STANDARDS RELATED DOCUMENT

AGeoP-11.3

GEOTIFF RASTER FORMAT SPECIFICATION IN A NATO ENVIRONMENT

EDITION A Version 1
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NORTH ATLANTIC TREATY ORGANIZATION

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NORTH ATLANTIC TREATY ORGANIZATION (NATO)

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NATO LETTER OF PROMULGATION

21 December 2018

1. The enclosed Standards Related Document, AGeoP–11.3, Edition A, Version 1, GEOTIFF RASTER FORMAT SPECIFICATION IN A NATO ENVIRONMENT, which has been approved in conjunction with AGeoP-11 by the nations in the Military Committee Joint Standardization Board is promulgated herewith.

2. AGeoP-11.3, Edition A, Version 1 is effective upon receipt.

4. This publication shall be handled in accordance with C-M(2002)60.

Dieter Schmaglowski
Deputy Director NSO
Branch Head P&C

Zoltán GULYÁS
Brigadier General, HUNAF
Director, NATO Standardization Office

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CHAPTER 1 AIM

The aim of this document is to facilitate the use of the “DGIWG-108: GeoTIFF Profile for Georeferenced Imagery” in the NATO environment for Raster and Orthoimagery products.

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CHAPTER 2 PURPOSE

The purpose of this specification is to ensure interoperability, when disseminating or exchanging Raster and Orthoimagery products on the basis of the DGIWG-108.

This document adds requirements to the current DGIWG-108 [1], including the requirement to use STANAG 2586 / AGeoP-08[2] for its metadata.

Participating nations agree to use the following GeoTIFF Raster / Orthoimagery format specification document for this purpose.

2.1 NATO general requirements on TIFF/GeoTIFF for data

This specification is aimed at the exchange and dissemination of Raster and Orthoimagery products based on the DGIWG-108 [1], itself based on TIFF format [3], with the specific requirements for TIFF tags and GeoTIFF tags specified respectively in sections 2.3 and 2.4 of this document and according to TIFF and GeoTIFF requirements stated in section 2.5 and 2.6.

Requirement 1: Conformant Raster and Orthoimagery products shall conform to the DGIWG-108 (Reference [1]) and its conformance classes (except for the conformance class ED for Elevation). The values for the “GeoTIFF Geographic CS” and “Projected CS Geo keys” will be extended (with respect to DGIWG-108) to allow for the CRS and projections specified by AGeoP-21 (Reference [3]).

Therefore it will use the following conformance classes of DGIWG-108: **B (Baseline)**, and as necessary any of the following:

- **TM (Transparency Mask)**,
- **IT (Internal TIFF Tiling)**,
- **CO (TIFF compression)** or
- **MB (TIFF Multiband for support of 4 to 8 bands)** in cases where there would be more than 3 bands for orthoimagery.

Note: According to DGIWG-108 for raster or imagery, the range (data) values for the pixels are constrained to be unsigned integer data, 8- or 16-bits per band.

2.2 NATO metadata requirements for geospatial data

Geospatial data will be documented and associated with metadata conformant with STANAG 2586 / AGeoP-08 [2] to be provided with the geospatial data file or embedded in the geospatial data file.

Requirement 2: Associated metadata conformant with STANAG 2586 / AGeoP-08 [2] shall be provided with the geospatial data file.

Requirement 3: Associated metadata shall be either external or embedded in the geospatial data file (under the GEO_METADATA TIFF tag). The binding of the geospatial data file to the metadata document shall be provided by the “code” of the RSID metadata element, with a unique geospatial data file ID.

2.3 NATO specific TIFF raster / image requirements

This section identifies requirements that are specific to NATO usage restricting DGIWG-108.

(a) Colour space

Requirement 4: Colour space shall be restricted as follows:

- 1 band image: either black and white (monochrome), or grey scale (PhotometricInterpretation tag = 1)
- 3-band image / raster : RGB (PhotometricInterpretation tag = 2)
- 3-band image / raster : YCbCr (PhotometricInterpretation tag = 6) used for JPEG compression
- Colour-coded shall not be used for raster or imagery data (therefore TIFF tag ColorMap shall not be used and PhotometricInterpretation tag = 3 is not a valid option for raster or imagery data).
  Note: This does not apply to quality masks (associated to imagery / raster via metadata) for which colour-coded values are allowed.
  Note: This requirement does not preclude the use of Multi-band. In case of Multi-band, the PhotometricInterpretation tag = 2, which means the first 3 bands are RGB.

In case a Transparency Mask is used, this is identified by PhotometricInterpretation tag = 4.

(b) Compression

Requirement 5: Compression shall be restricted as follows:

- Uncompressed (Compression tag = 1)
- Lossless compression : LZW (Compression tag = 5) or L77 (DEFLATE, compression tag = 32946)
- JPEG compression (lossy) (Compression tag = 7)

For JPEG compression, this specification recommends the use of YCbCr colour-space.

(c) Void areas

A void area is an area within the data where the value does not represent an actual measurement, or a NULL value is present, e.g. padding or missing measurement values.
The TIFF tag GDAL_NODATA may be used for the purpose of declaring these values (see Table A.1). The alternate solution is the use of a Transparency Mask, as specified in the DGIWG profile.

For 2D data (raster graphics or images), this NULL value (e.g. preferably “black“ or 0 or (0, 0, 0)) may be declared using the GDAL_NODATA tag.

Requirement 6: Void areas / NULL value shall be documented either by the GDAL_NODATA TIFF tag or by a Transparency Mask (internal to the TIFF file).

The recommended value for void pixels is “black“ or 0 (1 band data) or (0, 0, 0) in RGB colour-space, corresponding to a GDAL_NODATA value of “0”.

Note 1: As stated in DGIWG-108, a transparency mask is a bi-level image that is perfectly overlaid on the image data (pixel to pixel) specified by the first Image File Directory (IFD). This profile implements a Transparency Mask with the same size and resolution as the main image data. In this Transparency Mask, the value ‘1’ identifies a significant pixel whereas **a value ‘0’ identifies a padding pixel (no data)** that should be rendered as transparent. A transparency mask contains no GeoTIFF tags.

Note 2: The **GDAL_NODATA TIFF tag** (according to the GDAL implementation and specification of this private GDAL tag) accepts only a single numeric value (the “nodata” value), and the GDAL GeoTIFF driver **requires that all bands must use the same “nodata” value** (for RGB or multiband). As an example, a pixel value of (0, 0, 255) is not a valid void pixel, and the corresponding GDAL_NODATA value of “0 0 255” is not a valid GDAL_NODATA value.

Note 3: The GDAL_NODATA tag can’t be used for lossy compression (JPEG). The reason is that the ”nodata” value is a discrete value that is not preserved by such a lossy compression.

Note 4: The GDAL_NODATA tag and Transparency Masks may be used simultaneously (as neither mechanism is used by all software). **In case the GDAL_NODATA tag is used in conjunction with a Transparency Mask, the specified values must be equal, i.e. the GDAL_NODATA tag value shall align with the value specified in the Transparency Mask, and therefore be “black“ or 0 (1 band data) or (0, 0, 0) in RGB colour-space**.

2.4 NATO specific GeoTIFF requirements: Reference systems and geodetic parameters

Raster and Orthoimagery products will be projected (preferably), either in UTM/UPS or World Mercator. Unprojected Geographic 2D or other projections conforming with AGeoP-21 will be used only in limited cases, when UTM/UPS and World Mercator are impractical.

Requirement 7: Reference systems and geodetic parameters shall be restricted as follows:

- WGS84 [6] or equivalent (specified in [3] §D.2.2) as the base geodetic CRS in all cases
- Projection: World Mercator[1] (EPSG code 3395) or UTM/UPS (which are recommended in this specification) or other projections implemented in conformance with [3] §§ 1.2 and D.2.2.

[1] This extends DGIWG-108.

- Unprojected Geographic 2D (EPSG code 4326) in other cases, when the above projections are impractical (e.g. on large areas that extend far beyond a single UTM/UPS zone).

2.5 NATO requirements on TIFF tags

NATO requirements on TIFF tags are based on those of DGIWG-108, with the specific NATO requirements specified in this document.

Requirement 8: NATO requirements on TIFF tags and allowed tag values are provided in Annex A, in tables A.1, A.2 (TIFF extension JPEG “new style JPEG”, compression tag value = 7) and A.3 (TIFF extension YCbCR: use of TIFF fields, restricted for JPEG compression)

2.6 NATO requirements on GeoTIFF

NATO requirements on GeoTIFF tags are based on those of DGIWG-108, with the specific NATO requirements specified in this document.

Requirement 9: NATO requirements on GeoTIFF tags and allowed tag values are provided in Annex A, in table A.4.

CHAPTER 3 IMPLEMENTATION

This SRD is implemented when a nation has issued the necessary orders/instructions for the forces concerned, putting the provisions outlined in the agreement into effect.

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CHAPTER 4 TERMS AND DEFINITIONS

4.1 Definition

The definitions in Section 4 of DGIWG-108 apply to this specification.

4.2 Abbreviations

ARC	(equal) arc-second raster chart/map system
ASCII	American Standard Code for Information Interchange (ASA X3.4)
BIL	Band Interleaved by Line
BIP	Band Interleaved by Pixel
CRS	Coordinate Reference System
CS	Coordinate System
DGIWG	Defence Geospatial Information Working Group
DMF	DGIWG Metadata Foundation
GeoTIFF	Geographic Tagged Image File Format
IFD	Image File Directory (TIFF)
JPEG	Joint Photographic Expert Group (The joint ISO/ITU committee responsible for developing standards for continuous-tone still picture coding). It also refers to the standards produced by this committee
LZW	Lempel-Ziv-Welch compression algorithm
RGB	Red Green Blue (Colour-space)
RSID	Resource Identifier (DMF)
TIFF	Tagged Image File Format
UPS	Universal Polar Stereographic
UTF8	Unicode Transformation Format (8-Bit)
UTM	Universal Transverse Mercator
UUID	Universal Unique Identifier

WGS84	World Geodetic System 1984
YCbCr	Luminance component, Cb/Cr: blue/ red-difference chroma components (Colour-space)

CHAPTER 5 REFERENCES

[1] DGIWG GeoTIFF Profile for Georeferenced Imagery (DGIWG-108) – Version 2.2.1 – Dec. 2017

[2] AGeoP-08 NATO Geospatial Metadata Profile – Ed. A Ver. 2 - Feb. 2016

[3] AGeoP-21 Geodetic Datums, Projections, Grids and Grid References - Ed. A Ver. 1-

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

[5] GEOTIFF format specification, Revision 1.0, Specification Version 1.8.2, Last Modified: 28 December, 2000
NB: GeoTIFF specification is available at: http://trac.osgeo.org/geotiff/

[6] NGA.STND.0036 1.0.0 WGS84, Department of Defense World Geodetic System 1984: Its Definition and Relationships with Local Geodetic Systems, 8 July 2014 http://earth-info.nga.mil/GandG/publications/NGA_STND_0036_1_0_0_WGS84/NGA.STND.0036_1.0.0_WGS84.pdf

[7] NGA.SIG.0012_2.0.0_UTMUPS: The Universal Grids: Universal Transverse Mercator (UTM), Universal Polar Stereographic (UPS) - 25 March 2014 http://earth-info.nga.mil/GandG/publications/NGA_SIG_0012_2_0_0_UTMUPS/NGA.SIG.0012_2.0.0_UTMUPS.pdf

[8] NGA.STND.0037 2.0.0 GRIDS, Universal Grids and Grid Reference Systems, 28 February 2014 http://earth-info.nga.mil/GandG/publications/NGA_STND_0037_2_0_0_GRIDS/NGA.STND.0037_2.0.0_GRIDS.pdf

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ANNEX A *TIFF / GeoTIFF Format Constraints*
(Normative)

The following tables specify the required content and rules for TIFF and GeoTIFF tags used for Raster and Orthoimagery products in this specification.

Legend for following tables:

- columns Field, Description, Tag, Type refer to corresponding specification items of each tag (resp. geokey) according to the TIFF (resp. GeoTIFF) specifications
- Card column specifies cardinality of the item
- ROCI column specifies presence of the item:
  - R : required
  - 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

A - 1 TIFF Format

NB**:** An asterisk next to the tag number indicates the additional TIFF fields and extensions needed to support the profile. These asterisked tags are in addition to those listed in the TIFF baseline (Section 8 of [TIFF]).

Table A.1: Baseline TIFF Fields specifications of this profile

(from Section 8: Baseline Field Reference Guide of TIFF 6.0 specification)

Field	Description	Tag	Type	Card	ROCI	Restricted values (D: Default value)
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)
BitsPerSample	Number of bits per component	258	Short	1 Samples per pixel (for RGB data)	R	1 (for TM or bi-level imagery) For imagery, constrained to 8 and 16-bits-per-pixel-per-band (e.g 8 8 8 for RGB data)
Compression	Compression scheme used on the image data.	259	Short	1	R	1 (corresponding to not compressed) 5 LZW compression 7 JPEG compression 32946 L77(DEFLATE)
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, ...)
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)
ExtraSamples	Description of extra components For Profile: Use this tag for images with 4 or more bands. Set the value to 0 (unspecified data) and the number of values (count) is equal to the number of additional bands beyond the third band. E.g. for 8-band data, the count is 5 and the values is 0 (0,0,0,0,0).	338	Short	1	C	Populate with values of ‘0’ for additional bands and ‘1’ for opacity data
FillOrder	The logical order of bits within a byte.	266	Short	1	O	1 (Default) (2 shall never be used)

Field	Description	Tag	Type	Card	ROCI	Restricted values (D: Default value)
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.
ImageDescription	A string that describes the subject of the image.	270	ASCII	1..*	O	Identify the type of product e.g. map series, orthoimage series. It is recommended to include security constraint info in this field in order to support security marking of the data, consistent with additional XML metadata. "Transparency Mask" for transparency mask
ImageLength	The number of rows of pixels in the image.	257	Short or Long	1	R	
ImageWidth	The number of columns in the image, i.e. the number of pixels per row.	256	Short or Long	1	R	
Make	The scanner manufacturer	271	ASCII	1	O	The manufacturer of the instrument used to obtain the image.
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 image.
MinSampleValue[2]	The minimum component value used.	280	SHORT	1	O	If used for statistical purposes, applies to Integer values
MaxSampleValue[2]	The maximum component value used.	281	SHORT	1	O	If used for statistical purposes, applies to Integer values
NewSubfileType	A general indication of the kind of data contained in this subfile.	254	Long	1	C Present when transparency mask is used as 2nd subfile	All bits equal 0 except bit 2 = 1 (value = 4, e.g. 0...0100 if little-endian) (for transparency mask)
Orientation	The orientation of the image with respect to the rows and columns.	274	Short	1	O	1 (Default value) – Row major order Orientation of the image to the external coordinate reference system is defined by the GeoTIFF tags.

[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.

Field	Description	Tag	Type	Card	ROCI	Restricted values (D: Default value)
PhotometricInterpretation	The colour space of the image data.	262	Short	1	R	1 greyscale image file or bi-level qualification layer or elevation file 2 RGB (image file) 4 (for transparency mask) Note: A value for the multi-band case is not defined in the TIFF specification. In the multi-band case, use a value of 2 (RGB) and populate the ExtraSamples tag according to the number of additional bands. 6 YCbCr (image file), only for JPEG compression. **Otherwise 6 (YCbCr) shall not be used.**
Thresholding	For black and white TIFF files that represent shades of grey, the technique used to convert from grey to black and white pixels.	263	SHORT	1	O	If used, set to 1 (Default)), indicating that no dithering or halftoning has been applied to the image data.
PlanarConfiguration	How the components of each pixel are stored.	284	Short	1	C More than 1 band	1 (Include this tag when more than one band is described by the range values) (designating Band-Interleaved (BIL or BIP) i.e pixels organised as RGBRGB ...) set the value to 1 (chunky format) Or 2 (planar format).
SamplesPerPixel	The number of components per pixel. For Profile: Allowed values are 1, 3 and 4.	277	Short	1	R	1 for monochrome data or bi-level TM 3 for RGB or YCbCr data 4 for 4 or more (multi-band) data
SampleFormat	This field specifies how to interpret each data sample in a pixel. Possible values are: 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.	339*	SHORT	1	C For coverage other than images	For applicable coverage (other than images) select the value corresponding to the sample format used for representing the range (data) values. Optional (and equal to 1) for raster/ images.

Field	Description	Tag	Type	Card	ROCI	Restricted values (D: Default value)
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	O	If used for statistical purposes, when values are other than integer. Note that a value should be given for each data sample. That is, if the image has 3 SamplesPerPixel, 3 values must be specified.
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	O	If used for statistical purposes, when values are other than integer. Note that a value should be given for each data sample. That is, if the image has 3 SamplesPerPixel, 3 values must be specified.
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 the raw instrument data or other source of imagery and gridded data.
StripOffsets	For each strip, the byte offset of that strip.	273	Short or Long	Number of bands	C Not used if Tiling is used.	Populate per TIFF specification when opting to use strips (for each strip, byte index to strip within file)
RowsPerStrip	The number of rows per strip[3].	278	Short or Long	1	C Not used if Tiling is used.	Required if no tiling.
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 is used.	Populate per TIFF specification when opting to use strips (number of bytes of the strip)
XResolution[4]	The number of pixels per ResolutionUnit in the ImageWidth direction.	282	Rational	1	R	Populate with resolution for display, e.g. 254/1 for orthoimagery or raster maps with PixelScaleX/Y[5] = 100 microns.
YResolution[4]	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 (as above)
ResolutionUnit[4]	The unit of measurement for XResolution and YResolution.	296	Short	1	R	2 (designating dpi (dot per inch))

[3] The TIFF specification recommends selecting the value for RowsPerStrip such that each strip is about 8K bytes; it makes buffering simpler for readers.
[4] Used by TIFF readers for adequate display / printing of raster. GIS software should not use these TIFF tags.
[5] Where PixelScaleX/Y are the 1st/2nd component of GeoTIFF tag ModelPixelScaleTag. The formula for the calculation of the numerator is 2.54E-02/PixelScaleX (resp. PixelScaleY). The denominator is equal to 1 (inch, as this is the unit of measurement for XResolution and YResolution).

Field	Description	Tag	Type	Card	ROCI	Restricted values (D: Default value)
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	
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	
TileOffsets	For each tile, the byte offset of that tile, as (compressed and) stored on disk.	324*	Long	TilesPerImage [6]	C For internal TIFF tiling	
TileByteCounts	For each tile, the number of (compressed) bytes in that tile.	325*	Short or Long	TilesPerImage	C For internal 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. Note1: This tag **shall not** be used if JPEG compression is used. Note 2: This tag accepts only a single value and for multi-band the "nodata" value **is therefore** the same for all bands Note3: If used in conjunction with Transparency Mask, the value **shall** be "0".
TIFF_RSID	File Universal Unique Identifer, or RSID, according to DMF definition	50908	ASCII	1	R	Used to provide a unique file identifier for the TIFF file. The content shall be the UUID of the data file.
GEO_METADATA	This tag may be used and information populated with embedded XML metadata[7], prepared using DMF-based schema	50909*	Byte	Count: 4-byte (max. size = 4GB)	O For embedded XML metadata	May be used for XML metadata. ASCII or UTF8 characters may be used.

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

[7] Conformant with STANAG 2586 / AGeoP-08 (cf. requirement 2).

The following table lists the requirements for “TIFF extension JPEG fields – new style” and is based on the following references:

- http://www.awaresystems.be/imaging/tiff/tifftags/jpegtables.html (specification of JPEG Tables tag for use with compression tag = 7)
- http://download.osgeo.org/libtiff/doc/TIFFTechNote2.html (TIFF technical note explaining the issues with the method proposed in Section 22 [3]: JPEG compression extension of TIFF 6.0 specification (addressed by compression tag value = 6) and specification of “new style JPEG” in TIFF, with compression tag value = 7)
- http://www.fileformat.info/format/tiff/egff.htm (additional information on issues for “old style” JPEG in TIFF (as specified in Section 22 [3]) and new style JPEG solution.

Table A.2: TIFF extension JPEG fields (Compression JPEG) – New style JPEG in TIFF (compression tag value = 7)

Field	Description	Tag	Type	Card	ROCI	Restricted values (D: Default value)
JPEGTables	JPEG quantization and/or Huffman tables. The purpose of JPEG Tables is to predefine JPEG quantization and/or Huffman tables for subsequent use by JPEG image segments. When this is done, these rather bulky tables need not be duplicated in each segment, thus saving space and processing time. JPEGTables may be used even in a single-segment file, although there is no space savings in that case.	347	UNDEFINED	N = number of bytes in tables datastream	O	Used for JPEG compression (new style, when Compression tag = 7) Shall contain a valid JPEG "abbreviated table specification" datastream

Note: The following tags specified in Section 22: JPEG compression extension of TIFF 6.0 specification – as addressed by the compression tag value equal to 6 in Table A.1 **shall not be used**, as they are inefficient and are now obsoleted:

- JPEGProc, JPEGInterchangeFormat, JPEGInterchangeFormatLength, JPEGRestartInterval, JPEGLosslessPredictors, JPEGPointTransforms, JPEGQTables, JPEGDCTables, JPEGACTables.

The TIFF Advisory Committee has developed a replacement JPEG-in-TIFF scheme, based on the use of a JPEGTables tag (as specified above), and addressed by Compression tag value equal to 7.

The outline of the mechanism is as follows:

1. Each image segment (strip or tile) in a JPEG-compressed TIFF image contains a legal JPEG datastream, complete with all markers. This data forms an independent image of the proper dimensions for the strip or tile.
2. To avoid duplicate tables in a multi-segment file, segments may use the JPEG "abbreviated image data" datastream structure, in which DQT (Define Quantization Table) and DHT (Define Huffman Table) tables are omitted. The common tables are to be supplied in a JPEG "abbreviated table specification" datastream, which is contained in a newly defined "JPEGTables" TIFF field.

(Because the tables in question typically amount to 550 bytes or so, the savings are worthwhile.)

The JPEG "abbreviated table specification" datastream shall begin with SOI (Start Of Image marker) and end with EOI (End Of Image marker). It may contain zero or more JPEG "tables and miscellaneous" markers, namely:

- DQT (Define Quantization Table)
- DHT (Define Huffman Table)
- DAC (Define Arithmetic Table), not to appear unless arithmetic coding is used.
- DRI (Define Restart Interval)
- APPn (APPlication segment), shall be ignored by TIFF readers.
- COM (JPEG Comment segment), shall be ignored by TIFF readers.

The following table lists the requirements for TIFF extension for YCbCr and is based on the following reference in TIFF specification: Section 21 [3]: YCbCr Images ([TIFF]) - Minimum Requirements for YCbCr Images.

Table A.3: TIFF extension YCbCr: use of TIFF fields (restricted for JPEG compression JPEG)

Field	Description	Tag	Type	Card	ROCI	Restricted values (D: Default value)
SamplesPerPixel	The number of components per pixel.	277	Short	1	R	3. Three components representing Y, Cb and Cr
BitsPerSample	Number of bits per component	258	Short	1 samples per pixel (for YCbCr data)	R	8, 8, 8
Compression	Compression scheme used on the image data.	259	Short	1	R	7 (JPEG)
PhotometricInterpretation	The colour space of the image data.	262	Short	1	R	6 (YCbCr)
ReferenceBlackWhite	Specifies a pair of headroom and footroom image data values (codes) for each pixel component. The first component code within a pair is associated with ReferenceBlack, and the second is associated with ReferenceWhite. The ordering of pairs is the same as those for pixel components of the PhotometricInterpretation type.	532	Rational	6	R	Default value: 0 255 128 255 128 255 (no headroom/no footroom)

A - 2 GeoTIFF Format

Use of keys and parameters is constrained as indicated within this specification. All keys are referenced from one tag, the GeoKeyDirectoryTag.

NB: these tags only apply to image files and other gridded data; they **do not** apply to Transparency Masks.

Table A.4: GeoTIFF tags and parameter keys specifications of this profile

Field	Description	Tag	Type	Card	ROCI	Restricted values
GeoTIFF Tags						
GeoKeyDirectoryTag	Stores the 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)
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-valued parameter is required.
GeoAsciiParamsTag	Used to store all of the ASCII-valued GeoKeys, referenced by the GeoKeyDirectoryTag	34737	ASCII		R	Required for ASCII-valued GeoKeys
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[8]	33922	Double	6	R	Populate this tag with the tie point pair that correlates to the grid reference (grid origin (coordinates 0,0)) In case of 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 (therefore equal to 0)
ModelPixelScaleTag	Used to specify the size of raster pixel spacing in the model space units, and consists of the following three values ModelPixelScaleTag = (ScaleX, ScaleY, ScaleZ)	33550	Double	3	R	Value is: **px py pz** where px (resp. py/pz) is 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

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

Field	Description	Tag	Type	Card	ROCI	Restricted values
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)
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)
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.
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	4326 (i.e GCS_WGS84 meaning 'WGS84') or another geodetic datum conforming with [3] §D.2.2. Present only for ARC data (or other Geographic type data). In this case, GTModelTypeGeoKey = 2 and ProjectedCSTypeGeoKey is absent.
GeogCitationGeoKey	This key provides a general citation and reference for all Geographic CS parameters.	2049	ASCII		C When GeographicTypeGeoKey is present	WGS84 (or another geodetic datum conforming with [3]§D.2.2.) and may include Reference document citation (EPSG, DGIWG Registry or NGA.STND.0037 2.0.0 GRIDS[8])

Field	Description	Tag	Type	Card	ROCI	Restricted values
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) or 3395 (World Mercator) Present only for cartographic data. In this case, GTModelTypeGeoKey = 1 and GeographicTypeGeoKey is absent
PCSCitationGeoKey	This key is provided to give an ASCII reference to published documentation on the Projected Coordinate System.	3073	ASCII	1..*	C When ProjectedCSType GeoKey is present	Citation of Projected Coordinate System + may include Reference document citation (EPSG, DGIWG Registry or [NGA.SIG.0012_2.0.0] 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[9].	3076	Short	1	O When ProjectedCSType GeoKey is present	9001 (meaning Linear_Meter) (Default) (may be present only if ProjectedCSTypeGeoKey is present) **Note**: the unit defined by this tag must not modify the unit specified by the projection (as in EPSG registry)

[9] 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.

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