



DGIWG 907

DGIWG IMAGERY & GRIDDED DATA ROADMAP

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Abstract:	<p>The activities defined in this document are intended to serve as a guide to facilitate program/project management undertaken by the DGIWG in response to future state needs. The document places special emphasis on activities that promote interoperability of geospatial data, products, and services.</p> <p>The document is reviewed annually and is subject to change without notice.</p>
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Table of Contents

1. Scope.....	1
2. Purpose.....	1
3. Reference documents	2
3.1. International Organization for Standardization (ISO) standards.....	2
3.2. Open Geospatial Consortium (OGC).....	2
3.3. North Atlantic Treaty Organization (NATO).....	3
3.4. Defence Geospatial Information Working Group (DGWG).....	3
3.5. De facto.....	4
3.6. National.....	4
4. Geospatial Information – present state.....	5
4.1. User requirements.....	5
4.1.1. Imagery data.....	5
4.1.2. Gridded data	5
4.1.3. Point Clouds.....	6
4.1.4. Use of OGC web services for Imagery military products	6
4.2. Geospatial content	6
4.2.1. Imagery and Gridded data.....	6
4.2.2. Raster products	6
4.2.3. Orthoimagery products.....	6
4.2.4. Elevation products.....	6
4.2.5. Geolocated sensor data.....	6
4.3. Standards assessment.....	6
4.3.1. Imagery and gridded data reference models.....	6
4.3.2. Rules for application schemas.....	7
4.3.3. Metadata	7
4.3.4. Imagery sensors geopositioning models	8
4.3.5. Imagery and Gridded data encodings.....	8
4.3.6. Raster, Orthoimagery, SAR and elevation products	10
4.3.7. Imagery and gridded data web services	11
5. Technology considerations.....	12
5.1. Existing	12
5.2. Emerging.....	12
5.3. Research and development activities	12
6. Geospatial information - future state.....	13
6.1. Target objectives.....	13
6.2. Geospatial content	13
6.3. Geospatial services	14
6.4. Standardisation initiatives	14
6.4.1. Civil standards.....	14
6.4.1.1. ISO IGD standards.....	14
6.4.1.2. OGC IGD projects	14
6.4.2. Defence standards	14
7. Program plan.....	15
7.1. IGD Technical Panel (P2).....	15
7.1.1. Project P2.03 (DRP): Raster map / graphics products implementation profile standard	15
7.1.2. Project P2.04 (DOP): Orthoimagery products implementation profile standard.....	15
7.1.3. Project P2.05: Sensor Web Enablement (SWE) profiles for Defence	16
7.2. Other potential Requirements for future projects	16
8. Dependencies.....	17
Annex A - Abbreviations.....	18
Annex B - Summary of activities.....	20
Annex C - Activity details.....	21

Introduction

The DGIWG is a requirements-driven multi-national cooperative body responsible for providing advice and recommendations on the standardisation of geospatial information and services for its members. It works to facilitate geospatial interoperability through the adoption, adaption, and creation of standards that enable the creation, sharing, and use of geospatial information, including imagery and gridded data. The DGIWG utilizes public domain and industry standards from ISO TC 211 and the Open Geospatial Consortium (OGC), and influences their development as needed. Working Group 6 (WG6) of ISO TC 211 has a number of published standards covering imagery and gridded data, such as ISO 19123 for a Coverage model and schema or the set of ISO TS 19130 for Imagery sensor models for geo-positioning, and ISO/TS 19163-1 Content components and encoding rules for imagery and gridded data – Part 1: Content model. OGC standards of interest include: GeoTIFF 1.1, GMLJP2 (i.e. GML within JPEG2000), Web Coverage Service (WCS), and SensorML¹, and are addressed within this document.

The NATO Joint Capability Group – Intelligence Surveillance and Reconnaissance (JCGISR) has established a set of imagery related standards for use by NATO and NATO Nations, which leverage the geospatial information standards and profiles created by the DGIWG. Both the JCGISR and the DGIWG are looking towards a number of emerging international standards as a basis for a new generation of military standards.

¹ SensorML is one of the standards that form part of the OGC's "Sensor Web Enablement (SWE)" suite.

i. Contributing participants

Nation	Parent organization
AUS	Australian Geospatial-Intelligence Organisation
FRA	Direction Générale de l'Armement (DGA)
CAN	Department of National Defence (DND)
DEU	Bundeswehr Geoinformation Office (BGIO)
DNK	Agency for Data Supply and Efficiency (DNK), on behalf of DALO
CZE	Military Geographic and Hydrometeorologic Office
ESP	Cartographic Coordination Unit
SWE	Military Geographic Service
TUR	General Command of Mapping
USA	National Geospatial-Intelligence Agency (NGA)

ii. Document points of contact

All questions regarding this document shall be directed to the secretariat@dgiwg.org

iii. Revision history

Date	Edition number	Primary clauses modified	Description
17 November 2014	4.0 (draft)	All	Creation (on basis of previous IGD roadmap version 3.5 May 2014)
15 April 2015	4.0		Finalization after review during DGIWG TP – Amsterdam
13 May 2016	4.1 (draft)	3.3, 4.1, 4.3.1, 4.3.5, 4.3.6, 5.2, 6.1, 6.4.1, 6.4.2, 7.1, 7.2, Annexes B and C	Update April 2016 + IGD TP May 2016
01 June 2016	4.1	4.3.3, 4.3.5.2	Reference of revised DMF version 1.0.1 Addition of current DGIWG context for Point cloud data
06 June 2017	4.2		Update IGD TP May 2017 and final adjustments
03 May 2018	4.3	Section 7	Update IGD TP May 2018 and final adjustments
30 April 2019	4.4	4.2.5 added, 4.3.2, 7.1, 7.2, Annexes B and C	Update IGD TP April 2019
23 October 2020	4.5	Sections 3 and 7	Update IGD TP October 2020

1. Scope

This document serves as a strategy and planning tool for the DGIWG, its member organisations and associates. It provides the basis by which one is able to capture and address standardisation deficiencies in the area of imagery and gridded data. It describes the present state of geospatial interoperability across the civil and defence user communities and establishes a future state goals and objectives by which associated standardisation activities are based. Key factors used include: user requirements, relevant standards (published or in work), and emerging technologies.

2. Purpose

DGIWG is the multi-national body responsible to member nation defence organisations coordinating, advising and providing policy recommendations on geospatial standardisation issues. Coalition interoperability challenges are met by creating standards and procedures required to enable the provision, exchange and use of standardised geospatial information. The business vision of DGIWG is to significantly increase the levels of geospatial interoperability of all member nations to satisfy new requirements for geospatial intelligence in coalition operations.

The main goals of DGIWG works on imagery and gridded data are to enable modelling, encoding and access or exchange for geospatial imagery and gridded data, via medias or web services with the aim to increase interoperability across the civil and defence user communities, including imagery intelligence, surveillance and reconnaissance, and to provide standards for imagery and gridded data products.

The benefactors of DGIWG activities regarding imagery and gridded data are DGIWG nations and associates (e.g. MGCP, NATO – including JISR, TREx), and the general military community.

3. Reference documents

3.1. International Organization for Standardization (ISO) standards

- **ISO/TS 19101-2:2018**, Geographic information – Reference Model – Imagery
 - **ISO 19115-2:2019**, Geographic information – Metadata – Extensions for acquisition and processing
 - **ISO 19123:2005**, Geographic information – Schema for coverage geometry and functions
 - **ISO TS 19129:2009**, Geographic information – Framework for Imagery and Gridded Data
 - **ISO TS 19130-1:2018**, Geographic information – Imagery sensor models for geopositioning -- Part 1: Fundamentals
 - **ISO TS 19130-2:2014**, Geographic information – Imagery sensor models for geo-positioning - Part 2: SAR, InSAR, LiDAR and SONAR
 - **ISO/TS 19139-2:2012**, Geographic information – Metadata - XML schema - Part 2: Extensions for imagery and gridded data
 - **ISO 19156:2011**, Geographic information – Observations and measurements
 - **ISO 19159-1:2014**, Geographic information – Calibration and validation of remote sensing imagery sensors and data -- Part 1: Optical sensors
 - **ISO 19159-2:2016**, Geographic information – Calibration and validation of remote sensing imagery sensors and data -- Part 2 Lidar
 - **ISO 19159-3:2018**, Geographic information – Calibration and validation of remote sensing imagery sensors and data -- Part 3: SAR/InSAR
 - **ISO/TS 19163-1:2016**, Geographic information – Content components and encoding rules for imagery and gridded data -- Part 1: Content model
 - **ISO/TS 19163-2:2020**, Geographic information — Content components and encoding rules for imagery and gridded data — Part 2: Implementation schema
 - **ISO/IEC 12087-5:1998**, Image Processing and Interchange (IPI) – Functional specification – Part 5: Basic Image Interchange Format (BIIF) + Corrigenda 1 (2001) and 2 (2002)
 - **BPJ2K01.10**, BIIF Profile for JPEG 2000 Version 01.10
- Note: This BIIF Profile for JPEG 2000 is a profile using the JPEG 2000 proforma, intended to be used in BIIF applications.
- **ISO/IEC 15444-1:2016**, JPEG2000 image coding system - Core coding system
 - **ISO/IEC 15444-2:2004**, JPEG 2000 image coding system: Extensions system (+corrigenda 3 and 4)
 - **ISO/IEC 15444-9:2005**, Information technology -- JPEG 2000 image coding system: Interactivity tools, APIs and protocols (JPIP) (+ amendments 1 to 4, and corrigenda 1 to 3)
 - **ISO/IEC 15948:2004**, Portable Network Graphics (PNG) - Functional specification

3.2. Open Geospatial Consortium (OGC)

- **GeoTIFF 1.1**, GeoTIFF standard (ref. OGC 19-008r4)
- **GMLJP2**, GML in JPEG 2000 for Geographic Imagery Encoding Specification (ref. OGC 05-047r3)

- **GMLJP2 2.1**, GML in JPEG 2000 (GMLJP2) Encoding Standard Part 1: Core (ref. OGC 08-085r8)
- **O&M 2.0**, Observations & Measurements Abstract Specification Topic 20 (ref. OGC 10-004r3, aligned with ISO 19156)
- **WCS1.1.2**, Web Coverage Service Implementation Specification (ref. OGC 07-067r5)
- **WCS 2.0.1**, Web Coverage Service Interface Standard - Core (ref. OGC 09-110r4) + KVP, XML/SOAP and XML/POST protocol bindings
- **GMLCOV**, GML Application Schema - Coverages (1.0.1) (GMLCOV) (ref. OGC 09-146r2)
- **SensorML**, Sensor Model Language (ref. OGC 07-000)
- **SensorML 2.0**, Sensor Model Language: Model and XML Encoding Standard (ref. OGC 12-000)
- **SensorML 2.1**, Sensor Model Language: Model and XML Encoding Standard (ref. OGC 12-000r2)
- **SOS 2.0**, Sensor Observation Service (SOS), version 2.0, (ref. OGC 12-006)

3.3. North Atlantic Treaty Organization (NATO)

- **STANAG 2215**, Evaluation of land maps, aeronautical charts and digital Topographic data Ed 7, 13/07/2010 (including horizontal and vertical accuracies)
- **STANAG 4545**, NATO Secondary Imagery Format (NSIF), Ed. 2, 06/05/2013
- **STANAG 4559**, NATO Standard ISR Library Interface (NSILI), Ed. 3, 12/11/2010
- **STANAG 4607**, Ground Moving Target Imagery Format (GMTIF), Ed. 3, 14/09/2010
- **STANAG 4609**, NATO Digital Motion Imagery Format (DMIF), Ed. 4, 19/12/2016
- **STANAG 7023**, NATO Primary Image Format (NPIF), Ed. 4 Amdt1, 16/06/2016

“Legacy” imagery NATO STANAGs

- **STANAG 3809**, Digital Terrain Elevation Data Exchange Format (DTED), Ed. 4, 04/01/2004
- **STANAG 4387**, Arc standard raster products (ASRP), Ed. 1, 12/05/1998 (also known as AGeoP-5)
- **STANAG 7077**, Specification for UTM/UPS standards raster products (USRP), Version 1.2, 13/07/1998 (*cancelled in 2011*) (also known as AGeoP-6)
- **STANAG 7098**, Compressed arc digitized graphics (CADRG), Version 1.1, 23/01/2004
- **STANAG 7099**, Controlled image base (CIB), Version 1.1, 26/11/2004

3.4. Defence Geospatial Information Working Group (DGIWG)

- **DGIWG 108**, GeoTIFF profile for Georeferenced Imagery, Ed2.3, 23/01/2020
- **DGIWG 104**, DGIWG profile of JPEG 2000 for Georeferenced Imagery, Ed 1.0, 04/02/2014
- **DGIWG 104(2)**, DGIWG profile of JPEG 2000 for Georeferenced Imagery, Ed 2.1.1, 23/01/2020
- **DGIWG 116-1**, Elevation Surface Model (ESM), Ed 1.0.1, 19/10/2017
- **DGIWG 116-2**, Elevation Surface Model (ESM) GML Application Schema, Ed 1.0.1, 01/08/2016
- **DGIWG 116-3-1**, Elevation Surface Model (ESM) Encoding Rules: Part 1 - Core, Ed. 1.1.0, 18/05/2017
- **DGIWG 250**, Defense Gridded Elevation Data (DGED) Product Implementation Profile, Ed 1.2 03/05/2018
- **DGIWG 254**, Defence Raster Product (DRP) Implementation Profile, Ed 1.0 12/06/2020

3.5. De facto

- **GeoTIFF**, GeoTIFF format specification - JPL-SI Corp. Revision 1.0, Version 1.8.2, 28/12/2000
- **TIFF**, TIFF format specification Aldus/Adobe. Final revision 6.0 3/06/1992

3.6. National

- **NGA.IP.0002_1.1**, High Resolution Elevation (HRE) Product Profile, Version 1.1, 12/06/2014
- **NITF-HYPERSPECTRAL**, NITF Profile for Hyperspectral Imagery, Version 1.0, 07/27/2011
- **US MIL-PRF-32283**, Enhanced Compressed Raster Graphic (ECRG), 02/21/2008
- **US MIL-PRF-32466**, Enhanced Controlled Image Base (ECIB), 06/26/2013

4. Geospatial Information – present state

4.1. User requirements

This section identifies DGIWG customers and describes their requirements within the scope of DGIWG imagery and gridded data activities. The customer group includes:

- Defence organizations of DGIWG member nations including Armed Forces and Homeland Security organizations.
- NATO Core GIS Program.
- Joint Capability Group - Intelligence, Surveillance and Reconnaissance (JCGISR).
- Geospatial Maritime Working Group (GMWG).
- International Hydrographic Organization (IHO).
- EU Satellite Center.

The following user requirements have been identified; additional inputs are welcomed to complete the definition for military requirements for imagery:

- Standardisation for an interoperable use of still imagery encodings.
- The use of civilian emerging compression, formats, and interactive network services (JPEG 2000, including JP2 and JPX formats for still imagery, MPEG-2, MPEG-4, KLV for motion imagery, JPIP protocol...).
- Standardisation of high resolution terrain elevation models.
- Military profiles for Coverage data for OGC web services (WCS, GML coverage profile ...).
- Adequate georeferencing for Motion imagery².

NB: NATO Variable Resolution Grid initiative was formerly mentioned, but no relevant requirement has been identified or communicated to the IGD TP (T01) since autumn 2007.

The following items formalize priority user requirements, when actors are identified and sufficient information is available.

4.1.1. Imagery data

The main priority requirements are for profile(s) or recommendations for defence community for exchange of following types of data, with efficient and standard compression and imagery metadata transfer:

- Raster maps.
- Orthoimagery.
- Referenceable imagery (e.g. Sensor imagery), addressed by Referenceable extension of GMLJP2 and by STANAG 4545 (NSIF), this latter within the scope of JCGISR works.

4.1.2. Gridded data

The main priority requirements are profile(s) or recommendations for defence community for exchange of georeferenced gridded data (height, depth ...) with associated metadata, allowing:

- high resolution terrain elevation model (horizontal spatial resolution of 0.4 arc seconds of longitude at the equator and higher resolution levels,
- multi-resolution terrain elevation model (TEM), allowing high resolution patches over lower resolution TEM.

² The DGIWG Imagery and Gridded Data panel recognizes the need to investigate the options for common and harmonized geo-enabled still and motion imagery.

4.1.3. Point Clouds

Point clouds data may be bare earth or surface or bathymetric data. Surface models may allow classification of canopy or buildings ...

4.1.4. Use of OGC web services for Imagery military products

The defence geospatial information community must evaluate OGC web services, particularly WCS (Web Coverage Service), for use in the exchange of military imagery products or other gridded data. Consideration must be given to development of a WCS application (or extension) profile for the defence information community.

An Imagery Georeference Web Service (IGS) for accurate georeferencing of sensor images provided by a geospatial imagery server is another topic of interest and potential future requirement.

4.2. Geospatial content

4.2.1. Imagery and Gridded data

Imagery and gridded data include two types of data:

- Any georeferenced imagery and gridded data with associated metadata and georeferenced information.
- Sensor imagery with associated metadata and sensor geopositioning model.
- Other kinds of synthetic imagery and gridded data.

4.2.2. Raster products

Raster products are topographic maps in raster mode and format, either scanned or rasterized from vector topographic products.

4.2.3. Orthoimagery products

Orthoimagery products are georeferenced imagery adjusted for topographic relief (on the basis of a terrain elevation model), conforming to an orthoimagery product specification.

4.2.4. Elevation products

Topographic Elevation products address Terrain Elevation models and Elevation Surface models (elevation on top of vegetation or structures or buildings), conforming to an elevation product specification.

For maritime domain, elevation data is bathymetric data, providing depth instead of elevation.

4.2.5. Geolocated sensor data

This includes Point cloud data, chemical, biological, radiation and nuclear (CBRN) sensor observations.

4.3. Standards assessment

This clause provides assessment information for the identified civil and military standards and provides guidance and recommendation for implementation of imagery and gridded data standards.

Note: The consistency of the standards/profiles proposed by DGIWG and JCGISR implies a common understanding of the different aspects of imagery. The risk of divergence between DGIWG and JCGISR, or between GEO and GEOINT communities, must be minimized by adequate coordination of DGIWG and JCGISR and standardisation works based on civil standards.

4.3.1. Imagery and gridded data reference models

The imagery and gridded data reference models should be based on the following ISO TC211 civil standards:

- 19123 for the Coverage model.
- 19130 and 19130-2 for the Sensor ge positioning models.
- 19156 for the Observation and Measurement model.

The general vision is based on wider reference standards such as the one defined in ISO 19101 and ISO/TS 19101-2, with the framework vision of ISO/TS 19129.

There is no specific military imagery data reference model, nor any requirement for its development.

DGIWG Elevation Surface Model profile, providing models for elevation data adapted to the military requirements and allowing various standardised encodings, has been adopted in June 2013. A revised version aligned with DMF for metadata was published in June 2014 and updated in 2017. An application schema, based on GMLCOV for the ESM coverage data, or on a simple GML 3.2.1 with 3D point primitives for ESM Point sets has been published in October 2014 and revised in August 2016. ESM encoding rules have been also published in October 2014, and revised in 2017 with GeoTIFF, GMLJP2 and NSIF encoding rules.

4.3.2. Rules for application schemas

ISO 19109 – Rules for application schema is the specification defining how to go from the concepts to implementation specification, promoting an automated approach.

Imagery experts have expressed a multitude of conceptual and physical representations of an image. ISO 19123 defines a single concept of coverage which summarises the different conceptual representation of an image, going further by enlarging the spectrum of geospatial information that can be represented this way.

OGC GMLCOV is the implementation schema for coverages now used in OGC web services and emerging GMLJP2 2.0. This GMLCOV schema has also been named CIS (Coverage Implementation Schema) version 1.0 by the OGC.

DGIWG **recommends** the use of **GMLCOV (CIS 1.0) as the coverage schema to be used for imagery and gridded data** and associated web services.

4.3.3. Metadata

The set of ISO 19115 (and 19139 for XML encoding – including metadata rules for application schema) standards are the base metadata standard for geospatial data.

DGIWG Metadata Foundation specification (DMF), which is a general military metadata profile based on ISO 19115 for datasets, series, services and tiles has been published in November 2013 revised in November 2014 (version 1.0.1) and in July 2017 (Version 2.0).

The NATO Geospatial Metadata Profile (STANAG 2586) which standardises the content and encoding of the metadata describing geospatial data and services used by NATO armed forces has been ratified. It may be considered as a NATO restriction of DGIWG Metadata Foundation. It is also a profile of ISO 19115.

The **DMF specification is the reference metadata standard to be used for Imagery and gridded data**, on the basis of its Data and Data+ conformance classes, for the description of Coverage data. It handles the mapping with ISO TC211 metadata standards. Though some DGIWG IGD standards (e.g. GeoTIFF or GMLJP2 profiles, or ESM) have been published with reference to DMF 1.0 and before DMF 1.0.1 was published, DMF 1.0.1 should be used instead.

DMF version 2.0 including an extension for sensor imagery metadata is available since July 2017. The version 1.0.1 is being used (e.g. in DGED 1.0) and has to be retained.

Please refer to DGIWG metadata roadmap for further metadata consideration.

4.3.4. Imagery sensors geopositioning models

ISO TC211 WG6 (Imagery) has published in 2010 the technical specification **19130 Imagery Sensor models for Geo-positioning** providing the ISO standard for sensor models and revised it in 2018. 19130-2 has been published in Jan. 2014 on SAR, InSAR, LIDAR and SONAR models, as well as an aero-triangulation model. There is little feedback of implementation of these standards, which no reference schemas and provide no guidance for implementation.

OGC and its SWE (Sensor Web Enablement) initiative have also addressed Sensor model and encodings with SensorML standard, with the version 2.0 published early 2014. **SensorML2.0** is consistent with OGC standards for web services, including SOS (Sensor Observation Service). However, there is presently limited guidance for the encoding of the main imagery sensors geopositioning models in SensorML.

The **encoding of Sensor geopositioning models is still an open issue**: either 19130-based with XML application schemas, which may be derived from some generic TC211 rules for application schemas (either 19136 – GML – or 19139 – Metadata), or SensorML. It should be noted that the SensorML rules are based on GML rules for application schema (the assumption is that “a sensor is a feature”). This includes the use of Functional Fit Sensor Model for geo-referenceable imagery that addresses ground-to-image positioning, adjustability (e.g. from triangulation across multiple images), and rigorous error propagation, as specified in ISO 19130 works.

Another reference specification of interest is “Community Sensor Model (CSM) Technical Requirements Document (TRD) Version 3.0.3 – May 2017”, produced by US GWG CSM focus group.

4.3.5. Imagery and Gridded data encodings

The following guidelines are related to the use of the existing and emerging imagery encodings for the military community. In the future, these guidelines should incorporate additional technical criteria in order to evaluate these geospatial imagery encodings.

4.3.5.1. Civil

The **following general purpose standardised civil formats are applicable to imagery and gridded data**, with their key limitations (when applicable):

- **GeoTIFF**, based on TIFF legacy format; this is aimed at georeferenced imagery (though GeoTIFF allows the definition of a transformation function to a standard CRS).
- **GMLJP2** (emergent geospatial standard with JPEG2000 compression): OGC standard with JPEG2000 compression for encoding of geospatial raster, imagery or elevation. Lossless, near-lossless or lossy modes are available. A version 2.0 has been published in October 2014, based on ISO 19136 version of GML (OGC version 3.2.1) and OGC GML coverage application schema (GMLCOV). A corrigendum version 2.0.1 has been published early April 2016. This presently addresses georeferenced imagery. Version 2.1 incorporating referenceable imagery has been published by OGC in August 2018.
- **BIIF** - ISO/IEC 12087-5:1998/Cor 2:2002 Information technology -- Computer graphics and image processing -- Image Processing and Interchange (IPI) -- Functional specification -- Part 5: Basic Image Interchange Format (BIIF): this is a wide range standard for georeferenced and georeferenceable imagery. However its implementation is mostly for Defence and US governmental purposes, and its flexibility is beyond more recent technologies, making it not net-enabled.
- **Geospatial enabled PDF** (e.g. GeoPDF™ for which a Best Practise document has been published by OGC, or the Adobe's proposed geospatial extensions to ISO 32000) is another candidate option for the publication of geospatial data: however no recommendation may be given in the present context as no official standard is available and both formats are widely implemented.

Other standards such as netCDF may also be considered for geospatial imagery, as well as HDF-5 as a data container for imagery or scientific data.

Non geospatial imagery standards may also be used for the encodings of image or any raster (or elevation grids); the use of such standards requires associated geospatial metadata files including geo-reference information:

- **PNG** (pronounced "ping") - Portable Network Graphics (ISO/IEC 15948:2004): enables a lossless compressed computer graphics image in indexed-color, grey-scale, or true-color images, with optional transparency.
- **JPEG** (ISO/IEC 10918-4:1999): enables a lossy compressed computer graphics image in indexed-color, grey-scale, or true-color images, without any transparency.
- **JPEG2000** (ISO/IEC 15444-1:2016): enables a lossless, near-lossless or lossy compressed computer graphics image in indexed-color, grey-scale, or true-color images, with optional transparency. A proprietary specification GeoJP2™ provides a georeferencing capability (so a Geo-enabled JPEG2000) based on GeoTIFF tags in a JPEG2000 uuid box. GeoJP2™ is a trademark of Mapping Science, Inc., an ESRI Business Partner.
- **TIFF**: uncompressed data, LZW and JPEG2000 compressions are allowed by TIFF, but create some interoperability issues.

High-resolution Digital Elevation Models (DEMs) collected by InSAR and LIDAR are currently being encoded using GeoTIFF format; however the allowed compressions are not efficient and the transfer, manipulation and storage of the files are not optimized. This can make exploitation difficult in some cases (e.g. transfer of huge files on low bandwidth connections).

There are types of imagery data that are not yet supported by standard civilian encodings (though GeoTIFF and GMLJP2 provide such capabilities). This is the Terrain Elevation Model (wide use of proprietary formats), soundings (more generally, case for MTI, coverages based on a point geometry) and more generally coverages (even if some candidate solutions emerges from OGC, e.g. GMLJP2).

LIDAR elevation point clouds are commonly encoded in LAS Format Specification, developed by the ASPRS, which has now become an OGC Community standard in its version 1.4 (OGC # 17-030r1).

4.3.5.2. Defence

The **following standardised military standards are recommended for imagery and gridded data** in order to ensure interoperability in military context:

- **DGIWG GeoTIFF profile: legacy standard for georeferenced imagery and gridded data.** DGIWG has published a standardised profile for orthoimagery, raster maps and elevation data. No compression is allowed by this profile. No DGIWG product specification is available. A report named Report GeoTIFF.doc and produced by Lantmäteriet (SWE) is available on DGIWG portal.
- **DGIWG GMLJP2 profile: emergent standard for georeferenced imagery and gridded data** (georeferenceable extension under development). DGIWG has published a standardised profile for orthoimagery, raster maps and elevation data based on version 1 of OGC GMLJP2 standard, A version 2.0 based on OGC GMLJP2 v2.0.1 and the version 2.1 based on OGC GMLJP2 v2.1 which also allows for the Referenceable imagery as made available by the Referenceable coverage extension by the OGC (OGC #16-083r2).
- **NSIF (STANAG 4545): standard for georeferenceable and georeferenced imagery and gridded data:** the NATO Secondary Imagery Format (NSIF) is a profile of BIIF, for georeferenced and georeferenceable imagery. This encoding is mostly used in NATO for JISR communities, and by USA and a few other nations for geographic products. The aim of STANAG 4545 is to promote interoperability for the exchange of Electronic Secondary Imagery among NATO C3I Systems. NSIF is the standard for formatting digital imagery and imagery-related products and exchanging them among members of NATO intelligence communities.

For elevation data, the nations are commonly using GeoTIFF. DGIWG has provided an “**ESM encoding rules**” standard, associated to ESM standard, with **GeoTIFF, GMLJP2 and NSIF encoding rules annexes**. DGIWG also provides the DGED product specification (for Elevation data grids).

Other identified requirements for elevation data are presently addressed or have been identified:

- encoding annex for **TIN data**: GML has a TIN encoding capability, as well as CityGML (as it uses GML for the encoding of urban models in its CityGML:DTM:TIN Relief) as InfraGML Part 1: Land Features, in its LandFeature::LandSurface element. An ESM encoding annex for TINs is acknowledged as a **future work item**, when OGC will provide a Coverage Application Schema including TIN model (and the nations are able to bring resource on this requirement);
- encoding annex for **HDF-5 format** (as in S-102 developed by IHO): this is acknowledged as a potential **future work item**, when the nations are able to bring resource on this requirement;
- point cloud: DGIWG nations have identified the need for standardisation of Point Cloud data in a questionnaire on Requirements held in spring 2016, for data generated by Light Detection and Ranging (LIDAR) systems; this should be independent from instrument and provide processed point cloud data and metadata ready for exploitation. The scoping of such an action would need clarification.

At the time of publication of this version of the roadmap, these requirements are under consideration by DGIWG nations and NATO, and awaiting SME and lead nation to be pushed as DGIWG requirements for assessment.

The NATO GIRD elevation session on elevation held in April 2016 provided its results (a GIRD elevation model). DGED provides answers to requirements for Gridded Elevation at levels 0 to 5+³. The GIRD session also identified an interest in elevation point cloud data and urban 3D models for highest resolution levels.

The use of legacy encodings and the transition to a new generation of encodings based on open civil technologies need to be analysed in order to ensure a smooth and coordinated transition.

Note: Imagery in the context of this roadmap covers geospatial still imagery (as opposed to motion imagery). Depending of the evolution of the scope of the imagery roadmap, motion imagery encoding such as MPEG-2 would have to be considered. For now, motion imagery is addressed by JCGISR and the STANAG 4609 Custodian group.

4.3.6. Raster, Orthoimagery, SAR and elevation products

The following legacy standardised products are available:

- “Legacy raster DIGEST” products **ASRP** (STANAG 4387) or **USRP** (STANAG 7077, now cancelled), developed by DGIWG, mostly used for color-coded products respectively in ARC or UTM/UPS projections. These STANAGs are sun-setting (or retired for USRP).
- **CADRG** (STANAG 7098): Compressed (with Vector Quantization compression) ARC Digitized Raster Graphics (for raster maps), in Raster Product Format (RPF, which is NITF 2.0). This is a standard with compression and color-space limitations.
- **CIB** (STANAG 7099): Controlled Image Base, standard mosaicked imagery product, also in RPF.
- **DTED** (STANAG 3809) for Digital Terrain Elevation data, with level 0, 1 and 2 products specifications, limited to levels below or equal to 2, with limited embedded metadata.

The following additional products are used in the USA, all of them being encoded in NITF/NSIF:

- **ECRG** (Enhanced Compressed Raster Graphics, MIL-PRF-32283, dated 2/21/2008): compressed (with JPEG2000 compression) graphics (for raster maps), with a data content similar to CADRG.

³ As defined in ESM standard (cf. Table 4), based on NATO MC 0296/2, NATO Geospatial Policy, IMSTAM (GE0)-0001-2010 (SD3)

- **ECIB** (Enhanced Controlled Image Base, MIL-PRF-32466, dated 6/26/2013): compressed (with JPEG2000 compression) orthoimagery, with a data content similar to CIB.
- **HRE1.1** (High Resolution Elevation products, NGA.IP.0002_1.1, dated June 2014): uncompressed (or compressed in JPEG2000-lossless) elevation data, aligned with ESM specification.
- **Synthetic Aperture Radar (SAR)** published US standardisation documents for Sensor Independent Complex Data (SICD) specifies the content of complex image data products generated by SAR systems and their data processing elements. Currently, only NITF/NSIF encoding is allowed for SICD products. Also newly published are the US Sensor Independent Derived Data (SIDD) standards, which are designed to store SAR-derived image products and their associated metadata. The SIDD standard provides specifications for common tasks that are designed to support basic exploitation, geographic measurements, and proper visual display. Allowed file formats for SIDD datasets are NITF/NSIF and GeoTIFF.

Note: ECRG/ECIB files are physically formatted within a NITF 2.1 file. JPEG 2000 compression is employed at a 20:1 ratio for ECRG. Metadata for both products includes DIGEST Geospatial Support Data Extensions (GeoSDEs), and schema documents.

HRE1.1 specification is currently in production in the USA. NGA support for the DTED product will continue during a transition period, but NGA has advised NATO of its intention to phase out DTED and discontinue support for it after 2020.

Defence Gridded Elevation Data Product Implementation Profile (DGED) for a “**High resolution elevation products specification**”, is addressing levels 0 to 5 as specified in NATO Geospatial policy, with 11 levels specified in DGED from Level 0 to 9 (12.5 cm) .

The DGIWG P2.03 project for a raster maps / graphics product specification in replacement of ASRP and CADRG standards started in fall 2017 and the specification has been published in June 2020.

The IHO standard for **bathymetric data is S-102 Bathymetric Surface Product Specification (BAG)**. Bathymetric Attributed Grid (BAG) has been proposed by UK-HO and approved by NATO as the solution for the Network Model Bathymetry (NMB) category of the AML products (Additional Military Layer). Edition 2.0 has been published in October 2019.

4.3.7. Imagery and gridded data web services

OGC Web Coverage Service 2.0 (WCS2.0) and its set of extension is the emergent web service for Imagery and Gridded data.

DGIWG Defence Profile of OGC Web Coverage Service 2.0 has been published in November 2017.

OGC had a project (that stopped in 2008) for an Imagery Georeference Web Service (IGS) for accurate georeference of sensor images. This might be a future DGIWG requirement to consider.

Please refer to DGIWG web services roadmap for further web services consideration.

5. Technology considerations

Technology issues for imagery and gridded data are related to:

- Imagery and gridded data encoding, addressed below;
- Imagery and gridded data metadata (see metadata roadmap);
- Imagery Sensor geopositioning model: an emergent issue, addressed below;
- Imagery and gridded data web services (see services roadmap) and Sensor Web Enablement services.

5.1. Existing

As mentioned above, existing technologies for Imagery and gridded data encoding are:

- TIFF/GeoTIFF (allowing some compressed data such as JPEG), with a size limit of 4 Gb.
- JPEG2000 (JP2 format), including the GeoJP2™ (GeoTIFF Box in JPEG2000) specification or GMLJP2 for Geo-enablement.
- BIIF / NSIF, which provide a JPEG2000 compression capability, by the inclusion of the raw JPEG2000 codestream (compressed data from the JPEG2000 codec).
- Other non-Geo-enabled imagery standards such as PNG, JPEG and TIFF, or commercial Geo-enabled PDF for the publication of geospatial data.
- SensorML 2.0 for Geopositioning imagery sensor models and other Sensor models.
- O&M 2.0 (and OMXML) for the encoding of imagery and gridded data observations.

5.2. Emerging

Emergent technologies for imagery and gridded data encoding are:

- GMLJP2 2.1 for Georeferenced and Georeferenceable imagery.
- SensorML 2.1 for Geopositioning imagery sensor models and other sensor models.
- O&M 2.0 (and OMXML) for the encoding of imagery and gridded data observations.
- SensorThings API for IoT devices that may be imagery sensors.

5.3. Research and development activities

Research and development activities of imagery georeference services are a topic of interest for DGIWG.

6. Geospatial information - future state

6.1. Target objectives

The overall architecture of geospatial imagery information interchange in the defence community should support interoperable access and exploitation between nations for standalone or non-networked applications, and should progressively be extended to support network-enabled architectures.

The imagery standardisation coordinated DGIWG effort aims at:

- develop a defence community reference model dealing with imagery, but not an imagery specific model, i.e. extending a geospatial reference model to address imagery; this reference model must make use of general geospatial standards from ISO and OGC;
- coordinate with national (e.g. GWG), NATO, IHO, OGC and ISO TC 211 initiatives related to geospatial imagery;
- provide the defence community with a minimum suite of standards and resources with:
 - maximum use of general geospatial standards, resources and guidance,
 - imagery extensions when appropriate.

To ensure interoperability for imagery and gridded data between DGIWG nations, the following components may be required:

1. Defence community reference model for imagery and gridded data, based on:
 - a. the Coverage model (ISO 19123) and OGC GMLCOV implementation schema, as well as the Referenceable extension for GMLCOV (CIS 1.0), using SensorML for the encoding of the Sensor or Transformation model,
 - b. an Observation & Measurements model for IGD observations, for which ISO 19156 is a candidate standard to be assessed, and OMXML is a candidate encoding, and
 - c. Sensor geopositioning models, for which ISO 19130 is a candidate standard to be assessed, and SensorML is a candidate encoding.
2. General purpose encodings for imagery and gridded data, such as GeoTIFF, GMLJP2 and NSIF, and GMLJP2 2.0.1 as the emergent standard based on the efficient JPEG2000 compression. A GMLJP2 2.1 version is about to be sent for OGC ballot, handling Referenceable imagery.
3. Raster, Orthoimagery and Elevation Product standards for Defence, based on DGIWG standardised encodings and DGIWG metadata specifications (DMF).
4. General purpose web services for Coverage data access, such as WCS2.0, with the DGIWG profile developed by the Web Service Panel.
5. General purpose web services for Observation data access, such as SOS2.0.
6. Web processing services for Imagery and Gridded data, encapsulated under the OGC WPS2.0 (Web Processing Service) or WCPS (Web Coverage Processing Service) or any other service that would emerge, including an Imagery Georeference service.

The present situation of DGIWG existing standards and on-going works covers component items 1-a, 2, 3 (for elevation, raster and orthoimagery products), 4 and 5.

6.2. Geospatial content

(Same content as identified in 4.2)

In addition to this content, an extension for the harmonized geospatial model envisioned by the OGC COMC project is being considered.

6.3. Geospatial services

As identified in 6.1, the required geospatial web services for imagery and gridded data are:

1. General purpose web services for Coverage data access, such as WCS2.0, with the DGIWG profile developed by the Web Service Panel.
2. General purpose web services for Observation data access, such as SOS2.0.
3. Web processing services, may be encapsulated under the OGC WPS2.0 (Web Processing Service), including an Imagery Georeference service.

In addition to these, a registry service is required to be able to publish and maintain imagery and gridded data resources such as standardised encodings and standardised IGD products (and versions), in addition to the metadata resources (including quality description).

6.4. Standardisation initiatives

This clause addresses standards and standardisation documents that are available for use to address existing deficiencies, or future needs. Included are recommendations to amend, revise, or create a standard.

6.4.1. Civil standards

6.4.1.1. ISO IGD standards

On-going ISO TC211 IGD works are:

- 19123-1: revision of ISO 19123, project for the revision of **19123 – Coverage standard**;
- and possibly consider a **Web Coverage Service**⁴.

A DGIWG watch on JPEG2000 standard is necessary, though there is no such formal action. An action on an ISO Geo-enabled JPEG2000 profile would be recommended.

6.4.1.2. OGC IGD projects

On-going OGC IGD works directly connected to DGIWG IGD standards and works are:

- **GeoTIFF revision**: IGD Technical Panel is participating to these works. DGIWG P2 agrees to coordinate with OGC to promote the revision of GeoTIFF (starting with an identification of deficiencies for ESM and DGED in GeoTIFF).
- **Point cloud DWG**: DGIWG P2 panel has sent a contribution to the OGC questionnaire in 2016.
- **Perspective Imagery DWG**: DGIWG P2 panel has an interest on these works.

6.4.2. Defence standards

1. After the publication of DGIWG GMLJP2 v2 profile based on OGC GMLJP2 2.0.1, there is an emergent version 2.1 handling georeferenceable imagery, therefore using **GMLJP2 2.1 for both georectified and georeferenceable imagery**. This second version does not include an extension for annotations, as the requirement for annotation has been cancelled by USA and IMWG.
2. A DGIWG product specifications should be developed for **orthoimagery**. This is the aim of the **Defence Orthoimagery Product (DOP) Implementation Profile**.
3. **NGIF / DGIF** and nations should consider the requirement to integrate imagery and gridded data standards within the DGIWG Geospatial Information Framework (DGIF), in order to harmonize the interface to the geospatial services, for example for elevation data which may be under gridded or vector data, or METOC data.

⁴ Ideally based on OGC's WCS 2.0.1

7. Program plan

7.1. IGD Technical Panel (P2)

The IGD Technical Panel Team (previously named T01 project) coordinates IGD activities within DGIWG and ensures coordination with civilian standardisation bodies and military customers regarding Imagery and Gridded data.

Its aims are:

- To maintain (annual revision) this document, the DGIWG IGD Roadmap,
- To coordinate, contribute to, and support military requirements within the civilian standardisation activities related to geospatial IGD through the DGIWG liaison with ISO/TC 211 and OGC, as identified in 6.4.1.
- To coordinate and provide support to DGIWG projects regarding IGD aspects. This coordination is a two way process:
 - This roadmap must take advantage of the work of the various DGIWG project teams that are addressing IGD issues; and
 - The activities in these project teams must also align with this roadmap.
- To provide support and ensure a coordination regarding standardisation activities undertaken by other sectorial bodies (e.g. IHO, WMO) or other defence organisations (e.g. MGCP, NATO (JISR, JGSWG (GIR Team), etc.)).
- To maintain existing DGIWG IGD standards, presently GeoTIFF and GMLJP2 profiles as general encodings for IGD, and ESM and DGED standards for elevation/bathymetry.
- Follow-up of ISO/IEC JTC1/SC29 (JPEG2000 Committee): evolution of JPEG2000 standards.
- To determine and manage the requirements for IGD standards.
- To provide IGD best practices, guidelines, samples for the use by the military community.

7.1.1. Project P2.03 (DRP): Raster map / graphics products implementation profile standard

This project started in October 2017 and focused on developing a standard that would address current and emerging requirements for raster maps products, and subsequently serve as a replacement for the CADRG and ASRP specifications covered by STANAG 7098 and STANAG 4387 respectively.

The U.S. MIL-PRF-32283 (ECRG) was submitted as a candidate replacement specification, and was assessed as part of a questionnaire on raster map requirements to member nations in late 2017. Feedback from the questionnaire provided the information to properly scope the project and identify its requirements.

The standard, DGIWG 254: Defence Raster Product (DRP) Implementation Profile, was completed and published in June 2020. The project remains open until sample data sets have been created and validated.

7.1.2. Project P2.04 (DOP): Orthoimagery products implementation profile standard

This project started in February 2020. Requirements on Orthoimagery products, in replacement of STANAG for orthoimagery (STANAG 7099: CIB - Controlled Imagery Base).

The US MIL-PRF-32466 (ECIB) has been submitted as candidate input specification.

A questionnaire action to nations (in Spring 2020) has provided the material for scoping this project and identify its requirements.

This standard is scheduled to be submitted for ballot in fall 2020.

7.1.3. Project P2.05: Sensor Web Enablement (SWE) profiles for Defence

The aim of this project is to identify OGC Sensor Web Enablement standards for endorsement and provide guidance in order to address existing limitations in discoverability, accessibility, comprehensibility, trustworthiness, security, and interoperability for sensor information and observation data, across the range of computing environments for intelligence, surveillance, and reconnaissance (ISR) applications. Capabilities required are access and exploitation of geopositioned tactical sensor data through OGC SWE standards.

The deadline for the last deliverable (Guidance document in support of draft STANAG 4789) is mid-2021.

This project is in support of NATO ISR/MASINT.

7.2. Other potential Requirements for future projects

- Requirements on Point Clouds for data handling and exploitation. U.S. NGA has provided the SIPC (Sensor Independent Point Cloud) specification for information (available at https://portal.dgiwg.org/files/?artifact_id=11768&version=1 and https://portal.dgiwg.org/files/?artifact_id=11769&version=1)
- Integration with Motion imagery.
- DSMs such as Textured TINs or Textured meshes to represent terrain or urban scenes: In Germany, BGIC expressed some interest (though not in a situation to contribute any DGIWG project), and has an internal project on this topic, for which "Indexed 3D Scene Layers" (I3S) is considered as a candidate standard of interest. Canada and France also expressed an interest.
- Automated analytics on Geo Big Data and its impacts on DGIWG standards (e.g. Cloud optimized GeoTIFF, DGGS). One example is calculate and expose a quality rating for a resource (e.g. based on a 5 stars scale), which might apply to elevation models in order to identify and exploit the best data available to end users.

8. Dependencies

DGIWG IGD works must take into account current and upcoming works regarding IGD within civilian standardisation bodies as ISO and OGC, as well as metadata works within the Defence community (Metadata Panel and NATO).

DGIWG Imagery and Gridded data will be dependent on DGIWG metadata constraints.

DGIWG IGD Application schemas will be dependent on DGIWG Namespace rules and the availability of DGIWG standardised schemas.

Annex A - Abbreviations (Informative)

AML	Additional Military Layers
ARC	Equal Arc-second Raster Chart
ASPRS	American Society for Photogrammetry and Remote Sensing
ASRP	ARC Standard Raster Product
BAG	Bathymetric Attributed Grid
BIIF	Basic Image Interchange Format
CADRG	Compressed ARC Digitized Raster Graphics
C3I	C ommand, C ontrol, C ommunications, and I ntelligence
CIB	Controlled Image Base
CSM	Community Sensor Model
DEM	Digital Elevation Model
DGED	Defence Gridded Elevation Data
DRP	Defence Raster Product
DGIF	Defence Geospatial Information Framework
DGIWG	Defence Geospatial Information Working Group
DIGEST	Digital Geographic Information Exchange Standard
DTED	Digital Terrain Elevation Data
ECIB	Enhanced Controlled Image Base
ECRG	Enhanced Compressed Raster Graphic
ESM	Elevation Surface Model
GEOINT	Geospatial Intelligence
GML	Geography Markup Language
GMLJP2	GML in JPEG 2000
GMTIF	Ground Moving Target Imagery Format
GMWG	Geospatial Maritime Working Group
GWG	Geospatial Intelligence Standards Working Group
HDF	Hierarchical Data Format
HRE	High Resolution Elevation
InSAR	Interferometric Synthetic Aperture Radar
IGD	Imagery and Gridded Data
IHO	International Hydrographic Organization
IMWG	Imagery Working Group
ISO	International Organization for Standardization
ISR	Intelligence, Surveillance and Reconnaissance
JCGISR	Joint Capability Group on Intelligence Surveillance and Reconnaissance
JGSWG	Joint Geospatial Standards Working Group
JP2K	JPEG 2000
JPEG	Joint Photographic Experts Group
JPIP	JPEG 2000 Interactive Protocol
JPX	JPEG 2000 Extended File format

KLV	Key-Length-Value
MGCP	Multinational Geospatial Co-Production Program
MISB	Motion Imagery Standards Board
MPEG	Motion Picture Experts Group
MTI	Moving Target Indicator
netCDF	Network Common Data Form
NGIF	NATO Geospatial Information Framework
NITF	National Imagery Transmission Format
NMB	Network Model Bathymetry
NPIF	NATO Primary Image Format
NSIF	NATO Secondary Imagery Format
NSILI	NATO Standard ISR Library Interface
OGC	Open Geospatial Consortium
PNG	Portable Network Graphics
SAR	Synthetic Aperture Radar
SICD	Sensor Independent Complex Data
SIDD	Sensor Independent Derived Data
STANAG	Standardization Agreement
SWE	Sensor Web Enablement
TC	Technical Committee
TEM	Terrain Elevation Model
TIFF	Tagged Image File Format
TIN	Triangulated Irregular Network
TREx	TanDEM-X High Resolution Elevation Data Exchange
TS	Technical Specification
USRP	UTM/UPS Standard Raster Product
UML	Unified Modeling Language
UTM	Universal Transverse Mercator
WCS	Web Coverage Service
WG	Working Group
XML	eXtensible Markup Language

Annex B - Summary of activities (Informative)

Standardisation activity			Action ⁵	Description	Status
Identifier	Name	Date			
DGIWG-108	DGIWG GeoTIFF profile Version 2.3.1	2020.07.07	Combat ready	DGIWG GeoTIFF Profile for Georeferenced Imagery and Gridded data	Closed (<i>project A11</i>)
DGIWG-104	DGIWG GMLJP2 profile	2014.02.04	Combat ready	DGIWG Profile of JPEG2000 for Georeferenced Imagery	Closed
DGIWG-104(2)	DGIWG GMLJP2 profile – version 2.1	2020-01-23	Test and evaluate	DGIWG GMLJP2 Profile of JPEG2000 for Geospatial Imagery – version 2.1 (based on OGC GMLJP2 2.1) (including Georeferenceable and Georeferenced imagery)	Closed (published)
DGIWG-16-1	Elevation Surface Model (ESM) – version 1.1	2017.10.19	Combat ready	Elevation Surface Model (ESM) – ESM Core model and metadata NB: ESM UML models available (EAP file)	Closed
DGIWG-116-2	Elevation Surface Model (ESM): GML Application Schema - version 1.0.1	2016.08.01	Test and evaluate	ESM GML Application Schema for ESM Coverage or ESM Point set	Closed
DGIWG-116-3	Elevation Surface Model (ESM): Encoding Rules - version 1.0	2014.10.02	Combat ready	ESM Encoding Rules (only in GeoTIFF)	Closed
DGIWG-116-3 Ed. 1.1	Elevation Surface Model (ESM): Encoding Rules - extensions (GMLJP2, NSIF) (P2-02) – version 1.1	2017.12.21	Combat ready (GeoTIFF and NSIF)	ESM Encoding Rules (including GeoTIFF, GMLJP2 and NSIF) 4 parts : Core + GeoTIFF, GMLJP2, NSIF	Closed
DGIWG-250	Defence Gridded Elevation Products Implementation Profile (P2-01) – version 1.1	2017.12.21	Test and evaluate + combat ready for level 3	DGIWG High resolution Elevation Products specification	Closed (published)
DGIWG-254	Defence Raster Product Implementation Profile	2020-06-12	Test and evaluate	DGIWG Raster Products specification	Open (published)

⁵ Action is 1) assess, 2) develop, 3) modify, 4) test and evaluate, 5) combat ready, 6) fade, 7) cancel (retire)

Annex C - Activity details (Informative)

DGIWG GeoTIFF profile

Standard	DGIWG - 108	
Name	GeoTIFF Profile for Georeferenced Imagery and Gridded data	
Abbreviated Name	DGIWG GeoTIFF profile	
Edition	2.3.1	
Edition date	2020-07-07	
Responsible party	P2	
Abstract	TIFF/GeoTIFF encoding for Georeferenced Imagery and Gridded data	
Capability <i>(Overview of capability, addresses what is needed and why, who needs it, when is it needed.)</i>	Raster, Georeferenced Imagery and elevation encoding	
Capability assessment	Start: 2008-04	End:
Develop (or modify if applicable)	Start: 2008-04	End: 2019-12-15
Test and evaluation	Start: 2009-04	End:
Test and evaluation results	Fall 2009	
Implementation (operational) period	Start: 2010-04	End:
Fade	Start:	End:
Cancellation (or retire) date		
Superseded by		
Supersedes	DGIWG GeoTIFF profile (previous versions)	
Additional guidance	GeoTIFF report (SWE) https://portal.dgiwg.org/files/?artifact_id=5994	
Dependencies	DMF 1.0.1 (for metadata) or DMF 2.0	

DGIWG GMLJP2 profile

Standard	DGIWG - 104 + 104(2)	
Name	GMLJP2 Profile for Georeferenced Imagery and Gridded data (DGIWG - 104) GMLJP2 Profile for Georeferenced and Referenceable Imagery and Gridded data (DGIWG – 104(2.1))	
Abbreviated Name	DGIWG GMLJP2 profile	
Edition	1.0 + 2.1.1	
Edition date	2014-02-04 + + 2020-01-23	
Responsible party	P2	
Abstract	GMLJP2 encoding for Georeferenced Imagery and Gridded data	
Capability <i>(Overview of capability, addresses what is needed and why, who needs it, when is it needed.)</i>	Raster, Georeferenced Imagery and elevation encoding	
Capability assessment	Start: 2010-04 (JPEG2000 Scoping study)	End:
Develop (or modify if applicable)	Start: 2012-01	End: 2019-12-15
Test and evaluation	Start: 2014-02	End:
Test and evaluation results	2013-06 (Baseline)	
Implementation (operational) period	Start: Baseline only (2014)	End:
Fade	Start:	End:
Cancellation (or retire) date		
Superseded by		
Supersedes		
Additional guidance		
Dependencies	DMF	

DGIWG ESM profile (Model and Metadata)

Standard	DGIWG – 116-1	
Name	Elevation Surface Model	
Abbreviated Name	ESM	
Edition	1.1	
Edition date	2017-10-19	
Responsible party	D32, P2	
Abstract	Elevation Surface Model (ESM) – ESM Core model and metadata	
Capability <i>(Overview of capability, addresses what is needed and why, who needs it, when is it needed.)</i>	elevation model (with associated metadata) for Digital Terrain or Surface Model	
Capability assessment	Start: 2009-04	End:
Develop (or modify if applicable)	Start: 2009-10	End: 2017-10-19
Test and evaluation	Start: 2013-06	End:
Test and evaluation results		
Implementation (operational) period	Start:	End:
Fade	Start:	End:
Cancellation (or retire) date		
Superseded by		
Supersedes		
Additional guidance	Corrigendum v1.1.1 under publication Oct. 2020 (terminology + DGIWG standards architecture updates)	
Dependencies	DMF 2.0 DMF 1.0 (DMF 1.0.1 to be used instead) for version 1.0.1	

DGIWG ESM GML application Schema (Coverage and Point set data)

Standard	DGIWG – 116-2	
Name	Elevation Surface Model GML Application schema	
Abbreviated Name	ESM GML AS	
Edition	1.0.1	
Edition date	2016-08-01	
Responsible party	P2, D32	
Abstract	Elevation Surface Model (ESM) – GML Application schema	
Capability <i>(Overview of capability, addresses what is needed and why, who needs it, when is it needed.)</i>	elevation model (Grid or Point Coverage or Point sets or clouds) for Digital Terrain or Surface Model	
Capability assessment	Start: 2013-04	End:
Develop (or modify if applicable)	Start: 2013-10	End: 2016-08-01
Test and evaluation	Start: 2014-10	End:
Test and evaluation results		
Implementation (operational) period	Start:	End:
Fade	Start:	End:
Cancellation (or retire) date		
Superseded by		
Supersedes		
Additional guidance	Corrigendum v1.0.2 under publication Oct. 2020 (terminology + DGIWG standards architecture updates)	
Dependencies		

DGIWG ESM Encoding rules (Coverage and Point set data, GeoTIFF, GMLJP2 and NSIF in present version 1.1)

Standard	DGIWG – 116-3, Parts 1-4	
Name	Elevation Surface Model – Encoding Rules	
Abbreviated Name	ESM ER	
Edition	1.1	
Edition date	2017-05-18	
Responsible party	P2, D32	
Abstract	Elevation Surface Model (ESM) – Encoding Rules	
Capability <i>(Overview of capability, addresses what is needed and why, who needs it, when is it needed.)</i>	elevation model (Grid Coverage) for Digital Terrain or Surface Model – GeoTIFF encoding + GMLJP2 and NSIF encodings in Edition 1.1	
Capability assessment	Start: 2013-04	End:
Develop (or modify if applicable)	Start: 2013-10	End: 2017-05-18
Test and evaluation	Start: 2014-10	End:
Test and evaluation results		
Implementation (operational) period	Start:	End:
Fade	Start:	End:
Cancellation (or retire) date		
Superseded by		
Supersedes		
Additional guidance	Corrigendum v1.1.1 under publication Oct. 2020 (terminology + DGIWG standards architecture updates)	
Dependencies	DMF, DGIWG GeoTIFF profile, DGIWG GMLJP2 profile version 1 or 2	

DGIWG Gridded Elevation Data (Product Implementation Profile / DPS)

Standard	DGIWG – 250	
Name	DGIWG Gridded Elevation Data	
Abbreviated Name	DGED	
Edition	1.2	
Edition date	2018-05-03	
Responsible party	P2.01	
Abstract	DGIWG Gridded Elevation Data – Product Implementation Profile / DPS	
Capability <i>(Overview of capability, addresses what is needed and why, who needs it, when is it needed.)</i>	Grid coverage elevation model (RectifiedGrid Coverage) for Digital Terrain or Surface Model – GeoTIFF, or GMLJP2 (lossless) or NITF/NSIF encoding	
Capability assessment	Start: 2014-10	End:
Develop (or modify if applicable)	Start: 2015-05	End:
Test and evaluation	Start: 2016-05	End:
Test and evaluation results		
Implementation (operational) period	Start:	End:
Fade	Start:	End:
Cancellation (or retire) date		
Superseded by		
Supersedes		
Additional guidance	Corrigendum v1.2.1 under publication Oct. 2020 (terminology + DGIWG standards architecture updates)	
Dependencies	DMF 2.0 Note (DMF 1.0.1 in version 1.0.1)	

Defence Raster Product (Implementation Profile / DPS)

Standard	DGIWG – 256	
Name	Defence Raster Product	
Abbreviated Name	DRP	
Edition	1.0	
Edition date	2020-06-12	
Responsible party	P2.03	
Abstract	Defence Raster Product –Implementation Profile / DPS	
Capability <i>(Overview of capability, addresses what is needed and why, who needs it, when is it needed.)</i>	Grid coverage model (RectifiedGrid Coverage) for Raster maps – GeoTIFF, or GMLJP2 or NITF/NSIF encoding	
Capability assessment	Start: 2019-03	End:
Develop (or modify if applicable)	Start: 2019-04	End:
Test and evaluation	Start: 2020-06	End:
Test and evaluation results		
Implementation (operational) period	Start:	End:
Fade	Start:	End:
Cancellation (or retire) date		
Superseded by		
Supersedes		
Additional guidance		
Dependencies	DMF 2.0	