DGIWG 255

Defence Orthoimagery Product Implementation Profile

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Abstract:	This standard for Defence Orthoimagery products supports Defence requirements for the creation and exchange of a wide range of orthoimagery products. It defines a multi-resolution grid system for standardised products, the associated grid structure, tiling-scheme, the data and metadata content and encodings (GMLJP2, GeoTIFF and NSIF).
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Executive Summary

The development of this implementation profile for Defence Orthoimagery products (DOP) is intended to support defence requirements for production and exploitation of orthoimagery products over a wide range of resolutions (25m to 10cm) produced from various airborne or satellite sensors: optical, infrared, SAR, and LIDAR intensity images. The purpose of this document is to specify the data content and characteristics, format and metadata of orthoimagery products/data for producers, users and implementers, and provide subsequent conformance clauses.

i. Contributing participants

Nation	Parent organization
France (Lead Nation)	Institut National de l'Information Géographique et Forestière (IGN)
Canada	Canadian Forces Intelligence Command (CFINTCOM)
Spain	Cartographic Coordination Unit
Sweden	Military Geographic Service
United Kingdom	Defence Geographic Centre DGC)
United States	National Geospatial-Intelligence Agency (NGA)

ii. Document points of contact

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NOTE: All personal information will be removed when an internal document is made public. This includes names and personal e-mail accounts.

iii. Revision history

Date (yyyy-mm-dd)	Edition number	Primary clauses modified	Description
2020-10-09	0.1	All	Creation
2020-10-11	0.2	Executive summary, Introduction, Section 2 – Conformance, Section 11.3, Annex A	Finalization during and after DGIWG Technical Panel, October 2020
2021-05-05	1.0		Resolution of comments after ballot: 12th April 2021 telecom, and DGIWG Technical Panel, May 21

iv. Future work

Extension with parameters for polar zones to be added.

Contents

List of Figures

List of Tables

Introduction

An orthoimage is a two dimension (2D) raster image covering a territory on the Earth that has been geometrically corrected ("orthorectified") to remove distortion caused by differences in elevation, sensor tilt and, optionally, by sensor optics. Source is either satellite or airborne sensors. Data is orthorectified to achieve an accuracy commensurate with a given topographic map equivalent [source INSPIRE Orthoimagery data specification[1], section 2.2 Description].

Orthoimagery may be considered/used for:

- to provide an accurate view of a given territory at the acquisition date/situational awareness, aligned with a geographic/cartographic coordinate system,
- for display as a base layer/backdrop to other geospatial data,
- for the extraction, mapping and updating of specific features on the surface of the Earth (e.g. Transport network, hydrography, or military or industrial facilities),
- for mission planning,
- in support to GeoInt, IMINT and Targeting,
- for localisation of other thematic data or Earth observation image data.

This Defence Orthoimagery Products (DOP) implementation profile supports defence requirements for production and exploitation of orthoimagery products over a wide range of resolutions produced from various airborne or satellite sensors: optical, infrared, SAR, and LIDAR intensity images.

This specification is aimed at improving interoperability for defence and security, national defence agencies, producers, users, and defence systems for orthoimagery products in support of storage, access, exchange, visualization and exploitation, for mission planning tools, by all forces at all levels of command (strategic, operational and tactical).

The intent of this standard is to increase the level of interoperability with and between organizations producing and using orthoimagery, ensuring state of the art performance for data exchange / access and data display, and provide the necessary metadata to document sources and lineage, quality, and security handling information.

The spatial resolution layers covered on this profile include those resolutions considered by U.S. MIL-PRF-89041A, Controlled Image Base (CIB), which is the base of STANAG 7099, and U.S. Performance Specification MIL-PRF-32466, System specification for Enhanced Controlled Image Base (ECIB).

It should be noted that this document provides the parameters valid only for non-polar zones. An extension for polar zones is to be added.

[1] Available at https://inspire.ec.europa.eu/id/document/tg/oi

1 Scope

This product implementation profile for Orthoimagery products was developed to support defence requirements for production and exploitation of orthoimagery products. It covers a wide range of resolutions produced from various airborne or satellite sensors: optical, infrared, SAR, and LIDAR intensity images.

This specification is aimed at improving interoperability for defence and security, national defence agencies, producers, users, and defence systems for orthoimagery products in support of storage, access, exchange, visualization and exploitation, for mission planning tools, by all forces at all levels of command (strategic, operational and tactical). See Annex D for Orthoimagery DPS use cases overview.

The scope of this orthoimagery document specifies:

- the multi-resolution grid system (for standardized products, resolutions between 10m and 10cm);
- content for orthoimagery and metadata (according to DMF);
- tiling-scheme;
- based on the standardized Defence reference systems (either WGS84/Geographic and use of ARC system or WGS84/UTM (or UPS in polar zones)), though allowing ad hoc products;
- structure of the product;
- product distribution/delivery according to the DGIWG standardized encodings (GeoTIFF, GMLJP2 and NSIF/STANAG 4545).

This document does not include:

- Terrestrial imagery (e.g. from cameras based on the ground, on road and on rail vehicles).
- Aerial video imagery. However, it includes orthorectified images created from video frames.
- Meteorological satellite imagery (because such data is not primarily concerned with imagery of the Earth's surface).
- Imagery of the sea bed from underwater sensors (as this specification is restricted to imagery from air-borne and satellite sensors).
- Products derived from orthoimagery, such as thematic/classified imagery (e.g. land cover, land use).

This does not prevent data providers from delivering such datasets in conformity with this product specification if they have the need to do so.

It should be noted that this document provides the geographic orthoimagery products parameters valid only for non-polar zones[2].

[2] CIB (MIL-PRF-89041A / STANAG 7099) and ECIB (MIL-PRF-32466) provide specification and guidance on the use of the ARC system for WGS84 Geographic Orthoimagery (with imagery frames – or tiles - of 2304 x 2304 pixels and NSIF/NITF encoding).

2 Conformance

Any application, system, orthoimagery product specification or orthoimagery dataset claiming conformance to this implementation profile shall meet the criteria for data conformance provided in the abstract test suite, as specified in Annex A.

One Core conformance class and two specific conformance classes are specified in Annex A:

- **Core**: applicable to all Orthoimagery DPS products and derived specifications: general common requirements. See sections A.1 DOP Core and A.2 DOP Tiling scheme
- **ARC**: applicable to Orthoimagery DPS products. See section A.3
- **UTM**: applicable to Orthoimagery DPS products. See section A.4

Orthoimagery DPS ad hoc products will only adhere to the Core conformance class, and may conform to other requirements if their reference system is based on ARC or UTM.

3 Normative References

International Standards:

(1) ISO 639-2:1998, Codes for the representation of names and languages – Part 2: Alpha-3 code.

(2) ISO 19111:2019, Geographic information – Spatial referencing by coordinates.

(3) ISO 19115-1:2014, Geographic information – Metadata – Part 1: Fundamentals.

(4) ISO 19115-2:2019, Geographic information – Metadata – Part 2: Fundamentals.

(5) ISO 19123-2:2018, Geographic information -- Schema for coverage geometry and functions – Part 2: Coverage implementation schema (or OGC Coverage Implementation Schema ("CIS") v1.0.1, formerly named GML 3.2.1 Application Schema - Coverages ("GMLCOV") – OGC#09-146r2).

(6) NATO MC 0296/3**,** NATO Geospatial Policy, dated 31 October 2016.

(7) STANAG 2211 ED 7, Geodetic Datums, Projections, Grids and Grid References, February 2016

(8) AGeoP-21 Geodetic datums, projections, grids and grid references Ed. A Version 1, February 2016

(9) STANAG 2215 ED 7, Evaluation of Land maps, Aeronautical charts and Digital Topographic data, July 2010.

(10) DGIWG 114, DGIWG Metadata Foundation, Version 2.0.0, 12 July 2017.

(11) DGIWG 108, GeoTIFF Profile for Georeferenced Imagery, Version 2.3, January 2020.

(12) DGIWG 104, DGIWG Profile of JPEG 2000 for Georeferenced Imagery, Version 1.0.0, 4 February 2014.

(13) DGIWG 104(2), DGIWG Profile of JPEG 2000 for Georeferenced Imagery, Version 2.1.1, January 2020.

(14) DGIWG 101, Profile of ISO 19131 - Geographic Information - Data product specification, Version 1.0.0, 5 April 2018.

(15) DGIWG 016, DIGEST Support Document 3 - The ARC System, 30 April 2001 (available here).

National Standards:

(16) 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.

(17) NGA.STND.0037_2.0.0_GRIDS, Universal Grids and Grid Reference Systems, 28 February 2014.

(18) NGA.SIG.0012_2.0.0_UTMUPS, Implementation Practice – The Universal Grids and the Transverse Mercator and Polar Stereographic Map Projections, 25 March 2014 (available here).

4 Terms and definitions, and abbreviated terms

4.1 Terms and definitions

Terms and definitions have been taken from the references cited in the Normative References (section 3) and the Bibliography.

The following terms and definitions are provided for ensuring proper understanding of the key terms used in this document.

4.1.1 data product specification

Detailed description of a dataset or dataset series together with additional information that will enable it to be created, supplied to and used by another party.

[ISO 19131:2007]

NOTE: A data product specification provides a description of the universe of discourse and a specification for mapping the universe of discourse to a dataset. It may be used for production, sales, end-use or other purposes.

4.1.2 dataset

Identifiable collection of data.

NOTE: A dataset may be a smaller grouping of data which, though limited by some constraint such as spatial extent or feature type, is located physically within a larger dataset. Theoretically, a dataset may be as small as a single feature or feature attribute contained within a larger dataset. A hardcopy map or chart may be considered a dataset.

[ISO 19115-1:2014]

4.1.3 dataset series

Collection of datasets sharing common characteristics.

[ISO 19115-1:2014]

NOTE: The datasets in a series may have been derived from the same sensor or platform or may adhere to a common product specification. They typically share the same geometry (e.g. grid or TIN).

4.1.4 mosaic

Image composed of multiple overlapping or adjoining images merged together.

[Adapted from INSPIRE Orthoimagery Data specification (https://inspire.ec.eruropa.eu/)]

4.1.5 orthoimage

Image in which by orthogonal projection to a reference surface, displacement of image points due to sensor orientation and terrain relief has been removed

NOTE 1: The amount of displacement depends on the resolution, the level of detail of the elevation information and on the software implementation.

[ISO 19101-2:2018]

NOTE 2: An orthoimage is a raster image (2D) covering a territory on the Earth that has been geometrically corrected ("orthorectified") to remove distortion caused by differences in elevation, sensor tilt and, optionally, by sensor instrument. Data is orthorectified to achieve an accuracy commensurate with a given topographic map equivalent.

4.1.6 product unit

Elementary orthoimagery component of the product/dataset.

NOTE: This corresponds to the resource unit (as called by DMF) in which the orthoimagery component composing the dataset collection is made available. This product unit is also called frame in ECIB and NITF/NSIF standards.

4.1.7 tessellation

Partitioning of a space into a set of conterminous subspaces having the same dimension as the space being partitioned.

NOTE 1: A tessellation composed of congruent regular polygons or polyhedra is a regular tessellation. One composed of regular, but non-congruent polygons or polyhedra is semi-regular tessellation. Otherwise, the tessellation is irregular.

[ISO 19123:2005]

NOTE 2: Tiling is used as a synonym of tessellation. In this document, tiling is the external tiling that partitions the data space into a set of tiles resulting into the equivalent set of datasets/files that have manageable size (see 11.5).

4.1.8 tile

A rectangular array of points on the reference grid, registered with an offset from the reference grid origin and defined by a width and height.

NOTE: The tiles which overlap are used to define tile-components.

[ISO/IEC 15444-1]

4.1.9 tiling

See tessellation, 4.1.7.

4.2 Abbreviated terms

ARC	Equal Arc-Second Raster Chart
BIIF	Basic Image Interchange Format [ISO/IEC 12087-5]
CE90	Circular Error measured at the 90% confidence interval
CRS	Coordinate Reference System
DMF	DGIWG Metadata Foundation
DOP	Defence Orthoimagery Product
EPSG	European Petroleum Survey Group
GeoTIFF	Geographic Tagged Image File Format
GML	Geography Markup Language
GMLJP2	GML in JPEG 2000
GPHICS	Resource Graphics
GSD	Ground Sample Distance
ISO	International Organization for Standardization
IPB	Intelligence Preparation of the Battlefield

IEC	International Electrotechnical Commission
JPEG	Joint Photographic Experts Group
JPEG 2000	Wavelet compression standard defined by Joint Photographic Experts Group in 2000 [ISO 15444-1]
JP2	JPEG 2000 file format [ISO 15444-1]
LZW	Lempel-Ziv-Welch compression algorithm
LE90	Linear Error measured at the 90% confidence interval
MGRS	Military Grid Reference System
MP	Mission Planning
NATO	North Atlantic Treaty Organization
NIIRS	NATO Imagery Interpretability Rating Scale
NITF	National Imagery Transmission Format
NSIF	NATO Secondary Imagery Format [STANAG 4545]
OGC	Open Geospatial Consortium
OPP	Operations Planning Process
PNG	Portable Network Graphics
RGB	Red, Green, Blue
RPF	Raster Product Format [MIL-STD-2411]
TC211	Technical Committee 211
UoM	Unit of Measure
UPS	Universal Polar Stereographic
UTM	Universal Transverse Mercator
WGS 84	World Geodetic System 1984
XML	eXtensible Markup Language

5 Applicability and use

This profile provides a framework for interoperable and consistent multi-resolution orthoimagery product specifications, in support of orthoimagery storage, access, exploitation and exchange of standardized products. It applies to orthoimagery product specifications and to orthoimagery products (data). Orthoimagery products/data are mostly generated from several source images orthorectified, based on a digital elevation model (DEM), and mosaicked. An orthoimagery product may contain a number of orthoimage components also called product units (or frames).

The purpose of this document is to specify the data content and characteristics, format and metadata of orthoimagery products/data for producers, users and implementers, and provide subsequent conformance clauses.

NOTE: In this document, the decimal separator is the decimal comma, in accordance with the DGED specification (and usage outside the UK and USA).

6 Data content and structure

6.1 General Description

The Orthoimagery DPS data structure is a uniform, orthogonal grid-based raster model, supporting a wide range of orthoimagery resolutions according to 10 levels (see section 6.2). Table 1 – NATO Levels of Orthoimagery Geospatial Information describes the NATO Orthoimagery Geospatial Information levels (see NATO MC 0296/3, NATO Geospatial Policy).

Table 1: NATO Levels of Orthoimagery Geospatial Information

Level	Imagery resolution (IR) (meters)
0	Not used
1	IR ≥ 10 m
2	5 m ≤ IR < 10 m
3	1 m < IR < 5 m
4	1 m resolution
5	Better than 1 m resolution

This DOP specification document incorporates the following key features and capabilities:

- **Standardized orthoimagery products** aligned to a multi-resolution system from Level 0 to 9 (see Table 2 – Orthoimagery DPS standardized levels in 6.2) with two instances (Geographic/Angular grids or Cartographic/Metric grids) based on WGS 84 horizontal CRS with one of the two following projections:
  - Geographic/Angular grids in ARC system – see presentation in Annex C (and DGIWG DIGEST ARC system Support document) for orthoimagery between 25 m and 10 cm: Orthoimagery DPS ARC;
  - Cartographic/Metric grids in UTM system for orthoimagery between 25 m and 10 cm: Orthoimagery DPS UTM.
- **Ad hoc products with ad hoc resolutions**, where CRS may be:
  - either in ARC or UTM, to facilitate exploitation with other standardized resolution products: Orthoimagery DPS ARC or UTM, with ad hoc resolution and/or not aligned with the Orthoimagery standardized products;
  - or using specific CRS and projection, which should be considered as exceptions.
- **Ad hoc products not aligned with the standardized grids**, in order to center on an area of interest (e.g. a city area).
- Quality constraints on horizontal accuracy specified for each resolution level.
- Use of metadata for orthoimagery as specified by DMF version 2.0, as specified in annex B.
- Image compression:
  - use of JPEG 2000 compression (in near-lossless mode with compression ratio between 1:12 and 1:15) which is the recommended option in most cases in terms of volume of data (file size) and display speed;
  - or lossless compression (such as LZW or DEFLATE or Packbits or JPEG 2000 in lossless mode).

- Use of one DGIWG encoding standard, being either one of these 3 options:
  - GMLJP2 standard for encoding, in case of JPEG 2000 compression, on basis of DGIWG GMLJP2 profile;
  - or GeoTIFF format if uncompressed data or use of lossless compression such as LZW or Deflate or Packbits (usually of limited efficiency in terms of compression ratio), on basis of DGIWG GeoTIFF profile;
  - or NATO Secondary Imagery Format (NSIF) encoding with JPEG 2000 compression, with visually lossless compression, on basis of ECIB product specification.

NOTE 1: WGS 84 realization should be documented, see section 7.1.

NOTE 2: ARC in polar zones specification is not included in this document; it will be addressed by a dedicated extension of this Orthoimagery DPS standard.

DOP Geographic ARC products, at a given resolution, provide a seamless coverage of orthoimagery within the same ARC zone: the edges of contiguous source maps are indistinguishable. The data from each dataset abuts the data of neighboring datasets exactly to provide unbroken coverage. The boundaries of the distribution datasets (often called Distribution Rectangles) are not required to coincide with the source images edges. However, the East-West distortion is large in comparison to most grid systems (see section 3.5 in DIGEST Support Document for ARC system).

DOP UTM/UPS products are valid only on the associated zone or area as specified by the individual projection. Therefore the seamless coverage capability is limited to the extent of the zone or area covered by the individual projection.

6.2 Spatial resolution / GSD

The spatial resolution of the orthoimagery product depends on the spatial resolution of the image source from which the product is derived and any processing steps which affect the resolution.

In defence context, the pixels are indicators (depending of the sensor/instrument resolution) of the quality/information of the orthoimagery products and how deep they can be analysed. For instance, higher resolution and radiometric quality may allow detection of roads, construction, vehicles, etc. The NIIRS is commonly used to define and measure image quality (see Annex H).

This specification defines a consistent range of standardized resolutions with “phased” or “aligned” pixels for standardized orthoimagery products at the following discrete set of resolutions: 25m, 10 m, 5 m, 2.5 m or 2 m, 1 m, 0.5 m, 0.25 m, 0.125 m, 0.1 m.

Table 2: Orthoimagery DPS standardized levels

Orthoimagery DPS Level	Resolution / GSD (meter)	Corresponding NIIRS	Corresponding NATO level for geospatial information
0	25	0	0 (not used)
1	10	1	1
2	5	2	2
3	2,5	3	3
4	2	4	3
5	1	5	4
6	0,5	6	5
7	0,25	7	5
8	0,125	8	5
9	0,1	9	5

Orthoimagery products at a resolution between 2 standardized resolutions (see Table 2 above) are ad hoc DOP products. Their level is the level of the lower resolution of the interval; in other words, level n covers all resolutions in the interval greater than the standardized resolution of level n (and lower than standardized resolution of level n-1). For example, Level 3 covers the interval of resolution [2.5m, 5m].

NOTE: The DOP level is an indicator, based on the key value GSD / Resolution. GSD is to be documented by RSSRES element (with 1 distance value or an interval of 2 values) and exact resolution(s) may be provided by the RSRSQR-GSD resolution element (usually 2 distinct values according to the 2 axis in ARC system).

6.3 Spectral bands and radiometry

Depending of the source sensor/instrument of geospatial imagery and user requirements, the orthoimagery product may be:

- Panchromatric or Single band/channel. Panchromatic is a one band imagery that usually contains a couple of hundred nanometers bandwidth. Such bandwidth enables it to hold a high signal-noise, making the panchromatic data available at a high spatial resolution[3].
- True-Color, Red Green Blue (RGB) or other 3 bands imagery.
- Multispectral with 4 bands/channels, with NIR, RGB, or up to 8 bands, or SAR polarimetric channels (i.e. magnitude of correlation among HH, VV, HV, VH channels). See Annex G for further information and use of RGB and Multispectral imagery.
- Hyperspectral, with more than 8 bands. Hyperspectral imagery implies that bands are supposed to be close to each other.

For any orthoimagery product, the band dynamic will be 8 bits or 12 bits or up to 16 bits per band. The exploitation of Multispectral as “True-Color” imagery (24 bits per pixel) involves the default use of 8 bits per band, therefore dynamic reduction if dynamic is higher. In case of more than one band, the dynamic will be the same for all bands. SAR orthoimagery is handled by one band (or up to 4 bands for polarized imagery) with a dynamic of 16 bits.

An additional alpha band/channel is commonly used in order to handle transparency. The Alpha channel has the same dynamic/same number of bits per pixel as the other bands.

Documentation of spectral bands and band dynamic is provided by the range information of the GRCINF metadata element (see element #39 in Table 6: DOP Core Metadata).

In case there is no Alpha channel, a No-Data value (Null) is also commonly defined for pixels that are not handling information (padding or pixels identified as not holding radiometric information). The Null value, when used, will be specified according to the encoding standard used for data delivery and should be documented in the DOP metadata (SpecialCell mechanism):

- in the metadata (in DMF GRCINF.specialCell element);
- in the file format, depending of encoding format capability (for example with GDAL_NODATA tag in GeoTIFF format, or <swe:nilValues> in the rangeType description in case of GMLJP2 v2).

Recommended values are the White Color (RGB = (255, 255, 255), as Black is often present, or Black Color (RGB = (0, 0, 0).

Padding usage requires transparency information and it may be provided by the following products:

- JPEG 2000 products, an additional alpha channel;
- GeoTIFF products, use of No data value (see DGIWG GeoTIFF profile) or a transparency mask (in 2nd IFD (Image File Directory)).

[3] https://eos.com/panchromatic/

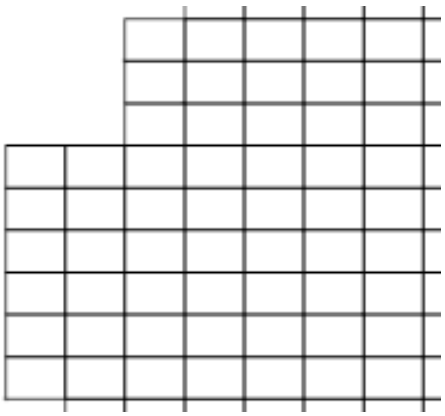
6.4 Grid Structure and orthoimagery resolution

The uniform regular grid structure is the data model used for raster data (ISO 19123), known as Rectified Grid Coverage according to the Coverage Implementation Schema (ISO 19123-2 or OGC CIS 1.0.1 whose namespace is GMLCOV). This grid structure is composed of the orthoimagery pixels which are the rectangular (or square) elements, to cover the orthoimagery coverage.

This coverage encapsulation of the rectified/regular grid structure is optional and may be implemented for some encodings (such as GMLJP2), or not.

NOTE: The Coverage Implementation Schema presently handles the following encodings: GeoTIFF and JPEG 2000/GMLJP2 (and CF-netCDF3.0, unused in this document).

To fit into the file size constraints, the grid structure is tessellated into quadrilateral (usually square or rectangular) tiles, each tile being encoded into a single file (see following illustration).



The grid structure is georeferenced by its origin (upper left or lower left corner) and its offsets which are the equivalent pixel size (in meters or decimal degrees) in terrain space in the 2 directions (rightwards and downwards). The grid structure (and its resolution, with square pixels for DOP products) is georeferenced and associated to the terrain according to 2 different correspondence methods between raster resolution and terrain resolution (or pixel equivalent size), depending on the type of grid:

- **either projected/metric**, **based on the following simple relationship:**

  Terrain Pixel size (m) = Ground Sample Distance

  Raster pixels therefore also represent a square area on Terrain.

  The number of pixels per raster file unit, or Tile, is by design an integer number.

- **or Geographic based on angular coordinates definition** (for DOP ARC products), defined on the basis of 2 integer parameters called A(ZT) = Pixel number along standard parallel and B(Z) = Pixel number along the meridian (round the earth) which vary with Latitude zone according to the ARC specification, and result in an approximate equivalent pixel size in meters.

  The terrain pixel size is in this case equal to 360 degrees divided by A(ZT) longitudinally, or by B(Z) latitudinally. It is measured in arc seconds.

  The number of pixels per square degree is by design an integer number, and per raster unit, or Tile. The Tile size may be a square degree if the resulting file size is within the file size constraint, or a sub-divider of the square degree.

NOTE: Unless explicitly specified (or due to any specific encoding standard such as **GeoTIFF where the location of the pixel is the upper left corner of the origin pixel**), DOP data pixels are surface area primitives whose location coordinates are defined at the center of each pixel. This is consistent with the usual conventions in the OGC and ISO/TC211 standards, as well as in GML encodings.

In both cases for standardized DOP products, the origin of each grid is derived from the origin of the zone (usually south-west corner of the zone), by the affine rectilinear function based on tile size and tile number/offset in both directions, as illustrated by the figure below and corresponding formulae. Ad hoc DOP products may have an origin not aligned as such, depending on the design choice of the producer.

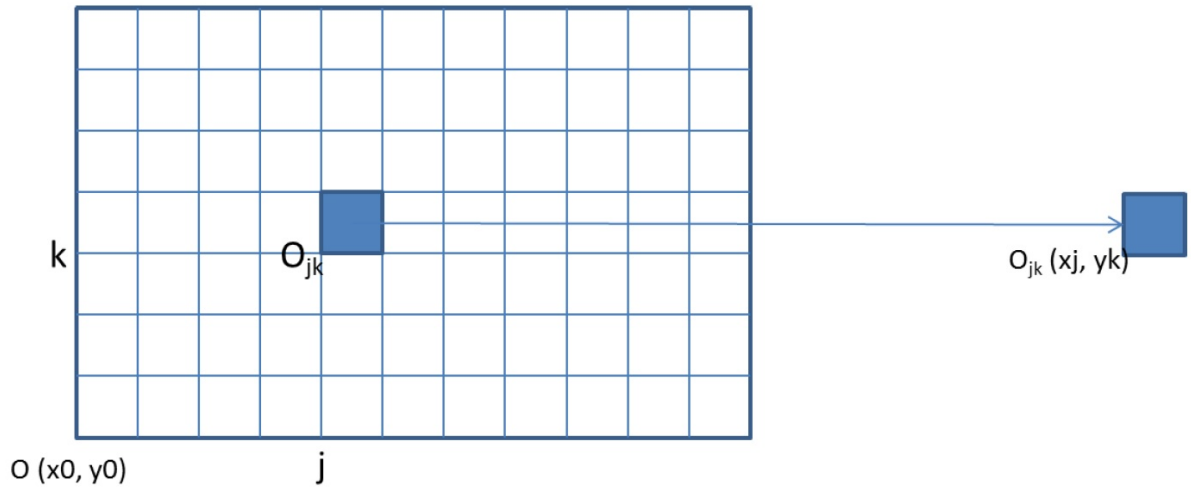


Figure 1: DOP grids and tiling scheme (individual grid raster shown as blue square)

With: $x_j = x_0 + j*T$, $y_k = y_0 + k*T$, where T is tile size (in terrain coordinates unit – meter or decimal degrees)

NOTE: In the case of this figure, the origin of the grid is the lower-left corner of the grid.

DOP grid records are structured in row major order such that the sequential order of the data within each record comprises a row of data for which the horizontal coordinates of each pixel for that row has the same northing coordinate value. The records are sequenced north to south (1 to n) by a distance Δy, such that the first record in the dataset is the northern most row and subsequent records are the rows sequentially ordered to the south. The first pixel value in a record is the western most pixel for that row/record with subsequent pixel values progressing west to east a distance Δx. The last pixel value in the dataset is the pixel in the south-eastern most location.

6.4.1 Multi-resolution Grids for UTM standardized DOP products

The projected grids and their terrain pixel size depend on the resolution / GSD, as specified in Table 2. The GSD is valid in both directions. The following table for UTM standardized products documents the corresponding number of pixels per 100km.

Table 3: Multi-scale grids and resolutions for UTM standardized DOP products

DOP Level	Orthoimagery Resolution / GSD (meters)	Number of pixels / 100 km (pixels/km)
0	25	4.000
1	10	10.000
2	5	20.000
3	2,5	40.000
4	2	50.000
5	1	100.000
6	0,5	200.000
7	0,25	400.000
8	0,125	800.000
9	0,1	1.000.000

For ad hoc products, Level n covers resolution greater or equal to the standardized level resolution (e.g. better than 2.5m for level 3).

6.4.2 Multi-scale Grids for Geographic ARC standardized DOP products

The grids for Geographic ARC DOP products and their terrain pixel size depend on the raster resolution and are precisely related to the definition of the values for A(ZT) and B(Z) for each raster resolution.

This specification is based on recommendations for the consistent definition of the values for A(ZT) and B(Z) for the full range of DOP ARC products for the range of orthoimagery products resolutions.

The definition of these A(ZT) and B(Z) parameters ensures an integer number of pixels per square degree, in both directions (N-S and E-W), in each ARC zone, and also set the total of pixels as multiple of 256.

For each resolution, a constant latitudinal (row) and longitudinal (column) pixel interval shall exist in each ARC zone, depending on the resolution of product, as explained in Annex C.

For the resolutions of the standardized projected DOP ARC products, the following table provides a synthetic view of the DOP specifications for ARC products:

- the latitudinal and longitudinal numbers of pixels and number of pixels in the 1st ARC zone from the equator (Annex C provides the number of pixels for other zones).
- the corresponding angular resolution and corresponding GSD north to south and west to east (approximate due to distortion within each ARC zone), as well as the number of pixels per square degree (in both directions for latitude and longitude) which is the basis of the definition of the tile size (other usual dimensions being 30 minutes or 15 minutes tile sizes for large number of pixels per square degree – and thus, having a few GB file size) for orthoimagery products.

For ad hoc ARC products, Level n covers resolution greater or equal to the standardized level resolution (e.g. better than 2,58m N-S or 2,57m W-E for level 3).

For more details, please refer to Annex C-3.

Table 4: Multi-scale Grids and resolutions for ARC standardized DOP products

	South-North axis				West-East axis (First ARC Zone only, for others zones see annex C)			
DOP Level	**B(Z)**	**Angular resolution (N-S) (degrees)**	**Equivalent GSD (N-S) (m)**	**Number of pixels /°d (lat.)**	**A(ZT) (1st ARC zone)**	**Angular resolution (W-E) (1st ARC zone) (degrees)**	**Equivalent GSD (W-E) (m)[4]**	**Number of pixels /°d (long.) in 1st ARC zone**
0	1548360	0,837014648	25,84	4301	1437840	0,901352028	25,65	3994
1	3870720	0,334821429	10,34	10752	3594240	0,360576923	10,26	9984
2	7741440	0,167410714	5,17	21504	7188480	0,180288462	5,13	19968
3	15482880	0,083705357	2,58	43008	14376960	0,090144231	2,57	39936
4	19353600	0,066964286	2,07	53760	17971200	0,072115385	2,05	49920
5	38707200	0,033482143	1,03	107520	35942400	0,036057692	1,03	99840
6	77414400	0,016741071	0,52	215040	71884800	0,018028846	0,51	199680
7	154828800	0,008370536	0,26	430080	143769600	0,009014423	0,26	399360
8	309657600	0,004185268	0,13	860160	287539200	0,004507212	0,13	798720
9	387072000	0,00334821	0,10	1075200	359424000	0,00360577	0,10	998400

This table shows the number of pixels per degree is different between the two directions, and the pixel size is not exactly the same in the two directions. Subsequently, pixel resolutions **shall be documented** in the metadata element RSRSQR-GSD resolution, as angular resolution.

It should be noted that this specification also allows the US ECIB set of specifications for ARC parameters but presently the only resolution specified are 5m, 1m and 0,5m, please refer to Annex C-4.

NOTE: Producers may adjust these A(ZT) and B(Z) parameters for specific constraints, and corresponding pixels sizes and number of pixels per square degree and shall document the pixel sizes in the metadata.

For a DOP ARC product dataset, the predefined reference origin is the pixel at the southwest corner of the one degree cell in which the southwest corner of the geographic data is located. The origin must be evenly divisible by the point spacing (GSD) to ensure alignment between datasets. If the point spacing is specified as {Δφ, Δλ} and the southwest corner of dataset with which it is associated is {φ, λ} then point location coordinates will be defined at {φ+ j*Δφ, λ+ i*Δλ}.

Where the values i and j are integer values of points in the longitude and latitude direction (respectively), +i*Δλ signifies an easterly direction from the origin and +j*Δφ signifies a northerly direction from the origin (See Figure 2).

When the tiling scheme is different from square degrees, the reference origin pixel is at the southwest corner of its tile, whose location is deduced from the formulae provided in Figure 1.

[4] This is the exact W-E GSD on standard parallel of the given ARC zone. Within one ARC zone, this resolution varies with latitude.

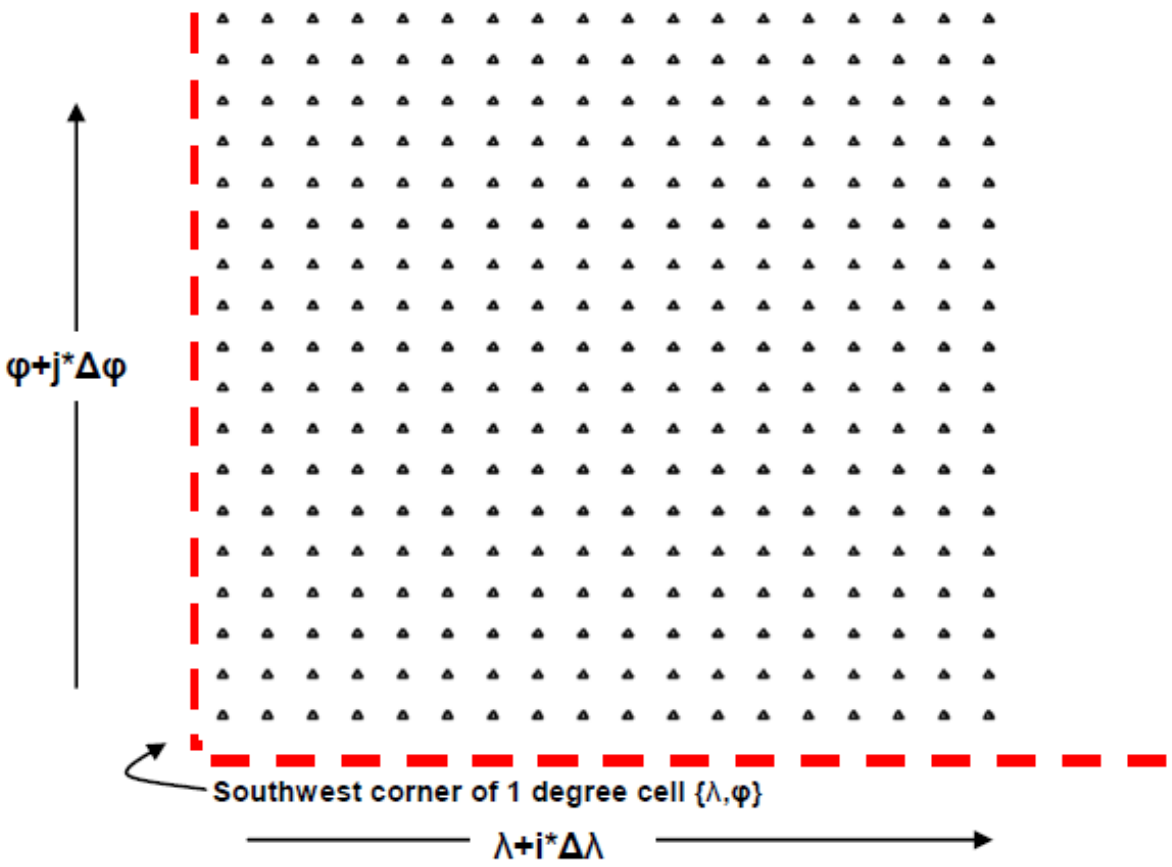


Figure 2: Example of Origin and Point Locations for DOP Data

6.4.3 Grids for ad hoc DOP products

DOP ad hoc products may have diverse characteristics, to cater to all specific orthoimagery productions that may adhere to the Core requirements of this specification:

- specific tiling scheme and grid alignment, not consistent with the 2 previously defined schemes (e.g. in order to center the orthoimagery on an area of interest),
- specific resolution, to align with the resolution of the source imagery, and
- specific reference system/projection.

Depending on the type of projection (if any) or reference system, terrain resolution(s) and relevant parameters (e.g. A(ZT) and B(Z) if ARC projection is used) must be documented, as in the ad hoc DOP specification. The DOP product metadata should also capture this information to have a self-sufficient product documentation within each DOP data.

6.5 Horizontal Spatial extent

The horizontal spatial extent of DOP standardized products varies based on a number of factors. These factors can include but are not limited to spatial resolution, geographic location, customer requirements (e.g. orthoimagery centred on a city area) and file size limitations. Typically, the horizontal spatial extent decreases in size for higher resolution (less than 5 meters).

DOP standardized products are either on the ARC geographic system or on a cartographic projection (i.e. UTM) and primarily cover large geospatial areas (nominally region sized). DOP products are

typically tiled[5] to allow them to be joined seamlessly. DOP Geographic datasets and tiles within a dataset shall be horizontally adjacent.

DOP standardized ARC products base tiling scheme is based on square degrees. However, at higher resolutions, recommended tiling-schemes in this specification are 30'x30', 15'x15' or 6'x6'.

DOP standardized cartographic products base tiling scheme are based on square 100 km x 100 km for resolutions above 1 m or smaller for higher resolutions. Refer to section 11.5 for estimation of DOP standardized products extent and subsequent size of individual files / tiles.

NOTE: The computation of the Bounding Box documenting the spatial extent should take account of the option for location of pixels (PixelCenter or PixelCorner – usually upper-left corner) and the fact that pixels are square or rectangular (in case of ARC) areas.

6.6 Other auxiliary files

Other files may be provided:

- Overview or quick -look file (size below 512x512) in JPEG, in same folder as its product unit; overview file should be documented under DMF metadata, under a Resource Graphics element (GPHICS), with GPHICS description = 'Overview'.
- Extents/footprints of all included product units, in GML or Shapefile.
- Quality information (including lineage) that are addressed by DMF metadata; quality information include quality measures and optional quality masks.
- Users file that may be grouped in the '_USERS' folder. This may include footprints (in GML or Shapefile).
- Other information documenting or facilitating the discovery the product accessible e.g in html may be provided with components contained in the _USERS folder.

7 Reference systems

7.1 Horizontal Reference system

The horizontal reference system for DOP shall be implementations of WGS 84 according to STANAG 2211 and AGeoP-21 Ed. A v1. Allowed horizontal reference systems for standardized products are:

- WGS 84 Geographic 2D (unprojected), as identified by EPSG code 4326, for DOP Arc products,
- WGS 84 and UTM projection, or UPS in Polar areas.

The WGS 84 datum realization (e.g. realization G1762, EPSG code 1156, which is the current WGS84 realization) should be documented in the metadata, associated to the RSRSYS element.

Other reference systems are allowed for DOP ad hoc products.

DOP data shall conform to the unit of measure specified for the Horizontal CRS, that is decimal degrees for geographic and meter for UTM.

The horizontal CRS shall be encoded in the data file (according to the encoding standard used) and in the associated DOP metadata. This information shall be consistent.

[5] Not to be confused with internal encoding format sub-block which is sometimes referred to as internal tiling.

8 Data quality

DOP quality characteristics are defined by the following factors:

- Resolution/GSD: according to table 5 and table 6 for standardized projected and ARC products,
- dataset lineage,
- absolute horizontal accuracy (CMAS/CE90 according to STANAG 2215),
- relative horizontal accuracy (Rel CE90) or point to point accuracy (√2 * RMSE (standard circular deviation)),
- cloud cover/snow cover information,
- completeness of data (percentage of missing pixels),
- conformity of the product,
- actuality of data, with mapping of updated zones (if any), and
- quality reports on source and quality zones (if any).

This information must be provided in the metadata, with a detailed description of quality and source zones.

An annexed Quality folder ('_QUALITY') shall provide for each orthoimagery element (also called product unit):

- cartography of source images zones (in GML or Shapefile),
- cartography of quality zones (in GML or Shapefile),
- cartography of updated zones (in GML or Shapefile), and
- optional quality masks. These masks may be sub-sampled with a lower resolution in order to minimize their volume and avoid unnecessary redundant information.

Horizontal accuracy depends on horizontal accuracy of the original (source) imagery from which it was derived and on the accuracy of the terrain model used for orthorectification.

9 Data lineage

9.1 Source data

The source data for DOP production is one of the following:

- The set of source imagery captured by sensor/instrument used for the orthoimagery product,
- The digital terrain model (DTM) or set of DTMs used for orthorectification, and
- The ground control points (GCPs) used for aero-triangulation.

The sources description used for DOP data shall be provided in the product metadata (in DMF/ Source of the Resource – RSSRC). For images and DTM sources, requires lineage area GML or Shapefile, with attributes documenting the source and its reference.

A reference to the source Metadata identifier of the RSSRC element of the product shall provide the metadata associated to each source images as well as the DTM and GCP base. Annex B Table 7: Orthoimagery DPS metadata requirements for Source images details the requirements for this metadata. If this source of metadata is not available (with the source imagery), the producer shall provide a source Metadata document (XML) and place it under the annexed QUALITY folder.

9.2 Data processing

Contextual note: DOP orthoimagery is designed to be seamless, within one ARC or UTM zone, as a mosaic of individual images.

Tracking of the geometric and radiometric processing steps is documented via the metadata resource process step metadata, from which all information of interest should be made available. The resource process step metadata (RSPRST, see Table 6: DOP Core Metadata) element should trace and document from source imagery the following processing steps for orthoimagery production, with one RSPRST for each process step.

- aero/spatio-triangulation of source images,
- orthorectification on basis of DTM,
- mosaicking: mosaicking seamlines usually pass through areas where radiometric image differences are minimum or alternatively follow natural borders to minimize the observation of borders between images ; mosaicking seamlines should be documented in the corresponding RSPRST element and provided as support files in the _QUALITY folder;
- radiometric correction including a brightness and/or contrast adjustment in order to minimize differences between pixels from adjacent source images.

10 Data maintenance

DOP datasets will be maintained and updated as requirements dictate. Data maintenance criteria will vary by data level. Each product should mention the maintenance date in its metadata (DMF RSMTNC maintenanceDate element, where RSMTNC is the Resource Maintenance element in DMF).

11 Data product delivery

11.1 Introduction

DOP products (individual orthoimage or mosaics of orthoimages) may be delivered according to diverse use cases, such as:

- on file media (CDROM, USB key, etc.). The full structure of the DOP product is duplicated on the media,
- through web services, or
- through file synchronization services.

The production and delivery of orthoimagery data requires tiling (the process of cutting out the orthoimage into tiles / product units that may be disseminated/delivered to the users and handled by their systems or applications).

DOP products may use various encoding formats for orthoimagery, including GeoTIFF, GMLJP2 and NITF/NSIF, which is used by ECIB product specification, GMLJP2 and ECIB both using JPEG 2000 compression.

To facilitate ingestion and processing of DOP products, the file structure and file naming conventions for geospatial datasets, their associated metadata files and annexed resources (such as quality information) must be defined and documented, and file names should be meaningful to humans (see section 11.3).

11.2 DOP Product structure

Specific instructions should be documented in a Product Specific Guidance document for DOP products. The Product Specific Guidance should instantiate the various capabilities provided by this

specification, identify conformance classes that are applicable and provide specific requirements, including the detailed naming rules.

DOP products shall be delivered with a “table of content” mechanism, describing the content and structure of products (addressing files and folders). This table of content could be provided in a XML file, to document the file structure for both human and information system consumption.

Additional detailed information on delivery, quality and description of product is provided within the DOP metadata file (XML) and therefore the file name need not duplicate this content. Information indicated in the file name must align with the information provided by the metadata. In case of any inconsistency, the metadata information prevails. Therefore, applications accessing datasets should utilize the metadata.

A DOP product may contain a single dataset or a collection of datasets corresponding to tiles, according to the tiling scheme (specified in 11.5). A DOP collection of datasets includes:

- The Table of content XML file, providing the product structure and file organisation should have a “table of content” file (e.g. in XML), conformant with the Product Specific Guidance.
- An Orthoimagery Collection metadata set in accordance with DMF for collection resource, with RSTYPE set to ‘series’.
- The set/collection of datasets, usually arranged in a hierarchical directory/subdirectory structure.
- A ‘_QUALITY’ subdirectory (if any at collection level), containing all collection quality information: quality areas, quality layers (if any). These quality elements resources must be addressed by DOP metadata (see section 8).
- A ‘_USERS’ subdirectory, containing all information related to Usage and User, footprints of the product units and auxiliary files for the collection. These Usage/User elements resources should be addressed by the DOP metadata.

Each DOP ortho product unit includes:

- The DOP orthoimage data file, in a standardized encoding format, as specified in 12.2.
- A DOP dataset GML instance (optional), based on the GMLCOV for Rectified Grid Coverage, providing the Coverage description of the orthoimage (rectified grid). In case the DOP GML instance is present, it shall reference the DOP dataset metadata set in its metaDataProperty.
- Its associated Orthoimage dataset metadata set in accordance with DMF for dataset resource, with RSTYPE set to ‘dataset’ (if metadata is in an external file). This metadata may otherwise be embedded / included in an XML section in the DOP orthoimage data file.
- A ‘_QUALITY’ subdirectory, containing all quality information (see section 8): source zones, quality areas, quality layers or masks (if any), mosaicking seamlines. These quality elements resources must be addressed by the DOP metadata.
- A ‘_USERS’ subdirectory, containing all information related to usage and user, including overview and thumbnail for the dataset and footprint of orthoimagery (in vector format such as GML or Shapefile). These Usage/User elements resources must be addressed by the DOP metadata).

NOTE: The metadata document/file and the orthoimage file are both constrained by specific requirements in terms of metadata or information on the data. Consequently, some information items are redundant in these two components of an “orthoimage dataset” and should be populated consistently. To avoid additional redundancy of information, the DOP GML instance information (if present) is specified with the minimum level of information required by the GMLCOV model. However, the constraints of GMLCOV schema require the provision of some information (e.g. CRS, UoM).

Packaging of the various elements of a DOP product is not specified here: producers may choose zip or any other interoperable and open source archiving or packaging tool. This should be indicated in the Product specific guidance.

11.3 File naming convention

The Product Specific Guidance for DOP products must document specific instructions. In addition to this document, products shall be delivered with a “table of content” mechanism, describing the content and structure of products (addressing files and folders). The table of content format should be XML (or JSON or other standardized encoding) in order to enable the file structure to humans and systems.

The DOP metadata file (XML) should also provide additional detailed information on delivery, quality and description of the product and therefore the file name need not duplicate this content. Information indicated in the file name must align with the information provided by metadata. In case of any inconsistency, metadata information prevails. Therefore, applications accessing datasets should use the metadata.

These conventions should follow the following rules:

- Product structure and file organisation should be provided by a “table of content” file (e.g. in XML), conformant with the Product Specific Guidance.
- Filenames should start by product type subfield indicating the Data Product Specification and any sub-type specified by this specification: for DOP products, this means DOPLnT, where n= level (1-9) and P (product type) = G (Geographic) or U (UTM / projected), plus Tile size indicator (Ti) as the prefix (1st subfield for product type) of the filename.

NOTE: For UTM DOP products, another option is the provision the MGRS grid square identification (UTM Zone number + 3 letters, but, as specified in STANAG-2211, this mechanism is valid only for tile sizes of 100 km (Tile Size T1). Therefore, the general purpose Tile Size Letter / Indicator is recommended.

File names should be unique considering these two identifier definitions:

- a producing agency or nation identifier as part of the name (that may be added as the second subfield of the filename),
- a producer allocated unique identifier (this may be an agency naming construct as indicated below).

Producer naming construct may contain the following information (brackets “[..]” indicate optional piece of information):

- Coordinates of SW corner of Orthoimage (geographic – including hemisphere) *DD[MM] hDDD[MM] e,* where h = hemisphere (N for north, S for south), e = longitudinal hemisphere (E for east, W for west). Minutes (MM) are required for 1 m or higher resolutions (tile size indicator equal to T2, T3, T4, T5 or T6 – see 11.5).

  This convention applies to geographic products and may also apply to UTM products. For UTM products, the coordinates may be prefixed by the UTM zone number, such as zz[h], zz being the zone number and h = hemisphere (N for north, S for south).

  For geographic grid products, minutes digits apply only for levels 5 and higher, as deemed appropriate. Products at levels 0-4 are delivered by square degree, therefore minutes are useless.
- Content data type[6] coded by 5 alphanumeric characters
  - GREYS = greyscale / Panchromatic / single band / channel

[6] This code provides the content data information in a simple way; the metadata must provide the detailed information on content.

- COLOR = Color RGB
- COLAL = Color RGB with Alpha channel
- MBAND = Multispectral band orthoimagery
- HSIOR = Hyperspectral (HSI) orthoimagery

- Filenames should also indicate the security classification: c = security classification (T, S, C, R, U), as required by national or NATO rules.
- Version of product, under 3 digits 001 to 999.

The file name construct should use ASCII characters between 0-9 (Hex 30-39), A-Z (Hex 41-5A) or a-z (Hex 61-7A) and should not have blank spaces; instead it should use a separator between each information field. The underscore character ('_', Hex 5F) is the recommended separator.
According to the instructions provided above, the following is a recommended file name rule.

DOPL*nP_CC*[T*S*]_[*ORG*]_[*DD*[*MM*]*hDD*D[*MM*]_*CCCCC_c_vvv, where:*

- Information in brackets '[ ]' is optionalIdentification of DOP product type, prefixed by DOP, incorporating:
  - *n*: product level (1-9). If level is not standardized (ad hoc orthoimagery, n = x)
  - *P*: product type = G or U
  - *CC*: product class = orthoimagery unit (OU) or orthoimagery mosaic base (OM)
  - TS: tile size indicator / (T1-T6), requested if tile size is not square degree
- *ORG*: Producer Organisation (or Nation), identified by 3-letter code (STANAG 1059)
- *DD[MM]hDDD[MM] e:* coordinates of South-West corner, as described above
- *CCCCC: Content data type*, as described above
- *c*: Security Classification code (T, S, C, R, U)
- *vvv*: product version number (3 digits).

Another file name rule (valid only for UTM products) is provided below.

DOPL*nP_CC*_[T*S*]_[*ORG*]_*ZZhnnnn*[*mmm*]_*eee*[*mmm*]_*CCCCC_c_vv, where:*

- *ZZ*: Zone number
- *h*: hemisphere (N or S)
- *nnnn*: northing (in km) + mmm (if relevant – at levels 7-9, when tile size letter is F or G) for south-west corner
- *eee*: easting (in km) + mmm (if relevant – at levels 7-9, when tile size letter is F or G) for south-west corner

NOTE: Any other information in this file naming rule shall follows the same indications as in the previous rule.

Examples of names

- DOPL5G_OMT2_27N056E_COLOR_U_001: DOP L5, COLOR (RGB), Unclassified, version 001
- DOPL4U_OM_33N5563_358_ COLOR_U_001: DOP L4 (UTM Zone 33N), COLOR (RGB), Unclassified, version 001. Here Tile size is not provided, therefore tile size is 100 km x 100 km

Filename extension shall follow the file extension rules specified by the encoding standard for the DOP product. The file extension for associated metadata file, shall be ".xml".

11.4 Encoding options and compression

Encoding standards options for DOP raster products are as follows:

- **GMLJP2** with JPEG 2000 compression (**according to DGIWG GMLJP2 profile**): GMLJP2 v2.1.1 profile is recommended (the older version GMLJP2 v1 is allowed). Visually lossless compression with a compression ratio between 1:10 and 1:15 is recommended. Lossless compression is also allowed, but compression ratio is limited (between 1:2 and 1:3).

  JPEG 2000 handles internal tiling (in image and transform spaces – the latter being called precinct) and scalable capabilities, as well as streaming (with JPIP protocol, as specified in ISO 15444-9). As a result, it has superior access/display performance and limited bandwidth environments. For additional recommendations for adjusting JPEG 2000 compression and codestream for such orthoimagery products, see Annex D.

- **NSIF** (STANAG 4545), visually lossless JPEG 2000 compression with a compression ratio between 1:12 and 1:15 is recommended. A ratio of 1:15 is specified by the ECIB specification (MIL-PRF-32466), based on the frame (tile) size of 2304 x 2304 pixels. Refer to Appendix D of BPJ2K01.10 for a description of NSIF preferred JPEG2000 Encoding. This encoding option has the same scalable and streaming capabilities as the previous GMLJP2/JPEG 2000.

- **GeoTIFF** (**according to DGIWG GeoTIFF profile**), either uncompressed or using lossless compression (LZW or LZ77 (DEFLATE) or Packbits). GeoTIFF has limited tiling and no streaming capability thus the transfer of the full file is required for exploitation which takes considerable display time because of its size.

NOTE 1: WCS 2.0 handles GeoTIFF and GMLJP2 but not NITF/NSIF format (at this date).

NOTE 2: Producers and users should be aware that the georeference of pixels (centroïd or corner of pixel – usually upper-left corner) depends on capabilities of encoding standard (e.g. GeoTIFF with use of GTRasterTypeGeoKey, or GMLJP2, this latter using the centroid convention for the pixels).

11.5 Tiling

Tiling is the organisation of DOP products according to a regular tessellation of space into individual frames or tiles (and resulting orthoimagery tiles files). The tiling scheme and the resulting tiles are a different mechanism than the “internal tiling” capability provided by encoding standards such as JPEG 2000 or TIFF/GeoTIFF. It is sometimes called “external tiling” which is the object of this section.

The aim of tiling is to partition the raster space into frames/files which fit technological constraints on file size and memory used when handling each individual frame/file. This constraint depends on compression and encoding standard, as well as end-user system(s) constraints. In this specification, three file size constraints are recommended (including compression if used): 0,5 Gb, 1 Gb or up to 4 Gb.

DOP tiling scheme shall be with no overlap: in other words, neighbour tiles are joint with no overlap pixels (remember that DOP raster pixels are surfaces (squares or rectangles)). DOP tiles are squared, i.e. tile size (in km or minutes) applies to both directions; however, the number of pixels per tile is different for ARC products.

For medium resolutions (i.e. 10 m or 5 m), the tiling scheme is on a square degree basis (for ARC products), or 100 km x 100 km (for projected products).

For higher resolutions (1 m and above), several tiling schemes are recommended to match the file size constraint (0,5 Gb, 1 Gb or up to 4 Gb).

DOP Tiling scheme specifications are provided in the following table, also indicating the recommended resolutions at which tile sizes are recommended to be used. The resolutions

addressed are the standardized DOP resolutions: 25m, 10 m, 5 m, 2,5 m, 2 m, 1 m, 0,5 m, 0,25 m, 0,125 m and 0,1 m. The tile size indicator (t) is an integer number between 1 and 6, as follows:

Table 5: DOP products tiling and recommended use by standardized products

Standardized DOP recommended resolutions	Tile Size		Tile Size Indicator
	Geo ARC (minutes)	Projected UTM (km)	
25 m	60 = 1°d	100	T1
10 m	60 = 1°d	100	T1
5 m	60 = 1°d	100	T1
2,5 and 2 m	60 = 1°d	100	T1
1 m	30	50	T2
0,5 m	15	25	T3
0,25 m	10	20	T4
0,125 m	5	10	T5
0,1 m	4	5	T6

Annex E provides estimates of the file sizes, depending on the tile sizes.

11.6 Security

Security metadata capture is required to comply with the DGIWG or NATO profile rules depending on the metadata's intended audience. Security metadata will use national or NATO security markings.

Individual DOP data and supporting files may have different security classifications and markings but when provided as one dataset or combined, the results shall be marked with the highest security level of the individual datasets.

12 Product metadata

The DOP product metadata specification is based on DMF metadata for Orthoimagery as specified in Annex B, for discovery, catalogues and orthoimagery delivery purposes.

DOP product metadata are associated to the DOP data (at collection level or at the level of individual orthoimage element – i.e. product unit) and may be encoded:

- either in an external XML metadata file,
- or in XML metadata document embedded in DOP raster data file.

NOTE 1: The GMLCOV Rectified Grid coverage that may be associated with the DOP orthoimage is encoded in a GML document, the metaDataProperty of this feature will reference the metadata file or resource.

NOTE 2: For external metadata (as well as GMLCOV description of the DOP Rectified Grid Coverage, in any), association between data and metadata shall be done either by sharing the same file basename or uuid. Grouping mechanisms such as zip may prevent the data from becoming separated from the metadata (see section 11.2).

The embedding mechanisms are depending on the encoding format:

- For GMLJP2, the use of an XML box embedded with an asoc JPEG 2000 box, as follows.

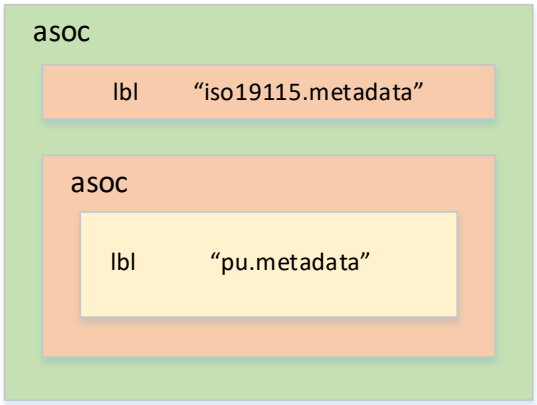


Figure 3: Packaging of GMLJP2 Boxes for XML metadata file

The second level of asoc box (labelled pu.metadata) is designed for flexibility and future potential extensions.

There is only one dataset /orthoimage per product unit (as stated in 11.2)

- For GeoTIFF, use of GEO_METADATA TIFF tag.
- For NSIF/NITF, use of metadata text segment.

DOP metadata elements (mandatory and recommended optional) for describing any orthoimagery dataset provide the basis for the elements specified in Annex B.

DOP product quality should be reported for a pre-defined registered data quality measure (Regulated Quality Element) for commonly used data quality measures or for an unregistered quality measure (Unregulated Quality Element) when the measure is too specific to proceed to its registration. For both the 'regulated' and 'unregulated' measures, either the result of the evaluation is a conformance, quantitative, descriptive, or coverage result (see DMF). If two results are reported, one of them must be a conformance result.

The coverage result is an instance of CoverageResult of a Regulated Quality Report (DMF) and used to report quality evaluation results on quality zones.

Quality reporting metadata for any DOP dataset should include, at a minimum, a completeness percentage and absolute horizontal accuracy of the dataset. Both require quantitative results. The completeness percentage shall be reported via the CompletenessCommission quality measure and the absolute horizontal accuracy of the dataset shall be reported via the AbsoluteExternalPositionalAccuracy of the Regulated Quality Report quality measure (DMF), based on the corresponding ISO DQ_CompletenessCommission and DQ_AbsoluteExternalPositionalAccuracy.

The conformance quality reporting metadata is required in all cases and it is recommended to provide the result of the quality control test regarding conformance to this specification, as indicated in Annex A). When quality control is not available, the result will be False, with explanation ='Conformity to Product Specification: Not tested'.

Additional metadata elements not described in the DMF can be included in the orthoimagery dataset's metadata in accordance with extension rules specified in DMF section B.3. Such extensions should be applied to a dedicated DMF requirement class. The additional elements may represent a profile of the DMF, and described either within each metadata instance document, or within an online resource (i.e. a registered profile).

Reference to an online registry of metadata elements is a more efficient method, particularly when an entire class of extended elements are required (e.g. a country or organization-specific extension to the ISO MD_SecurityConstraints class) to accommodate additional security requirements within a classification system.

Annex A
Abstract Test Suites
(normative)

Any application or system or raster map product specification or raster dataset claiming conformance to this implementation profile shall meet the following criteria for data conformance. For application or system, this applies to the data that is produced. For a product specification, this applies to the requirements and conformance tests.

A.1 DOP Core

A.1.1 Use of the DOP grid structure, either for geographic or projected orthoimagery products

As specified in Sections 6.1 and 6.4.

A.1.2 Definition of spatial resolution / GSD

As specified in Section 6.2.

A.1.3 Definition of spectral band and radiometry for EO and SAR orthoimagery

As specified in Section 6.3.

A.1.4 Definition of CRS for DOP geographic products or DOP projected products

As specified in Section 7.1. Ad hoc products may use other Horizontal systems.

A.1.5 Data quality and horizontal spatial resolution

Datasets shall conform to the requirements specified in section 8. An absolute horizontal accuracy estimate shall be reported for each dataset, as well as actuality of data by use of DOP metadata (see Section 12 and Annex B).

Horizontal resolution shall conform to Table 3 – Multi-scale grids and resolutions for UTM standardized DOP products or Table 4 – Multi-scale Grids and resolutions for ARC standardized DOP products, pending the case (geographic ARC or projected).

A.1.6 Source data and data processing

Datasets shall conform to the requirements specified in Section 9. Lineage and data processing shall be reported for each dataset by use of DOP metadata (see Section 12 and Annex B).

A.1.7 DOP product structure

As specified in Sections 11.1 and 11.2.

This includes Quality and Users subdirectory information / auxiliary files, as described in sections 6.6 and 11.2.

A.1.8 DOP file naming conventions

As specified in Section 11.3. The files naming conventions are recommendations and file naming may differ.

A.1.9 DOP encoding

Implementation shall follow the rules provided for DOP encoding in section 11.4 and on the basis of one of the specified encoding standards: GeoTIFF, GMLJP2 or NSIF. This includes the encoding of null values.

Requirements in Section 6.3 Spectral bands and radiometry also apply.

A.1.10 DOP Security

Implementation shall follow the rules provided for security marking and security metadata in Section 11.6.

A.1.11 DOP metadata

Implementation shall follow the principles provided for DOP metadata in Section 12 and the rules specified in Annex B.

A.2 Alignment with DOP tiling scheme

As specified in Section 11.5 and Table 5 – DOP products tiling and recommended use by standardized products.

A.3 DOP Standardized ARC products

A.3.1 Alignment with DOP ARC grids

As specified in Section 6.4.2 and Table 4 – Multi-scale Grids and resolutions for ARC standardized DOP products

A.3.2 Alignment of CRS with WGS84 Geographic 2D and ARC system

WGS84 Geographic 2D is to be used as the horizontal reference system (EPSG code 4326) and ARC system zones as specified in Annex C.

A.4 DOP Standardized UTM products

A.4.1 Alignment with DOP UTM grids

DOP UTM grids shall follow the principles specified in Section 6.4.1 and Table 3 – Multi-scale grids and resolutions for UTM standardized DOP products.

A.4.2 Alignment of CRS with DOP UTM reference system

WGS84 UTM is to be used as the horizontal reference system (see EPSG registry for applicable codes), see Section 7.1.

Annex B
DOP Metadata Specification
(normative)

This DOP metadata specification is specified by the following table based on DMF (on the basis of ISO TC211 metadata standards) and serves to define the model for DOP minimum required metadata.

The last two elements in the table provide the DOP maximum occurrence and Value Domain values as specified for Orthoimagery on basis of DMF. The Obligation, Maximum Occurrence, and Value Domain requirement for each element is derived from DMF (and based on ISO), with any additional constraints on the corresponding DMF element indicated in the table.

In the Obligation column, the following letters are used:

- 'M' indicates that the metadata element is mandatory,
- 'O' indicates that the element is optional,
- 'C' indicates that the element is mandatory under the condition provided.

The obligation letter code is in bold text when the obligation exceeds the DMF obligation (i.e. when the DMF obligation has been changed from optional to conditional or mandatory for Orthoimagery DPS).

The Max Occur (Maximum Occurrence) column is simply an indication of whether the DMF allows one or multiple instances (N) of the element to be included in the metadata file. The contents of the Value Domain column indicate the allowed values for the element. For most elements, these are presented as DMF-defined basic types, complex types and codelists, but Ortho-DPS-specific constraints on the domain may be specified.

Table 6: DOP Core Metadata

ID	**Name** DMF ID (Requirement Class)	**Definition**	**Obligation**	**Max Occur**	**Value Domain**
1	**Metadata Set identifier** MDSID (Core)	unique identifier for this metadata file	**M**	1	String NOTE: DMF recommends a unique identifier (e.g. UUID or URI or URL).
2	**Parent metadata file identifier** MDPTMD (Common)	file identifier of the metadata to which this metadata is a subset (child)	**C / if parent metadata file exists**	1	Parent Metadata Reference
3	**Metadata language** MDDLOC (Core) + language	language used for documenting metadata	**M**	1	Locale Language Codelist Default value: 'eng' NOTE: If additional languages are used MDTLOC should be used to capture these.
4	**Metadata character set** MDDLOC (Core) + encoding	character coding standard used for the metadata	**M**	1	Locale Character Set Codelist fixed to 'utf8'

Table 6: DOP Core Metadata (continued)

ID	Name DMF ID (Requirement Class)	Definition	Obligation	Max Occur	Value Domain
5	**Metadata Translation** MDTLOC (Common)	locale in which some metadata elements may be translated	**O**	N	Locale
6	**Metadata date stamp** MDDATE (Core)	date that the metadata was created	**M**	1	Date
7	**Metadata point of contact** MDRPTY (Core)	identification of, and means of communication with, person(s) and organizations associated with the metadata	**M**	N	Responsible Party (minimum is) party.organisation party.role Otherwise capture all party elements. NOTE: The party.role is usually defaulted to pointOfContact.
8	**Metadata standard name** MDSTD (Core) + title	name of the metadata standard (including profile name) used	**M**	1	'urn:dgiwg:metadata:dmf'
9	**Metadata standard version** MDSTD (Core) + version	version (profile) of the metadata standard used	**M**	1	'2.0'
10	**Metadata security constraint level** MDSCST (Common) + level	security classification level of the metadata	**C / required if presence of metadata security constraint**	1	Security Constraint Level Classification Level Codelist
11	**Metadata security constraint system** MDSCST (Common) + system	national or international system used to classify the metadata	**C / required if presence of metadata security constraint level** (MDSCST level)	1	Security Constraint System String String value is expected to be a 3-character country code from STANAG 1059, unless not available.
12	**Metadata releasability Addressee** MDREL (Defence)	establishes a body to which the metadata can be released	O	N	String (a 3-character country code from STANAG 1059 when available).
13	**Metadata legal constraint** MDLCST (Common)	provides a means to express a set of legal constraints applicable to the metadata	**C / legal constraints exist**	N	Legal Constraint

Table 6: DOP Core Metadata (continued)

ID	Name DMF ID (Requirement Class)	Definition	Obligation	Max Occur	Value Domain
14	**Metadata maintenance frequency** MDMFRQ (Common)	information on the frequency with which changes and additions are made to the metadata after the initial metadata is completed	O	1	Frequency Codelist
15	**Dataset title** RSTITLE (Core)	name by which the cited resource is known	**M**	1	Free Text (see DMF recommendation for RSTITLE)
16	**Dataset alternate title** RSALT (Common)	short name, informal name, or name in another language by which the dataset is known	O	1	Free Text
17	**Abstract describing the dataset** RSABSTR (Core)	brief narrative summary of the content of the dataset NOTE: The abstract should include human-readable information to explain the product specificity.	**M**	1	Free Text **Recommendation**: DOP (Defence Orthoimagery Product) Version 1.0 + additional information as necessary describing the dataset
18	**Collection Tiling Scheme** GPHICS (Common) +name +description	reference to a graphic that provides a description of the collection's tiling scheme	**C / if RSTYPE= series and tiling scheme is defined**	1	Browse Graphic name (file name) String or URI and description = 'TilingScheme'
19	**Dataset purpose** RSPURP (Core)	A summary of the intentions with which the dataset was developed	O	1	Free Text
20	**Metadata type code** RSTYPE (Core)	This is the type code of the resource described by the metadata (here dataset or series/collection)	**M**	1	Resource Type Codelist Value = 'dataset', or 'series' for a collection
21	**Metadata type name** RSTYPN (Core)	This is the type name of the resource described by the metadata (here dataset or series/collection)	**C / RSTYPE = series**	1	Free Text 'Collection' (e.g. when Eng. Is used)
22	**Dataset edition** RSED (Core)	version identifier of the resource	O	1	String
23	**Dataset edition date** RSEDDAT (Core)	reference date of this edition of the resource	O	1	Date
24	**Dataset identifier** RSID (Core)	value uniquely identifying an object within a namespace	**M**	N	Identifier: UUID
25	**Name of Resource Series** RSSERI (Core)	When the resource pertains to a series, this is the name of the series.	**C / when dataset is a member of a series**	1	String

Table 6: DOP Core Metadata (continued)

ID	Name DMF ID (Requirement Class)	Definition	Obligation	Max Occur	Value Domain
26	**Resource Sheet Name** RSSHNA (Core)	When the resource pertains to a series, this is the name or identifier of the resource as part of the series.	**C / when dataset is a member of a series**	1	String
27	**Keywords** RSKWDS (Core)	commonly used word(s) or formalized word(s) or phrase(s) used to describe the subject. NOTE: It is strongly recommended to use keywords from an identified thesaurus.	**M**	N	Controlled Vocabulary orthoimageType of instrument (optical, SAR, …) should be identified + type of RSKWDS shall be RSKWDS.type='instrument' for such keywords NOTE: Instrument type should be equal to the instrument type of ACINS.
28	**Resource Spatial Resolution** RSSRES (Core) + distance	Factor which provides a general understanding of the density of spatial data in the resource or describes the range of resolution in which a digital resource may be used. NOTE: this element should be repeated when describing the lower and upper range. Ground Sample Distance Horizontal ground sample distance of the resource (typically for gridded data and imagery-derived products).	**M**	N	Resolution / GSD Distance (value + unit) NOTE: general/approximate resolution. If GSD is different in both directions, use RSRQR for more accurate resolution information.
29	**Dataset language** RSDLOC (Core) + language	language used within the dataset	**M**	1	Locale Language Language Codelist
30	**Dataset character set** RSDLOC (Core) + encoding	character coding standard used for the dataset	**M**	1	Locale Encoding Character Set Codelist
31	**Spatial representation type** RSRPTP (Core)	method used to spatially represent geographic information	**M**	1	Spatial Representation type Codelist Fixed to “grid”
32	**Dataset type** DGITYP (Core)	information about the type of geospatial information provided by the dataset	**M**	1	Geospatial Information Type Codelist Fixed to “imageCoverage”
33	**Dataset georeferencing level** RSGFLV (Core)	level of georeferencing of the dataset	O	1	Georeferencing Level Codelist georectified

Table 6: DOP Core Metadata (continued)

ID	Name DMF ID (Requirement Class)	Definition	Obligation	Max Occur	Value Domain
34	**Dataset level / Resource Data Level** RSDTLVL (Core)	Method of categorizing resolution bands of digital geospatial information (including imagery) by equivalence to paper map scales.	O	1	String Orthoimagery DPS Resolution level
35	**Dataset topic category** RSTOPIC (Core)	main theme(s) of the dataset	**M**	**1**	Topic Category Enumeration 'imageryBaseMapsEarthCover'
36	**Dataset theme** RSTHEME (Core)	provides more precise thematic information enabling discovery of the dataset	O	N	Thematic Codelist GlobalEarthCover
37	**Dataset environment description** RSENVD (Data)	Information on producer's processing environment, including items such as the software, the computer operating system, file name, and the dataset size.	O	1	Free text
38	**Value type** GRCINF (Data) + contentType	type of information represented by the cell value	**M**	1	Coverage Content Type CodeList Fixed to "image"
39	**Content Information of the Coverage** GRCINF (Data) + range - identifier - type - descriptor - maxValue - minValue - units - bitsPerValue - transPolarisation - detPolarisation	description of the attribute described by the measurement value	M	N	Range (one range per band or polarimetric channel – for SAR -, including alpha channel – if any) Provision of identifier, type (integer), description of band (e.g. NIR), Longest + shortest wavelengths for the band + unit for wavelengths, **bitsPerValue** (**mandatory**) (e.g. 8) and transmitted + detected polarisations (for SAR imagery) NOTE: e.g. for HH polarization, select horizontal both for transPolarisation and detPolarisation.
40	**Special Cell** GRCINF (Data) +specialCell	cell playing a specific role (e.g. no data or cloud) in the coverage.	O	N	Special Cell Values e.g. White (255, 255, 255) (no data or Black (0, 0, 0)) Recommendation: use and document this element when dataset contains Null values.
41	**Imaging Condition** GRCINF (Data) + imagingCondition	Conditions affecting the dataset. NOTE: if multiple reasons for bad condition exist, use the worst case.	O	1	Imaging Condition Codelist (e.g. cloud, snow, …)

Table 6: DOP Core Metadata (continued)

ID	Name DMF ID (Requirement Class)	Definition	Obligation	Max Occur	Value Domain
42	**Geographic location of the dataset (by coordinates)** RSEXT/boundingBox (Core)	geographic position (spatial extent) of the dataset as a bounding box	**O** **Constraint**: at least one of RSEXT/boundingBox and RSEXT/boundingPolygon elements shall be used.	N	Geographic Box (Extent) NOTE: RSEXT/boundingBox may be repeated if the area covered is discontinuous
43	**Dataset positional extent** RSEXT/boundingPolygon (Core)	the boundary enclosing the dataset, given as a set of (x,y) WGS84 coordinates of a polygon, with the last point replicating the first	**O** **Constraint**: at least one of RSEXT/boundingBox and RSEXT/boundingPolygon elements shall be used.	1	Polygon (Extent)
44	**Dataset extent description** RSEXT/description	Description of the extent NOTE: may be used for additional extent description (such as extent size in km)	**O**	1	String
45	**Coordinate reference system – horizontal** RSRSYS (Core) +description	Horizontal reference system used in the dataset	**M**	1	Identifier code URI Description property (optional): name of CRS + Realization
46	**Dataset status** RSSTAT (Common)	Information about the status of the dataset	O	1	Status Codelist
47	**Dataset reference date** RSDATE (Core) +date +type	reference date for the cited dataset	**M**	N	Reference Date
48	**Dataset originator** RSRPTY (Core)	party that created the dataset	**M**	1	ResponsibleParty (role = originator)
49	**Dataset point of contact** RSRPTY (Core)	party that can be contacted for inquiries regarding or acquisition of the dataset	O	N	ResponsibleParty (role = pointOfContact) NOTE: Should be present if different from Originator

Table 6: DOP Core Metadata (continued)

ID	Name DMF ID (Requirement Class)	Definition	Obligation	Max Occur	Value Domain
50	**Maintenance frequency** RSMTNC (Common) + maintenanceFrequency	frequency with which changes and additions are made to the resource after the initial resource is completed	O	1	Maintenance Information maintenanceFrequency Frequency Codelist
51	**Dataset classification** RSSCST (Core) + level	name of the handling restrictions on the resource	**C / required if presence of dataset security constraint**	1	Security Constraint Level Classification Level Codelist
52	**Dataset classification system** RSSCST (Core) + system	national or international system used to classify the dataset	**C / required if presence of dataset classification** (RSSCST level)	1	Security Constraint system String String value is expected to be a 3-character country code from STANAG 1059, unless not available.
53	**Dataset releasability** RSREL (Defence)	provides a means to express a set of releasability information applicable to the dataset	O	N	Releasability
54	**Dataset use limitations** RSUSE (Core)	provides a means to express general use limitations (limitations not implied by security or legal constraints) of the dataset	O	N	Free Text
55	**Dataset legal constraints** RSLCST (Core)	restrictions and legal prerequisites for accessing and using the resource	**C / legal access/ use constraint exist?**	N	Legal Constraint

Table 6: DOP Core Metadata (continued)

ID	Name DMF ID (Requirement Class)	Definition	Obligation	Max Occur	Value Domain
56	**Dataset lineage** RSLING (Core)	Information about the sources, the method of data capture, and any information on the transformation, conversion, or resampling that has been applied to the data, if available.	**M**	1	Free Text **Recommendation**: should be documented: - Sources: image sources, control data (e.g. control points), elevation data (DTM), calibration data. Metadata for the sources (or data as support information) should be provided (e.g. as sourceMetadata with RSSRC, see Table 7 – Orthoimagery DPS metadata requirements for Source images). - Process step: General processing and Reference to documentation - Data quality: General statement on quality / Warning if unofficial data
57	**Source of the Resource** RSSRC (Common)	This element provides information about the source data used in creating the resource.	M	0..N	Source For each source, documentation of its key metadata (description, extent, distance/GSD, citation of the source and source metadata as the identifier of the metadata of the source) NOTE: detailed information on source image should be provided by the **sourceMetadata** identifier. This includes Incidence angle masks for SAR imagery, see Table 7 – Orthoimagery DPS metadata requirements for Source images).
58	Acquisition Instrument ACINS(Sensor)	Information about the instrument (sensor) used in data acquisition of source images.	**M**	N	Instrument Documentation of each Sensor/Instrument for acquisition of source images: identifier, type of Sensor, Description + collection mode for SAR imagery NOTE: if source images are collected by different sensors, the instrument metadata is repeated.
59	Spectral Mode SPECTMOD(Sensor)	Mentions the spectral mode used (panchromatic, multi or hyper spectral)	**M**	1	Spectral Mode Information Codelist (panchromatic, multi-spectral, hyper-spectral)

Table 6: DOP Core Metadata (continued)

ID	Name DMF ID (Requirement Class)	Definition	Obligation	Max Occur	Value Domain
60	Acquisition Platform Information ACPLAT(Sensor)	Designation of the platform used to acquire the source images	O	1	Platform Identifier and description of the platform
61	**Resource Process Step** RSPRST (Common)	This element provides information about an event or transformation in the life of a resource including the process used to maintain the resource	O	0..N	Process Step For each processing (radiometric or geometric or mosaicing), description, rationale, date and time of the process step and responsible party. NOTE: for mosaicking, seamlines as support file identified in Description.
62	**Dataset Regulated quality report** RSRQR (Common)	Information related to the result of regulated quality evaluation of the dataset, as follows (58-1 to 58-3), following pre-defined registered data quality measures.	**M**	1..N	Regulated Quality Report
62-1	**Dataset quality report** RSRQR (Common) – Absolute Horizontal Accuracy	Information related to the result of a quality evaluation of the dataset on absolute horizontal accuracy (CE90)	**M**	1	Regulated Quality Report identifier.code = "http://dgiwg.org/metadata/qualityMeasure/ACE" qtyResult.unit = 'metre' qtyResult.result (Float) = Result of the quality measure
62-2	**Dataset quality report** RSRQR (Common) – Relative Horizontal Accuracy	Information related to the result of a quality evaluation of the dataset on relative horizontal accuracy (RelCE90)	O	1	Regulated Quality Report identifier.code = "http://dgiwg.org/metadata/qualityMeasure/RelCE90" qtyResult.unit = 'metre' qtyResult.result (Float) = Result of the quality measure
62-3	**Dataset quality report** RSRQR (Common) - Completeness Percentage of missing items	Information related to the result of a quality evaluation of the dataset on completeness: ratio of missing pixels (on uncovered zones)	O	1	Regulated Quality Report identifier.code = " http://dgiwg.org/metadata/qualityMeasure/missRate" qtyResult.unit = 'percent' qtyResult.result (Float) = Result of the quality measure Example: 0 (if dataset is complete)

Table 6: DOP Core Metadata (continued)

ID	Name DMF ID (Requirement Class)	Definition	Obligation	Max Occur	Value Domain
62-4	**Dataset quality report** RSRQR (Common) - Conformity	Information related to compliance with Orthoimagery DPS specification	**M**	1	Regulated Quality Report identifier.code = 'http://dgiwg.org/metadata/qualityMeasure/ProdSpecComp ' cnfResult.conformance = *TRUE or FALSE* cnfResult.explanation = 'Conformity to Product Specification' or 'Conformity to Product Specification: Not tested' (if not tested) cnfResult.specification.title = 'Defence Orthoimagery Product Product Implementation Profile' cnfResult.specification.referenceDate.date = '2020-xx-xx' cnfResult.specification.referenceDate.type = publication cnfResult.specification.version = '1.0'
62-5	**Dataset quality report** RSRQR (Common) - Cartography of source zones	Cartography of source images zones (defined by their boundaries in GML or Shapefile)	O	1	Regulated Quality Report identifier.code = "http://www.dgiwg.org/metadata/qualityMeasure/CSZ" covResult should contain the geometry of the source zones (vector geometry codelist code = surface)
62-6	**Dataset quality report** RSRQR (Common) - Cartography of quality zones	Cartography of horizontal quality zones (defined by their boundaries in GML or Shapefile)	O	1	Regulated Quality Report identifier.code = "http://www.dgiwg.org/metadata/qualityMeasure/CQZ" covResult should contain the geometry of the horizontal quality zones (vector geometry codelist code = surface)
62-7	**Dataset quality report** RSRQR (Common) - Cartography of updated zones	Cartography of updated zones of the orthoimagery (defined by their boundaries in GML or Shapefile)	O	1	Regulated Quality Report identifier.code = "http://www.dgiwg.org/metadata/qualityMeasure/CUZ" covResult should contain the geometry of the updated zones (vector geometry codelist code = surface)
62-8	**Dataset quality report** RSRQR (Common) - Image Quality level (NIIRS)	NIIRS mapping product level value	O	1	Regulated Quality Report identifier.code = http://www.dgiwg.org/metadata/qualityMeasure/NIIRS qtyResult.result (Int) = NIIRS rating

Table 6: DOP Core Metadata (continued)

ID	Name DMF ID (Requirement Class)	Definition	Obligation	Max Occur	Value Domain
62-9	**Dataset quality report** RSRQR (Common) - GSD resolution	Ground Sampling Distance (GSD): distance between two consecutive pixel centers measured on the ground, along the 2 image directions (along line, along columns)	O	1	Regulated Quality Report identifier.code = http://dgiwg.org/metadata/qualityMeasure/GSD GSD-X (resolution along line): Measure GSD-Y (resolution along column): Measure
63	**Dataset Unspecified quality report** RSUQR (Common)	Information related to the result of a quality evaluation of the dataset, result of an unspecified quality evaluation. **NOTE**: any other DOP detailed quality information on specific quality areas, or per pixel, such as quality areas.	O	N	Unregulated Quality Report
64	Dataset intended usage RSSPUS (Common)	Brief description of ways in which the resource(s) is/are currently or has been used	O	N	Usage
65	**Dataset distribution format** RSDFMT (Core)	Name of the data distribution format(s) and version of the format (date, number, etc.) and also file decompression technique if any.	**M**	**N**	Format
66	**Online resource** RSONLLC (Core)	Information about on-line sources from which the dataset, specification or community profile name and extended metadata elements can be obtained.	**M**	N	Online Location
67	**Dataset distribution unit** RSUD (Data)	a description of the unit (tiles, layers, geographic areas, etc.) in which the data is available	O	1	Free Text
68	**Dataset transfer size** RSTS (Data)	Estimated size of a unit in the specified transfer format, expressed in megabytes. The transfer size is > 0.0	O	1	Float
69	**Dataset offline distribution** RSOFDM (Data)	Information about offline media through which the dataset can be obtained	O	N	Medium

Additionally, for each source image, the corresponding metadata resource where possible should be provided, with the following requirements:

Table 7: Orthoimagery DPS metadata requirements for Source images

Name DMF ID (Requirement Class)	**Definition**	**Obligation**	**Max Occur**	**Value Domain**
Resource Spatial Resolution RSSRES (Core) + distance	Factor which provides a general understanding of the density of spatial data in the resource or describes the range of resolution in which a digital resource may be used. NOTE: this element should be repeated when describing the lower and upper range. Ground Sample Distance Horizontal ground sample distance of the resource (typically for gridded data and imagery-derived products).	**M**	N	Resolution / GSD Distance (value + unit)
Resource Georeferencing Level RSGFLV(Core)	Level of georeferencing of the resource.	**M**	1	
Acquisition Date Time ACDATE(Sensor)	Date and time of the collection of the source images	**M**	1	DateTime
Acquisition Instrument ACINS(Sensor)	Information about the instrument (sensor) used in data acquisition of source images.	**M**	1	Instrument Documentation of each Sensor/Instrument for acquisition of source images: identifier, type of Sensor, Description + collection mode for SAR imagery
Spectral Mode SPECTMOD(Sensor)	Mentions the spectral mode used (panchromatic, multi or hyper spectral)	0	1	Spectral Mode Information Codelist (panchromatic, multi-spectral, hyper-spectral)
Acquisition Platform Information ACPLAT(Sensor)	Designation of the platform used to acquire the source images	**O**	1	Platform Identifier and description of the platform
Spatial Representation of a Georeferenceable Gridded Coverage RFGRSPREP(Sensor)	Spatial representation of the grid provides the parameters needed to georeference the cell of the grid.	**M**	1	Georeferenceable Grid Spatial Representation (including GeoreferencingParameters and Control Point Availability)
Resource Process Step RSPRST (Common)	This element provides information about an event or transformation in the life of a resource including the process used to maintain the resource	O	0..N	Process Step For each processing (radiometric or geometric), description, rationale, date and time of the process step and responsible party.

Table 7: Orthoimagery DPS metadata requirements for Source images (continued)

Name DMF ID (Requirement Class)	**Definition**	**Obligation**	**Max Occur**	**Value Domain**
Imaging Condition GRCINF (Data) + imagingCondition	Conditions affecting the dataset. NOTE: if multiple reasons for bad condition exist, use the worst case.	O	1	Imaging Condition Codelist (e.g. cloud, snow, …)
Meteorological Conditions of Acquisition ACMETCD(Sensor)	Meteorological conditions in the area at collection time. NOTE: This element is intended for airborne or in-situ acquisition	**O**	1	Meteorological Condition
Sun Azimuth SUNAZ(Sensor)	Clockwise angle in degrees from north to the centre of the sun's disc. (ESA definition) NOTE: This angle is calculated from the nadir point of the sensor, not at the centre point of the image.	**O**	1	Float 0..360
Sun Elevation SUNEL(Sensor)	Angle between the horizon and the centre of the sun's disc (ESA definition). NOTE: This angle is calculated from the nadir point of the sensor, not at the centre point of the image.	**O**	1	Float -90..90

Annex C
DOP Geographic ARC product parameters
(normative)

Annex C-1. Introduction

The Equal Arc-Second Raster Chart/Map system, usually known as the ARC System, is a special grid system covering the entire ellipsoid of the World Geodetic System 1984. It provides a rectangular coordinate system based on 18 latitudinal zones. In this “very simple” system and projection (in non-polar zones), the meridians and parallels are equidistant straight parallel lines, the two sets of lines are supposed to be orthogonal. As a result, there is a significant distortion in the longitudinal direction (East-West) is large in comparison to most grid systems.

These allow an image-dependent relative coordinate system to be used with individual raster maps. The design objective of ARC is to provide graphic data in a manner as seamless as possible, and to permit direct display with a simple representation of directions.

This Annex documents one set of ARC parameters which is consistent between the set of resolutions that are covered. This set of parameters is recommended, but producers may prefer other set of ARC parameters, due to specific constraints.

Annex C-2. ARC zones system

The ARC system specifies 9 zones per hemisphere (i.e. 18 zones) as follows:

Table 8: ARC system zone

Northern Zones	Latitude Range	Southern Zones	Latitude Range
Zone 1	0°N to 32°N	Zone 10 (*Zone A*)	0°S to 32S°
Zone 2	32°N to 48°N	Zone 11 (*Zone B*)	32°S to 48S°
Zone 3	48°N to 56°N	Zone 12 (*Zone C*)	48°S to 56S°
Zone 4	56°N to 64°N	Zone 13 (*Zone D*)	56°S to 64S°
Zone 5	64°N to 68°N	Zone 14 (*Zone E*)	64°S to 68S°
Zone 6	68°N to 72°N	Zone 15 (*Zone F*)	68°S to 72S°
Zone 7	72°N to 76°N	Zone 16(*Zone G*)	72°S to 76S°
Zone 8	76°N to 80°N	Zone 17 (*Zone H*)	76°S to 80S°
Zone 9 (Polar)[7]	80°N to 90°N	Zone 18 (Zone J) (Polar)[7]	80°S to 90S°

NOTE: This document only addresses the non-polar zones. Polar zones are to be addressed in a Orthoimagery DPS polar zones extension.

Zones 10 to 17 are sometimes called Zones A to H (respectively), Zone 18 being called Zone J.

Theoretically, the projection used to convert (latitude, longitude) is the Equi-rectangular projection in the non-polar zones (as explained in the DIGEST support document for ARC system). However, as the coordinate system for ARC products is geographic (2D), there is no need to process any projection.

[7] Not addressed by this specification

In each ARC zone, the longitudinal pixel size (E-W) depends on each arc zone. To minimize the longitudinal distortion within an ARC zone, the longitudinal pixel size in a given zone is computed on the basis of the parallel length measured at the ***standard latitude***, which is an intermediate latitude between the two latitude limits of the zone, defined in such a way as to minimize the error (between stretch and shrink) within the zone when latitude varies (see DIGEST support document for ARC system). The following table provides the standard latitude values for the 18 zones.

Table 9: Standard Latitudes of the ARC Non-Polar Zones

Northern Zones	Standard Latitude	Southern Zones	Standard Latitude	Standard parallel (m)
Zone 1	22,94791772°N	Zone 10	22,94791772°S	36884683,4
Zone 2	41,12682127°N	Zone 11	41,12682127°S	30142987,4
Zone 3	52,28859923°N	Zone 12	52,28859923°S	24461860,6
Zone 4	60,32378942°N	Zone 13	60,32378942°S	19790863,0
Zone 5	66,09421768°N	Zone 14	66,09421768°S	16194258,4
Zone 6	70,10896259°N	Zone 15	70,10896259°S	13594406,3
Zone 7	74,13230145°N	Zone 16	74,13230145°S	10923203,2
Zone 8	78,17283750°N	Zone 17	78,17283750°S	8187398,3

For each orthoimage product, a constant longitudinal (column) and latitudinal (row) pixel interval shall exist in each ARC zone, based on 2 parameters, A(ZT) = Pixel number along the standard parallel (o in 360° longitude) and B(Z) = Pixel number along the meridian (or in 360° latitude), whose values depend on the intended resolution of the product.

As the delivery unit (tile/file) for orthoimagery is the square degree (if file size is acceptable as such) or a set of square degrees, the values specified for each of these two parameters are such that they can be divided by 360.

The set of parameters of the U.S. ECRG specification are also indicated as an alternate option.

Annex C-3. DOP ARC products – Set of ARC parameters for resolutions between 10m and 0,1m

The computation of the A(ZT) & B(Z) values is based on the additional constraint that the number of pixels per square degree in both directions must be multiple of 256, for all resolution levels.

Table 10: DOP ARC products parameters for all resolution levels

Resolution (approximate)	25	10	5	2,5	2	1	0,5	0,25	0,125	0,1
B(Z)	1548360	3870720	7741440	15482880	19353600	38707200	77414400	154828800	309657600	387072000
ARC Zone	**A(ZT) values**									
A	1437840	3594240	7188480	14376960	17971200	35942400	71884800	143769600	287539200	359424000
B	1216440	3041280	6082560	12165120	15206400	30412800	60825600	121651200	243302400	304128000
C	995040	2488320	4976640	9953280	12441600	24883200	49766400	99532800	199065600	248832000
D	774000	1935360	3870720	7741440	9676800	19353600	38707200	77414400	154828800	193536000
E	663480	1658880	3317760	6635520	8294400	16588800	33177600	66355200	132710400	165888000
F	552960	1382400	2764800	5529600	6912000	13824000	27648000	55296000	110592000	138240000
G	442440	1105920	2211840	4423680	5529600	11059200	22118400	44236800	88473600	110592000
H	331920	829440	1658880	3317760	4147200	8294400	16588800	33177600	66355200	82944000

a. DOP ARC product at resolution 25m

The following table provides the parameters for DOP 25m resolution ARC product, and the size of a 1° x 1° DOP image (in pixels), for each ARC zone.

Table 11: DOP 25m ARC product: parameters and size in pixels in ARC zones

ARC Zone	1 and A	2 and B	3 and C	4 and D	5 and E	6 and F	7 and G	8 and H
	Lat <=32	32< Lat <=48	48< Lat <=56	56< Lat <=64	64< Lat <=68	68< Lat <=72	72< Lat <=76	76< Lat <=80
A(ZT)	1437840	1216440	995040	774000	663480	552960	442440	331920
size (pixels)/ 1° longitude	3994	3379	2764	2150	1843	1536	1229	922
E-W angular resolution (degrees)	0,901352028	1,06540397	1,3024602	1,6744186	1,95333695	2,34375	2,92921074	3,90455531
E-W GSD (m)	25,65	24,78	24,58	25,57	24,41	24,58	24,69	24,67
B(Z)	1548360							
size (pixels)/ 1° latitude	4301							
N-S angular resolution (degrees)	0,837014648							
N-S GSD (m)	25,84							

A DOP 25m resolution 1°x1° product unit maximum size is 3994 pixels (horizontally) x 4301 pixels (vertically).

b. DOP ARC product at resolution 10m

The following table provides the parameters for DOP 10m resolution ARC product, and the size of a 1° x 1° DOP image (in pixels), for each ARC zone.

Table 12: DOP 10m ARC product: parameters and size in pixels in ARC zones

ARC Zone	1 and A	2 and B	3 and C	4 and D	5 and E	6 and F	7 and G	8 and H
	Lat <=32	32< Lat <=48	48< Lat <=56	56< Lat <=64	64< Lat <=68	68< Lat <=72	72< Lat <=76	76< Lat <=80
A(ZT)	3594240	3041280	2488320	1935360	1658880	1382400	1105920	829440
size (pixels)/ 1° longitude	9984	8448	6912	5376	4608	3840	3072	2304
E-W angular resolution (degrees)	0,360576923	0,42613636	0,52083333	0,66964286	0,78125	0,9375	1,171875	1,5625
E-W GSD (m)	10,26	9,91	9,83	10,23	9,76	9,83	9,88	9,87
B(Z)	3870720							
size (pixels)/ 1° latitude	10752							
N-S angular resolution (degrees)	0,334821429							
N-S GSD (m)	10,34							

A DOP 10m resolution 1°x1° product unit maximum size is 9984 pixels (horizontally) x 10752 pixels (vertically).

c. DOP ARC product at resolution 5m

The following table provides the parameters for DOP 5m resolution ARC product, and the size of a 1° x 1° DOP image (in pixels), for each ARC zone.

Table 13: DOP 5m ARC product: parameters and size in pixels in ARC zones

ARC Zone	1 and A Lat <=32	2 and B 32< Lat <=48	3 and C 48< Lat <=56	4 and D 56< Lat <=64	5 and E 64< Lat <=68	6 and F 68< Lat <=72	7 and G 72< Lat <=76	8 and H 76< Lat <=80
A(ZT)	7188480	6082560	4976640	3870720	3317760	2764800	2211840	1658880
size (pixels)/ 1° longitude	19968	16896	13824	10752	9216	7680	6144	4608
E-W angular resolution (degrees)	0,180288462	0,213068182	0,260416667	0,334821429	0,390625	0,46875	0,5859375	0,78125
E-W GSD (m)	5,13	4,96	4,92	5,11	4,88	4,92	4,94	4,94
B(Z)	7741440							
size (pixels)/ 1° latitude	21504							
N-S angular resolution (degrees)	0,167410714							
N-S GSD (m)	5,17							

A DOP 5m resolution 1°x1° product unit maximum size is 19968 pixels (horizontally) x 21504 pixels (vertically).

d. DOP ARC product at resolution 2,5m

The following table provides the parameters for DOP 2,5m resolution ARC product, and the size of a 1° x 1° DOP image (in pixels), for each ARC zone.

Table 14: DOP 2,5m ARC product: parameters and size in pixels in ARC zones

ARC Zone	1 and A Lat <=32	2 and B 32< Lat <=48	3 and C 48< Lat <=56	4 and D 56< Lat <=64	5 and E 64< Lat <=68	6 and F 68< Lat <=72	7 and G 72< Lat <=76	8 and H 76< Lat <=80
A(ZT)	14376960	12165120	9953280	7741440	6635520	5529600	4423680	3317760
size (pixels)/ 1° longitude	39936	33792	27648	21504	18432	15360	12288	9216
E-W angular resolution (degrees)	0,090144231	0,106534091	0,130208333	0,167410714	0,1953125	0,234375	0,29296875	0,390625
E-W GSD (m)	2,57	2,48	2,46	2,56	2,44	2,46	2,47	2,47
B(Z)	15482880							
size (pixels)/ 1° latitude	43008							
N-S angular resolution (degrees)	0,083705357							
N-S GSD (m)	2,58							

A DOP 2,5m resolution 1°x1° product unit maximum size is 39936 pixels (horizontally) x 43008 pixels (vertically).

e. DOP ARC product at resolution 2m

The following table provides the parameters for DOP 2m resolution ARC product, and the size of a 1° x 1° DOP image (in pixels), for each ARC zone.

Table 15: DOP 2m ARC product: parameters and size in pixels in ARC zones

ARC Zone	1 and A Lat <=32	2 and B 32< Lat <=48	3 and C 48< Lat <=56	4 and D 56< Lat <=64	5 and E 64< Lat <=68	6 and F 68< Lat <=72	7 and G 72< Lat <=76	8 and H 76< Lat <=80
A(ZT)	17971200	15206400	12441600	9676800	8294400	6912000	5529600	4147200
size (pixels)/ 1° longitude	49920	42240	34560	26880	23040	19200	15360	11520
E-W angular resolution (degrees)	0,072115385	0,085227273	0,104166667	0,133928571	0,15625	0,1875	0,234375	0,3125
E-W GSD (m)	2,05	1,98	1,97	2,05	1,95	1,97	1,98	1,97
B(Z)	19353600							
size (pixels)/ 1° latitude	53760							
N-S angular resolution (degrees)	0,066964286							
N-S GSD (m)	2,07							

A DOP 2m resolution 1°x1° product unit maximum size is 49920 pixels (horizontally) x 53760 pixels (vertically).

f. DOP ARC product at resolution 1m

The following table provides the parameters for DOP 1m resolution ARC product, and the size of a 1° x 1° DOP image (in pixels), for each ARC zone.

Table 16: DOP 1m ARC product: parameters and size in pixels in ARC zones

ARC Zone	1 and A Lat <=32	2 and B 32< Lat <=48	3 and C 48< Lat <=56	4 and D 56< Lat <=64	5 and E 64< Lat <=68	6 and F 68< Lat <=72	7 and G 72< Lat <=76	8 and H 76< Lat <=80
A(ZT)	35942400	30412800	24883200	19353600	16588800	13824000	11059200	8294400
size (pixels)/ 1° longitude	99840	84480	69120	53760	46080	38400	30720	23040
E-W angular resolution (degrees)	0,036057692	0,042613636	0,052083333	0,066964286	0,078125	0,09375	0,1171875	0,15625
E-W GSD (m)	1,03	0,99	0,98	1,02	0,98	0,98	0,99	0,99
B(Z)	38707200							
size (pixels)/ 1° latitude	107520							
N-S angular resolution (degrees)	0,033482143							
N-S GSD (m)	1,03							

A DOP 1m resolution 1°x1° product unit maximum size is 99840 pixels (horizontally) x 107520 pixels (vertically).

g. DOP ARC product at resolution 0,5m

The following table provides the parameters for DOP 0,5m resolution ARC product, and the size of a 1° x 1° DOP image (in pixels), for each ARC zone.

Table 17: DOP 0,5m ARC product: parameters and size in pixels in ARC zones

ARC Zone	1 and A Lat <=32	2 and B 32< Lat <=48	3 and C 48< Lat <=56	4 and D 56< Lat <=64	5 and E 64< Lat <=68	6 and F 68< Lat <=72	7 and G 72< Lat <=76	8 and H 76< Lat <=80
A(ZT)	71 884 800	60825600	49766400	38707200	33177600	27648000	22118400	16588800
size (pixels)/ 1° longitude	199680	168960	138240	107520	92160	76800	61440	46080
E-W angular resolution (degrees)	0,018028846	0,021306818	0,026041667	0,033482143	0,0390625	0,046875	0,05859375	0,078125
E-W GSD (m)	0,51	0,50	0,49	0,51	0,49	0,49	0,49	0,49
B(Z)	77414400							
size (pixels)/ 1° latitude	215040							
N-S angular resolution (degrees)	0,016741071							
N-S GSD (m)	0,52							

A DOP 0,5m resolution 1°x1° product unit maximum size is 199680 pixels (horizontally) x 215040 pixels (vertically).

h. DOP ARC product at resolution 0,25m

The following table provides the parameters for DOP 0,25m resolution ARC product, and the size of a 1° x 1° DOP image (in pixels), for each ARC zone.

Table 18: DOP 0,25m ARC product: parameters and size in pixels in ARC zones

ARC Zone	1 and A Lat <=32	2 and B 32< Lat <=48	3 and C 48< Lat <=56	4 and D 56< Lat <=64	5 and E 64< Lat <=68	6 and F 68< Lat <=72	7 and G 72< Lat <=76	8 and H 76< Lat <=80
A(ZT)	143769600	121651200	99532800	77414400	66355200	55296000	44236800	33177600
size (pixels)/ 1° longitude	399360	337920	276480	215040	184320	153600	122880	92160
E-W angular resolution (degrees)	0,009014423	0,010653409	0,013020833	0,016741071	0,01953125	0,0234375	0,029296875	0,0390625
E-W GSD (m)	0,26	0,25	0,25	0,26	0,24	0,25	0,25	0,25
B(Z)	154828800							
size (pixels)/ 1° latitude	430080							
N-S angular resolution (degrees)	0,008370536							
N-S GSD (m)	0,26							

A DOP 0,25m resolution 1°x1° product unit maximum size is 399360 pixels (horizontally) x 430080 pixels (vertically).

i. DOP ARC product at resolution 0,125m

The following table provides the parameters for DOP 0,125m resolution ARC product, and the size of a 1° x 1° DOP image (in pixels), for each ARC zone.

Table 19: DOP 0,125m ARC product: parameters and size in pixels in ARC zones

ARC Zone	1 and A	2 and B	3 and C	4 and D	5 and E	6 and F	7 and G	8 and H
	Lat <=32	32< Lat <=48	48< Lat <=56	56< Lat <=64	64< Lat <=68	68< Lat <=72	72< Lat <=76	76< Lat <=80
A(ZT)	287539200	243302400	199065600	154828800	132710400	110592000	88473600	66355200
size (pixels)/ 1° longitude	798720	675840	552960	430080	368640	307200	245760	184320
E-W angular resolution (degrees)	0,004507212	0,005326705	0,006510417	0,008370536	0,009765625	0,01171875	0,014648438	0,01953125
E-W GSD (m)	0,13	0,12	0,12	0,13	0,12	0,12	0,12	0,12
B(Z)	309657600							
size (pixels)/ 1° latitude	860160							
N-S angular resolution (degrees)	0,004185268							
N-S GSD (m)	0,13							

A DOP 0,125m resolution 1°x1° product unit maximum size is 798720 pixels (horizontally) x 860160 pixels (vertically).

j. DOP ARC product at resolution 0,1m

The following table provides the parameters for DOP 0,1m resolution ARC product, and the size of a 1° x 1° DOP image (in pixels), for each ARC zone.

Table 20: DOP 0,1m ARC product: parameters and size in pixels in ARC zones

ARC Zone	1 and A	2 and B	3 and C	4 and D	5 and E	6 and F	7 and G	8 and H
	Lat <=32	32< Lat <=48	48< Lat <=56	56< Lat <=64	64< Lat <=68	68< Lat <=72	72< Lat <=76	76< Lat <=80
A(ZT)	359424000	304128000	248832000	193536000	165888000	138240000	110592000	82944000
size (pixels)/ 1° longitude	998400	844800	691200	537600	460800	384000	307200	230400
E-W angular resolution (degrees)	0,003605769	0,004261364	0,005208333	0,006696429	0,0078125	0,009375	0,01171875	0,015625
E-W GSD (m)	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10
B(Z)	387072000							
size (pixels)/ 1° latitude	1075200							
N-S angular resolution (degrees)	0,003348214							
N-S GSD (m)	0,10							

A DOP 0,1m resolution 1°x1° product unit maximum size is 998400 pixels (horizontally) x 1075200 pixels (vertically).

Annex C-4. ECIB ARC products – Set of ARC parameters for resolutions between 5m and 0,5m

The A(ZT) & B(Z) values and table values are copied from the ECIB specification (see [MIL-PRF-32466]). The values are supposed to be multiple of 128, and the size of the EPF frames is 2304 = 18 * 128. Note that the ECIB specification only specifies the 5m, 1m and 0.5m resolutions.

Table 21: DOP ECIB ARC parameters

	ARC parameters	Resolution (m)	ARC parameters	Resolution (m)	ARC parameters	Resolution (m)
B(Z)	8007168	4,997	40038912	0,999	80076288	0,500
ARC Zone	**A(ZT)**		**A(ZT)**		**A(ZT)**	
A	7393152	4,989	36966528	0,998	73932672	0,499
B	6051840	4,981	30259200	0,996	60518400	0,498
C	4915200	4,977	24576000	0,995	49152000	0,498
D	3983232	4,969	19916928	0,994	39833472	0,497
E	3266688	4,957	16332672	0,992	32665728	0,496
F	2744448	4,953	13721472	0,991	27443328	0,495
G	2201472	4,962	11008128	0,992	22015872	0,496
H	1648512	4,967	8243328	0,993	16486272	0,497

NOTE: In the ECIB specification the number of pixel per degree is not an integer, as neither B or the A(z) values are multiple of 360.

Annex D
JPEG 2000 recommendations for DOP
(informative)

ISO/IEC 15444-1:2016 Information technology -- JPEG 2000 image coding system: Core coding system ISO/IEC 15444-2:2004 Information technology -- JPEG 2000 image coding system: Extensions

Introduction

JPEG 2000 is strongly recommended for the compression of DOP products, as it provides superior compression performance, faster access to zones of interest within big/huge[8] image file, with a scalable standard for compression and encoding, allowing streaming capabilities (via JPIP / ISO/IEC 15444-9).

When using JPEG 2000, it is recommended that producers take advantage of the capabilities of JPEG 2000 and its associated decoder/decompressor for handling data access to a region of interest within the codestream, or raster view at lower resolution level, and to minimize external tiling in several frames / files by specifying frames of “relatively big” dimensions. JPEG 2000 software works efficiently – with fast data access - with files up to 4 Gb (compressed), the only issue then being the memory consumption resource. Subsequently, it is recommended to limit the compressed DOP product to about 0.5 Gb (and avoid compressed files above 1 Gb).

For DOP products using JPEG 2000 compression, two options are available (see section 11.4):

- use of GMLJP2 standard, on basis of **DGIWG GMLJP2 profile**, based on JP2 and/or JPX file format (as specified in ISO/IEC 15444-1 / resp. ISO/IEC 15444-2), where GML provides the georeference information by use of the Rectified Grid Coverage element
- use of JPC Compressed codestream only (as specified in ISO/IEC 15444-1) on basis of ECIB standard. In this case, the JPC Compressed codestream is contained within the NSIF/NITF 2.1 described by the Image Segment Sub-header in Section 0. NSIF provides the georeference information.

DOP products: recommended JPEG 2000 parameters

NOTE: The following compression recommended parameters are presently indicative; tests on a set of DOP products samples are necessary to confirm these parameters.

- JPEG 2000 Part 1 Profile 1 Compliant (the main constraint is that Tiling/Blocking <= 1024), which allows to handle files up to 4 Gb, unless the size of the product file requires to use Profile 2 (in this case Tiling/Blocking > 1024 and usually equal to 2048).
- 2 compression modes:
    - Visually lossless:

      15:1 compression (0,533 bit-per-pixel-per band - bpppb)

      12:1 compression (0,667 bit-per-pixel-per band – bpppb)

      or 10:1 compression (0.8 bit-per-pixel-per band - bpppb)

      9-7I Irreversible wavelet Transformation (for visually lossless mode), which implements ICT (Irreversible Component Transform),

      NOTE: Transformation to **YCbCr colorspace** is always used for 9-7I transform

    - lossless; in this case, compression ratio depends on the data (usually between 2 and 3) with 5-3R(Reversible Component Transformation)
- 5 decomposition layers => 6 viewing resolutions

[8] Within the context of this document, files sizes measured in gigabytes are considered ‘huge’.

- 5 quality layers (or more), as follows (for 8bits per pixel per band imagery):
    - 0,03125, 0,0625, 0,125, 0,25, 0,53 bpppb for compression ratio 15,
    - 0,042, 0,083, 0,167, 0,333, 0,667 bpppb for compression ratio 12,
    - 0,05, 0,1, 0,2, 0,4, 0,8 bpppb for compression ratio 10,
- Precinct Size 256x256 for highest resolution levels, 128x128 for lower resolution level.
- Code-Block Size : 64x64 (or 32x32)
- Tiling (optional). NOTE: Tiling facilitates streaming with JPEG 2000 codestream.
    - Either no tiling, i.e Tile Size = Frame Size, i.e. no tiles within an image
    - or tile size = 1024 (or 2048 in order to reduce Tile index – and thus accelerate initial loading of tile index)
    - or tile size = 2048 (if the use of Profile 2 is needed on huge files).
- Codestream order:
    - RPCL (Resolution Position Component Layer). RPCL accelerates access to codestream regions of interest when navigating or zooming in the image.
    - LRCP (Layer Resolution Component Position). LRCP facilitates direct access to a specific resolution level in the codestream.
    - CPRL ‘Component Position Resolution Layer). CPRL allows accelerated access to a downgraded greyscale image, before full color-image is available / displayed.
- Use of PLT (Packet Length Tile) Marker (optional). This facilitates random access within JPEG 2000 codestream (used by most implementations).
- In case of Tiling, use of TLM (Tile-part Lengths) Marker (optional) (most implementations do not use).

Optionally, the two following markers may be used to facilitate access in case of a low transfer rate:

- SOP (Start Of Packet): facilitates synchronisation on codestream transfer flow
- EPH (End of Packet Header): this facilitates random access and error detection on the codestream transfer flow.

Annex E
DOP tiling and file size estimates
(informative)

Annex E-1. DOP Standardized ARC products: Tiling Scheme and file size estimates

The following table provides maximum file size estimates for DOP standardized ARC Geographic products (in Zone 1), with total number of pixels par tile, and approximate file size for JPEG 2000 visually lossless compression (compression ratio 1:10) for RGB orthoimagery (24 bits per pixel i.e. 8 bits per pixel per band).

Table 22: DOP Standardized ARC products - Tiling Scheme and file size estimates

Resolution / GSD (m)	File Coverage / Extent	Number of files/tiles in a square degree	Number of pixels per tile (Zone 1) (width x height)	File Size estimate (uncompressed) (Mb)	File Size estimate (compressed at ratio 1:10) (Mb)
25	1°d x 1°d	1	3994 X 4301	49,15	4,91
10	1°d x 1°d	1	9984 x 10752	307,13	30,71
5	1°d x 1°d	1	19968 x 21504	1228,50	122,85
2,5	1°d x 1°d	1	39936 x 43008	4914,00	491,40
2	1°d x 1°d	1	49920 x 53760	7678,13	767,81
1	30 min x 30 min	4	49920 x 53760	7678,125	767,8125
0,5	15 min x 15 min	16	49920 x 53760	7678,125	767,8125
0,25	10 min x 10 min	36	66560 x 71680	1,37E+04	1,37E+03
0,125	5 min x 5 min	144	66560 x 71680	1,37E+04	1,37E+03
0,1	4 min x 4 min	225	66560 x 71680	1,37E+04	1,37E+03

Annex E-2. DOP Standardized Projected products: Tiling Scheme and file size estimates

The following table provides maximum file size estimates for DOP projected products, with total number of pixels per tile and approximate file size for JPEG 2000 visually-lossless (compression ratio 1:10) for RGB orthoimagery (24 bits per pixel i.e. 8 bits per pixel per band).

Table 23: DOP Standardized projected products - Tiling Scheme and file size estimates

Resolution / GSD (m)	File Coverage / Extent	Number of pixels per tile	File Size estimate (uncompressed) (Mb)	File Size estimate (compressed) (Mb)
25	100 km x 100km	1,60E+07	45,78	4,58
10	100 km x 100km	1,00E+08	286,10	28,61
5	100 km x 100km	4,00E+08	1144,41	114,44
2,5	100 km x 100km	1,60E+09	4577,64	457,76
2	100 km x 100km	2,50E+09	7152,56	715,26
1	50 km x 50km	2,50E+09	7152,56	715,26
0,5	25 km x 25km	2,50E+09	7152,56	715,26
0,25	20 km x 20km	6,40E+09	18310,55	1831,05
0,125	10km x 10km	6,40E+09	18310,55	1831,05
0,1	5 km x 5km	2,50E+09	7,15E+03	715,26

Annex F
DOP use case overview
(informative)

Orthoimagery may be considered / used for:

- To provide an accurate view of a given territory at the acquisition date / Situational awareness / IPB - C3I theatre battle management, aligned with a geographic / cartographic coordinate system
- Base layer in Geo viewers or any geospatial information system (for OPP/IPB) (including aircraft displays) and for Military command and control systems
- Localisation of other thematic data or Earth observation image data
- For the extraction, mapping and updating of specific features on the surface of the Earth (e.g. transport network, Hydrography, or military or industrial facilities)
- Mission Planning: for the Air Force, UAV operations or ground-based force to unit-level mission planning systems
- In support to GeoInt, IMINT and Targeting

The use cases for this Orthoimagery DPS specification are:

- Seamless orthoimagery serving as base layer (worldwide), as addressed by CIB (Controlled Image Base - US Performance Specification 89041A dated 28 March 2000) or its NATO STANAG 7099 associated agreement

  (This is the base use case for this specification. This is also the use case addressed by US MIL-PRF-32466 (ECIB))
- Orthoimagery products encoding, exchange and dissemination
- Geospatial Products development support
- Mission specific datasets / products + corresponding development support

Annex G
Use cases and multispectral imagery
(informative)

The spectral bands used / choice of wavelengths will depend on the sensor imagery available to the producer and the user requirements. The following tables describe the wavelengths, their uses and the potential clients that would use multispectral imagery, for either analysis or planning use-cases.

Table 24: Multispectral imagery (EO and SAR) and military usages

Color	Band (nm)	Use	Strategic[8]	Army[8]	Navy[9]	AirForce
Blue	450-515..520	Atmosphere and deep-water imaging, can reach depths up to 50m in clear water				
Green	515..520–590..600	Imaging vegetation and deep-water structures, up to 30m in clear water.				
Red	600..630–680..690	Imaging man-made objects, in water up to 9m deep, soil, and vegetation				
Near infrared (NIR)	750–900	Primarily imaging vegetation				
Mid-infrared (MIR)	1550–1750	Imaging vegetation, soil moisture content, and some forest fires				
Far-infrared (FIR)	2080–2350	Imaging soil, moisture, geological features, silicates, clays, and fires				
Thermal infrared	10400-12500	Uses emitted instead of reflected radiation to image geological structures, thermal differences in water currents, fires, and for night studies				
Radar / SAR		Useful for mapping terrain and for detecting various objects				

Different combinations of spectral bands can be used. They are usually represented with red, green, and blue channels. Mapping of bands to colours depends on the purpose of the image.

Combination	General Use[8]
True-color	Uses red, green, and blue channels, mapped to their respective colours. As a plain color photograph, it is good for analyzing man-made objects, and is easy to understand for beginner analysts.
Green-red-infrared	Where the blue channel is replaced with near infrared, is used for vegetation, which is highly reflective in near IR. This combination is often used to detect vegetation and camouflage.
Blue-NIR-MIR	Such images allow the water depth, vegetation coverage, soil moisture content, and the presence of fires to be seen, all in a single image.

Many other combinations are in use. NIR is often shown as red, causing vegetation-covered areas to appear red.

[9] https://en.wikipedia.org/wiki/Multispectral_image

Based on the above tables, the ability to provide or support: analysis, planning, monitoring, most use-cases will use “True-Color” with the three primary bands (blue/green/red). Any combination of other bands will involve specialized analysis, as required, though other means.

Annex H
NIIRS overview
(informative)

The NATO Imagery Interpretability Rating Scales allow for the evaluation of imagery quality and use of a consistent measure for such evaluations. The aim is that Imagery deposited in libraries can be accessed with confidence in the consistency of quality measures.

The aerial imaging community utilizes the NATO Imagery Interpretability Rating Scale (NIIRS) to define and measure the quality of images and performance of imaging systems. Through a process referred to as "rating" an image, the NIIRS is used by imagery analysts to assign a number which indicates the interpretability of a given image. The NIIRS concept provides a means to directly relate the quality of an image to the interpretation tasks for which it may be used. Although the NIIRS has been primarily applied in the evaluation of aerial imagery, it provides a systematic approach to measuring the quality of photographic or digital imagery, the performance of image capture devices, and the effects of image processing algorithms, and therefore also applies to satellite imagery.

See STANAG 7194 Ed: 2 NATO Imagery Interpretability Rating Scale (NIIRS) - AIntP-7 Edition A 2018-09-28 (not publicly available). See also https://fas.org/irp/imint/niirs.htm .

The NIIRS / STANAG 7194 define the ranges of resolution for imagery, and corresponding quality of imagery for interpretation, for Electro-Optical, InfraRed and SAR imagery, based on 3 criteria / capabilities: Detect, Distinguish and Identify.

The table below provides the NIIRS ranges of resolution, together with some illustrative capabilities. See the above references for more details.

Table 25: NIIRS ranges of resolution (EO, IR and SAR) and capabilities

NIIRS	Resolution (m)	EO	IR	Radar
0		Un-interpretable image	Un-interpretable image	Un-interpretable image
1	> 9,0	Distinguish between roads, runways	Detect large (> 1 km2) cleared areas	Detect lines of transportation, either road or rail, but do not distinguish between them
2	4,5 to 9,0	Detect large buildings	Distinguish vegetation	Identify athletic stadiums
3	2,4 to 4,5	Detect rows of vehicles parked in a parking area	Detect tank tracks	Detect multiple wings of large buildings
4	1,2 to 2,5	Distinguish vehicle types	Detect thermally active vehicles	Detect smokestacks in industrial facilities
5	0,8 to 1,2	Distinguish vehicle configurations	Identify outdoor tennis courts	Detect small helicopters
6	0,4 to 0,8	Identify vehicle classes	Detect engines	Detect cargo on a railroad flatcar
7	0,2 to 0,4	Distinguish between tracks made by wheeled and tracked vehicles	Identify automobiles as sedans or station wagons	Identify fighter aircraft by type
8	0,1 to 0,2	Identify individual rungs on between-deck ladders	Detect tank turrets	Identify small helicopters by type
9	< 0,1	Identify farm or construction tools by general shape	Detect guns	Distinguish between models of fighter aircraft

Annex I
Bibliography

(1) MIL-PRF-32466 System Specification for Enhanced Controlled Image Base (ECIB) 26 June 2013

(2) MIL-PRF-89041A Controlled Image Base (CIB) - US Performance Specification, 28 March 2000

(3) BPJ2K01.10 — ISO/IEC BIIF Profile for JPEG2000, Version 01.10
(Copies of this publication are available online from the National Geospatial-Intelligence Agency, NITF Technical Board (NTB) at www.gwg.nga.mil/ntb/baseline/documents.html)

(4) ESRI Shapefile Technical Description – An ESRI White Paper – July 1998
(Copies of this publication are available from Adobe at
http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf)