DGIWG 124
Defence Profile of OGC's Web Map Tile Service 1.0

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Abstract:	This document is a profile of OGC 07-057r7, v.1.0.0, dated 2010-04-06. It defines specific Defence requirements, recommendations and guidelines for implementations of a Web Map Tile Service.
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Executive Summary

This document defines specific DGIWG requirements, recommendations and guidelines for implementations of a Web Map Tile Service (WMTS) based on the Open Geospatial Consortium (OGC) OpenGIS® Web Map Tile Service Implementation Standard version 1.0.0. As an Interoperability Standard, it provides detailed direction on how to use the clauses, options, and parameters of the base standard(s). This guidance is designed to be specific enough for any two independent and compliant software implementations to 'plug and play' with each other.

The OGC WMTS specification was developed to improve the performance of a Web Map Service by enabling pre-cached tiles at defined set scales.

The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance to the underlying OGC WMTS specification, are summarised in the OGC Compliance Testing Policies and Procedures on the OGC Compliance Testing web site[1].

To ensure the ability of implementing this profile, existing constraints among submitting organizations and vendors have been taken into account, in order to distinguish between requirements, recommendations and future work directions. Requirements include both extensions/restrictions of the OGC WMTS base standard and system requirements in order to enable interoperability by appropriate configuration of existing software. System requirements are intended to be applied in the design of systems requiring services compliant to this profile. Requirements are associated with conformance tests which provide guidelines for testing the compliance of implementations.

The WMTS interface offers three Operations:

- GetCapabilities (mandatory): Allows for obtaining Service Metadata
- GetTile (mandatory): Returns a map tile
- GetFeatureInfo (optional): Provides additional information about features in the pictures of maps that were returned by previous GetTile requests

A DGIWG Server Software implementation that claims to be conformant with the DGIWG WMTS standard **shall** support **all mandatory operations, parameters**, and **elements** as defined in this document.

The DGIWG WMTS profile **references** the different **operations** and **parameters** of the base **OGC WMTS** standard and subsequently defines specific **DGIWG requirements** and **recommendations** for software implimentations to foster interoperability and use in the military domain.

www.opengeospatial.org/cite

i. Submitting organisations

For the Defence Geospatial Information Working Group (DGIWG):

Nation	Parent organisations
France	Institut Géographique National (IGN)
Germany	Bundeswehr Geoinformation Centre (BGIC)
Sweden	Defence Materiel Administration
United Kingdom	Defence Science and Technology Laboratory (DSTL) Joint Forces Intelligence Group (JFIG)
United States	National Geospatial-Intelligence Agency (NGA)

ii. Contributing participants

Note: Due to the complexity of this document, it was necessary to seek the guidance of individual agencies to reach out to a wider community.

Nation	Parent organizations
Finland	National Land Survey of Finland
New Zealand	GEOINT New Zealand, New Zealand Defence Force (NZDF)
NATO	Joint Warfare Centre

1. Introduction

This document defines specific DGIWG requirements, recommendations and guidelines for implementations of the OGC Web Map Tiled Service (WMTS) standard which is based on the OGC Web Map Tile Service Implementation Specification (document number OGC 07-057r7), version 1.0.0, dated 2010-04-06. This DGIWG profile should be followed in its entirety to enable interoperability in a coalition environment.

The goal of providing a WMTS enabled service is to be performance-oriented and scalable. Therefore, servers must be able to return tiles quickly. A good way to achieve this is to use locally stored pre-rendered tiles that will not require any image manipulation or geo-processing. Server developers will decide if pre-rendered tiles will be generated in a previous tile-preparation process or generated on-the-fly utilizing a caching mechanism. With tile-based mapping it is important that the server will be able to handle asynchronous access to tiles as most clients will simultaneously query for multiple tiles to fill a single view.

The purpose of a WMTS service is to serve maps divided in individual tiles. The WMTS interface allows a client to receive three types of resources either in response to a resource request in the resource oriented architectural style or in response to an operation in the procedure oriented architectural style. Those resources and operations are:

- **GetCapabilities** (mandatory): Allows for obtaining Service Metadata.
- **GetTile** (mandatory): Returns a map tile.
- **GetFeatureInfo** (optional): Provides additional information about features in the pictures of maps that were returned by previous GetTile requests.

A traditional Web Map Service (WMS) creates maps dynamically based on the end users area of interest. However, the dynamic nature of these services can often slow performance especially in low bandwidth environments. The OGC Web Map Tile Service (OGC WMTS) specification was developed to improve this performance by enabling pre-cached tiles at set scales to be called by the system when required. To enable the full effect of this performance WMTS services require large volumes of data to be pre-cached at set scale bands. However, if the end user wishes to display services using different projections or scales, then the provider either has to generate a new cache or the system has to convert the data on the fly. To minimise the burden on the data manager or system it is important that a single projection and scale set is decided upon. This may create a number of problems which are summarised below:

1.1 Projection

Traditionally geospatially enabled systems have utilised unprojected geographically referenced data as it is processed. However, this produces an asymmetric distortation which increases towards the poles; resulting in positional inaccuracies. To improve the end user experience the web based commercial sector developed the Web Mercator projection, which is a simplified form of the World Mercator projection. Both the Mercator and Web Mercator projections provide an improved user experience by replacing the asymmetric distortion by a symmetric distortion towards the poles. In simplifying the mathematical equations, the Web Mercator projection introduced additional small distortions (no more than 0.5%) because it does not preserve the linear scale. Because of this, this projection is not suitable for use cases that require accuracy such as navigation or targeting. The Mercator projection provides the best near-global view, but is not suitable for polar regions, where the Universal Polar Stereographic projection is best suited.

1.2 Well Known Scale Sets (WKSS)

WKSS are the predefined scale bands utilised by GIS services and systems to improve performance by only displaying the data relevant to the scale being viewed. The WMTS service utilises these WKSS to display tiled data. However, often geospatial systems are unable to perform the complex calculations required to display tiled data using different WKSS. This means that the systems are unable to display tiled data created using different scales on screen at the same time. To avoid this problem, it is important to agree on a common combination of a coordinate reference system and a set of scales for a tile matrix set. By providing data based on agreed WKSS, clients can easily overlay WMTS tiles from different services.

The issues summarised above make it essential to agree projection and WKSS to make sharing tiled raster data and interoperability in a coalition environment possible, as the OGC WMTS specification does provide not sufficient guidance. DGIWG has created this profile to provide additional clarity and guidance for implementing the OGC WMTS specification to enable interoperability in the coalition environment. However, this profile also recognises that organisations may need to utilise different configurations of the WMTS such as different projections or WKSS to meet specific operational requirements.

The following table summarises the various use cases for this profile.

Table 1: Use Cases

ID	Name	Use case	How to use DGIWG Profile
Use Case 1	National \Organisational	An organisation has a specific operational requirement to use a WMTS to disseminate tiled raster data using a local projection and WKSS.	This profile SHALL be used as guidance for implementing a WMTS. In this instance the profile should be followed and only changed to meet operational requirements.
Use case 2	Coalition	Operations where a WMTS is required to share tiled raster data with coalition partners.	This profile SHALL be followed in its entirety.

2. Scope

This version is an evolution of the previous version 1.0 of the DGIWG profile from October 2017, also referenced by STANAG 6523 Ed.1 (AGeoP26 Ed.A). This version 2.0 has been produced alongside the harmonization work done by the STANAG 6523 CST team, which lead to produce one single profile for WMS (and also one from WMTS) from the DGIWG profile and the SIP – Map for rendering services. Requirements from STANAG 6523 Ed.2 (AGeoP-26, conformance class “View Services”) and requirements from this document (conformance class “DGIWG Basic WMTS”) are strictly identical. This document provides nevertheless additional guidance.

This version 2.0 of the DGIWG WMTS profile is not backward compatible with the version 1.0. Some requirements have been clarified or deleted, but some new have been created, only from a harmonization perspective (with the WMS profile). Details are provided in Annex D.

The OGC WMTS Implementation Specification defines two conformance classes, “Basic WMTS” and “Queryable WMTS”. The Basic WMTS supports the mandatory GetCapabilities and GetTile operations (requests and responses) whereas the Queryable WMTS supports all Basic WMTS operations and the GetFeatureInfo operation.

The DGIWG WMTS profile mandates the implementation of the OGC **Basic WMTS** but also provides for implementation of the optional OGC **Queryable WMTS** This document is divided into two parts based on conformance classes related to

- the mandatory DGIWG Basic WMTS (see 7 DGIWG Basic WMTS profile)
- and to the optional DGIWG Queryable WMTS (see section 8 DGIWG Queryable WMTS profile).

Software implementations that claim to be conformant with the DGIWG WMTS profile SHALL support the OGC WMTS 1.0 specification, as per normative reference [1] of this document.

The DGIWG WMTS profile is written in such a way that it references the different operations and parameters of the base standard and then defines specific requirements for software implementation.

3. Conformance

3.1 Conformance classes

This document establishes two conformance classes for the DGIWG WMTS profile:

1. DGIWG Basic WMTS (mandatory)
2. DGIWG Queryable WMTS, which extends the DGIWG basic WMTS.

Annex A lists the conformance abstract tests which shall be exercised on any software artefact claiming to implement a DGIWG WMTS profile.

DGIWG WMTS Profile conformance class defines requirements for WMTS servers allowing distribution of geographic data in a military environment.

Table 2: DGIWG WMTS Profile conformance class in a military environment

Conformance class name	**Operation or behavior**	**OGC WMTS Conformance Test**	**DGIWG WMTS Conformance Test**
OGC WMTS	The server shall implement the OGC WMTS standard Requirement 1	A.2.1 OGC WMTS	
DGIWG Basic WMTS (URI) http://www.dgiwg.org/std/wmts/1.0/conf/basic	**DGIWG requirements** **Error! Reference source not found.**DGIWG Basic WMTS Profile (normative) Requirement 2 to Requirement 17		A.2.2 DGIWG basic WMTS specific tests
DGIWG Queryable WMTS (URI) http://www.dgiwg.org/std/wmts/1.0/conf/queryable	**DGIWG requirements** DGIWG Queryable WMTS (normative) All requirements from DGIWG Basic WMTS and Requirement 18 to Requirement 22		A.3 Server test Module (Queryable DGIWG WMTS)

4. Normative and Informative References

4.1 Normative References

Normative references in this standard are identified in Table 1.

Table 3: Normative References in WMTS interoperability Standard

ID	Title	Reference	Version
[1]	OpenGIS® Web Map Tile Service Implementation Standard	OGC 07-057r7	1.0.0
[2]	OGC Two Dimensional Tile Matrix Set and Tile Set Metadata	OGC 17-083r4	2.0
[3]	NATO Communications and Information Agency, Instr Tech 06.02.06, “Service Interface Profile for Messaging”, R. Fiske, M. https://portal.dgiwg.org/files/?artifact_id=74437	[NCIA AITech 06.02.06, 2012]	1.0

4.2 Informative References

The documents listed in Table 4 contain useful information to augment understanding and application of the material in this interoperability standard in conjunction with the actual standard profiled.

Table 4: Informative References in the DGIWG WMTS Interoperability Standard

Title	Reference	Version
OGC WMTS Simple Profile	OGC 13-082r2,	NA
Revision to Axis Order Policy and Recommendations	OGC 08-038r7,	NA
Technical Guidance for the Implementation of INSPIRE View Services Version 3.0	Implementing INSPIREView Services Version 3.0 21/03/2011: Section 5	3.0
Geographic information — Profiles	ISO 19106:2004(E)	1
Key Words for use in RFCs to Indicate Requirement Levels	IETF RFC 2119, S. Bradner, Harvard University, March 1997	1
OpenGIS® Reference Model	OGC 03-040	1.3
Geospatial Digital Rights Management Reference Model (GeoDRM RM)	OGC 06-004r4	1.0
National Geospatial-Intelligence Agency (NGA) Standardization Document Implementation Practice - Map Projections for Tiled Raster Graphics, 24 April 2015	NGA.SIG.0014_1.0_PROJRAS	1.0

Title	Reference	Version
Specifies many of the aspects that are, or should be, common to all or multiple OGC Web Service (OWS) interface Implementation Standards.	OGC Web Service Common Implementation Specification, Version 2.0.0, OGC 06-121r9, Date: 2010-04-07	2.0
DGIWG Metadata Foundation Version 2.0	DGIWG 114	2.0
GML Simple Features Profile that specifies restricted subset of simple geometry types.	Implementation Practice Web Mercator Map Projection	
W3C SOAP Version 1.2 Part 1: Messaging Framework, W3C Recommendation, Date 2003-06-24	W3C SOAP Version 1.2 Part 1	1.2
W3C SOAP 1.2 Attachment Feature, W3C Working Group Note, Date 2004-06-08	W3C SOAP 1.2 Attachment Feature	1.2

NOTE: Implementers of the DGIWG WMTS 1.0 Profile should verify all Reference documents for latest edition against the holdings found under http://www.dgiwg.org/dgiwg/htm/documents/documents.htm; Open Geospatial Consortium (OGC) documents are located at http://www.opengeospatial.org/standards and the NSG Standards Registry of Documents.

5. Terms, Definitions and abbreviations

5.1 Terms and Definitions

For the purposes of this document, terms and definitions found in **ref [1]** apply.

5.2 Abbreviations

Abbreviation associated with this document only.

CRS	Coordinate Reference System
DGIWG	Defence Geospatrial Information Working Group
EPSG	European Petroleum Survey Group
GIS	Geographic Information System
GML	Geographic Markup Language
HTTP	HyperText Markup Language
IC	Intelligence Community
ISO	International Organization for Standardization
JPEG	Joint Photographic Experts Group
KVP	Key-Value Pair
NAS	NSG Application Schema
NATO	North Atlantic Treaty Organisation
NFDD	NSG Feature Data Dictionary
NSG	National System for Geospatial-Intelligence
OGC	Open Geospatial Consortium
OWS	OGC Web Services
PNG	Portable Network Graphics (Image Format)
REST	Representational State Transfer
SLD	Styled Layer Descriptor
SOAP	Simple Object Access Protocol
TC	Technical Committee
UML	Unified Modelling Language
UPS	Universal Polar Stereographic
URL	Uniform Resource Locator
WGS 84	World Geodetic System 1984
WKSS	Well Known Scale Sets
WMS	Web Map Service
WMTS	Web Map Tile Service
XML	Extensible Markup Language

6. Compliance

A WMTS that complies with this standard shall

a) satisfy all requirements stipulated in the OGC WMTS 1.0.0 Specification; and

b) satisfy all requirements stipulated in this document.

This profile provides advice on the implementation of the WMTS so that tests can be provided to ensure objective compliance to the profile. The profile provides a “Normative Clause” to describe how each component shall be implemented. The Normative Clause defines requirements where mandatory compliance is required for attainment of conformance. However, the profile also includes optional recommendations that may require a subjective test.

The following syntax is used to indicate the compliance requirement within the profile:

- **Mandatory** (**M**) – The requirement shall be implemented
- **Conditional** (**C**) – Mandatory when “If” statement applies
- **Optional** (**O**) – Should be implemented

Note: All Requirements and Recommendations presented within this document are the result of information gathered during the DGIWG Nations questionnaire/survey process.

7. DGIWG Basic WMTS profile

7.1 Normative Requirements

The Normative requirements (mandatory) for a DGIWG WMTS 1.0 Basic server implementation as required by this profile are summarized in Table 5. Numbering is sequential and linked to the specific Requirement number as defined within this document.

Table 5: DGIWG Basic WMTS Profile Normative Requirements

No.	DGIWG Requirement	Compliance
1	A WMTS server shall be compliant to OGC WMTS 1.0.	M
2	A WMTS Server shall support HTTP GET operation using KVP (clause 8 of OGC WMTS) and RESTful (clause 10 of OGC WMTS 1.0) encodings.	M
3	A WMTS server shall support at least one of the folowwing WKSS: see DGIWG ANNEX B.1 (EPSG:3395), B.2 (EPSG:4326 and CRS 84) and B.3 (UPS Tiles EPSG:5041 and EPSG:5042).	M
4	A WMTS server shall provide tiles in at least one of the following raster formats: - image/png (Portable Network Graphics), OR - image/gif (Graphics Interchange Format), OR - image/jpeg (Joint Photographics Expert Group).	M
5	If a WMTS server is providing services to a coalition mission federated network, in support of operations or an exercise, it shall provide a minimum keyword list at the service level (“ServiceIdentification” section) , based on ISO 19115 Topic Categories. It's recommended to provide additional details based on the DGIF groups. The provision of these keywords elements is optional for a WMTS server which is providing services across one single non-mission network.	C
6	A WMTS server shall provide the service exceptions in the English language. Exception text content may also be provided in additional languages, but English must always be included.	M
7	A WMTS server shall provide an "Abstract" at the service level, in the GetCapabilities response document.	M
8	If a WMTS server is providing services to a coalition mission federated network, in support of operations or an exercise, it shall provide "ServiceContact", "AccessConstraints" and "Keywords" elements at the service level (“ServiceIdentification” section). The provision of these metadata elements is optional for a WMTS server which is providing services across one single non-mission network.	C
9	A WMTS server SHALL use the <AccessContraints> element to hold the classification information for this web service instance."	M
10	If a WMTS server is providing services to a coalition mission federated network, in support of operations or an exercise, it shall include the following information in the <abstract> element of the service metadata: "This service implements the WMTS 1.0 STANAG 6523 Ed.2 profile". The provision of these metadata elements is optional for a WMTS server which is providing services across one single non-mission network.	C
11	A RESTful WMTS server shall provide tile expiration date, in an appropriate HTTP header ("Expires" header in HTTP 1.0, "Cache-control" header for HTTP 1.1 and for HTTP 2).	M

No.	DGIWG Requirement	Compliance
12	A WMTS server shall provide the service metadata document (GetCapabilities response or ServiceMetadata resource document) and the featureInfo document (if supported, GetFeatureInfo response or FeatureInfo resource document) in the English language. Metadata content may also be provided in additional languages, but English must always be included.	M
13	A WMTS server shall provide a <title> element for each supported style.	M
14	Each layer's style shall have an associated legend (using the <legendURL >element) if the data being provisioned is symbolized/portrayed (i.e. not imagery).	C
15	Legends shall be available as an image in at least one of the following formats: PNG (image/png), GIF (image/gif) or JPEG (image/jpeg).	M
16	If legend is present (see req 14), the <LegendURL> element shall specify a URL to allow access to an image of the legend.	C
17	If a WMTS server offers its functionality via the SOAP protocol, it shall do so in compliance with the Messaging Service SIP [NCIA TR/2012/SPW008000/30, 2012] which defines general requirements that apply to all services in the NNEC environment that make use of SOAP.	C

7.2 Non-Normative Recommendations for Implementation

The non-normative requirements requested by this profile are summarized in Table 6

Table 6: DGIWG WMTS Profile Non-normative Recommendations

No.	Category	Recommendation	Compliance
1	SOAP Encodings	A DGIWG WMTS server should support SOAP encodings, if required.	O
2	MIME Type	If a service requires feature coordinate information, it is recommended that FeatureInfo documents be offered in the MIME type format “application/gml+xml; version=3.2”.	O
3	Order of Variables and Values in URL Template	Any possible order of the variables and values in the URL template is valid. Nevertheless, recommend the following order: style, firstDimension, ..., lastDimension, TileMatrixSet, TileMatrix, TileRow, TileCol, J and I.	O
4	Themes	It is recommended that the themes section of a WMTS service metadata document contain data about how layers are organized thematically. [Normative Reference 1, P.28]	O
5	Profile	A WMTS server should identify the profile it supports by adding the corresponding URI in a <Profile> element (<Profile>http://www.dgiwg.org/std/wmts/2.0/conf/basic</Profile> or <Profile>http://www.dgiwg.org/std/wmts/2.0/conf/queryable</Profile>).	O

7.3 Service Structure

The goal of providing a WMTS enabled service is to be performance oriented and scalable. Therefore, servers must be able to return tiles quickly. A good way to achieve this is to use locally stored pre-rendered tiles that will not require any image manipulation or geo-processing. Server developers will decide if pre-rendered tiles will be generated in a previous tile-preparation process or generated on the fly utilizing a caching mechanism. With tile-based mapping it is important that the server will be able to handle asynchronous access to tiles as most clients will simultaneously query for multiple tiles to fill a single view. The purpose of a WMTS service is to serve maps divided in individual tiles.

The WMTS interface allows a client to receive three types of resources either in response to a resource request in the resource oriented architectural style or in response to an operation in the procedure oriented architectural style. Those resources and operations are:

a) A **ServiceMetadata** resource (in response to a GetCapabilities operation for the procedure oriented architectural style) (required implementation by servers) – It describes the abilities and information holdings of the specific server implementation. In procedure oriented architectural style this operation also supports negotiation of the standard version being used for client-server interactions.

b) A **tile** resource (in response to a GetTile operation for the procedure oriented architectural style) (required implementation by servers) – It shows a fragment of a map representation of a layer.

c) A **FeatureInfo** resource (in response to a GetFeatureInfo operation for the procedure oriented architectural style) (required implementation by servers) – It provides information about the features located at a particular pixel of a tile map, in a similar way to the WMTS GetFeatureInfo operation, by providing, for example, the thematic attribute name and value pairs in textual form

7.4 Service Type

Requirement 1: A WMTS server shall be compliant to OGC WMTS 1.0.

According to this requirement a DGIWG WMTS server shall support the GetCapabilities and GetTile operations. This requirement ensures compatibility with the base standard.

7.5 Architectural Styles

OGC's WMTS Implementation Standard defines a standardised approach to declaring the images which a client can request from a server, enabling a single type of client to be developed for all servers. The standard specifies two different architectural styles, a procedure oriented architectural style and a resource oriented architectural style. For the former architectural style, there are several exchange mechanisms between clients and servers identified, including messages encoded using KVP, XML messages, or XML messages embedded in SOAP envelopes. The standard also defines the request mechanisms and endpoint publishing strategy to enable a resource oriented architectural style based on web based URL endpoints allowing clients to simply request resources as documents.

Requirement 2: A WMTS Server shall support HTTP GET operation using KVP (clause 8 of OGC WMTS) and RESTful (clause 10 of OGC WMTS 1.0) encodings.

According to this requirement, a DGIWG WMTS server SHALL support the resource oriented architectural style with REST and KVP encodings.

NOTE 1: The intent of DGIWG Requirement 1, and DGIWG Recommendation 1 (see section 7.2. Recommendations for Implementation), is to increase interoperability opportunities with DGIWG WMTS servers. However, based upon the operational requirements for a specific system, a program may elect to reduce the number of supported architectural patterns/interfaces. It is anticipated that operational requirements such as increased security may drive optional implementations to adopt different security measures especially those enabled by SOAP encodings.

Requirement 17: If a WMTS server offers its functionality via the SOAP protocol, it shall do so in compliance with the Messaging Service SIP [NCIA TR/2012/SPW008000/30, 2012] which defines general requirements that apply to all services in the NNEC environment that make use of SOAP.

7.5.1 GetCapabilities

In response to a valid request for a ServiceMetadata representation from a client, a DGIWG WMTS server will generate a document that conforms to the example described in section 7.1.1.3 of [Normative Reference **1**]

Requirement 7: A WMTS server shall provide an "Abstract" at the service level, in the in the GetCapabilities response document.

Requirement 8: If a WMTS server is providing services to a coalition mission federated network, in support of operations or an exercise, it shall provide "ServiceContact", "AccessConstraints" and "KeywordList" elements at the service level (“ServiceIdentification” section). The provision of these metadata elements are optional for a WMTS server which is providing services across one single non-mission network.

Requirement 9: A WMTS server SHALL use the <AccessContraints> element to hold the classification information for this web service instance."

Requirement 10: If a WMTS server is providing services to a coalition mission federated network, in support of operations or an exercise, it shall include the following information in the <abstract> element of the service metadata: "This service implements the WMTS 1.0 STANAG 6523 Ed.2 profile". The provision of these metadata elements are optional for a WMTS server which is providing services across one single non-mission network.

Requirement 13: A WMTS server shall provide a <title> element for each supported style.

Requirement 14: Each layer's style shall have an associated legend (using the <legendURL >element) if the data being provisioned is symbolized/portrayed (i.e. not imagery).

Requirement 15: Legends shall be available as an image in at least one of the following formats: PNG (image/png), GIF (image/gif) or JPEG (image/jpeg).

Requirement 16: If legend is present (see req 14), the <LegendURL> element shall specify a URL to allow access to an image of the legend.

Note: This URL will relate to the source system and may not be resolvable on all connected/unconnected systems or applications. This requirement is conditional on the <LegendURL> being relevant to the generated service.

7.5.2 GetTile Request

DGIWG WMTS servers SHALL support KVP requests for representations of image tiles by declaring support for and correctly handling GetTile requests. The tile resource representation

shall be returned in the format specified in the request when the format has been advertised in the ServiceMetadata document as available for that tile resource.

The ServiceMetadata document contains a list of Layer elements and each layer that is available to be retrieved shall have one or more <ResourceURL> elements with the "resourceType" attribute set to "tile" and a template attribute. The template attribute contains a URL template that can be converted to a URL by applying the rules shown in [Normative Reference 1, Table 32], URL template variables and possible values for tile. A standard HTTP GET is used to request the tile in the format specified by the attribute "format" as shown in [Normative Reference 1, Table 31, Parts of the URL Template data structure for tiles. P.62]

7.6 Well Known Scale Sets

Requirement 3: A WMTS server shall support at least one of the folowwing WKSS: see ANNEX B.1 (EPSG:3395), B.2 (EPSG:4326 and CRS 84) and B.3 (UPS Tiles EPSG:5041 and EPSG:5042).

NOTE: The WMTS user is expected to decide what WMTS layer and CRS is appropriate for the scale, location and precision of the operations using the WMTS.

The list of map projections and their tiling schemes for global coverage is given in Table 7

Table 7: Common Tilematrix sets for Global Coverage

Tiled Projection Identifier	Map Projection	EPSG Code	Bounding Box	Zoom Levels	Description
WorldMercatorWGS84Quad	World Mercator	3395	Square	0 to 24	Mercator between +/- 85.05 degrees
World EPSG:4326 Quad	N/A	4326	Rectangular	1 to 24	-90 to 90; 180 to -180
UPSArcticWGS84 Quad	UPS North	5041	Square	0 to 24	UPS centred on North Pole
UPSAntarcticWGS 84Quad	UPS South	5042	Square	0 to 24	UPS centred on South Pole

NOTE: Web Mercator is a de facto standard used for web mapping applications. It is used by virtually all major online map providers, including Google Maps, Bing Maps, OpenStreetMap, Mapquest, Esri, Mapbox, and others. If using WMTS map data from a Volunteered Geographic Information (VGI) or commodity data source which is in the Web Mercator projection, it is highly recommended that your service warns users that this data is suitable for visualization use cases only and cannot be combined with other WMTS datasets as positioning will be different.

For a use case that requires precise locations and precise navigation (land, air, and sea) the World Mercator projection is mandated.

7.7 Tile File Formats

Requirement 4: A WMTS server shall provide tiles in at least one of the following raster formats:

- **image/png (Portable Network Graphics)**
- **image/gif (Graphics Interchange Format)**
- **image/jpeg (Joint Photographics Expert Group).**

Formats vary in utility to support thematic mapping, image quality, and transparency. Servers shall provide .png, .jpeg, and .gif to support varying utility and requirements. The png image format is recommended where transparency is needed. The jpeg image format is recommended where image quality is needed and transparency is not required. Since a GetTile operation can serve only one tile at a time, clients should have the ability to support transparency and also be able to overlap tiles from the same geographical area.

NOTE: Users should be aware that only the output formats GIF and PNG support transparency.

7.8 Negotiation of Standard Version

The GetCapabilities operation includes a version-negotiation mechanism, allowing the client and server to agree on a standard version on which to base all future communication. The information below is an excerpt from [Normative Reference 1, Table 17], which describes the “accept Versions” parameter in the GetCapabilities operation request.

Table 8: Accept Versions Parameter in GetCapabilities Operation Request

Names	Definition	Data type and values	Multiplicity and use
accept Versions Accept Versions	Prioritized sequence of one or more standard versions accepted by client, with preferred versions listed first	Sequence of Character String type, each not empty Value is list of x.y.z —version‖ values. SHALL contain "1.0.0"	Zero or one (optional) When omitted, return latest supported version

7.9 Keywords

Requirement 5: If a WMTS server is providing services to a coalition mission federated network, in support of operations or an exercise, it shall provide a minimum keyword list at the service level (“ServiceIdentification” section) based on ISO 19115 Topic Categories. It's recommended to provide additional details based on the DGIF groups.

The provision of these keywords elements are optional for a WMTS server which is providing services across one single non-mission network.

NOTE 1: Annex C presents ISO 19115 Topic Categories and DGIF groups

NOTE 2: Additional keywords may be added to the list as appropriate to support data discovery.

Zero or more Styles may be advertised for a Layer or collection of layers using <Style> elements, each of which shall have <Name> and <Title> elements.

- The style's **Name** is used in the Map request STYLES parameter.
- The **Title** is a human-readable string. If only a single style is available, that style is known as the “default” style and need not be advertised by the server.

7.10 Cacheable Resources

Requirement 11: A RESTful WMTS server shall provide tile expiration date, in an appropriate HTTP header ("Expires" header in HTTP 1.0, "Cache-control" header for HTTP 1.1 and for HTTP 2).

Provision of expiration information is important because it improves the efficiency of client caching thereby reducing the WMTS server load and ultimately reducing the load time for users. To enable efficient web caching, a DGIWG WMTS server shall include expiration date in the server responses.

Caching works by marking certain data as being needed to be updated at different intervals. For example, information on a 1:5,000,000 scale Joint Navigation Chart (JNC) is relatively static, and is unlikely to change from one month to the next. By caching the tiles associated with the JNC, the client is able to only download this information as needed, e.g., once a year. By the server telling the client to store these files and not download them when revisiting the geographic area, display performance is improved and network bandwidth is conserved. Conversely, for information that may change rapidly, such as weather data, the update interval may be set to expire in a very short timeframe, possibly on the order of minutes.

Internally caching this is achieved by means of the proper HTTP control headers:

- HTTP 1.0, uses the "Expires" header. This header indicates an expiration date. If your data is guaranteed to be static, or you know when the data is going to be updated, you can use a convenient future date in the Expires header.
- HTTP 1.1 and 2.0, uses the "Cache-control" header. This header indicates a period of time to cache the data before expiration. If your data is guaranteed to be static, or you know when the data is going to be updated, you can use a convenient period of time in the Cache-control header.

Client caching capabilities will vary greatly and should be designed around a number of considerations to include data latency, currency requirement, area of interest coverage requirements, storage capacity, and network connectivity.

7.11 Support of English language

Requirement 6: A WMTS server shall provide the service exceptions in the English language. Exception text content may also be provided in additional languages, but English must always be included.

Requirement 12: A WMTS server shall provide the service metadata document (GetCapabilities response or ServiceMetadata resource document) and the featureInfo

document (if supported, GetFeatureInfo response or FeatureInfo resource document) in the English language. Metadata content may also be provided in additional languages, but English must always be included.

7.12 Recommendations for Server Implementation

Recommendation 1: A DGIWG WMTS server should support SOAP encodings, if required.

Recommendation 2: If a service requires feature coordinate information, it is recommended that FeatureInfo documents be offered in the MIME type format "application/gml+xml; version=3.2".

Recommendation 3: The themes section of a DGIWG WMTS service metadata document should contain data about how layers are organized thematically.

In the Contents section of WMTS, layers are represented as a linear list without hierarchy, and a hierarchy of themes is specified separately in the themes section, removing the need to specify complex inheritance rules for layer properties. This separates both concepts and makes it easy for a client to ignore the theme hierarchy or even to force another layer organization. Also it allows servers to offer more than one layer organization (in more than one themes section).

Each theme has a human-readable description (i.e., a title) and a list of layer references and child themes. It is possible for a layer to be a member of more than one theme, and for a layer to exist without being a member of any theme.

The reference for designation of theme names is the Defence Geospatial Information Framework (DGIF), which are listed in Annex C of this standard. Appropriate theme names are to be determined at the schema package bundle level, i.e., Transportation, or at the Schema Package level, i.e., Inland Water Transportation and Associated Features, Railways and Associated Features, etc.

8. DGIWG Queryable WMTS profile

8.1 Normative Requirements

The Normative requirements requested by this conformance class are summarized inTable 9

Table 9: DGIWG Queryable WMTS Normative Server Requirements

No.	Requirement	Compliance
18	A DGIWG Queryable WMTS server shall be compliant to the DGIWG WMTS Basic and the Queryable WMTS conformance classes.	M
19	A DGIWG Queryable WMTS server shall support text/xml and text/html as output format for the GetFeatureInfo operation.	M
20	A DGIWG WMTS server shall include the following information in the abstract element of the service metadata: “This service implements the DGIWG WMTS profile version 1.0, DGIWG Queryable WMTS conformance class (URI) (http://www.dgiwg.org/std/wmts/2.0/conf/queryable).”	M
21	A DGIWG WMTS server SHALL implement HTTP GET transfer of the GetFeatureInfo operation request using KVP encoding	M
22	A DGIWG WMTS server SHALL provide standard endpoints from which representation of the FeatureInfo resources can be obtained. [Normative Reference 1 P.49]	M

8.2 Service Type

According to this profile, a Queryable WMTS includes all Basic WMTS operations and an additional GetFeatureInfo operation.

Requirement 18: A DGIWG Queryable WMTS server shall be compliant to the Basic WMTS and Queryable WMTS conformance classes.

8.3 Basic Service elements

8.3.1 Output Formats

The response to a Web Map Tile Service request is always a computer file. The file may contain text, or the file may represent a map image depending on the operation. For the particular operations a DGIWG WMTS server shall support the following output formats.

8.3.2 Output formats for GetFeatureInfo requests

The response to a GetFeatureInfo request is always a text file.

Requirement 19: A DGIWG Queryable WMTS server shall support text/xml and text/html as output format for the GetFeatureInfo operation.

8.4 Operations

8.4.1 GetCapabilities Operation Response

Requirement 20: A DGIWG WMTS server shall include the following information in the abstract element of the service metadata: "This service implements the DGIWG WMTS 1.0 profile version 2.0, DGIWG Queryable WMTS conformance class* (URI) (http://www.dgiwg.org/std/wmts/2.0/conf/queryable)*."

NOTE: this requirement replaces the WMTS Basic requirement that advertises for support of the DGIWG Basic conformance class.

8.5 GetFeatureInfo Request

Requirement 21: A DGIWG WMTS server SHALL implement HTTP GET transfer of the GetFeatureInfo operation request using KVP encoding.

KVP encoding of the GetFeatureInfo operation request shall follow the requirement for operation parameters specified in Table **10** below and that follows the abstract description specified in [Normative Reference 1, Table **25**].

Table 10: GetFeatureInfo operation request URL parameters

ID	Request Parameter	OGC Mandatory/Optional	DGIWG Mandatory/Optional	Definition and Format
1	Service=WMTS	M	M	Service type identifier
2	Request=GetFeature Info	M	M	Operation name
3	Version=1.0.0	M	M	Standard and schema version for this operation
4	Layer	O use of these parameters SHALL match those in the corresponding GetTile request described in [Table **29,** Normative Reference 1]	M	Layer Identifier
5	Style	O	M	Style Layer Identifier
6	Format	O	M	Output format of File
7	Sample dimensions[a]	O	M	Value allowed for this dimension
8	TileMatrixSet	O	M	Value allowed for this dimension
9	TileMatrix	O	M	TileMatrix identifier
10	TileRow	O	M	Row index of the Matrix

ID	Request Parameter	OGC Mandatory/Optional	DGIWG Mandatory/Optional	Definition and Format
11	TileCol	O	M	Column index of the Matrix
12	J	M	M	Row index of a pixel in the tile
13	I	M	M	Column index of a pixel in the tile
14	InfoFormat	M	M	Output format of the retrieved information
a Names for this parameter SHALL be the names indicated in the ServiceMetadata document as described in Normative Reference 1 . Typical examples are Time, Elevation, and Band				

Requirement 22: A DGIWG WMTS server SHALL provide standard endpoints from which representation of the FeatureInfo resources can be obtained. [Normative Reference 1 P.49]

The ServiceMetadata document contains a list of Layer Elements and each layer that is available to be retrieved and is queryable shall have on or more <ResourceURL> elements with the “resourceType” attribute set to “FeatureInfo” and a template attribute. The template attribute contains a URL template that can be converted to a URL by using a template processor. The FeatureInfo is obtained in the format specified by the attribute “format” by requesting the resource with a standard HTTP GET. **P.65**

9. Client Requirements and Recommendations

This section describes the normative requirements for client implementations of the DGIWG Profile

Table 11: Normative WMTS Client Requirements

No.	Category	Modifier	DGIWG Client Requirement	Compliance
1	Architectural Patterns/Encoding	N/A	A DGIWG WMTS client shall support REST	M
2	GetCapabilities	KVP	A DGIWG WMTS client shall support a GetCapabilities operation by sending a GET or POST HTTP message with the “request” parameter set to “GetCapabilities.	M
3		SOAP	A DGIWG WMTS client shall be capable of issuing SOAP encoded GetCapabilities operation requests.	C
4		REST	A DGIWG WMTS client shall issue a GetResourceRepresentation request to access a Service Metadata document by requesting a file using the URL.	M
5	GetTile	KVP	A DGIWG WMTS client shall support KVP encoding of the GetTile operation request using parameters specified in Normative Reference 1, Table 29 (GetTile operation request URL parameters).	M
6		SOAP	A DGIWG WMTS client shall support SOAP encoding using HTTP POST transfer of the GetTile operation request, using SOAP 1.2.	C
7		REST	A DGIWG WMTS client shall request a tile representation using a tile URL.	M
8	GetFeatureInfo	KVP	A DGIWG WMTS client shall provide the capability to obtain more information for a pixel (I,J) on a particular tile by using data parameters as specified in Normative Reference 1, Figure 11 and Table 25. Only if implementing a Queryable WMTS	C
9		SOAP	A DGIWG WMTS client shall provide the capability to obtain more information for a pixel (I, J) on a particular tile by SOAP encoding the GetFeatureInfo request.	C
10		REST	A DGIWG WMTS client shall have the capability to query those layers with one or more <ResourceURL> elements with the “resourceType” attribute set to “FeatureInfo” and a template attribute. Only if implementing a Queryable WMTS	C

No.	Category	Modifier	DGIWG Client Requirement	Compliance
11	Coordinate Reference systems	N/A	A DGIWG WMTS client shall support the following coordinate reference systems: • CRS:84 WGS84 geographic longitude, then latitude, expressed in decimal degrees • EPSG:4326 WGS84 geographic latitude, then longitude, expressed in decimal degrees	M
12	Projections	N/A	A DGIWG WMTS client shall support the following projections whose validity zones overlap data published by the service: • World Mercator Projection… EPSG:3395 • UPS projection over WGS84 (north zone)…… EPSG:5041 • UPS projection over WGS84 (south zone)…… EPSG:5042	M
13	Well-Known Scale Sets	N/A	A DGIWG WMTS client shall support the Well-Known Scale Sets identified in Annex B	M
14	Tile Formats	N/A	A DGIWG WMTS client shall support image/png, image/jpeg, and image/gif file formats.	M
15	Negotiation of Standard Version	SOAP	A DGIWG WMTS client shall support negotiation of the standard version used for client-server interactions.	C
16	Key Word List	N/A	A DGIWG WMTS server SHALL have a minimum keyword list based on the Defence Geospatial Information Framework (DGIF) Groupings	M
17	Metadata	N/A	A DGIWG WMTS server SHALL provide all service metadata elements based upon the DGIWG Metadata Foundation (DMF) v2.0.	M
18	Cacheable Resources	N/A	A DGIWG WMTS client shall support caching information (expiration date) for the data.	M
19	Output Format (GetFeatureInfo)	N/A	A DGIWG WMTS client shall support the GetFeatureInfo output format in text/XML and text/HTML. Only if implementing a Queryable WMTS	C

Table 12: Non-normative WMTS Client recommendations

No.	Recommendation	Compliance
1	A DGIWG WMTS client should be able to display legends also for raster layers	O

	representing numeric data like for instance elevation or temperature data.	
2	A DGIWG WMTS client should provide a link to the metadata resource via a resolvable URL for example to a CSW server.	O
3	A DGIWG WMTS client should be able to connect to, display and overlay multiple services at the same time.	O
4	A DGIWG WMTS client should have the ability to support transparency. (Client support of transparency is important to be able to overlay tiles on top of other map data for the same geographical area).	O

Annex A
DGIWG
AbstractTest Suite
(Normative)

A.1 Introduction

This abstract test suite specifies at a high level how server and client implementations of this standard SHALL be tested for conformance to this standard. The framework for such abstract test suites is specified in ISO 19105: Geographic information – Conformance and testing, especially Clauses 7 and 9.

An abstract test suite contains multiple abstract tests, grouped into one or more test modules. This abstract test suite consists of two top-level test modules:

a) Server test module – Abstract tests for checking conformance of server implementations with the requirements of this standard that are normatively referenced by this Implementation Specification.

b) Client test module – Abstract tests for checking conformance of client implementations with the requirements of this standard that are normatively referenced by this Implementation Specification.

Any of these modules could contain lower-level test modules. At this time, only the Server test module contains lower-level test modules, namely:

a) All operations implemented test module – Abstract tests for checking server properties that are common to all operations implemented.

b) GetCapabilities, GetTile and GetFeatureInfo operation test module – Abstract tests for checking server properties that are specific to an operation.

In the client and server test modules, all operations specified and implemented SHALL be tested, including KVP HTTP GET, and SOAP HTTP POST transfer and RESTFul HTTP GET transfer of each operation request. In the standard test module, all operations specified SHALL be checked, including KVP HTTP GET, SOAP HTTP POST and RESTFul HTTP GET transfer of operation requests. And all operation request and response parameters specified or implemented SHALL be tested. Of course, some operations, transfer methods, and parameters are specified as optional implementation by servers. Any optional item not implemented by a server SHALL not be tested. Also, items not implemented by a client SHALL not be tested.

A.2 Server test module (DGIWG Basic WMTS)

A.2.1 Service type

a) Test Purpose:

Verify that a DGIWG WMTS server satisfies all requirements for an OGC WMTS conformance class (DGIWG Requirement 1)

b) Test Method:

Submit a GetCapabilities and a GetTile requests to the server and verify that it is providing proper responses.

c) References:

Clause 7.4

d) Test Type:

Capability

A.2.2 Architectural Styles

a) Test Purpose:

Verify that a server is capable of handling procedure-oriented architectural style through KVP encoding as well as Resource Oriented Architectural style through REST encoding.

Verify that when the server is capable of supporting SOAP, it is according to requirement 17.

b) Test Method:

This requirement is satisfied upon successful completion of testing for the following Requirements: 2, 17

Submit HTTP GET/KVP requests for each operation. Verify that the server accepts and responds to these requests as specified and implemented.

Request a Service metadata URL and other URL resources using correct and incorrect URLs. Verify that the server respond with the right resource to correct URLs, and a returns HTTP errors for invalid URLs.

For server supporting SOAP, verify corresponding requirements in the Messaging Service SIP [NCIA TR/2012/SPW008000/30, 2012]

c) Reference:

Clause 7.5

d) Test Type:

Capability

A.2.3 Getcapabilities

a) Test Purpose:

Verify that A DGIWG WMTS server satisfies all Service Metadata requirements for a GetCapabilities operation request (procedure oriented architectural style) or a

resource request (resource oriented architectural style) (Requirements 7, 8, 9, 10, 13, 14, 15 and 16).

b) Test Method:

Submit a GetCapabilities operation request (and access the Metadata ressource document) and verify that the response contains all the requirements elements with expected content.

c) Reference:

Clause 7.5.1

d) Test Type:

Capability

A.2.4 Well Known Scale Sets

a) Test Purpose:

Verify that a DGIWG WMTS server satisfies all the requirements for handling coordinate reference systems and WKSS (DGIWG Requirement 3).

b) Test Method:

1. Submit GetCapabilties request (and access the Metadata resource document) and verify that all supported coordinate reference systems and WKSS are advertised for all available data in the XML response (Capabilities document).
2. Submit GetTile requests (and acces the Tile resource document) and verify that tiles are provided in appropriate projections for each validity zone.

c) Reference:

Clause 7.6

d) Test Type:

Capability

A.2.5 Tile File Formats

a) Test Purpose:

Verify that A DGIWG WMTS server provides tiles in the required formats in accordance of Requirement 4.

b) Test Method:

Submit requests and verify that the server implements support for:

1. Submit a GetTile request (FORMAT = image/png) and access the tile resource document and verify that the returned tile is in image/png format.
2. Submit a GetTile request (FORMAT = image/gif) and access the tile resource document and verify that the returned tile is in image/gif format.
3. Submit a GetTile request (FORMAT = image/jpeg) and access the tile resource document and verify that the returned tile is in image/jped format.

c) Reference:

Clause 7.7

d) Test Type:

Capability

A.2.6 Keywords

a) Test Purpose:

Verify that a server satisfies the requirements about keywords (requirement 5).

b) Test Method:

Submit a GetCapabilities request (and access the Metadata resource document) and verify that the response implements the required keywords.

c) Reference:

Clause 7.9

d) Test Type:

Capability

A.2.7 Cacheable resources

a) Test Purpose:

Verify that a server provides caching information for the data.

b) Test Method:

Access Tile resource documents and verify that the response provides caching information for tile data returned by the server (requirement 11).

c) Reference:

Clause 7.10

d) Test Type:

Capability

A.2.8 Support of english

a) Test Purpose:

Verify that a server supports English language (requirements 6 and 12).

b) Test Method:

Submit GetCapabilites request (or access Metadata resource document) and verify that the content of the response is in English language.

Submit GetFeayureInfo request (or access FeatureInfo resource document) and verify that the content of the response is in English language.

Submit request generating expceptions and verify that responses are in English language.

c) Reference:

Clause 7.11

e) Test Type:

Capability

A.3 Server test module (Queryable WMTS)

A.3.1 Queryable WMTS

a) Test Purpose:

Verify that a DGIWG Queryable WMTS server satisfies all requirements for a DGIWG Basic WMTS (Requirements 1 to 17 = Requirement 18).

b) Test Method:

See Annex A.2

c) References:

N/A

d) **Test Type**:

Capability

A.3.2 GetFeateureInfo support

a) Test Purpose:

Verify that a server provides GetFeatureInfo in a text/XML or text/HTML format (requirements 19 and 21).

b) Test Method:

Submit a GetFeatureInfo request and verify that the response is in text/XML or text/HTML format

c) Reference:

Clause 8.3 and 8.5

d) Test Type:

Capability

A.3.3 GetCapabilities / Conformance declaration

a) Test Purpose:

Verify that A DGIWG Queryable WMTS interface satisfies requirement 20 by adding the correct text to the abstract in the GetCapabilities response.

b) Test Method:

Submit a GetCapabilities request and verify that the response in the Abstract element contains the following information: " shall include the following information in the abstract element of the service metadata: “This service implements the DGIWG WMTS profile version 2.0, DGIWG Queryable WMTS conformance class (URI) (http://www.dgiwg.org/std/wmts/2.0/conf/queryable).”

c) Reference:

Clause 8.5

d) Test Type:

Capability

A.3.4 Restfull support

a) Test Purpose:

Verify that a server satisfies requirement 22.

b) Test Method:

Verify that the server provides a Service Metadata document that includes complete ResourceURL information with resourceType=tile on Layer section if tiles of this layer are able for RESTful.

c) Reference:

Clause 8.5

d) Test Type:

Capability

Annex B
Well-known Scale Sets
(Normative)

Note: All WKSS defined here are designed to be used for 256 x 256 pixel tiles.

WKSS are defined by normative reference document [2], which provides Well Known Scales Sets and defines the corresponding Tile Matrix Sets and XML implementations.

B.1 World Mercator EPSG:3395[2]

Please note that this WKKS is equivalent to the OGC defined http://www.opengis.net/def/wkss/OGC/1.0/WorldMercatorWGS84 in OGC 17-083r4 (see https://docs.ogc.org/is/17-083r4/17-083r4.html#toc47).

It may be implemented by the following TMS http://www.opengis.net/def/tilematrixset/OGC/1.0/WorldMercatorWGS84Quad (see https://docs.ogc.org/is/17-083r4/17-083r4.html#toc51).

To be conformant to this well-known scale set, a WMTS server SHALL allow responses from the largest scale denominator in Table D.4 –from https://docs.ogc.org/is/17-083r4/17-083r4.html) and all intermediate scale denominators down to the most detailed scale resolution of that data. It is therefore not required to support the smallest scale denominator in order to be conformant to a well-known scale set.

The World Mercator (EPSG:3395) WMTS tile scheme has a square layout.

The projection bounds for the World Mercator raster tile pyramid are (-20037508.342789244, -20037508.342789244) to (20037508.342789244, 20037508.342789244) meters which yields the corresponding longitude, latitude limits of (-180, -85.084059) to (180, 85.084059)

The zoom level 0 tile covers the whole bounds of the projection which yields an area of 40,075,016.68557849 meters by 40,075,016.68557849 meters.

As referenced in Normative Reference [1], section 6.1. a) "The scale denominator is defined with respect to a 'standardized rendering pixel size' of 0.28 mm × 0.28 mm (millimeters) and the WGS84 equatorial earth circumference.

Two hundred fifty six (256) pixels in the horizontal dimension are defined to be 71.68 mm or 0.07168 meters. It represents 40,075,016.68557849 meters of Earth distance. Thus, the scale is 40,075,016.68557849 / 0.07168 or 559082264.0287178.

At zoom level 0, the pixel size in meters is 40,075,016.68557849 / 256 = 156543.033928041.

Scales and pixel sizes for the 3395 projection match the GoogleMapsCompatible scale set, even though the projections are different. The actual tile contents will also differ slightly.

[2] EPSG Geodetic Parameter Registry (http://www.epsg-registry.org/)

The zoom level scale set and matrix width and height for the World Mercator raster tile pyramid are listed below in Table 13.

Table 13: Zoom Level Scale Set and Matrix Dimensions-EPSG:3395

Zoom Level	Scale	Pixel Size (m)	*matrix_width*	*matrix_height*
0	559082264.028718	156543.033928041	1	1
1	279541132.014359	78271.5169640205	2	2
2	139770566.007179	39135.7584820103	4	4
3	69885283.0035897	19567.8792410051	8	8
4	34942641.5017949	9783.9396205026	16	16
5	17471320.7508974	4891.9698102513	32	32
6	8735660.37544872	2445.9849051256	64	64
7	4367830.18772436	1222.9924525628	128	128
8	2183915.09386218	611.4962262814	256	256
9	1091957.54693109	305.7481131407	512	512
10	545978.773465545	152.8740565704	1024	1024
11	272989.386732772	76.4370282852	2048	2048
12	136494.693366386	38.2185141426	4096	4096
13	68247.3466831931	19.1092570713	8192	8192
14	34123.6733415965	9.5546285356	16384	16384
15	17061.8366707983	4.7773142678	32768	32768
16	8530.9183353991	2.3886571339	65536	65536
17	4265.4591676996	1.194328567	131072	131072
18	2132.7295838498	0.5971642835	262144	262144
19	1066.3647919249	0.2985821417	524288	524288
20	533.1823959624	0.1492910709	1048576	1048576
21	266.5911979812	0.0746455354	2097152	2097152
22	133.2955989906	0.0373227677	4194304	4194304
23	66.6477994953	0.0186613839	8388608	8388608
24	33.3238997477	0.0093306919	16777216	16777216

All tiles are globally referenced based on the zoom level and (column, row) index values on the global World Mercator grid. Figure 1 below shows the (column, row) index values for zoom levels 0 through 3.

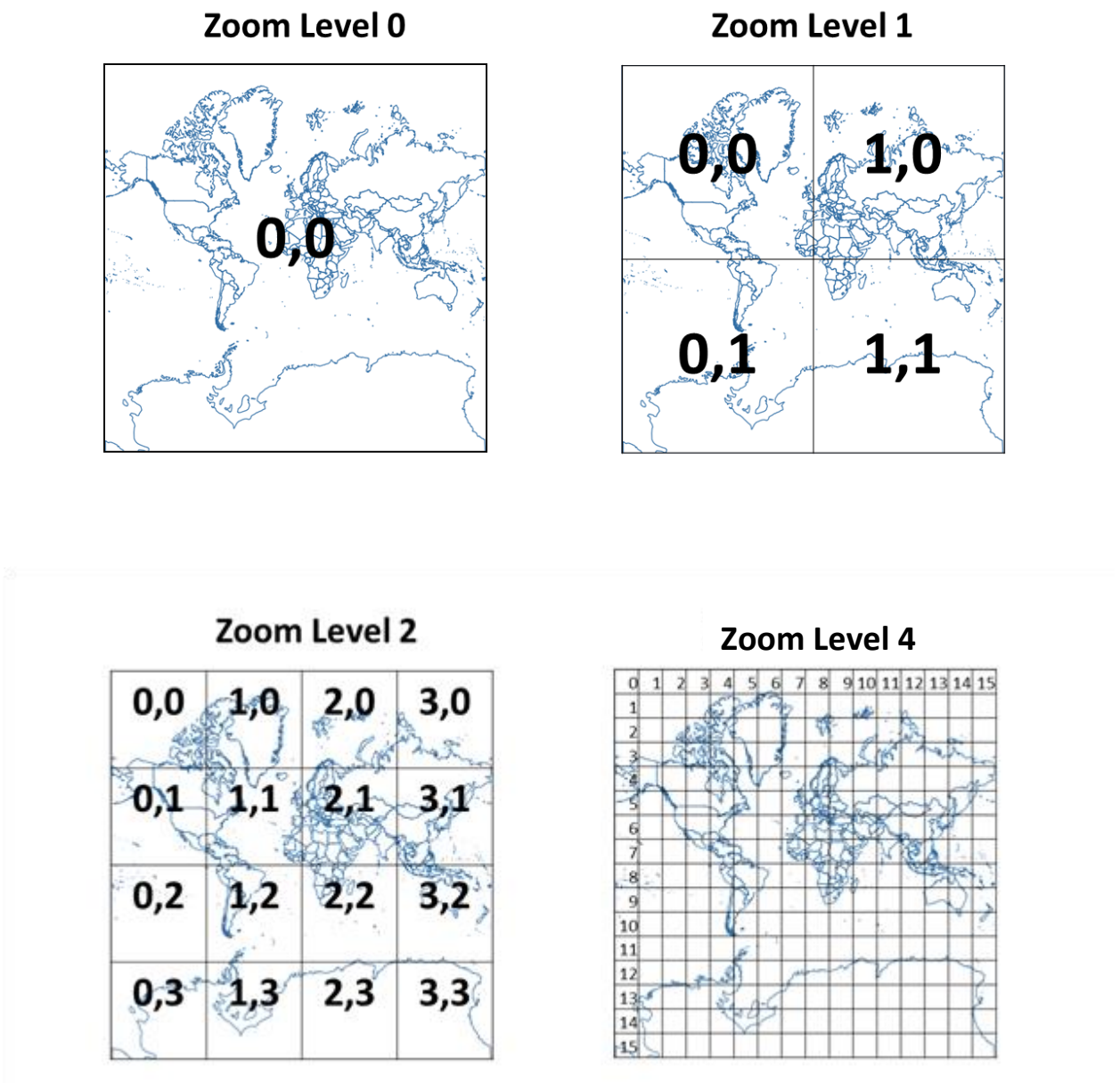

Figure 1: World Mercator tile indexing

The bounding box should describe the maximum extent of the tiles. If source data does not completely fill a tile, pixels without data within the tile must be completely filled with a default value (e.g. transparency). The bounding box must be aligned with tile boundaries, not to data boundaries (Figure 2).

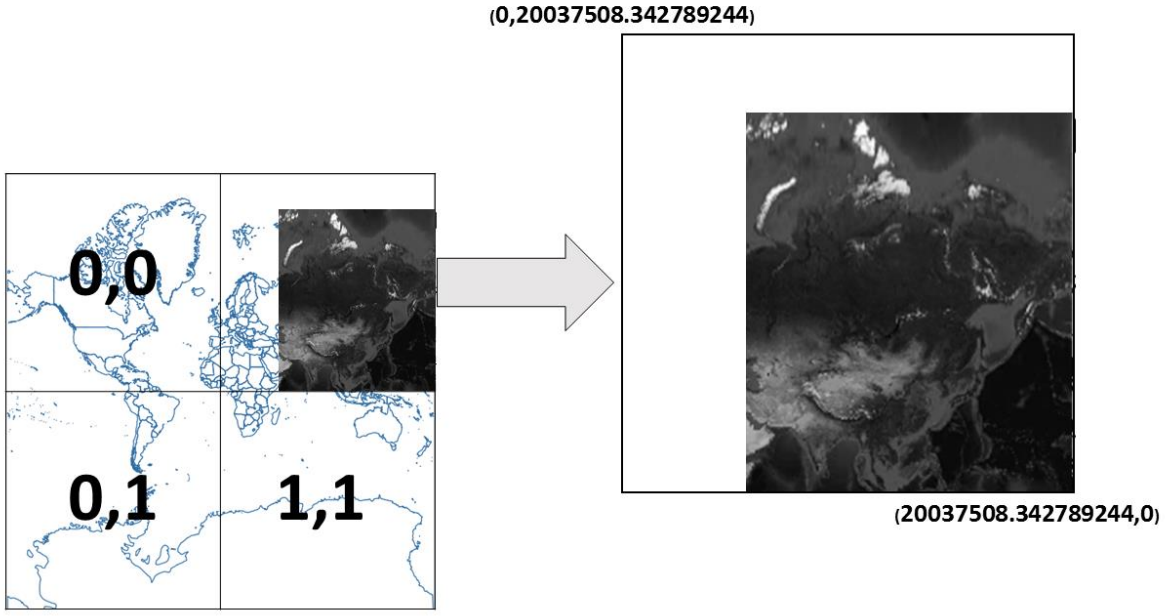

Figure 2: Bounding box and partial tile example

B.2 WGS 84 Geodetic lat/long EPSG:4326[3] and CRS 84

This section references two different WKSS:

- GoogleCRS84Quad (urn:ogc:def:wkss:OGC:1.0:GoogleCRS84Quad) in OGC WMTS 1.0, equivalent to http://www.opengis.net/def/wkss/OGC/1.0/GoogleCRS84Quad (see https://docs.ogc.org/is/17-083r4/17-083r4.html#toc45)
  It may be implemented by TMS http://www.opengis.net/def/tilematrixset/OGC/1.0/WorldCRS84Quad (see https://docs.ogc.org/is/17-083r4/17-083r4.html#toc50)
- A second WKSS with same scales set as for GoogleCRS84Quad but with EPSG:4326 CRS (switching lat/long coordinates). The WGS 84 Geodetic lat/long (EPSG: 4326) tile scheme has an equirectangular layout.

The projection bounds for the WGS 84 Geodetic raster tile pyramid are (-180, -90) to (180, 90)

A zoom level 0 tile should generally not be used in the WGS 84 Geodetic tiling scheme. Zoom level 1 will consist of two square tiles that cover the whole bounds of the projection.

As referenced in the Normative Reference 1, section 6.1. a) "The scale denominator is defined with respect to a 'standardized rendering pixel size' of 0.28 mm × 0.28 mm (millimeters)"

At zoom level 1, the pixel size in degrees is 180/ 256 = 0.7031250.

The zoom level scale set and matrix width and height for the WGS 84 Geodetic raster tile pyramid are defined below in Table 12.

These scale sets are compatiable with WKSS defined in ANNEX E.3 of the OGC WMTS Standard Table E.1 GlobalCRS84Scale (urn:ogc:def:wkss:OGC:1.0:GlobalCRS84Scale), document ID; 07-057r7

Table 14: Zoom Level Scale Set and Matrix dimensions - WGS 84 Geodetic lat/long

Zoom Level	Pixel Size (degrees)	matrix_width	matrix_height
0	1.4062500	1	1
1	0.7031250	2	1
2	0.3515625	4	2
3	0.1757813	8	4
4	0.0878906250	16	8
5	0.0439453125	32	16
6	0.0219726563	64	32
7	0.0109863281	128	64
8	0.0054931641	256	128

[3] EPSG Geodetic Parameter Registry (http://www.epsg-registry.org/)

Zoom Level	Pixel Size (degrees)	matrix_width	matrix_height
9	0.0027465820	512	256
10	0.0013732910	1024	512
11	0.0006866455	2048	1024
12	0.0003433228	4096	2048
13	0.0001716614	8192	4096
14	0.0000858307	16384	8192
15	0.0000429153	32768	16384
16	0.0000214577	65536	32768
17	0.0000107288	131072	65536
18	0.0000053644	262144	131072
19	0.0000026822	524288	262144
20	0.0000013411	1048576	524288
21	0.0000006706	2097152	1048576
22	0.0000003353	4194304	2097152
23	0.0000001676	8388608	4194304
24	0.0000000838	16777216	8388608

All tiles are globally referenced based on the zoom level and (column, row) index values on the global WGS 84 Geodetic grid. Figure 3 below shows the (column, row) index values for zoom levels 1 through 3.

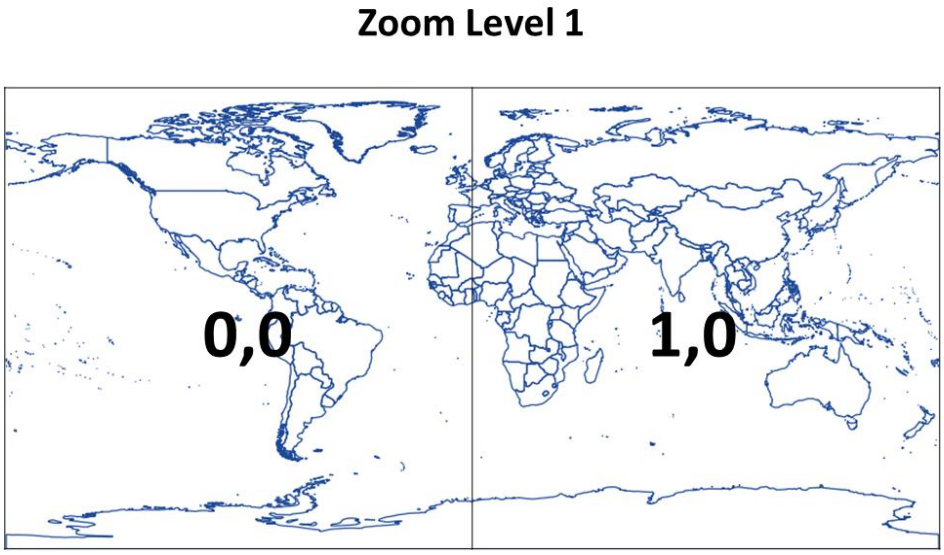

Figure 3: WGS 84 Tile Indexing – Zoom Level 1

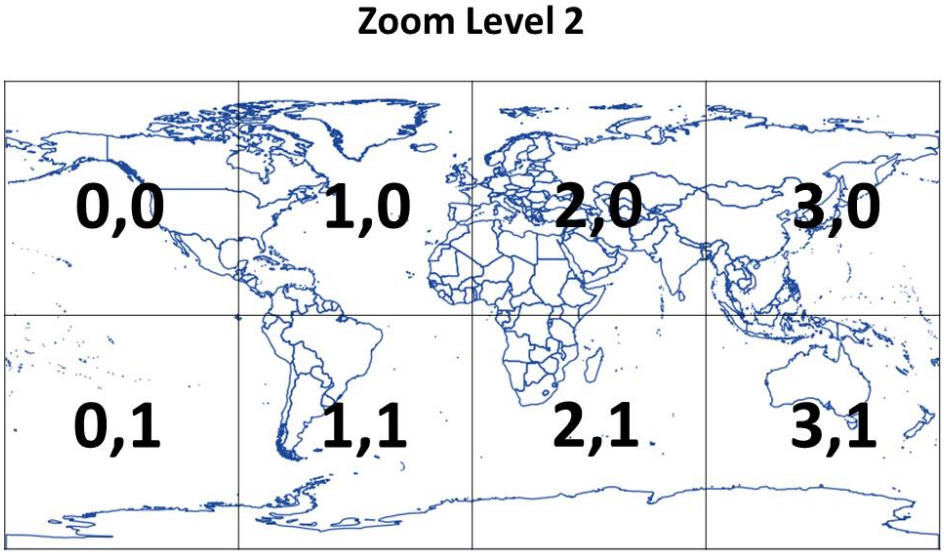

Figure 4: WGS 84 Tile Indexing – Zoom Level 2

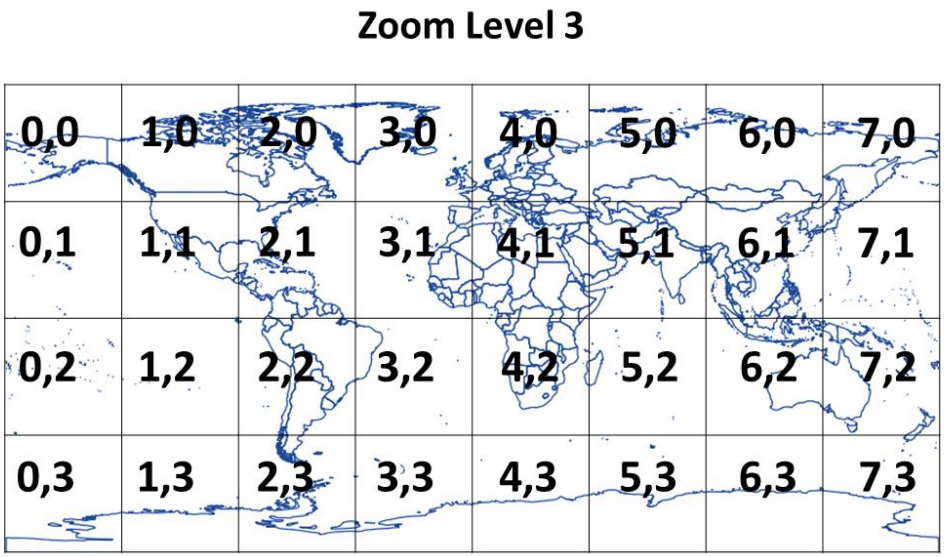

Figure 5: WGS 84 Tile Indexing – Zoom Level 3

B.3 UPS Tiles EPSG:5041 and EPSG:5042

EPSG:5041 refers to a coordinate reference system having axes and coordinates in the order Easting-Northing. It is employed by NATO in the Northern hemisphere – north of 60 degrees N onshore and offshore, including the Arctic. EPSG: 32661 refers to a similar system having axes and coordinates in the order Northing-Easting.

May be implemented by TMS http://www.opengis.net/def/tilematrixset/OGC/1.0/UPSArcticWGS84Quad

EPSG:5042 refers to a coordinate reference system having axes and coordinates in the order Easting-Northing. It is employed by NATO in the Southern hemisphere – south of 60 degrees S onshore and offshore, including Antarctica. EPSG: 32761 refers to a similar system having axes and coordinates in the order Northing-Easting.[4]

May be implemented by TMS http://www.opengis.net/def/tilematrixset/OGC/1.0/UPSAntarcticWGS84Quad

B.4 NATO Compatible well known scale set definition.

This well-known scale set has been defined to be compatible with NATO systems using the **WGS_1984_World_Mercator** map projection. It consists of 29 levels made from a Renard series of five scale denominators per decade (R5). This may be extended to larger scales following the same pattern if required. The tiling scheme has its origin at -20050000 m east and 30200000 m north (approximate longitude 180° west and latitude 89° north) and is designed to be used for 256 x 256 pixel tiles. Table X summarises the scale denominator and approximate resolution for each scale level. The exact resolution can be calculated from the scale denominator for a screen resolution of 96 pixels per US Survey inch. The XML encoding is also shown in this ANNEX.

Table 15: NATO Compatible well known scale set

CRS	Level ID	Scale Denominator	Approximate Resolution
EPSG:3395 World Mercator **OGC Well know text description for 3395:** *PROJCS["WGS_1984_World_Mercator",GEOGCS["GCS_WGS_1984",DATUM["D_WGS_1984",SPHEROID["WGS_1984",6378137.0,298.257223563]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Mercator"],PARAMETER["False_Easting",0.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",0.0],PARAMETER["Standard_Parallel_1",0.0],UNIT["Meter",1.0],AUTHORITY["EPSG",3395]]*	0	630000000	166687.833
	1	400000000	105833.545
	2	250000000	66145.9656
	3	160000000	42333.418
	4	100000000	26458.3863
	5	63000000	16668.7833
	6	40000000	10583.3545
	7	25000000	6614.59656
	8	16000000	4233.3418
	9	10000000	2645.83863
	10	6300000	1666.87833
	11	4000000	1058.33545

[4] EPSG Geodetic Parameter Registry (http://www.epsg-registry.org/)

	12	2500000	661.459656
	13	1600000	423.33418
	14	1000000	264.583863
	15	630000	166.687833
	16	400000	105.833545
	17	250000	66.1459656
	18	160000	42.333418
	19	100000	26.4583863
	20	63000	16.6687833
	21	40000	10.5833545
	22	25000	6.61459656
	23	16000	4.2333418
	24	10000	2.64583863
	25	6300	1.66687833
	26	4000	1.05833545
	27	2500	0.66145966
	28	1600	0.42333418
	29	1000	0.26458386

Annex C
ISO 19115 topic category and DGIF group
(Normative)

ISO 19115 Topic Category	Definition
biota	Flora or fauna in natural environment, for example wildlife, vegetation, biological sciences, ecology, wilderness, sea life, wetlands, habitat, biological resources
boundaries	Legal land descriptions, for example political and administrative boundaries, governmental units, marine boundaries, voting districts, school districts, international boundaries
climatologyMeteorologyAtmosphere	Processes and phenomena of the atmosphere, for example cloud cover, weather, climate, atmospheric conditions, climate change, precipitation
economy	Economic activities, conditions, and employment, for example production, labor, revenue, business, commerce, industry, tourism and ecotourism, forestry, fisheries, commercial or subsistence hunting, exploration and exploitation of resources such as minerals, oil and gas
elevation	Height above or below sea level, for example altitude, bathymetry, digital elevation models, slope, derived products, DEMs, TINs
environment	Environmental resources, protection and conservation, for example environmental pollution, waste storage and treatment, environmental impact assessment, monitoring environmental risk, nature reserves, landscape, water quality, air quality, environmental modeling
farming	Rearing of animals or cultivation of plants, for example agriculture, irrigation, aquaculture, plantations, herding, pests and diseases affecting crops and livestock
geoscientificInformation	Information pertaining to earth sciences, for example geophysical features and processes, geology, minerals, sciences dealing with the composition, structure and origin of the earth's rocks, risks of earthquakes, volcanic activity, landslides, gravity information, soils, permafrost, hydrogeology, groundwater, erosion
health	Health, health services, human ecology, and safety, for example disease and illness, factors affecting health, hygiene, substance abuse, mental and physical health, health services, health care providers, public health
imageryBaseMapsEarthCover	Base maps, for example land/earth cover, topographic maps, imagery, unclassified images, annotations, digital ortho imagery

inlandWaters	Inland water features, drainage systems and characteristics, for example rivers and glaciers, salt lakes, water utilization plans, dams, currents, floods and flood hazards, water quality, hydrographic charts, watersheds, wetlands, hydrography
intelligenceMilitary	Military bases, structures, activities, for example barracks, training grounds, military transportation, information collection
location	Positional information and services, for example addresses, geodetic networks, geodetic control points, postal zones and services, place names, geographic names
oceans	Features and characteristics of salt water bodies (excluding inland waters), for example tides, tidal waves, coastal information, reefs, maritime, outer continental shelf submerged lands, shoreline
planningCadastre	Information used for appropriate actions for future use of the land, for example land use maps, zoning maps, cadastral surveys, land ownership, parcels, easements, tax maps, federal land ownership status, public land conveyance records
society	Characteristics of society and culture, for example settlements, housing, anthropology, archaeology, education, traditional beliefs, manners and customs, demographic data, tourism, recreational areas and activities, parks, recreational trails, historical sites, cultural resources, social impact assessments, crime and justice, law enforcement, census information, immigration, ethnicity
structure	Man-made construction, for example buildings, museums, churches, factories, housing, monuments, shops, towers, building footprints, architectural and structural plans
transportation	Means and aids for conveying persons or goods, for example roads, airports/airstrips, shipping routes, tunnels nautical charts, vehicle or vessel location, aeronautical charts, railways
utilitiesCommunication	Energy, water and waste systems and communications infrastructure and services, for example hydroelectricity, geothermal, solar and nuclear sources of energy, water purification and distribution, sewage collection and disposal, electricity and gas distribution, data communication, telecommunication, radio, communication networks

DGIF Group first level	DGIF Groups (second level of the hierachy)
IndustriesServices	
	Extraction
	FabricationProcessing
	Agriculture
	PowerSupplies
	Communication
	AssociatedSupportStruct
	StorageProvision
	WasteManagement
SocioEconomicGeography	
	Habitats
	SettlementsAssociated
	EconomicCommercial
	Leisure
	PoliticsAdministration
	SciencesEducation
	CulturalContext
Transportation	
	Railways
	RoadsTracks
	GuidedTransportation
	WaterBorneTransportation
	AirTransportation
	Restrictions
	CrossingsLinks
	TransportationAssociated
	SpaceTransportation
	DistributionNetworks
HydrographyOceanography	
	CoastalLittoralZones
	PortsHarbours
	Depths
	NatureOfSeabed
	OffshoreConstructInstall
	TidesCurrents
	RoutesNavigation
	HazardsObstructions
	SeaIce
	RegulatedRestrictedZones
	InlandWaters
	PhysicsOfWater
Physiography	
	Hypsography
	Geomorphology

	Rocks
	Soils
	NaturalResources
	SeismologyVolcanology
	Glaciers
	Anomalies
	GlobalEarthCover
Biota	
	CultivatedLand
	Rangeland
	Woodland
	Wetland
	AridAreas
	RegionsRestrictedAreas
	Fauna
	Flora
Demarcation	
	BoundariesLimits
	LandSurveyRealEstate
Aeronautical	
	AerodromesMoveSurfLighting
	AirspaceRoutes
	NavaidsLandAidsPointsObst
	ServicesOrgsTimetables
	TerminalProcedures
Military	
	DefensiveOperationalStruct
	RestrictedAreasBoundaries
	OperationsEvents
WeatherClimate	
	WeatherPhenomena
	ClimateConditions
	ClimateZonesRegions
Characteristics	
	Position
	MeasurableValues
	DatesDurations
	Appearance
	FunctionStatus
NamesDesignations	
	Names
	Designations
MetadataReferences	
	Annotation
	Portrayal
	DateCurrency
	Quality
	ReferencesSources

SystemsOfClassification

Abstract

Annex D
Evolutions from v1.0 and 2.0 of the DGWIG WMTS profile
(Informative)

req #	requirement	Source (DGIWG WMTS 1.0/ DGIWG WMS 3.0 or NCIA SIP for Map rendering Services v1.0)	comments
1	A WMTS server shall be compliant to OGC WMTS 1.0.	DGIWG WMTS req1	equivalent, there is no basic WMTS.
2	A WMTS Server shall support HTTP GET operation using KVP (clause 8 of OGC WMTS) and RESTful (clause 10 of OGC WMTS 1.0) encodings.	DGIWG WMTS req2-6	equivalent, all requirements are merged into one. Other DGIWG requirements do not add any additional value (GetCapabilities and GetTile operations are mandatory; ServiceMetadata ad Tile ressources are mandatory).
3	A WMTS server shall support at least one of the folowwing WKSS: see DGIWG ANNEX B.1 (EPSG:3395), B.2 (EPSG:4326 and CRS 84) and B.3 (UPS Tiles EPSG:5041 and EPSG:5042).	DGIWG req7-9	DGIWG requirements have been reworked. WKSS also contain CRS/Projection information. Specifying the two is the redondant and could be missleading. Same WKSS from DGIWG, NATO WKSS has evolved from EPSG:3395 to EPSG:3357.
4	A WMTS server shall provide tiles in at least one of the following raster formats: • image/png (Portable Network Graphics) • image/gif (Graphics Interchange Format) • image/jpeg (Joint Photographics Expert Group).	DGIWG req10	equivalent

5	If a WMTS server is providing services to a coalition mission federated network, in support of operations or an exercise, it shall provide a minimum keyword list, based on ISO 19115 Topic Categories. It's recommended to provide additional details based on the DGIF groups. The provision of these keywords elements are optional for a WMTS server which is providing services across one single non-mission network.	DGIWG req12	condition added, simpler to implement (requirement isonly on the first level of keyword (ISO 19115 Topic Categories), recommendation is in line with DGIWG Req12).
6	A WMTS server shall provide the service exceptions in the English language. Exception text content may also be provided in additional languages, but English must always be included.	WMS harmonized req6	
7	A WMTS server shall provide an "Abstract" at the service level, in the in the GetCapabilities response document.	WMS harmonized req7	requirement imported from the WMS harmonized
8	If a WMTS server is providing services to a coalition mission federated network, in support of operations or an exercise, it shall provide "ServiceContact", "AccessConstraints" and "KeywordList" elements. The provision of these metadata elements are optional for a WMTS server which is providing services across one single non-mission network.	WMS harmonized req8	requirement imported from the WMS harmonized
9	A WMTS server SHALL use the <AccessContraints> element to hold the classification information for this web service instance."	WMS harmonized req9	requirement imported from the WMS harmonized
10	If a WMTS server is providing services to a coalition mission federated network, in support of operations or an exercise, it shall include the following information in the <abstract> element of the service metadata: "This service implements the WMTS 1.0 STANAG 6523 Ed.2 profile". The provision of these metadata elements are optional for a WMTS server which is providing services across one single non-mission network.	WMS harmonized req10	requirement imported from the WMS harmonized
11	A RESTful WMTS server shall provide tile expiration date, in an appropriate HTTP header ("Expires" header in HTTP 1.0, "Cache-control" header for HTTP 1.1 and for HTTP 2).	DGIWG req14	equivalent, reformulated for restfull aproach only
12	A WMTS server shall provide the service metadata document (GetCapabilities response or ServiceMetadata resource document) and the featureInfo document (if supported, GetFeatureInfo response or FeatureInfo resource document) in the English language. Metadata content may also be provided in additional languages, but English must always be included.	WMS harmonized req3	requirement adapted from the harmonized WMS

13	A WMTS server shall provide a <title> element for each supported style.	from old WMS harmonized 12 OGC WMS required Name and Title for all supported styles.	<identifier> is required by OGC WMTS, but not the <title>
14	Each layer's style shall have an associated legend (using the <legendURL >element) if the data being provisioned is symbolized/portrayed (i.e. not imagery).	WMS harmonized req13	same
15	Legends shall be available as an image in at least one of the following formats: PNG (image/png), GIF (image/gif) or JPEG (image/jpeg).	WMS harmonized req14	same
16	If legend is present (see req 14), the <LegendURL> element shall specify a URL to allow access to an image of the legend. Note : This URL will relate to the source system and may not be resolvable on all connected/unconnected systems or applications. This requirement is conditional on the <LegendURL> being relevant to the generated service.	WMS harmonized req15	LegenURL is provided as an attribute xlink:href of the legendURL
17	If a WMTS server offers its functionality via the SOAP protocol, it shall do so in compliance with the Messaging Service SIP [NCIA TR/2012/SPW008000/30, 2012] which defines general requirements that apply to all services in the NNEC environment that make use of SOAP.	NCIA SIP for Map Rendering Services	equivalent, reformulated