage instance shall be of type gmlcov:RectifiedGridCoverage or gmlcov: MultiPointCoverage, or a subtype thereof.

Method: If the coverage instance under test is encoded in a multipart message check that its first part consists of a GML instance of type gmlcov:RectifiedGridCoverage or gmlcov: MultiPointCoverage, or a subtype thereof.

Reference: [OGC 09-146r2] multipart or gml conformance classes.

A.1.4 Abstract test for ESM Coverage GML instance (multipart for delivery)

Purpose: Verify that ESM Coverage GML instance encoded as multipart message satisfy requirement 6 in section 6.3 of this document (multipart conformance class of GMLCOV).

Method: Inspect whether ESM coverage GML instance is encoded as a multipart message

Reference: This document, requirement 6 + [OGC 09-146r2] multipart conformance class.

A.1.5 Abstract test for ESM Coverage GML instance (external ESM data file encoding)

Purpose: Verify that ESM Coverage GML instance encoded with an ESM external data file satisfy requirement 7 in section 6.3 of this document (gml conformance class of GMLCOV, except for the rangeSet).

Method: Inspect whether ESM coverage GML instance is valid with gml/special-format implementation of GMLCOV

Reference: This document, requirement 7 + GML requirements class, gml/special-format (requirement 17 in [OGC 09-146r2]).

A.2 ESM PointSet GML instance conformance test

A.2.1 Abstract test for ESM PointSet GML instance (collection or dataset) as valid ESM PointSet GML implementation for the relevant resource (ESM data PointSet structure + schema validation test)

Purpose: Verify that the ESM PointSet GML instance is a valid implementation of ESM GML schema for the corresponding resource (ESM PointSet Collection, ESM PointSet).

Method: Inspect ESM data + Validation against ESM schema according to the required conformance class (ESM_PTS).

Reference: DGIWG ESM GML AS: Annex B Abstract test suites for ESM Coverage GML data + this document, requirements 1, 2, 8.

A.3 ESM metadata encoding conformance test

The ESM metadata set associated to each ESM resource (collection, dataset) must follow:

- DMF-All schema specified in DMF, for the Data+ conformance class.
- ESM 1.0 metadata requirements
- The ESM metadata encoding rules specified in 6.5.

A.3.1 Abstract test for ESM metadata set as valid DMF Metadata set for the relevant resource (schema validation test + ESM metadata test)

Purpose: Verify that the ESM metadata set is a valid metadata set implementation of DMF (based on DMF/Data+) for the corresponding resource.

Method: Validation against DMF-All schema + Inspection of ESM metadata set (for Collection/Series or Dataset metadata).

Reference: DGIWG DMF: Annex A.4 Test module on candidate metadata set + this document, requirements 9, 11, 12.

A.3.2 Abstract test for association between ESM metadata and ESM data

Purpose: Verify that the association between ESM metadata and ESM data is well defined

Method: Inspect the implementation.

Reference: This document, requirement 10.

A.3.3 Abstract test for ESM metadata set as valid ESM metadata set implementation

Purpose: Verify that the ESM metadata is a valid ESM metadata set

Method: Inspect the implementation.

Reference: DGIWG ESM 1.0: Annex A.2 Metadata Test Suite and A.3 User-defined Extension Metadata Test Suite (if applicable) and A.4.1 Metadata Profiles Test Case (if applicable) + this document, requirements 11 and 12.

A.3.4 Abstract test for ESM metadata set as consistent with ESM data file

Purpose: Verify that ESM Metadata set is consistent with ESM GML instance and ESM data file.

Method: Inspect the the implementation.

Reference: This document, requirement 13 + Mapping table for the relevant format in Annexes B to E.

A.3.5 Abstract test for TilingScheme documentation in ESM collection metadata set (if applicable)

Purpose: Verify that the TilingScheme metadata is addressed in ESM collection metadataset if the ESM data is tiled

Method: Inspect the implementation of the ESM collection metadata set.

Reference: this document, requirements 12 and 24.

A.4 Conformity with general rules for ESM encodings

A.4.1 Test for the CRS in ESM GML instance, ESM metadata set and ESM data file

Purpose: Verify that the CRS identification is based on EPSG or DGIWG registry and consistent in its 3 locations in ESM data resources (GML instance (if present), metadata set, external data file)

Method: Inspect the CRS information content in these 2 (or 3) locations.

Reference: This document, requirement 14 and 15.

A.4.2 Test for the Unit of Measure in ESM GML instance and ESM data file

Test Purpose: Verify that the Unit of Measure identification is identified and consistent in its 2 locations in ESM data resources (GML instance, external data file)

Test Method: Inspect the Unit of Measure information content in these 2 locations.

Reference: This document, requirement 16.

A.4.3 Tests for the Security classification and IPR in ESM metadata set and ESM data file

Test Purpose: Verify that the Security classification and IPR is identified and consistent in its 2 locations in ESM data resources (ESM metadata set, external data file)

Test Method: Inspect the Security classification and IPR information content in these 2 locations.

Reference: This document, requirement 17 and 18.

A.4.4 Tests for the void area encoding in ESM metadata set and ESM data file

Test Purpose: Verify that the void area encoding is identified and consistent in its 2 locations in ESM data resources (ESM metadata set, external data file)

Test Method: Inspect the Security classification and IPR information content in these 2 locations.

Reference: This document, requirement 19.

A.4.5 Tests for the quality information in ESM metadata set

Test Purpose: Verify that the quality information is provided correctly in ESM metadata set

Test Method: Inspect the quality information (Absolute horizontal and vertical accuracy reports + report of completeness).

Reference: This document, requirement 20 + ESM Metadata Test suite.

A.5 ESM Coverage data encoding format conformance

A.5.1 Tests for ESM Coverage data encoding (special format case)

Test Purpose: Verify that ESM Coverage data file is encoded with one of the ‘well known’ binary formats, such as GeoTIFF, GMLJP2, NSIF, DTED, following the rules for ESM encodings

Test Method: Inspect the ESM Coverage data file.

Reference: This document, requirement 21 + conformance part of annexes B to E.

A.5.2 Tests for ESM elevation values encoding (special format case)

Test Purpose: Verify that ESM elevation values are encoded correctly (depending on encoding format capabilities)

Test Method: Inspect the ESM Coverage data file.

Reference: This document, requirement 22

A.5.3 Tests for ESM elevation data compression (special format case, in case of compressed data)

Test Purpose: Verify that ESM elevation values are compressed in a lossless mode (depending on encoding format capabilities)

Test Method: Inspect the ESM Coverage data file.

Reference: This document, requirement 23

Annex B
ESM TIFF/GeoTIFF encoding rules

(normative)

B.1 Scope

This Annex describes how the Elevation Surface Model (ESM) shall use the Tagged Image File Format (TIFF) and GeoTIFF tags 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 GeoTIFF profile for Georeferenced Imagery (STD-108).

B.2 Normative Documents

The format and contents of the TIFF and GeoTIFF are based upon the following industry specifications, in addition to the DGIWG GeoTIFF profile STS-108 referenced in this document:

OGC® GML Application Schema – Coverages - GeoTIFF Coverage Encoding Profile, Version: 0.0.6, 26 June 2013 (OGC 12-100r1)

[GEOTIFF] GEOTIFF format specification, Revision 1.0, Specification Version 1.8.2, Last Modified: 28 December, 2000

[TIFF] TIFF format specification, Revision 6.0 Specification, Final 03/06/92

[EPSG] EPSG Geodetic Parameter Dataset v 6.17 – 14 July 2008

NB: GeoTIFF specification is available at: http://www.remotesensing.org/geotiff/geotiff.html
TIFF specification is available at: http://partners.adobe.com/public/developer/tiff

EPSG Online Registry is available at: http://www.epsg.org/Geodetic.html

B.3 Terms and Definitions

“For the purposes of this document, the terms and definitions given in the TIFF and GeoTIFF specifications and the following apply.”

B.4 Symbols and Abbreviated Terms

IEEE Institute of Electrical & Electronic Engineers

B.5 GeoTIFF Coverage encoding

The OGC specification GMLCOV GeoTIFF extension (OGC 12-100r1) provides additional requirements to the domain and range of a GMLCOV for GeoTIFF encoded Coverages.

Requirement GTF1: An ESM coverage encoded in GeoTIFF shall conform to the tests A.1.2 to A.1.11 of GMLCOV GeoTIFF extension (OGC 12-100r1):
- TIFF and GeoTIFF conformance,
- Coverage type (`gmlcov:RectifiedGridCoverage`),
- URI to GMLCOV_geotiff-coverages/1.0/conf/geotiff-coverage,
- MIME type (image/tiff),
- 2 dimensions coverage,
- CRS,
- axis order,

- raster space,
- range order (if more than 1 elevation component).

Requirement GTF2: 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

B.6 TIFF and GeoTIFF rules

In general, the elevation value records described by the ESM delivered in GeoTIFF format will conform to the specifications in DGIWG TIFF/GeoTIFF profile. The following clauses constrain the implementation of TIFF and GeoTIFF for use with the ESM.

B.6.1 Introduction

Requirement GTF3: Elevation Surface Model (ESM) TIFF/GeoTIFF data shall be encoded on the basis of the DGIWG standardized GeoTIFF profile for Georeferenced Imagery (STD-108), according to the Elevation data (ED) conformance class, with support of TIFF extension for elevation values encoding and GeoTIFF vertical parameters extension.

The individual TIFF/GeoTIFF values file population strategy is defined with a means to associate each GeoTIFF file with:

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

The general rules specified in 6.2 - General rules for ESM data apply to the TIFF/GeoTIFF encoding, as stated in the following paragraphs of this section.

B.6.2 CRS

Requirement GTF4: Horizontal and Vertical datum, CRS

Horizontal datum and Coordinate systems: shall be provided by the following GeoTIFF fields:

GeographicTypeGeoKey / GeogCitationGeoKey, in case of geographic coordinate system;

ProjectedCSTypeGeoKey / PCSCitationGeoKey, in case of projected coordinate system.

Vertical datum: shall be provided by the following GeoTIFF field (*Vertical CS parameter keys*):

VerticalCSTypeGeoKey / VerticalCitationGeoKey

Note: According to 6.6.1, CRS information shall also be documented accordingly in:

- the ESM metadata,
- the ESM Coverage GML instance (if present) based on GMLCOV model or the ESM PointSet GML instance based on DGIWG GML L1.3D.0d profile.

B.6.3 Units of Measure

Requirement GTF5: Horizontal and Vertical units

Geographic / Projected units: shall be provided by the following GeoTIFF fields, in accordance with the CRS (according to EPSG register):

- GeogAngularUnitsGeokey, in case of geographic coordinate system;
- ProjLinearUnitsGeoKey, in case of projected coordinate system.
- Vertical unit: shall be provided by the following GeoTIFF field: VerticalUnitsGeoKey.

Note: According to 6.6.2, unit of measure information shall also be documented accordingly in the ESM GML instance, either based on GMLCOV model or DGIWG GML L1.3D.0d profile.

B.6.4 Security Classification

Requirement GTF6: When the ESM data is classified, the security marking shall be provided in the TIFF ImageDescription field.

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.

B.6.5 Intellectual property rights information

Requirement GTF7: In case of any copyright to the data or any restriction of usage of ESM data, the TIFF field “Copyright” 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 field 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.

B.6.6 Void Areas

DGIWG TIFF/GeoTIFF profile provides 2 methods for the encoding of void values / void areas:

- The unofficial private TIFF tag, GDAL_NODATA (#42113) for declaring this void area value (see Table A.1 in DGIWG STD-108), which should be populated with the most negative value available for the data type selected (or the non-number value designated for the selected data type).
- The use of a transparency mask (refer to **Erreur ! Source du renvoi introuvable.** in DGIWG STD-108) for identification of void data values treated as transparent.

Requirement GTF8: When an ESM data has void areas, the void area value shall be provided in the TIFF GDAL_NODATA field or in a Transparency Mask according to DGIWG GeoTIFF profile (STD-108).

Note: This void area value shall also be declared in the ESM metadata, as stated in 6.6.5.

B.6.7 ESM Data Representation

TIFF image file directory (IFD) allows the definition of the field types

Depending on encoding format, ESM data may be represented by:

- signed integer, encoded on 2 bytes (signed short) or 4 bytes (signed long)
- floating point values: single precision (4-byte) or double precision (8-byte) IEEE formats

High resolution Elevation data are usually stored as 4 bytes signed integers or single precision point values.

Section 19 of the TIFF specification presents a scheme for describing a variety of data sample formats. The BitsPerSample field in the TIFF Image File Directory defines the number of bits per component.

Appendix B Mapping between ESM GML instance, ESM metadata and TIFF/GeoTIFF data structures

This table provides the mapping between values in TIFF/GeoTIFF encoding format and the required ESM GML Elements and ESM metadata elements.

Legend for following tables:

- columns Field, Description, Tag, Type refer to corresponding specification items of tag (resp. geokey) according to TIFF (resp. GeoTIFF) 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 tag or geokey for this profile.

TM: transparency mask

Table B.1: Baseline TIFF Fields in DGIWG profile and mapping with GML elements from ESM GML AS and ESM metadata

TIFF Field	Description	Tag	Datatype	Card	Obligation	Restricted value	GML element / attribute	DMF element / attribute
Artist	Person who created the image	315	ASCII	1	O	If used, populate with the name of the organization responsible for the file. (This information is redundant with additional metadata)	N/A	Dataset originator RSRPTY:originator
BitsPerSample	Number of bits per component	258	Short	1 Samples per post	R	1 (for Transparency mask) For other ESM data, constrained to 16 and 32 bits per range (sample) value.	For each sample per post *i*, rangeType.field[*i*].constraint.interval =“0 *2^BitsPerSample[i]-1*”	N/A
ColorMap	A color map for palette color images	320	Short	)	I	Not used for elevation data	N/A	N/A
Compression	Compression scheme used on the image data.	259	Short	1	R	1 (corresponding to not compressed) 5 LZW compression	N/A	Resource Format.decompression (RSFMT) NB: This information must

TIFF Field	Description	Tag	Datatype	Card	Obligation	Restricted value	GML element / attribute	DMF element / attribute
								be populated in order to provide decompression information (if LZW compression)
Copyright	Copyright notice	33432	ASCII	1..*	O I (for TM)	(When restricted) Restrictions for access or usage, complete copyright statement (including person or organization claiming the copyright, dates ...)	N/A	Resource Legal Constraint (RSLCST)
DateTime	Date and time of image creation	306	ASCII	20	O	Creation date of image Use of this tag is recommended in order to support discovery of the data. This information should be consistent with additional XML metadata, where other dates can also be provided. Date and Time in Coordinated Universal Time (UTC)	N/A NOTE the field DateTime should not be confused with the properties *phenomenonTime* and *beginLifespanVersion* that report other types of temporal information	Resource Reference Date (RSDATE)
ExtraSamples	Description of extra components For the ESM Profile:, this value should not be used	338	Short	1	I	Populate with values of '0' for additional bands and '1' for opacity data	N/A	N/A
FillOrder	The logical order of bits within a byte.	266	Short	1	O	1 (Default) (2 shall never be used)	N/A	N/A
HostComputer	The computer and/or operating system in use at the time of image creation.	316	ASCII	1..*	O	If used, populate with descriptor of the computer system used to process/create the range values from the raw instrument data or other source of sample data.	N/A	N/A
ImageDescription	A string that describes the subject of the image.	270	ASCII	1..*	O	Identify the product type ; must content the identification of product. It is recommended to include security constraint	N§A	Resource Abstract (RSABSTR) for identification of data + Resource

TIFF Field	Description	Tag	Datatype	Card	Obligation	Restricted value	GML element / attribute	DMF element / attribute
						info in this field in order to support Security marking of the data, consistently with additional XML metadata. « Transparency Mask » for transparency mask		Security Constraint (RSSCST) if security constraint
ImageLength	The number of rows of pixels in the image.	257	Short or Long	1	R		domainSet.extent.high.coordValues[*0*] - domainSet.extent.low.coordValues[*0*]	axisDimensionsProperties of Grid Spatial Representation (GRSPREP)
ImageWidth	The number of columns in the image, i.e. the number of pixels per row.	256	Short or Long	1	R		domainSet.extent.high.coordValues[*1*] - domainSet.extent.low.coordValues[*1*]	axisDimensionsProperties of Grid Spatial Representation (GRSPREP)
Make	The scanner manufacturer	271	ASCII	1	O	The manufacturer of the instrument used to obtain the range values.	N/A	N/A
Model	The scanner model name or number.	272	ASCII	1	O	The manufacturer's model name or number of the instrument used to obtain the range values.	N/A	Resource Environment description (RSENVD
MinSampleValue[2]	The minimum component value used.	280	SHORT	1	O	If used for statistical purposes, applies to Integer case values	N/A	Vertical Extent (WGS84 ellipsoid) (minZ)
MaxSampleValue2	The maximum component value used.	281	SHORT	1	O	If used for statistical purposes, applies to Integer case values	N/A	Vertical Extent (WGS84 ellipsoid) (maxZ)
NewSubfileType	A general indication of the kind of data contained in this subfile.	254	Long	1	C Present when	All bits equal 0 except bit 2 = 1 (value = 4, e.g 0...0100 if little-endian)	N/A	N/A

[2] This field is not to be used to affect the visual appearance of an image, nor to affect the interpretation of any other field; it is used only for statistical purposes

TIFF Field	Description	Tag	Datatype	Card	Obligation	Restricted value	GML element / attribute	DMF element / attribute
					transparency mask is used as 2nd subfile	(for transparency mask)		
Orientation	The orientation of the image with respect to the rows and columns.	274	Short	1	O	1 (Default value) Orientation of the image to the external coordinate reference system is defined by the GeoTIFF tags.	N/A	N/A
PhotometricInterpretation	The color space of the image data.	262	Short	1	R	1 greyscale image file or bi-level qualification layer or elevation file) 4 (for transparency mask).	N/A	Content Information of the Coverage GRCINF
Thresholding	For black and white TIFF files that represent shades of gray, the technique used to convert from gray to black and white pixels.	263	SHORT	1	I	This field should be never used for ESM data.	N/A	N/A
PlanarConfiguration	How the components of each pixel are stored.	284	Short	1	I	This field should be never used for ESM data.		N/A
ResolutionUnit	The unit of measurement for XResolution and YResolution.	296	Short	1	R	2 (designating dpi (dot per inch)) Used by TIFF readers that do not read GeoTIFF keys.	N/A	N/A[3]
SamplesPerPixel	The number of components per pixel. For Profile: Allowed values are 1, 3 and 4.	277	Short	1	R	1 for monochrome/greyscale data or bi-level TM	rangeType.field.size()=SamplesPerPixel	N/A
SampleFormat	This field specifies how to interpret each data sample in a pixel. Possible values are:	339*	SHORT	1	M	2 or 3 for ESM data	N/A	N/A

[3] This information is relevant for display or printing ; no mapping should be established to GRCINF.range.units.

TIFF Field	Description	Tag	Datatype	Card	Obligation	Restricted value	GML element / attribute	DMF element / attribute
	1 = unsigned integer data (Default) 2 = two's complement signed integer data 3 = IEEE floating point data [IEEE] NB: This field does not specify the size of data samples; the BitsPerSample field does this.							
SminSampleValue	The minimum sample value. This tag is used in lieu of MinSampleValue when the sample type is other than integer.	340*	Field type that best matches the sample data	SamplesPerPixel	I	This field should be never used	N/A	If this fiel dis used, maps to Vertical Extent (WGS84 ellipsoid) (minZ)
SmaxSampleValue	The maximum sample value. . This tag is used in lieu of MaxSampleValue when the sample type is other than integer.	341*	Field type that best matches the sample data	SamplesPerPixel	I	This field should be never used.	N/A	If this fiel dis used, maps to Vertical Extent (WGS84 ellipsoid) (maxZ)
Software	Name and version number of the software package(s) used to create the image.	305	ASCII	1..*	O	If used, populate with descriptor of the software package(s) used to process/create the range values from source of gridded data.	N/A	Resource Process Step RSPRST
StripOffsets	For each strip, the byte offset of that strip.	273	Short or Long	Number of bands	C Not used if Tiling	Populate per TIFF specification when opting to use strips (for each strip, byte index to strip within file)	N/A	N/A
RowsPerStrip	The number of rows per strip[4].	278	Short or Long	1	C Not used if Tiling		N/A	N/A

[4] TIFF specification recommends selecting the value for RowsPerStrip such that each strip is about 8K bytes; it makes buffering simpler for readers.

TIFF Field	Description	Tag	Datatype	Card	Obligation	Restricted value	GML element / attribute	DMF element / attribute
StripByteCounts	For each strip, the number of bytes in the strip after compression.	279	Short or Long	Number of bands	C Not used if Tiling.	Populate per TIFF specification when opting to use strips (number of bytes of the strip)	N/A	N/A
XResolution	The number of pixels per ResolutionUnit in the ImageWidth direction.	282	Rational	1	R	Populate with resolution for display or prints, e.g. 254/1. Used by TIFF readers that do not read GeoTIFF keys	N/A	N/A[3] Note: As these dimensions are not geographic but related to display or printing diemensions, no mapping should be made for XResolution and YResolution.
YResolution	The number of pixels per ResolutionUnit in the ImageLength direction.	283	Rational	1	R	Populate with resolution for display or prints, e.g. 254/1	N/A	N/A[3]
TileWidth	The tile width in pixels. This is the number of columns in each tile.	322*	Short or Long	1	C For internal TIFF tiling		N/A	N/A
TileLength	The tile length (height) in pixels. This is the number of rows in each tile.	323*	Short or Long	1	C For internal TIFF tiling		N/A	N/A
TileOffsets	For each tile, the byte offset of that tile, as (compressed and) stored on disk.	324*	Long	TilesPerImage[5]	C For internal TIFF tiling		N/A	N/A
TileByteCounts	For each tile, the number of (compressed) bytes in that tile.	325*	Short or Long	TilesPerImage	C For internal		N/A	N/A

[5] TilesPerImage = (ImageWidth + TileWidth - 1) / TileWidth * (ImageLength + TileLength - 1) / TileLength

TIFF Field	Description	Tag	Datatype	Card	Obligation	Restricted value	GML element / attribute	DMF element / attribute
					TIFF tiling			
GDAL_NODATA	An ASCII value intended to specify what pixel value is being used to represent missing or background data.	42113*	ASCII	1	R for 3D data with void areas (otherwise optional)	If used, populate with the number that represents void areas in the dataset.	N/A	Coverage Content Information. SpecialCell
GEO_METADATA	This tag may be used for embedding XML-encoded instance documents prepared using 19139-based schema	50909*	ASCII	Count: 4-byte (max. size = 4GB)	O For embedded XML metadata	This tag may be used and information populated with embedded additional XML metadata[6].	N/A Note: When this tag is used, the GML instance should not include the metadata set. The metadata attribute of the coverage may reference the metadata set resource.	N/A

[6] Also refer to Chapter **Erreur ! Source du renvoi introuvable.**. A “DGIWG metadata profile“ is being developed.

Table B.2: GeoTIFF tags and parameter keys specifications in DGIWG profile and mapping with GML elements from ESM GML AS and ESM metadata

Field	Description	Tag	Datatype	Card	Obligation	Restricted value	GML element / attribute	DMF element / attribute
GeoTIFF Tags								
GeoKeyDirectoryTag	Stores GeoKey Directory, which defines and references the GeoKeys specified below. All Keys in GeoTIFF are referenced from the GeoKeyDirectoryTag	34735	Short	4..*	R	Values of header field: KeyDirectoryVersion = **1** KeyRevision = **1** MinorRevision = **0** NumberOfKeys = variable (cf. following GeoKeys)	N/A	N/A
GeoDoubleParamsTag	Used to store all of the Double valued GeoKeys, referenced by the GeoKeyDirectoryTag	34736	Double		I	There is no need to include this tag if no double parameter is required.	N/A	N/A
GeoAsciiParamsTag	Used to store all of the ASCII valued GeoKeys, referenced by the GeoKeyDirectoryTag	34737	ASCII		R	Required for ASCII valued GeoKeys	N/A	N/A
ModelTiePointTag	raster -> model tiepoint pairs in the order ModelTiepointTag = (…,I,J,K, X,Y,Z...) where (I,J,K) is the point at location (I,J) in raster space with pixel-value K, and (X,Y,Z) is a vector in model space[7]	33922	Double	6	R	grid origin, tag value is: **0 0 0 Ox Oy Oz** where Ox, Oy et Oz are coordinates of the grid origin (in the reference system identified by GeoKeyDirectoryTag) Oz only used for elevation data.	gml:origin element of the domain of the gmlcov:RectifiedGridCoverage	1st cornerPoint of the gridLocation of the Grid Spatial Representation (GRSPREP)
ModelPixelScaleTag	Used to specify the size of raster pixel spacing in the model space units, consists of the following three values ModelPixelScaleTag =	33550	Double	3	R	Value is: **px py pz** where px (resp. py/pz) is	gml:offsetVector of the domain of the gmlcov:RectifiedGridCover	N/A

[7] Note that X is always equal to Easting or Longitude, and Y is always equal to Northing or Latitude.

Field	Description	Tag	Datatype	Card	Obligation	Restricted value	GML element / attribute	DMF element / attribute
	(ScaleX, ScaleY, ScaleZ)					pixel spacing along X axis (resp. Y resp. Z axis) (in the reference system identified by GeoKeyDirectoryTag and in its associated unit) Pz= 0 for 2D images or 1 for elevation data	age	
GeoTIFF Configuration GeoKeys								
GTModelTypeGeoKey	Defines general type of model coordinate system used, and to which the raster space will be transformed.	1024	Short	1	R	The applicable codes are: 1 – ModelTypeProjected (UTM / UPS, ...) 2 – ModelTypeGeographic (e.g ARC)	N/A	N/A
GTRasterTypeGeoKey	Establishes the raster space coordinate system: RasterPixelIsPoint RasterPixelIsArea	1025	Short	1	R	The applicable codes are: 1 – RasterPixelIsArea (used by imagery products) 2 – RasterPixelIsPoint (for discrete coverage data including elevation data)	N/A	cellGeom of the Grid Spatial Representation (GRSPREP)
GTCitationGeoKey	Provided to give an ASCII reference to published documentation on the overall configuration of this GeoTIFF file.	1026	ASCII	1..*	0	This tag may identify detailed product specification (e.g this profile), used to define this GeoTIFF file.	N/A	Resource product specification.citation (RSPSPC)
Geographic CS Parameter Keys								
GeographicTypeGeoKey	This key may be used to specify the code for the geographic coordinate system used to map lat-long to a specific ellipsoid over the earth.	2048	Short	1	C Present only for ARC data (or other Geographic type data).	EPSG code for CRS, as specified in DGIWG STD-108.	srsName of the gml:origin or gml:offsetVector elements of the domain of the gmlcov:RectifiedGridCoverage	Resource Reference System (RSRSYS) (for HOR CRS) Note: URI or URI+ text
GeogCitationGeoKey	This key provides a general citation and reference for all Geographic CS parameters.	2049	ASCII		C	WGS84 + may include Reference document	N/A	N/A

Field	Description	Tag	Datatype	Card	Obligation	Restricted value	GML element / attribute	DMF element / attribute
					When GeographicTypeGeoKey is present	citation (EPSG, DGIWG Registry or [DMA TR 8350.2])		
GeogAngularUnitsGeokey	This key Allows the definition of **geocentric** CS Angular units. It is optional in this profile (though no user-defined GCS is allowed) in order to clarify that "decimal degrees" is the angular unit to be used.	2054	Short	1	O When GeographicTypeGeoKey is present	9102 (meaning decimal degrees) (Default) (may be present only if GeographicTypeGeoKey is present)	Implicit Uom attached to CRS in GMLCOV document	N/A
Projected CS Parameter Keys								
ProjectedCSTypeGeoKey	This code is provided to specify the projected coordinate system.	3072	Short	1	C	Value = 326zz – UTM Northern Hemisphere 327zz – UTM Southern Hemisphere (Where zz is the UTM zone number) Other PCS allowed by this standard (in conformance with DGIWG Geodetic Codes and Parameters Registry)**Erreur ! Signet non défini.** Present only for cartographic data. In this case, GTModelTypeGeoKey = 1 and GeographicTypeGeoKey is absent	srsName of the gml:origin or gml:offsetVector elements of the domain of the gmlcov:RectifiedGridCoverage	Resource Reference System (RSRSYS) (for HOR CRS) Note: URI or URI+ text
PCSCitationGeoKey	This key is provided to give an ASCII reference to published documentation on the Projected Coordinate System.	3073	ASCII	1..*	C When ProjectedCSTypeGeoKey is	Citation of Projected Coordinate System + may include Reference document citation (EPSG, DGIWG Registry or [NIMA	N/A	N/A

Field	Description	Tag	Datatype	Card	Obligation	Restricted value	GML element / attribute	DMF element / attribute
					present	TM 8358.2] For example, value may be: « **UTM zzN / WGS84** »		
ProjLinearUnitsGeoKey	This key defines the linear units used by the projection. It is optional in this profile (though no user-defined GCS is allowed) in order to clarify that "meters" is the linear unit to be used[8].	3076	Short	1	O When ProjectedCSTypeGeoKey is present	9001 (meaning Linear_Meter) (Default) (may be present only if ProjectedCSTypeGeoKey is present)	Implicit Uom attached to CRS in GMLCOV document	N/A

[8] The use of this optional tag for UTM projection adds no information as meters is adequately defined in EPSG codes (for UTM). However, it might prove useful for other PCS.

Table B.3: GeoTIFF Vertical CS parameter keys specifications in DGIWG profile and mapping with GML elements from ESM GML AS and ESM metadata

Field	Description	Tag	Datatype	Card	Obligation	Restricted value	GML element / attribute	DMF element / attribute
Vertical CS Parameter Keys								
VerticalCSTypeGeoKey	This key may be used to specify the vertical coordinate system.	4096	Short	1	C Only for 3D data	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 idenfied in DGIWG Geodetic registry, or user defined Vertical CRS (see **Erreur ! Source du renvoi introuvable.**).	srsName for the swe:uom quantity of the swe:DataRecord of the gmlcov:rangeType	Resource Reference System (RSRSYS) (for Vert. CRS) Note: URI or URI+ text
VerticalCitationGeoKey	This key may be used to document the vertical coordinate system used, and its parameters. For other vertical datum than WGS84, this information must content identification of EPSG code or name for the datum (e.g EGM96, or EPSG code= 5119 for IGN69,NGF in France). It may also include reference of the datum in the DGIWG Geodetic Codes and Parameters registry.	4097	ASCII		C Only for 3D data	Allowed values are (see **Erreur ! Source du renvoi introuvable.**): WGS84 Ellipsoid, EGM84, EGM96, EGM2008, MSL height, MSL depth , or the name of the Sounding datum identified in DGIWG Geodetic registry (S-1 to S-40),	N/A	N/A
VerticalUnitsGeoKey	This key may be used to specify the vertical units of measurement used in the geographic coordinate system, in cases where geographic CS's needs to reference the vertical coordinate. This, together with the Citation key, comprises the only fully implemented keys in this section, at present.	4099	Short	1	C Only for 3D data	9001 (meaning Linear_Meter) (Default)	swe:uom quantity of the swe:DataRecord of the gmlcov:rangeType	Unit of Range of Content Information of the Coverage GRCINF

Annex C
ESM BIIF/NSIF encoding rules

NOTE: This annex is to be included in the next version (future work).

Annex D
ESM DTED encoding

NOTE: This annex is to be included in the next version (future work).

Annex E
ESM GMLJP2 encoding

NOTE: This annex is to be included in the next version (future work) and when DGIWG GMLJP2 profile 2.0 is made available.

Bibliography

D2.8.II.1 Data Specification on Elevation – Draft Technical Guidelines, 2013-02-04 (INSPIRE document D2.8.II.1_v3.